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BIQLQGY

eighth edition

Sylvia S. Mader

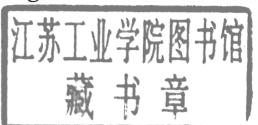
Selected Chapters From

BIOLOGY

Eighth Edition

Sylvia S. Mader

For Wilbur Wright College





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Selected Chapters from BIOLOGY, 8E

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This book contains selected material from Biology, Eighth Edition, by Sylvia S. Mader.

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History of Biology

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	Year	Name	Country	Contribution
	1628	William Harvey	Britain	Demonstrates that the blood circulates and the heart is a pump.
	1665	Robert Hooke	Britain	Uses the word <i>cell</i> to describe compartments he sees in cork under the microscope.
	1668	Francesco Redi	Italy	Shows that decaying meat protected from flies does not spontaneously produce maggots.
	1673	Antonie van Leeuwenhoek	Holland	Uses microscope to view living microorganisms.
	1735	Carolus Linnaeus	Sweden	Initiates the binomial system of naming organisms.
Antonie van Leeuwenhoek	1809	Jean B. Lamarck	France	Supports the idea of evolution but thinks there is inheritance of acquired characteristics.
	1825	Georges Cuvier	France	Founds the science of paleontology and shows that fossils are related to living forms.
177	1828	Karl E. von Baer	Germany	Establishes the germ layer theory of development.
	1838	Matthias Schleiden	Germany	States that plants are multicellular organisms.
9	1839	Theodor Schwann	Germany	States that animals are multicellular organisms.
Charles Darwin	1851	Claude Bernard	France	Concludes that a relatively constant internal environment allows organisms to survive under varying conditions.
数整使 Mg	1858	Rudolf Virchow	Germany	States that cells come only from preexisting cells.
	1858	Charles Darwin	Britain	Presents evidence that natural selection guides the evolutionary process.
	1858	Alfred R. Wallace	Britain	Independently comes to same conclusions as Darwin.
	1865	Louis Pasteur	France	Disproves the theory of spontaneous generation for bacteria; shows that infections are caused by bacteria, and develops vaccines against rabies and anthrax.
Louis Pasteur	1866	Gregor Mendel	Austria	Proposes basic laws of genetics based on his experiments with garden peas.
	1882	Robert Koch	Germany	Establishes the germ theory of disease and develops many techniques used in bacteriology.
6 3	1900	Walter Reed	United States	Discovers that the yellow fever virus is transmitted by a mosquito.
	1902	Walter S. Sutton Theodor Boveri	United States Germany	Suggest that genes are on the chromosomes, after noting the similar behavior of genes and chromosomes.
	1903	Karl Landsteiner	Austria	Discovers ABO blood types.
Robert Koch	1904	Ivan Pavlov	Russia	Shows that conditioned reflexes affect behavior, based on experiments with dogs.
	1910	Thomas H. Morgan	United States	States that each gene has a locus on a particular chromosome, based on experiments with <i>Drosophila</i> .
	1922	Sir Frederick Banting Charles Best	Canada	Isolate insulin from the pancreas.
	1924	Hans Spemann Hilde Mangold	Germany	Show that induction occurs during development, based on experiments with frog embryos.
	1927	Hermann J. Muller	United States	Proves that X rays cause mutations
	1929	Sir Alexander Fleming	Britain	Discovers the toxic effect of a mold product he called
Ivan Pavlov				penicillin on certain bacteria.

History of Biology

Year	Name	Country	Contribution	
1937	Konrad Z. Lorenz	Austria	Founds the study of ethology and shows the importance of imprinting as a form of early learning.	
1937	Sir Hans A. Krebs	Britain	Discovers the reactions of a cycle that produces carbon dioxide during cellular respiration.	
1940	George Beadle Edward Tatum	United States	Develop the one gene—one enzyme theory, based on red bread mold studies.	
1944	O. T. Avery Maclyn McCarty Colin MacLeod	United States	Demonstrate that DNA alone from virulent bacteria can transform nonvirulent bacteria.	
1945	Melvin Calvin Andrew A. Benson	United States	Discover the individual reactions of a cycle that reduces carbon dioxide during photosynthesis.	
1950	Barbara McClintock	United States	Discovers transposons (jumping genes) while doing experiments with corn.	
1952	Alfred D. Hershey Martha Chase	United States	Find that only DNA from viruses enters cells and directs the reproduction of new viruses.	
1953	James Watson Francis Crick Rosalind Franklin	United States Britain	Establish that the molecular structure for DNA is a double helix.	
1953	Harold Urey Stanley Miller	United States	Demonstrate that the first organic molecules may have arisen from the gases of the primitive atmosphere.	
1954	Linus Pauling	United States	States that disease-causing abnormal hemoglobins are du to mutations.	
1954	Jonas Salk	United States	Develops a vaccine that protects against polio.	
1958	Matthew S. Meselson Franklin W. Stahl	United States	Demonstrate that DNA replication is semiconservative.	
1961	Francois Jacob Jacques Monod	France	Discover that genetic expression is controlled by regulatory genes.	
1964	Marshall W. Nirenberg Philip Leder	United States	Produce synthetic RNA, enabling them to break the DNA cod	
1967	Christiaan Barnard	South Africa	Performs first human heart transplant operation.	
1973	Stanley Cohen	United States	Uses recombinant DNA technique (genetic engineering) to place plant and animal genes in <i>Escherichia coli</i> .	
1976	Georges Kohler Cesar Milstein	Britain	Fuse mouse leukemia cells with lymphocytes, developing clones, each of which produces only one type of "monoclonal" antibody.	
1977	Carl Woese	United States	Based on differences in ribosomal RNA sequences, proposes the three domain system of clasifications.	
1978	Peter Mitchell	Britain	Determines chemiosmotic mechanism by which ATP is produced in chloroplasts and mitochondria.	
1982	William De Vries	United States	Performs first complete replacement of human heart with artificial heart on Dr. Barney B. Clark at University of Utah.	
1989	Sidney Altman Thomas R. Check	United States	Independently discover that some RNA molecules can act as enzymes.	
1990	R. Michael Blaese W. French Anderson	United States	Develop procedure to infuse genetically engineered blood cells for treatment of immune system disorder—	
	Kenneth W. Culver		first gene therapy used in a human.	



Konrad Z. Lorenz



Barbara McClintock



Rosalind Franklin



Linus Pauling

It hardly seems possible that this is the eighth edition of *Biology*, a text that has continued to excel and become more widely used with each edition. Preparing the eighth edition was challenging and exciting because so many instructors have suggested ways to make the book even more serviceable to them and their students. Still, my goals have remained the same as they were in the first edition: to give students a conceptual understanding of biology and a working knowledge of the scientific process.

Birth of Biology

I am an instructor of biology, and I have taught students from the community college to the university level. *Biology* was born out of my desire for students to develop a particular view of the world—a biological view. It seemed to me that a thorough grounding in biological principles would lead to an appreciation of the structure and function of individual organisms, how they have evolved, and how they interact in the biosphere. Thinking so led me to use the levels of biological organization as my guide; thus the book begins with chemistry and ends with the biosphere.

I want to provide students with a solid foundation in the principles of biology while sharing with them the most up-to-date findings in most, if not all, biological fields. Everyone is interested in the very latest advances in molecular genetics, from cloning to sequencing the human genome. My coverage of genetics mirrors the excitement and rapid development in this area. However, no aspect of biology is neglected. For example, knowing about the many other species of organisms here on Earth not only enriches our lives, but also may inspire us to preserve biodiversity.

Students need to be aware that our knowledge of biology is built on scientific discovery. The first chapter explains the process of science and thoroughly reviews examples of how this process works. Throughout the text, biologists are introduced, and their experiments are explained. An appreciation of the scientific process should include the perception that, without it, biology would not exist.

Paging the Book

It takes a few years of practice to become a good instructor, and similarly, textbook writers improve their skills with practice. A few years ago, my daughter learned desktop publishing, and I began to realize that I could use the same program to page a book. Previously, text and illustrations had been on two separate tracks until, near the time of publication, a designer put it all together on the page. Artists complained that they had no idea how large or small to make illustrations; adopters complained that the illustra-

tions were too far from the figure number—some were three pages beyond the reference! Now, because I page the book, I am able to make sure that every illustration is on the same page as its reference or on a facing page so that students are able to follow the discussion without flipping back and forth between pages.

Illustrations

My hope is to create a book that both verbally and visually engenders a love of biology. An idea for a new illustration must be conceived and brought to fruition long before it appears in the book. For this edition, I have developed many new illustrations. Among them, the introductory chapter has a new levels-of-organization figure that begins with chemicals and ends with the biosphere. A new combined starch and glycogen illustration in the organic chemistry chapter allows students to better appreciate the differences between these two carbohydrates. An illustration depicting the entire endomembrane system in the cell chapter emphasizes how different cell organelles communicate. A much-improved overview of photosynthesis became an icon for other illustrations in this chapter. An illustration concerning X-inactivation in mammalian females better explains the occurrence of Barr bodies. Replication of HIV-1 in the microbiology chapter outlines the reproductive cycle of retroviruses. A new phylogenetic tree for plants and another for animals became icons for their respective sections. And also, many new micrographs have been added to illustrations that formerly contained art only.

This Edition

Biology has a new table of contents that strengthens its evolutionary theme. Previously separated plant chapters and animal chapters have been brought together so that students can more fully relate the evolutionary history of plants and animals to their anatomical and physiological adaptations. Thus, Part V, "Plant Evolution and Biology," begins with a chapter on the evolution and diversity of plants and then continues with a chapter on plant structure and function. The other plant chapters follow. Part VI, "Animal Evolution," traces the evolution of animals, from invertebrates to the evolution of humans. The next part is "Comparative Animal Biology."

Reorganizing the book inspired me to thoroughly revise the plant biology chapters. Chapter 24, "Evolution and Diversity of Plants," is a new chapter, which clearly traces the ways in which plants have become adapted to the terrestrial environment. Chapter 28, "Reproduction in Plants," was rewritten, and the accuracy was increased. Many new and beautiful illustrations were also added.

The many changes and revisions in this edition are too numerous to completely review, but you may want to know that Part II, "Genetic Basis of Life," now begins with a chapter entitled "The Cell Cycle and Cellular Reproduction." Revised discussions of the cell cycle and also apoptosis begin this chapter, which considers mitosis but ends with a more complete coverage of cancer. The chapter on human genetics has been eliminated, and that material has been integrated into the other genetics chapters. Because of this reorganization, Chapter 12, "Chromosomal Patterns of Inheritance," is now particularly appealing. Chapter 16, "Biotechnology and Genomics," is so named because it now has an expanded section on the expected benefits of the Human Genome Project.

Pedagogy

Pages xx–xxii of this preface review "The Learning System" of *Biology*. As you will see there, each chapter-opening page provides an outline and lists the concepts that are

discussed and reinforced within the chapter. As before, an opening vignette captures the interest of students, and at the close of each chapter, "Connecting the Concepts" discusses the relationships between various biological principles. The end matter of a chapter also gives students an opportunity to test themselves on their progress. The number of objective questions has been increased considerably in this eighth edition after learning how much they are utilized by students.

It has been my privilege to develop a style and methodology that appeals to students because it meets them where they are and brings them along to a thorough understanding of the concept being presented. Concepts are only grasped if a student comes away with "take-home messages." The interweaving of concepts allows the student to develop a biological view of the world that is essential in the twenty-first century.

Overview of Changes to Biology, Eighth Edition

All Plant Biology Chapters Extensively Revised

In addition to extensively revising previous plant chapters, a new chapter, "Evolution and Diversity of Plants," has been added.

Revised and Reorganized Table of Contents Strengthens Biology's Evolutionary Theme

All chapters pertaining to plants are now grouped in one unit, thereby giving students the opportunity to see plant classification, structure, and function from an evolutionary perspective.

The new Part VI, "Animal Evolution," traces the evolution of animals from invertebrates to humans.

Revised Part II, "Genetic Basis of Life"

This part now begins with a chapter "The Cell Cycle and Cellular Reproduction" in keeping with an emphasis on genes that control the cell cycle.

Chapter 16, "Biotechnology and Genomics"

This chapter has an expanded section on the expected benefits of the Human Genome Project.

Classification System

This edition uses the three-domain system of classification based on RNA comparisons.

Illustrations

Many new illustrations include micrographs combined with line art to clarify difficult concepts.

e-Learning Connection

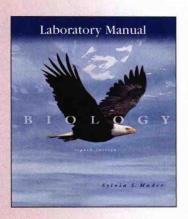
Online study aids are organized according to major sections of a chapter so that students can easily determine what resources are available for help with difficult concepts. Visit www.mhhe.com/maderbiology8.

Teaching and Learning Supplements

McGraw-Hill offers a variety of tools and technology products to support the eighth edition of *Biology*. Students can order supplemental study materials by contacting their local bookstore or the McGraw-Hill Customer

Service Department at (800) 338-3987. Instructors can obtain teaching aids by calling the Customer Service Department or by contacting their local McGraw-Hill sales representative.

For the Instructor



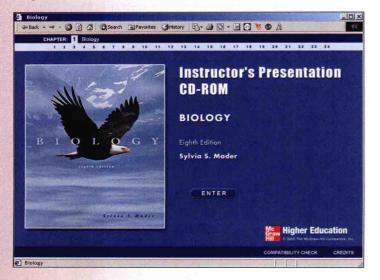
Biology Laboratory Manual

The Biology Laboratory Manual, eighth edition, is written by Dr. Sylvia Mader. With few exceptions, each chapter in the text has an accompanying laboratory exercise in the manual. Every laboratory has been written to help students learn the fundamental concepts of biology and the specific content of the chap-

ter to which the lab relates, as well as gain a better understanding of the scientific method. ISBN 0-07-246464-X

Instructor's Presentation CD-ROM

This collection of multimedia resources provides tools for rich visual support of your lectures. You can utilize artwork from the text in multiple formats to create customized classroom presentations, visually based tests and quizzes, dynamic course website content, or attractive printed support materials. The digital assets on this cross-platform CD-ROM are grouped by chapter within the following easy-to-use folders:



Active Art Library. Illustrations depicting key processes have been converted to a format that allows each figure to be broken down to its core elements, thereby allowing the instructor to manipulate the art and adapt the figure to meet the needs of the lecture environment.

Art Libraries. Full color digital files of all illustrations in the book, plus the same art saved in unlabeled and gray scale versions, can be readily incorporated into lecture presentations, exams, or custom-made classroom materials.

Photo Library. All photos from the text are available on this CD-ROM. A separate folder contains hundreds of additional photos relative to the study of biology.

Video Library. Harness the visual impact of key physiological processes in motion by importing these videos into classroom presentations.

Tables Library. Every table that appears in the text is provided in electronic format.

PowerPoint Lecture Outlines. A ready-made presentation that combines lecture notes and art is written for each chapter. They can be used as they are, or the instructor can tailor them to preferred lecture topics and sequences.

PowerPoint Art Slides. Art, photographs, and tables from each chapter have been pre-inserted into blank PowerPoint slides.

Instructor's Testing and Resource CD-ROM

This cross-platform CD-ROM provides a wealth of resources for the instructor:

Computerized Test Bank utilizes Brownstone Diploma[®] testing software to quickly create customized exams. This user-friendly program allows instructors to search for questions by topic or format; edit existing questions or add new ones; and scramble questions and answer keys for multiple versions of the same test. Word files of the test bank are included for those instructors who prefer to work outside of the test-generator software.

Instructor's Manual provides learning objectives, extended lecture outlines, lecture enrichment ideas, technology resources, and critical thinking questions.

Laboratory Resource Guide is a preparation guide that provides set-up instructions for each lab in the *Biology Laboratory Manual*, suggested sources for materials and supplies, time estimates, expected results for the exercises, and suggested answers to questions in the laboratory manual.

Online Learning Center



The *Biology* Online Learning Center (OLC) at www.mhhe.com/maderbiology8 offers access to a vast array of premium online content to fortify the learning and teaching experience for students and instructors.

Instructor Edition. In addition to all of the resources for students, the Instructor Edition of the Online Learning Center has these assets:

- Instructor's Manual This resource provides learning objectives, lecture outlines, lecture enrichment topics, technology resources, and critical thinking questions.
- Laboratory Resource Guide This preparation guide that provides set-up instructions, sources for materials and supplies, time estimates, special requirements, and suggested answers to all questions in the laboratory manual.
- PageOut McGraw-Hill's exclusive tool for creating your own website for your general biology course. It requires no knowledge of coding and is hosted by McGraw-Hill.

 Course Management System OLC content is readily compatible with online course management software such as WebCT and Blackboard. Contact your local McGraw-Hill sales representative for details.

Transparencies

This set of more than 850 overhead transparencies includes all line art in the textbook, plus tables. Images are printed with better visibility and contrast than ever before, and labels are large and bold for clear projection.

Mader Micrograph Slides

This set contains one hundred 35 mm slides of many of the photomicrographs and electron micrographs in the text. ISBN 0-07-239977-5

Life Science Animations Library 3.0 CD-ROM

This CD-ROM contains over 600 full-color animations of biological concepts and processes. Harness the visual impact of processes in motion by importing these files into classroom presentations or online course materials. ISBN 0-07-248438-1

iLaBS



Interactive Laboratories and Biological Simulations, or iLaBS, dynamically illustrate molecular genetics and biotechnology through lively, engaging tutorials and interactive, inquiry-based

labs. These web-based labs, developed as a collaboration between instructors and students, provide rigorous yet entertaining exercises that relate lecture and lab content to real-life applications. In addition to providing students the opportunity for repetitive practice in techniques that they would be limited to doing only once in a normal lab setting, iLaBS also allow students to virtually perform time-consuming or hazardous techniques that they would not otherwise be able to experience. ISBN 0-07-285012-4

For the Student

Student Study Guide

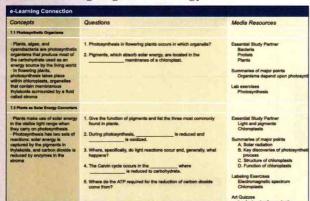
Dr. Sylvia Mader has also written the *Student Study Guide* that accompanies the eighth edition of *Biology*. Each text chapter has a corresponding study guide chapter that includes a chapter review, study exercises for each section of the chapter, a chapter test, and critical thinking questions. Answers for all questions are provided to give students immediate feedback. ISBN 0-07-241883-4

Online Learning Center

The *Biology* Online Learning Center (OLC) at www.mhhe.com/maderbiology8 offers access to a vast array of premium online content to fortify the learning and teaching experience for students and instructors.

Student Edition. The Student Edition of the OLC features a wide variety of tools to help students learn biological concepts and to reinforce their knowledge:

 e-Learning Connection Online study aids are organized according to the major sections of each chapter. Practice quizzes, interactive activities, animations, labeling exercises, flashcards, and much more will complement the learning and understanding of general biology.

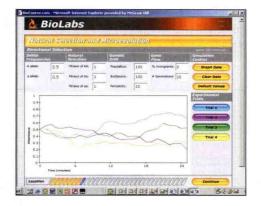


- PowerWeb: Biology An online supplement that
 offers access to current course-specific articles, realtime news, research links, articles, journals, and much
 more. Bring your course into today's world with the
 resources available here.
- Online Tutoring A 24-hour tutorial service moderated by qualified instructors. Help with difficult concepts is only an email away!

 Essential Study Partner 2.0 A collection of interactive study modules that contains hundreds of animations, learning activities, and quizzes designed to help students grasp complex concepts.



 BioLabs Using the scientific method, students can master skills vital to success in the laboratory by using these online simulations.



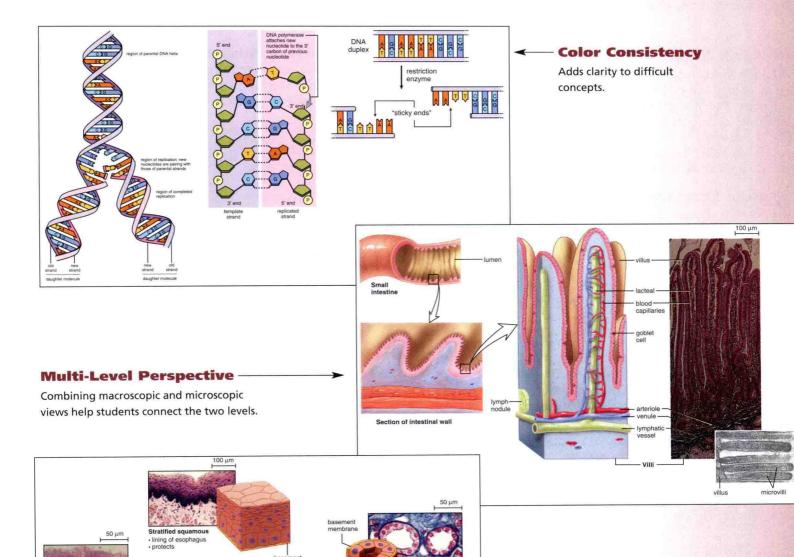
GradeSummit



GradeSummit, found at www.gradesummit.com, is an Internet-based self-assessment service that provides students and faculty with diagnostic information about subject strengths and weaknesses. This detailed feedback enables students and instructors to focus study time on areas where it will be most effective. GradeSummit also enables instructors to measure their students' progress and assess that progress relative to others in their classes.

Outstanding Illustration Program

Biology Uses Art to Clarify and Dramatize the Text



goblet cell

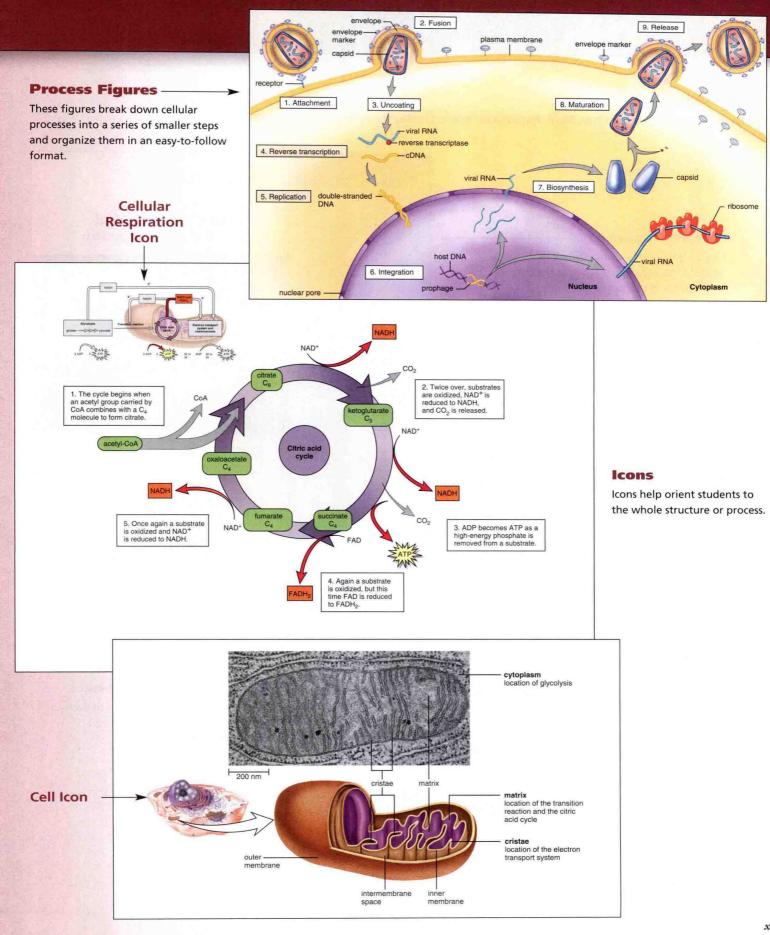
Combination Art

Drawings of structures are often paired with micrographs to enhance visualization.

xviii

lining of lungs

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The Learning System

Time-Proven Features That Will Facilitate Your Understanding of Biology

Chapter Concepts -

that numbers the major topics of the chapter and lists the concepts for each topic.

9.1 The Cell Cycle The cell cycle is a repeating sequence of growth, replication of DNA, and cell division. 150

The Cell Cycle and Cellular Reproduction



onsider the development of a human being. We begin life as one cellonsider the development of a furnish using the segment of an egg fertilized by a sperm. Yet in nine short months, we become a complex organism consisting of trillions of cells. How is such a feat possible?

Cell division enables a single cell to produce many cells, allowing an organism to grow in size and to replace worn-out tissues.

The instructions for cell division lie in the genes. During the first part of an organism's life, the genes instruct all cells to divide. When adulthood is reached, however, only specific cells—human blood and skin cells, for examplecontinue to divide daily. Other cells, such as nerve cells, no longer routinely

Since all types of adult cells contain the full complement of genetic material in their nuclei, why don't they all reproduce routinely? Such questions are being intensely studied. Cell biologists have recently discovered that specific signaling proteins regulate the cell cycle, the period extending from the time a new cell is produced until it too completes division. The presence or absence of signaling proteins ensures the regulation of cell division. Cancer results when the genes that code for these signaling proteins mutate and cell division occurs

The chapter begins with an integrated outline

The cell cycle, which leads to an increase in cell number, is oppose by apoptosis, which is programm cell death. 151 9.2 Mitosis and Cytokinesis

The cell cycle is tightly controlled can stop at three different checkpoints if conditions are not normal. 150

- .3 The Cell Cycle and Cancer

chapter 35 Lymph Transport and Imm

B Cells and Antibody-Mediated Immunity When a B cell in a lymph node of the spleen encounters a specific antigen, it is activated to divide many times. Most of the resulting cells are plasma cells. A plasma cell is a mature

B cell that mass-produces antibodies against a specific antigen.

The clonal selection theory states that the antigen selects which lymphocyte will undergo clonal expansion and lects which hymphocyte will undergo clonal expansion and produce more lymphocytes bearing the same type of anti-gen receptor. Notice in Figure 35.5 that different types of anti-gen receptors are represented by color. The B cell with blue receptors undergoes clonal expansion because a spe-cific antigen (red dots) is present and binds to its receptors. B cells are stimulated to divide and become plasma cells by helper T-cell secretions called cytokines, as is discussed in the next section. Some members of the clone become mem-ory cells, which are the means by which long-term immu-nity is possible. If the same antigen enters the system again,

my sposted squickly divide and give rise to more lym-phocytes capable of quickly producing antibodes. Once the threat of an infection has passed, the develop-ment of new plasma cells ceases, and those present undergo apoptosis. Apoptosis is a process of programmed cell death

(PCD) involving a cascade of specific cellular events leading to the death and destruction of the cell. The methodology of to the ueuth and useful to the recent the inchanceously of PCD is still being worked out, but we know it is an essential physiological mechanism regulating the cell population within an organ system. PCD normally plays a central role in maintaining tissue homeostasis. Defense by B cells is called antibody-mediated immu-

nity because the various types of B cells produce antibodies. It is also called humoral immunity because these antibodies are present in blood and lymph. A humor is any fluid normally occurring in the body.

- Antibody-mediated immunity against bacteria
 Produced and mature in bone marrow
 Reside in spleen and lymph nodes; circulate in blood
- Directly recognize antigen and then undergo clonal

Clonal expansion produces antibody-secreting plasma cells as well as memory B cells

Figure 35.5 Clonal selection theory as it applies to B cells.

Each type of B cell bears a specific antigen receptor (note different colors). When an antigen (red dots) combines with the antiblue, that B cell is stimulated by cytokines, and it undergoes clonal expansion. The result is many plasma cells, which produceagainst this antigen, and memory B cells, which immediately recognize this antigen in the future. After the infection passes, p

Internal Summary Statements

A summary statement appears at the end of each major section of the chapter to immediately reinforce the concepts just discussed.

chapter 4 Cell Structure and Function Science Focus ctionation and Differential Centrifugation odern microscopic techniques can be counted on to reveal the structure and distribute But how do rese ent types of orgations of the process o spins, the fluid portion of the previous cycle must be poured into a clean tube A process called differential centrifugation allows researchers to separate the chapter 2 Basic Chemistry they can detern pose, for examp the function of r acquire some rib remove cells fro **Ecology Focus** The Harm Done by Acid Deposition ture, and place t tion. Then they ormally, rainwater has a pH of about 5.6 because the <u>carbon dioxide</u> in the air combines wit weak solution of ca and toxic methyl mercury. Lakes not only become more acidic, but they also accutries in northern Europe have also re falling in the northead and southeastern Can between 5.0 and 4.0. V ber that a pH of 4 is te chapter 8 Cellular Respiration Health Focus **Exercise: A Test of Homeostatic Control** than rain with a pH the increase in acidity xercise is a dramatic test of the body's acid cycle and increased fatty acid metabolism, because fatty acids are bro-ken down to acetyl-CoA, which enters the citric acid cycle. This preserves plasma glu-cose concentration and also helps the body maintain homeostasis. homeostatic control systems—there is a large increase in muscle oxygen (O₂) requirement, and a large amount of car-bon dioxide (CO₂) is produced. These changes must be countered by increases ide and nitrogen oxide they combine with wa mosphere to form sulf These acids return to in breathing and blood flow to increase oxygen delivery and removal of the meta-bolically produced carbon dioxide. Also, heavy exercise can produce a large amount rain or snow, a proces deposition, but morrain. Dry particles of salts descend from the of lactic acid due to the utilization of feror lactic acid due to the utilization of ter-mentation, an anaerobic process. The accu-mulation of both carbon dioxide and lactic acid can lead to an increase in intracellular and extracellular acidi er, during heavy ex-ercise, working muscles produce large amounts of heat that must be removed to dry deposition. Unfortunately, require the use of tall sm local air pollution only be carried far from t amounts of neat that must be removed to prevent overheating. In a strict sense, the body rarely maintains true homeostasis while performing intense exercise or dur-ning prolonged exercise in a hot or humid environment. However, better maintenance of homeostasis is observed in those who have had endurance training. The number of mitochondria in-creases in the muscles of persons who train; therefore, their bodies rely more on the citric acid cycle and the electron trans-

ort system to generate energy. Muscle

145

Readings

Biology has three types of boxed readings:

- Science Focus readings describe how experimentation and observations have contributed to our knowledge about the living world.
- **Ecology Focus readings show** how the concepts of the chapter can be applied to ecological concerns.
- Health Focus readings review procedures and technology that can contribute to our well-being.

chapter 8 Cellular Respiration Connecting the Concepts

The organelles of eukaryotic cells have a structure that suits their function. Cells didn't arise until they had a membranous covering, and membrane is also absolutely essential to the organization of chloroplasts and mito-chondria. In a chloroplast, membrane forms the grana, which are stacks of intercon nected, flattened membranous sacs called thylakoids. The inner membrane of a mito-chondrion invaginates to form the convo-

The detailed structure of chloroplasts chondria is different, but essentially they operate similarly. An assembly line of particles in the thylakoid membrane and cristae carry out functions necessary to pho-

tosynthesis and cellular respiration, respec tively. In both organelles, electron transport system carriers pump hydrogen ions into an enclosed space, establishing an electrochemical gradient. When hydrogen ions flow down this gradient through an ATP synthase down this gradient through an AIP synthasic complex, the energy released is used to pro-duce ATP. In chloroplasts, the electrons sent to the electron transport system are ener-gized by the sun; in mitochondria, energized electrons are removed from the substrates of

the glycolytic pathway and citric acid cycle.

In chloroplasts, the gel-like fluid of the stroma contains the enzymes of the Cabin cycle, which reduce carbon dioxide to a carbohydrate, and in mitochondria, the gel-like

fluid of the matrix contains the enzymes of the Krebs cycle, which oxidiz carbohydrate products received from the cytoplasm, in chloroplasts, reduction of carbon dioxide requires ATP produced by chemicamenis, while in mitochondria, oxidation of substrates releases carbon dioxide the ATP produced by chemicomosis is made available to the cell. According to the endosymbiotic replication of the control of the co

Summary

8.1 Cellular Respiration

8.1 Cellular Respiration
The exidation of glucose to CQ, and H₂O is an exergonic reaction that drives ATP synthesis, an endergonic reaction that drives ATP synthesis, an endergonic reaction. Four phases are required: glycolysis, the transition reaction, the citric acid cycle, and passage of electrons along the electron transport system. Oxidation of substrates involves the removal of hydrogen atoms (H⁺ + e⁻) from the substrate molecules, usually by redox coenzymes. NAD becomes NADH, and FAD becomes FADH₂.

8.2 Outside the Mitochondria: Glycolysis

Glycolysis, the breakdown of glucose to two molecules of pyruvate, is a series of enzymatic reaction to crur in the cytoplasm. Breakdown released on energy to immediately give a net gain of two ATP by substrate-level phosphorylation. Two NADH are two many control of the c

8.3 Inside the Mitochondria

8.3 Inside the Mitochondria When oxygen is available, privavate from glycolysis enters the mitochondrion, where the transition reaction takes place. During this reaction, oxidation occurs as CO₂ is removed from private. NAD* is reduced, and CoA receives the C₂ acetyl group that remains. Since the reaction must take place twice per glucose molecule, two NADH result.

The acetyl group enters the citric acid cycle, a cyclical series of reactions located in the mitochondrial matrix. Complete oxidation follows, as two CO₂ molecules, three NADH molecules, and one FADH, molecule are formed. The cycle also produces one ATP molecule. The entire cycle must turn twice per glucose molecule.

The cristae of mitochondria contain complexes of the electron transport system that not only pass electrons from one to the other but also jump H⁻ into the intermembrane space, setting up an electrochemical gradient. When H⁻ flows down this gradient through an ATP synthase complex, energy is captured and used to form ATP molecules from ADP and [®]D. This is ATP synthesis by chemiosmosis.

Of the 36 to 38 ATP formed by complete glucose breakdown, four are the result of substrate-level phosphorylation. The energy for the latter comes from the electron transport system. For most NADH molecules that donate electrons to the electron transport system, three ATP molecules are produced. However, in some cells each NADH formed in the cytoplasm results in only two ATP molecules. This occurs when the hydrogen atoms are shuttled across the mitochondrial membrane by a carrier that passes them to FAD. FADH, results in the formation of only two ATP because its electrons enter the electron transport system at a lower energy level.

8.4 Fermentation involves glycolysis followed by the reduction of pyruwate by NADH either to lactate or to alcohol and carbon dioxide (CO₂). The reduction process "frees" NADI 's othat it can accept more hydrogen atoms from glycolysis. Although fermentation results in only two ATP molecules, it still serves a purpose. In vertebrates, it provides a quick burst of ATP energy for short-term, strenuous muscular activity. The accumulation of lactate puts the individual in oxygen debt because oxygen is needed when lactate is completely metabolized to CO₂ and H₂O.

Connecting the Concepts

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 other concepts in the text.

Chapter Summary

The summary is organized according to the major sections in the chapter and helps students review the important topics and concepts.

Substrate-level phosphorylation takes place in a. glycolysis and the citric acid cycle.
 the electron transport system and the transition

reaction.

c. glycolysis and the electron transport system.

d. the citric acid cycle and the transition reaction.

e. Both b and d are correct.

Which of these is not true of fermentation?
 a. net gain of only two ATP
 b. occurs in cytoplasm
 c. NADH donates electrons to electron trans
 d. begins with glucose
 e. carried on by yeast

 Fatty acids are broken down to
 a. pyruvate molecules, which take electrons to the b. acetyl groups, which enter the citric acid cycle.
c. amino acids, which excrete ammonia.
d. glycerol, which is found in fats.
e. All of these are correct. 14. How many ATP molecules are usually produced per

16. What is the name of the process that adds the third phosphate to an ADP molecule using the flow of hydrogen ions?
a. substrate-level phosphorylation

17. Which are possible products of fermentation? a. lactic acid

18. The metabolic process that produces the most ATP

19. Which of these is not true of citric acid cycle? The citric

acid cycle

a. includes the transition reaction.
b. produces ATP by substrate-level phosphorylation.
c. occurs in the mitochondria.
d. is a metabolic pathway, as is glycolysis.

produces more NADH than any metabolic pathway.

20. Which of these is not true of the electron transport system? The electron transport system a. is located on the cristae.

c. contains cytochrome molecules. d. ends when oxygen accepts electrons.

reduction d. chemiosmosis

b. alcohol c. CO₂ d. All of these are possible

a. glycolysis.
 b. citric acid cycle.

c. 36 d. 10 15. How many NADH molecules are produced during the complete breakdown of one molecule of glucose a. 5 c. 10 b. 30 d. 6

electron transport system.
 fermentation.

Reviewing the Chapter

These page-referenced study questions follow the sequence of the chapter.

Testing Yourself

These objective questions allow students to test their ability to answer recall-based questions. Answers to Testing Yourself questions are given in Appendix A.

Thinking Scientifically -

Critical thinking questions give students an opportunity to reason as a scientist. Detailed answers to these questions are found on the Online Learning Center.

Bioethical Issue

A Bioethical Issue is found at the end of many chapters. These short readings discuss a variety of controversial topics that confront our society. The reading ends with appropriate questions to help students fully consider the issue and arrive at an opinion.

Reviewing the Chapter

What is the overall chemical equation for the complete breakdown of glucose to CO₂ and H₂O? Explain how th

breakdown of glucose to CO₂ and H₂O? Explain how this is an oxidation-reduction reaction. Why is the reaction able to drive ATP synthesis? 132

2. What are NAO? and FADP What are their functions? 132

3. What are the three pathways involved in the complete breakdown of glucose to carbon dioxide (CO₂) and water (H₂O)? What reaction is needed to join two of these pathways? 133

4. What are the main events of glycolysis? How is ATP formed? 134

5. Give the substrates and products of the transition reaction. Where does it take place? 136

Key:

1. carbon dioxide (CO2) given off

2. water (H₂O) formed

3. PGAL

8. FAD becomes FADH₂

Thinking Scientifically

Bioethical Issue Organic Pollutants

reaction. Where does it take place? 136
What are the main events during the citric acid cycle? 137

What is the electron transport system, and what are its functions? 138

functions? 138

Describe the organization of protein complexes within the cristae. Explain how the complexes are involved in ATP production. 139

Calculate the energy yield of glycolysis and complete glucose breakdown. Distinguish between substrate-level phosphorylation and oxidative phosphorylation. 140

10. What is fermentation, and how does it differ from glycolysis? Mention the benefit of pruvate reduction during fermentation, what types of organisms carry out lactate fermentation, and what types carry out alcoholic fermentation? 142

11. Give examples to support the concept of the metabolic pool. 144

Testing Yourself

Choose the best answer for each question. For questions 1–8, identify the pathway involved by matching each description to the terms in the key.

4. NADH becomes NAD+

5. oxidative phosphorylation

6. cytochrome carriers

7. pyruvate

9. The transition react

The transition reaction
a. connects glycolysis to the citric acid cycle.
b. gives off CO₂,
c. utilizes NAD⁺.
d. results in an acetyl group,
e. All of these are correct.

10. The greatest contributor of electrons to the electron

transport system is

a. oxygen.b. glycolysis.

part 1 The Cell

monomer 38 monosaccharide 39

nucleic acid 50 nucleotide 50

peptide bond phospholipid

oil 42 organic chemistry 36 organic molecule 36 pentose 39 peptide 46

Understanding the Terms hydrolysis reaction 38 hydrophilic 37 hydrophobic 37 inorganic chemistry 36 isomer 37 lipid 42

adenosine 52
ADP (adenosine diphosphate) 52
amino acid 46
ATP (adenosine triphosphate) 50
carbohydrate 39
cellulose 41
chaperone 49
chitin 41
coenzyme 50

ninking Scientifically
You are studying the fat content of different types of
seeds. You have discovered that some types of seeds have
a much higher percentage of saturated fatty acids than
others. You know the property difference (solid versus
liquid) and the structural difference (more hydrogen
versus of the structural difference force hydrogen
versus of the structural difference with climate (tropical compared to temperate), the size of
seeds (small compared to large), and environmental
conditions for germination (favorable compared to
unfavorable)?
You are investigating molecules that inhibit a bacterial
enzyme. You discover that the addition of several
phosphate groups to an inhibitor improves its
effectivenes. Why would knowledge of the threedimensional structure of the bacterial enzyme help you
understand why the phosphate groups improve the
inhibitor's effectiveness?

chitin 41 coenzyme 50 complementary base pairing 51 dehydration reaction 38 denatured 49 deoxyribosa 39 disaccharide 39 DNA (deoxyribonucleic acid) 50 enzyme 38 fat 42 fatty acid 42

Bioethical Issue Organic Pollutants
Organic compounds include the carbohydrates, proteins,
lipids, and nucleic acids that make up our bodies. Modern
industry also uses all sorts of organic compounds,
synthetically produced, Indeed, our modern way of life
wouldn't be possible without synthetic organic compounds.
Pesticides, herbicides, disinfectants, plastics, and testiles
contain organic substances that are termed pollutants when
they enter the natural environment and cause harm to living
things. Global use of pesticides has increased dramatically
since the 1950s, and modern pesticides are ten times more
toxic than those of the 1950s. The Centers for Disease Control
and Prevention in Atlanta report that 40% of children
working in agricultural fields now show signs of pesticide
poisoning. The U.S. Geological Survey estimates that 32 million
people in urban areas and 10 million people in rural areas are
using groundwater that contains organic pollutants. J. Charles
Fox, an official of the Environmental Protection Agency, says
that "over the life of a person, ingestion of these chemicals
has been shown to have adverse health effects such as cancer,
reproductive problems, and developmental effects, which
in the environment is connected to everything else. In other
words, they didn't know that an organic chemical can wander
far from the site of its entry into the environment and that
eventually these chemicals can enter our own bodies and
cause harm. Now that we are aware of this outcome, we have
to decide as a society how to proceed. We might decide to do
nothing if the percentage of people dying from exposure to
organic pollutants is small. Or we might decide to regulate the
use of industrial compounds more strictly than has been done
in the past. We could also decide that we need better ways of
purifying public and private water supplies so that they do not
contain organic pollutants. fatty acid 42

fatty acid 42 fibrous protein 49 functional group 37 globular protein 49 glucose 39 glycerol 42 glycogen 40 hemoglobin 46 hexose 39

phospholipid 44 polypeptide 46 polysaccharide 40 protein 46 ribose 39 RNA (ribonucleic acid) 50 saturated fatty acid 42 starch 40 starch 40 steroid 44 triglyceride unsaturated fatty acid 42 wax 45

Match the terms to these definitions:

Class of organic compounds that includes monosaccharides, disaccharides, and polysaccharides.
 Class of organic compounds that tend to be soluble in nonpolar solvents such as alcohol.
 Macromolecule consisting of covalently bonded monomers.
 Molecules that have the same molecular formula but a different structure and, therefore, shape.
 Two or more amino acids joined together by covalent bonding.

Online Learning Center

The Online Learning Center provides a wealth of information organized and integrated by chapter. You will find practice quizzes, interactive activities, labeling exercises, flashcards, and much more that will complement your learning and understanding of general biology.



http://www.mhhe.com/maderbiology8

Understanding the Terms

The boldface terms in the chapter are page referenced, and a matching exercise allows students to test their knowledge of the terms.

Website Reminder

Located at the end of the chapter is this reminder that additional study questions and other learning activities are on the Online Learning Center.

o prepare a new edition of Biology is a daunting and complex task, and its successful completion depends on the efforts of many dedicated and talented individuals. Let me begin by thanking the people I work with at McGraw-Hill. It is a rewarding experience to be associated with so many professionals truly dedicated to excellence in publishing. I want to thank Michael Lange, Editor-in-Chief, whose vision and constant support have guided me for many years. Patrick Reidy became my editor and friend about seven years ago, and his support of my texts has been steadfast ever since. The boundless energy and skills of my developmental editor, Margaret Horn, have allowed her to orchestrate the activities of others while contributing to the completion of the manuscript in so many ways. My project manager, Jayne Klein, faithfully and carefully steered the book as it progressed from manuscript to final product. I am particularly indebted to Kennie Harris, my copy editor, who painstakingly read and improved just about every sentence in the book.

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The content of the eighth edition of *Biology* is not due to my efforts alone. It is also a product of the many reviewers whose individual specialties allowed them to give me guidance on some particular part of the book. The botany chapters were improved by botanists; the ecology chapters by ecologists; the genetics chapters by geneticists; and so forth. No one person can be abreast of all fields, and I want to thank these reviewers for their expertise and their willingness to share their knowledge with me. Other reviewers are generalists particularly good at seeing the big picture. The overall organization and improved pedagogy of the book are due to their efforts. I am very much indebted to all the reviewers who generously sent me their comments, corrections, and suggestions for improvement. The eighth edition of Biology would not have the same excellent quality without the many reviewers who are listed here.

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