Concepts of Biology

Third Edition

Sylvia S. Mader

Mc Graw Hill Education

CONCEPTS OF BIOLOGY, THIRD EDITION

This book is printed on acid-free paper.

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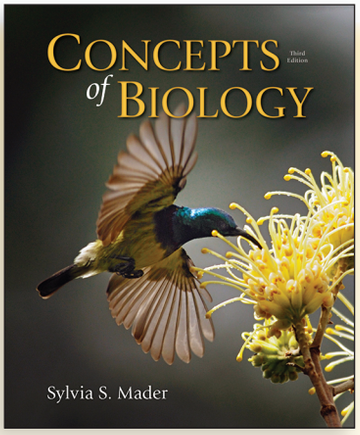
About the Author

Dr. Sylvia S. Mader has authored several nationally recognized biology texts published by McGraw-Hill. Educated at Bryn Mawr College, Harvard University, Tufts University, and Nova Southeastern University, she holds degrees in both Biology and Education. Over the years she has taught at University of Massachusetts, Lowell, Massachusetts Bay Community College, Suffolk University, and Nathan Mathew Seminars. Her ability to reach out to science-shy students led to the writing of her first text, *Inquiry into Life,* that is now in its fourteenth edition. Highly acclaimed for her crisp and entertaining writing style, her books have become models for others who write in the field of biology.

Although her writing schedule is always quite demanding, Dr. Mader enjoys taking time to visit and explore the various ecosystems of the biosphere. Her several trips to the Florida Everglades and Caribbean coral reefs resulted in talks she has given to various groups around the country. She has visited the tundra in Alaska, the taiga in the Canadian Rockies, the Sonoran Desert in Arizona, and tropical rain forests in South America and Australia. She was thrilled to think of walking in Darwin's steps when she journeyed to the Galápagos Islands with a group of biology educators. Dr. Mader was also a member of a group of biology educators who traveled to China to meet with their Chinese counterparts and exchange ideas about the teaching of modern-day biology.

For My Children **—Sylvia Mader**

Preface

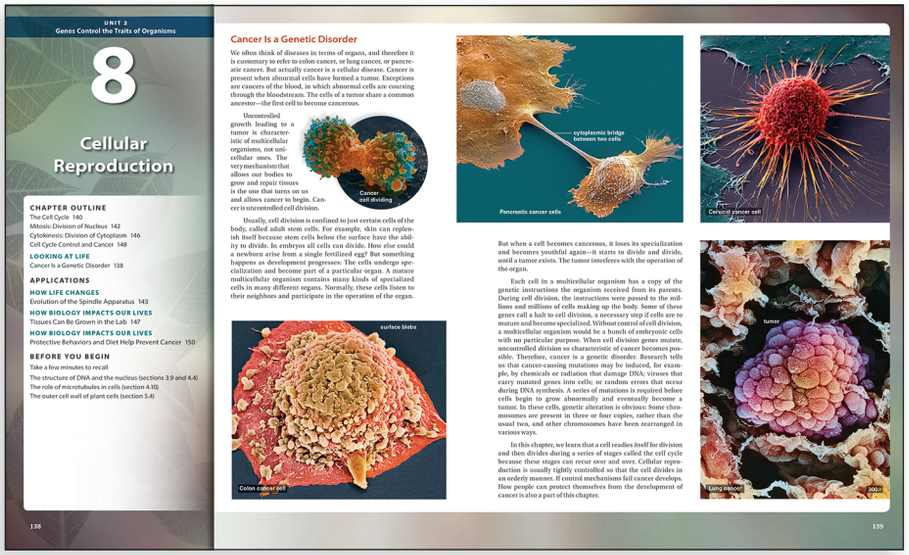


Concepts of Biology, Third Edition, recognizes the value of the traditional approach while still engaging students in the excitement of relevancy to themselves and the world around them. The text abounds with analogies and engaging illustrations as it proceeds from an examination of chemistry to the biosphere.

A significant new feature of this edition is the integration of media assets into the chapter content. Virtually every section of the textbook is now linked to MP3 files, 3D and 2D animations of biological processes, and National Geographic and ScienCentral videos. In addition, McGraw-Hill offers a full suite of adaptive learning tools including LearnSmart, LearnSmart Labs, LearnSmart Prep, LearnSmart Achieve, and SmartBook, all designed to assess a student's existing knowledge base and then adapt to address any deficiencies (see pages xii-xiii).

The conceptual approach of this text is apparent in its organization. *Concepts of Biology* is organized around the five major theories of biology: The Cell Theory, The Gene Theory, The Theory of Homeostasis, The Theory of Ecosystems, and The Theory of Evolution. The evolutionary theme was strengthened this edition to show the relevancy of the evolutionary approach. Natural selection, for example explains how resistance occurs among bacteria as well as pests, and common descent explains why the same genes, such as *Hox* genes, are found in organisms as different as bacteria, plants, and humans. Today, an understanding of evolution is assisting researchers in numerous fields from molecular biology to ecological restoration. To be consistent with this trend, the explanatory power of evolution has been increased in the running text, the chapter introductions, and the applications.

The revised introductions are now entitled "Looking at Life." Their varied topics illustrate how biology pertains to the life of organisms, including humans. The many applications in this text reflect its major themes: evolution, relevancy, and the scientific process. Like all parts of this text, the introductions and applications encourage a conceptual understanding of life.



New to this Edition

In this edition, many former one-page sections have been combined into attractive two-page sections with a single title; half page sections have become one-page sections with new titles. This modular approach has the benefit that each illustration is on the same or facing page to its reference and it will rarely be necessary for students to turn a page in order to reach the end of a section. A short introduction ties numbered subsections into a comprehensive whole.

- A new feature in the Chapter Outline "Before You Begin" alerts students to any previous references in the book that pertain to the Learning Outcomes of the chapter.
- Many introductions are new and most contain new photographs and arrangements to be more visually appealing to today's students.
- The Learning Outcomes are new and placed at the start of each numbered section. Connect homework and test bank content are directly tied to these outcomes, allowing instructors to test student comprehension of specific concepts and focus classroom time where it is needed.
- Check Your Progress questions at the end of each section are new and are now better tied to the learning outcomes. All questions are answered in the Appendix.
- All Summaries are new: The number of bullets has been reduced to only one or two for each section.
- Several media tools (MP3 files, Animations, 3D Animations, Videos) are integrated into the running text as icons, alerting students to the availability of these learning tools. These icons become active links in the online eBook version of the textbook.

MP3 Files
These three- to five-minute audio files serve as a review of the material in the chapter, and they also assist the student in the pronunciation of scientific terms.

Animations
Drawing on McGraw-Hill's vast library of animations, the author has selected animations that will enhance the student's understanding of complex biological processes.

3D Animations
For topics such as photosynthesis and cellular respiration, McGraw-Hill has produced a series of dynamic 3D animations that may be used both as presentation tools in the classroom, and as mini-tutorials that can be assigned within Connect or your course management system.

Videos
Two different types of movies are integrated into this edition of the text. The ScienCentral videos are short news clips on advances in the sciences. The National Geographic videos provide students with a glimpse of the complexity of life that normally would not be possible in the classroom.

Virtual Labs
These simulated experiments serve as excellent tutorials, allowing students to explore the topics covered in select chapters of the text.

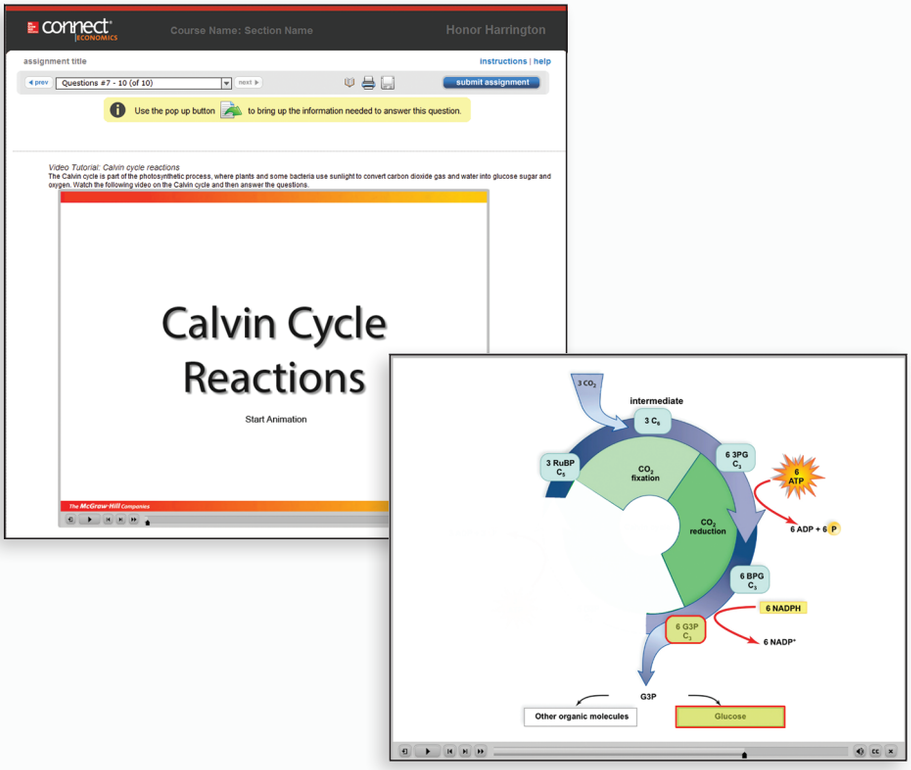
Guided Tutorials
In addition to the assets listed above, a series of 2-minute guided tutorials of some of the more difficult topics in the text are available. A complete list of these tutorials is provided on page vi of the Preface.

Guided Tutorials

The narrated videos below were prepared by the authors of the textbook to assist you in understanding some of the more difficult topics in biology. Each video explores a specific figure in the text and is narrated by Mader series co-author Michael Windelspecht. During the video, important terms and processes are called out, allowing you to focus on the key aspects of the figure. All of these tutorials are embedded within the Connect Plus eBook and are available with assessment in the Connect question bank.

Hydrogen Bonding
Levels of Protein Organization
Endomembrane System
Endosymbiotic Theory
Osmosis and Tonicity
Sodium-Potassium Pump
Activation Energy
Cellular Respiration Overview
Electron Transport Chain
Noncyclic Photosynthesis
Calvin Reactions
Mitosis
Tumor Suppressor Genes
Proto-Oncogenes
Meiosis
Dihybrid Cross
Linkage
DNA Replication
Overview of Gene Expression
Lac Operon
Polymerase Chain Reaction
Hardy-Weinberg Equilibrium
Viral Life Cycle
Zygospore Life Cycle
Angiosperm Life Cycle
Protostomes and Deuterostomes
Primate Classification
Cohesion-Tension Model
Pressure-Flow Model
Alternation of Generations
Negative Feedback
Cardiac Cycle
Capillary Exchange
Blood Clotting
Inflammatory Response
B-Cell Clonal Selection
T-Cell Clonal Selection
HIV Infection Cycle

Hormonal Control of Digestion
External and Internal Respiration
Urine Formation
Neuron Action Potentials
Synaptic Cleft
Skeletal Muscle Contraction
Action of a Peptide Hormone
Action of a Steroid Hormone
Ovarian Cycle
Embryonic Stages of Development
Fetal Circulation
Patterns of Population Growth
Carbon Cycle
Cycling of Energy and Nutrients in an Ecosystem
Factors Influencing the Distribution of Biomes
Global Climate Change



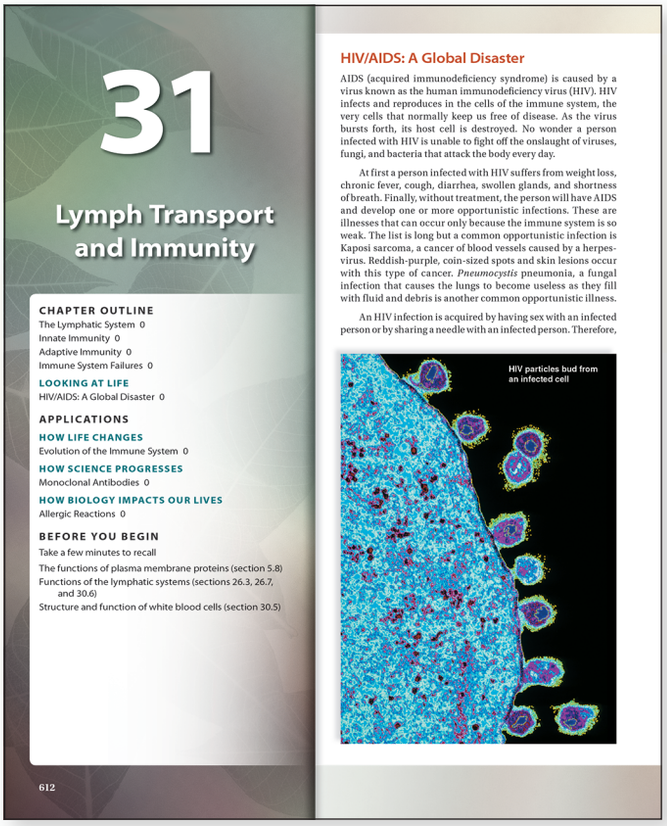
Applications

HOW BIOLOGY IMPACTS OUR LIVES

HOW LIFE CHANGES

HOW SCIENCE PROGRESSES

A Student's Guide to Using This Textbook

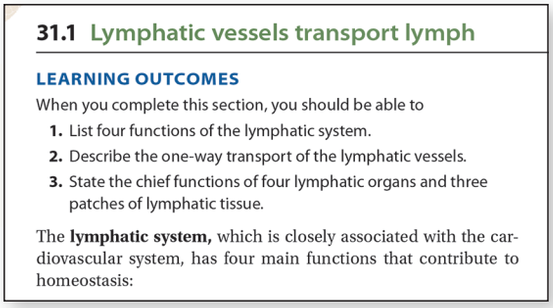


Looking at Life
The opening essay illustrates how biology pertains to the life of organisms including humans. Like all parts of this text, the introductions encourage a conceptual understanding of life.

Chapter Outline
Lists the concepts and applications that will be discussed in the chapter.

Before You Begin
Links the content of the chapter with material from earlier in the text.

Learning Outcomes
Placed at the start of each numbered section, the learning outcomes provide you with an overview of what you are to know.



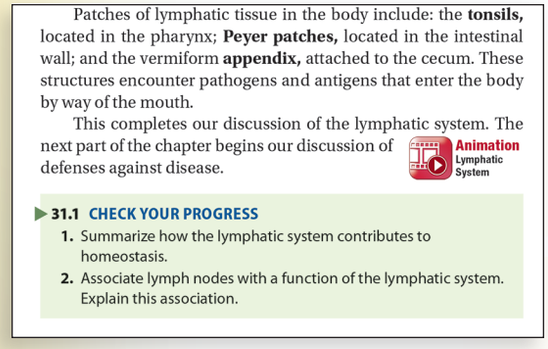
31.1 Lymphatic vessels transport lymph

LEARNING OUTCOMES

When you complete this section, you should be able to

1. List four functions of the lymphatic system.
2. Describe the one-way transport of the lymphatic vessels.
3. State the chief functions of four lymphatic organs and three patches of lymphatic tissue.

The **lymphatic system,** which is closely associated with the cardiovascular system, has four main functions that contribute to homeostasis:



Patches of lymphatic tissue in the body include: the **tonsils,** located in the pharynx; **Peyer patches,** located in the intestinal wall; and the vermiform **appendix,** attached to the cecum. These structures encounter pathogens and antigens that enter the body by way of the mouth.

This completes our discussion of the lymphatic system. The next part of the chapter begins our discussion of defenses against disease.

Animation Lymphatic System

31.1 CHECK YOUR PROGRESS

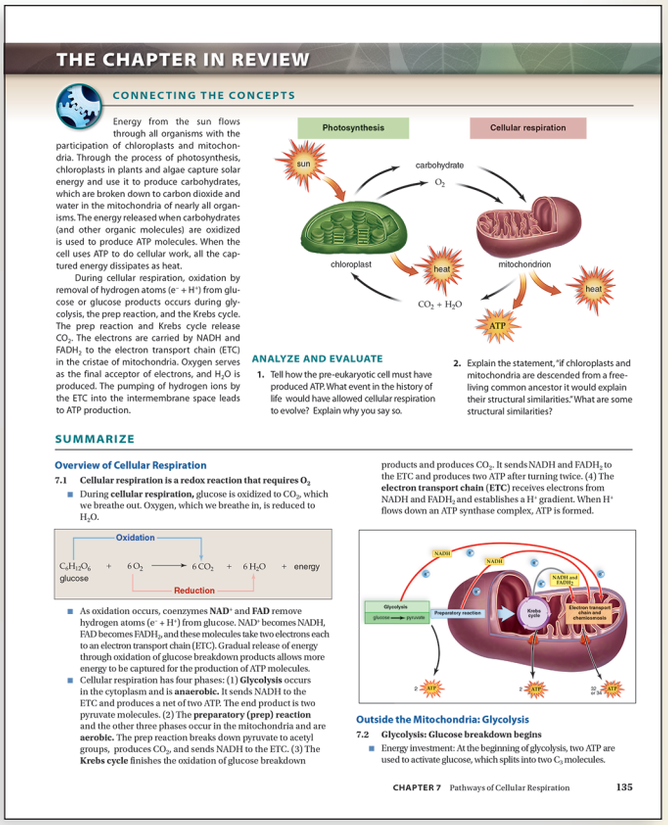
1. Summarize how the lymphatic system contributes to homeostasis.
2. Associate lymph nodes with a function of the lymphatic system. Explain this association.

Media Integration
Enhances your study of biology with media. Go to **www.mhhe.com/maderconcepts3** to access animations, videos, and MP3 files referenced throughout this book. Also, ask your instructor about the eBook, LearnSmart™, and related quizzes available through Connect® and ConnectPlus® Biology.

Check Your Progress
Questions at the end of each section help you assess or apply your understanding of the concept.

Connecting the Concepts

Shows how the concepts of the chapter are related, and how they relate to concepts in other chapters. *Analyze and Evaluate* questions allow you to test your reasoning ability. All questions are answered in the Appendix.



THE CHAPTER IN REVIEW

CONNECTING THE CONCEPTS

Energy from the sun flows through all organisms with the participation of chloroplasts and mitochondria. Through the process of photosynthesis, chloroplasts in plants and algae capture solar energy and use it to produce carbohydrates, which are broken down to carbon dioxide and water in the mitochondria of nearly all organisms. The energy released when carbohydrates (and other organic molecules) are oxidized is used to produce ATP molecules. When the cell uses ATP to do cellular work, all the captured energy dissipates as heat.

During cellular respiration, oxidation by removal of hydrogen atoms ($e^- + H^+$) from glucose or glucose products occurs during glycolysis, the prep reaction, and the Krebs cycle. The prep reaction and Krebs cycle release CO_2. The electrons are carried by NADH and $FADH_2$ to the electron transport chain (ETC) in the cristae of mitochondria. Oxygen serves as the final acceptor of electrons, and H_2O is produced. The pumping of hydrogen ions by the ETC into the intermembrane space leads to ATP production.

Photosynthesis | Cellular respiration

sun | carbohydrate | O_2 | chloroplast | heat | mitochondrion | heat | $CO_2 + H_2O$ | ATP

ANALYZE AND EVALUATE

1. Tell how the pre-eukaryotic cell must have produced ATP. What event in the history of life would have allowed cellular respiration to evolve? Explain why you say so.
2. Explain the statement, "if chloroplasts and mitochondria are descended from a free-living common ancestor it would explain their structural similarities." What are some structural similarities?

SUMMARIZE

Overview of Cellular Respiration

7.1 Cellular respiration is a redox reaction that requires O_2

- During **cellular respiration,** glucose is oxidized to CO_2, which we breathe out. Oxygen, which we breathe in, is reduced to H_2O.

Oxidation: $C_6H_{12}O_6$ (glucose) + $6\,O_2$ → $6\,CO_2$ + $6\,H_2O$ + energy; Reduction

- As oxidation occurs, coenzymes **NAD^+** and **FAD** remove hydrogen atoms ($e^- + H^+$) from glucose. NAD^+ becomes NADH, FAD becomes $FADH_2$, and these molecules take two electrons each to an electron transport chain (ETC). Gradual release of energy through oxidation of glucose breakdown products allows more energy to be captured for the production of ATP molecules.
- Cellular respiration has four phases: (1) **Glycolysis** occurs in the cytoplasm and is **anaerobic.** It sends NADH to the ETC and produces a net of two ATP. The end product is two pyruvate molecules. (2) The **preparatory (prep) reaction** and the other three phases occur in the mitochondria and are **aerobic.** The prep reaction breaks down pyruvate to acetyl groups, produces CO_2, and sends NADH to the ETC. (3) The **Krebs cycle** finishes the oxidation of glucose breakdown products and produces CO_2. It sends NADH and $FADH_2$ to the ETC and produces two ATP after turning twice. (4) The **electron transport chain (ETC)** receives electrons from NADH and $FADH_2$ and establishes a H^+ gradient. When H^+ flows down an ATP synthase complex, ATP is formed.

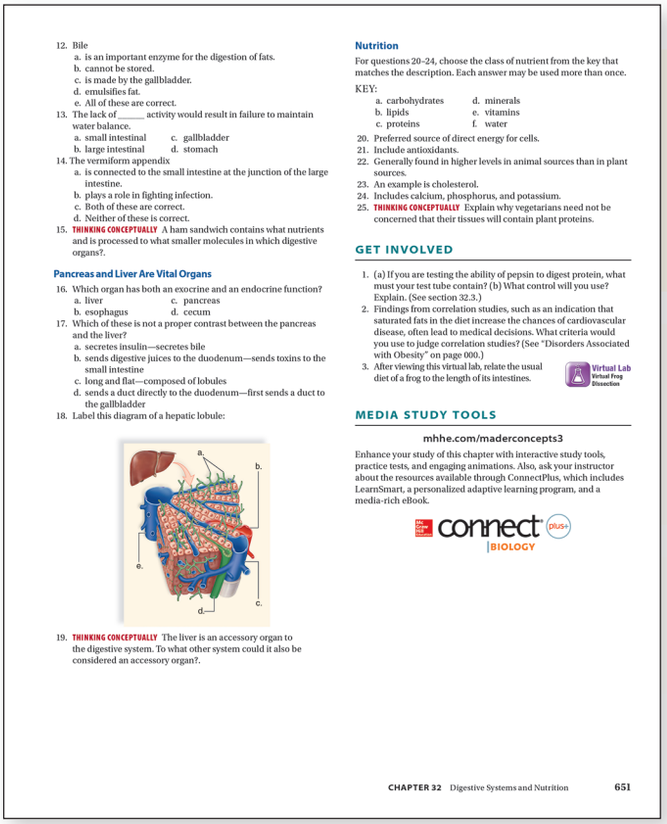
Outside the Mitochondria: Glycolysis

7.2 Glycolysis: Glucose breakdown begins

- Energy investment: At the beginning of glycolysis, two ATP are used to activate glucose, which splits into two C_3 molecules.

Chapter Summary

This illustrated and bulleted summary is organized according to the chapter concepts. Boldface terms are included as an additional aid to help you review the chapter.



12. Bile
    a. is an important enzyme for the digestion of fats.
    b. cannot be stored.
    c. is made by the gallbladder.
    d. emulsifies fat.
    e. All of these are correct.
13. The lack of _____ activity would result in failure to maintain water balance.
    a. small intestinal c. gallbladder
    b. large intestinal d. stomach
14. The vermiform appendix
    a. is connected to the small intestine at the junction of the large intestine.
    b. plays a role in fighting infection.
    c. Both of these are correct.
    d. Neither of these is correct.
15. **THINKING CONCEPTUALLY** A ham sandwich contains what nutrients and is processed to what smaller molecules in which digestive organs?.

Pancreas and Liver Are Vital Organs

16. Which organ has both an exocrine and an endocrine function?
    a. liver c. pancreas
    b. esophagus d. cecum
17. Which of these is not a proper contrast between the pancreas and the liver?
    a. secretes insulin—secretes bile
    b. sends digestive juices to the duodenum—sends toxins to the small intestine
    c. long and flat—composed of lobules
    d. sends a duct directly to the duodenum—first sends a duct to the gallbladder
18. Label this diagram of a hepatic lobule:

19. **THINKING CONCEPTUALLY** The liver is an accessory organ to the digestive system. To what other system could it also be considered an accessory organ?.

Nutrition

For questions 20–24, choose the class of nutrient from the key that matches the description. Each answer may be used more than once.

KEY:
a. carbohydrates d. minerals
b. lipids e. vitamins
c. proteins f. water

20. Preferred source of direct energy for cells.
21. Include antioxidants.
22. Generally found in higher levels in animal sources than in plant sources.
23. An example is cholesterol.
24. Includes calcium, phosphorus, and potassium.
25. **THINKING CONCEPTUALLY** Explain why vegetarians need not be concerned that their tissues will contain plant proteins.

GET INVOLVED

1. (a) If you are testing the ability of pepsin to digest protein, what must your test tube contain? (b) What control will you use? Explain. (See section 32.3.)
2. Findings from correlation studies, such as an indication that saturated fats in the diet increase the chances of cardiovascular disease, often lead to medical decisions. What criteria would you use to judge correlation studies? (See "Disorders Associated with Obesity" on page 000.)
3. After viewing this virtual lab, relate the usual diet of a frog to the length of its intestines. Virtual Lab Virtual Frog Dissection

MEDIA STUDY TOOLS

mhhe.com/maderconcepts3

Enhance your study of this chapter with interactive study tools, practice tests, and engaging animations. Also, ask your instructor about the resources available through ConnectPlus, which includes LearnSmart, a personalized adaptive learning program, and a media-rich eBook.

connect plus+ BIOLOGY

Chapter Review Questions

The end-of-chapter questions offer another way to review the chapter concepts. Included are *Test Yourself* multiple-choice questions and *Thinking Conceptually* questions that ask you to apply your understanding of a concept. *Get Involved* questions give you an opportunity to reason as a scientist.

Virtual Labs

For selected chapters, these online labs can help you better understand the content and provide you with the opportunity to investigate associated topics from a scientific perspective.

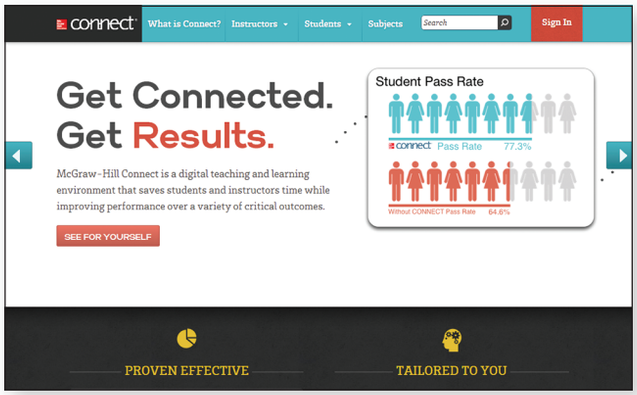
Media Study Tools

Provides a link to the *Concepts of Biology* companion website where you can find additional review materials.

Teaching and Learning Tools

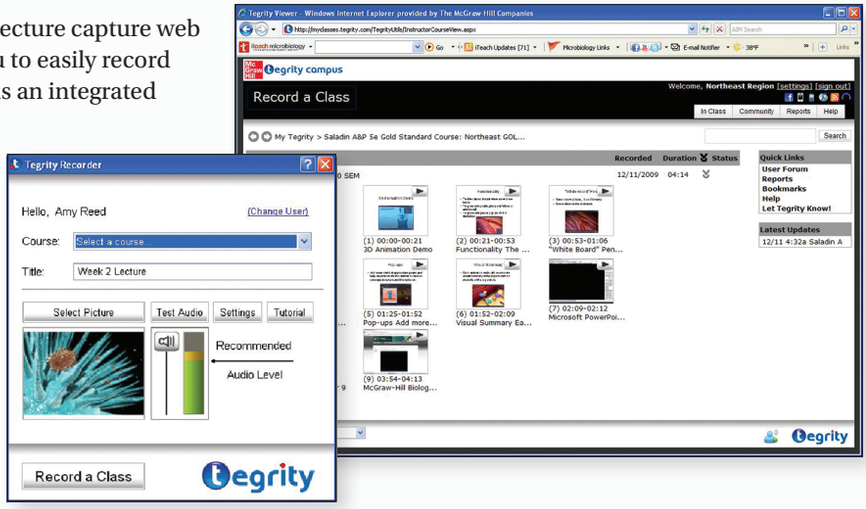
McGraw-Hill Connect® is a web-based assignment and assessment platform that gives students the means to better connect with coursework, instructors, and important concepts that they will need to know for success now and in the future.

McGraw-Hill Connect Plus® provides students with all the advantage of Connect Biology, plus a dynamic, media-rich eBook. To learn more visit **www.mcgrawhillconnect.com**



Tegrity Campus® is a lecture capture web service that allows you to easily record every class for every student. Tegrity is available as an integrated feature of Connect Biology and as a standalone.

- Make your classes available anytime, anywhere
- Simple one-click recording. No IT assistance required.
- Students can search a word or phrase and be taken to the exact place in your lecture they need to view.



LEARNSMART®

Integrated within Connect and available as a standalone, **McGraw-Hill LearnSmart™** is the premier learning system designed to effectively assess a student's knowledge of course content. Through a series of adaptive questions, LearnSmart intelligently pinpoints concepts the student does not understand and maps out a personalized study plan for success. LearnSmart prepares students with a base of knowledge, allowing instructors to focus valuable class time on higher-level concepts.

New **SmartBook™** facilitates the reading process by identifying what content a student knows and doesn't know through adaptive assessments. As the student reads, the reading material constantly adapts to ensure the student is focused on the content he or she needs the most to close any knowledge gaps.

See pages xii-xiii of the preface for more information about the **LearnSmart Advantage™** suite of adaptive tools or go to **www.LearnSmartAdvantage.com.**

The Best of Both Worlds

McGraw-Hill and Blackboard Inc. teamed up to deliver the first to market integrated course solution which offers the deepest integration of publisher content within an LMS for Blackboard versions 8.0, 9.0, and 9.1.

Connect Single Sign-on. A single login and single environment provide seamless access to all course resources—all McGraw-Hill's resources are available within the Blackboard Learn platform.

Deep Integration. One-click access to McGraw-Hill Connect assignments and tools—all from within Blackboard Learn™.

One Gradebook. Automatic grade synchronization with Blackboard gradebook. All grades for McGraw-Hill assignments are recorded in the Blackboard gradebook automatically.

Instructor Resources

Connect Biology provides easy access to the following resources:

Presentation Tools

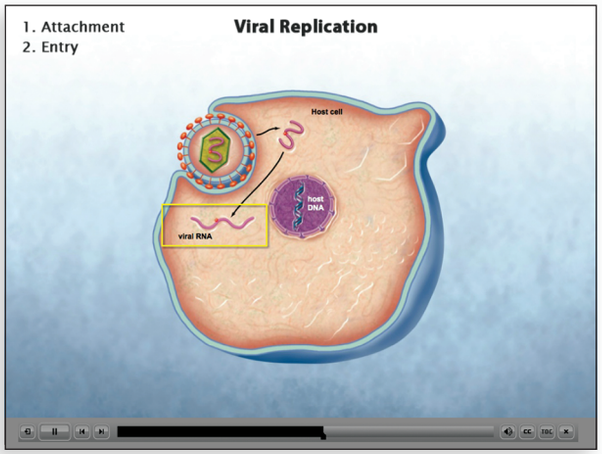
- Enhanced image PowerPoints® with editable art
- Lecture PowerPoints with animations
- Animation PowerPoints
- Labeled and unlabeled JPEG files of art, photos, and tables from the textbook.
- Instructor's Manual containing chapter outlines, lecture enrichment ideas, and discussion questions.
- Laboratory Resource Guide to accompany the *Concepts of Biology Laboratory Manual*

Animations for a New Generation

Dynamic, 3D animations of key biological processes bring an unprecedented level of control to the classroom. Innovative features keep the emphasis on teaching rather than entertaining.

New Guided Tutorials

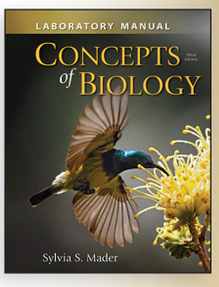
Prepared by the authors of the textbook to assist students in understanding some of the more difficult topics in biology. Each video explores a specific figure in the text and is narrated by Mader series co-author Michael Windelspecht. During the video, important terms and processes are called out, allowing the student to focus on the key aspects of the figure. A list of tutorials can be found on page vi of the preface.



Computerized Test Bank

A comprehensive bank of test questions is provided within a computerized test bank powered by McGraw-Hill's flexible electronic testing program, **EZ Test Online.** A new tagging scheme allows you to sort questions by Bloom's difficulty level, learning outcome, topic, and section. With EZ Test Online, instructors can select questions from multiple McGraw-Hill test banks or author their own, and then either print the test for paper distribution or give it online.

Laboratory Manual



The *Concepts of Biology Laboratory Manual* is written by Dr. Sylvia Mader. Every laboratory has been written to help students learn the fundamental concepts of biology and the specific content of the chapter to which the lab relates, as well as gain a better understanding of the scientific method.

Companion Website

www.mhhe.com/maderconcepts3

The *Concepts of Biology* companion website allows students to access a variety of free digital learning tools that include

- Animations, videos, and MP3 files
- Chapter-level quizzing
- Vocabulary flashcards
- Virtual Labs
- Biology Prep

Create

Design your teaching resources to match the way you teach! With McGraw-Hill Create™ you can easily rearrange chapters, combine material from other content sources, and quickly upload content you have written. Access thousands of leading McGraw-Hill textbooks for content that fits your objectives and arrange your book to fit your teaching style. Create even allows you to personalize your book's appearance by selecting the cover and adding your name, school, and course information. Order a Create book and you'll receive a complimentary print review copy in 3–5 business days or a complimentary electronic review copy (eComp) via email in minutes. Go to **www.mcgrawhillcreate.com** today and register to experience how McGraw-Hill Create™ empowers you to teach *your* students *your* way.

The LearnSmart Advantage

LEARNSMART®

LearnSmart is the only truly adaptive learning system that intelligently identifies course-content students have not yet mastered and maps out personalized study plans for their success.

When LearnSmart has identified a specific subject area where the student is struggling, he or she is given a "time out" and directed to the textbook section and learning objective for remediation.

Dynamically generated reports document student progress and areas for additional reinforcement, offering at-a-glance views of their strengths and weaknesses.

SMARTBOOK™

Powered by an intelligent diagnostic and adaptive engine, **SmartBook** facilitates the reading process by identifying what content a student knows and doesn't know through adaptive assessments.

As the student reads, the reading material constantly adapts to ensure the student is focused on the content he or she needs the most to close any knowledge gaps.

The Evolution of Learning

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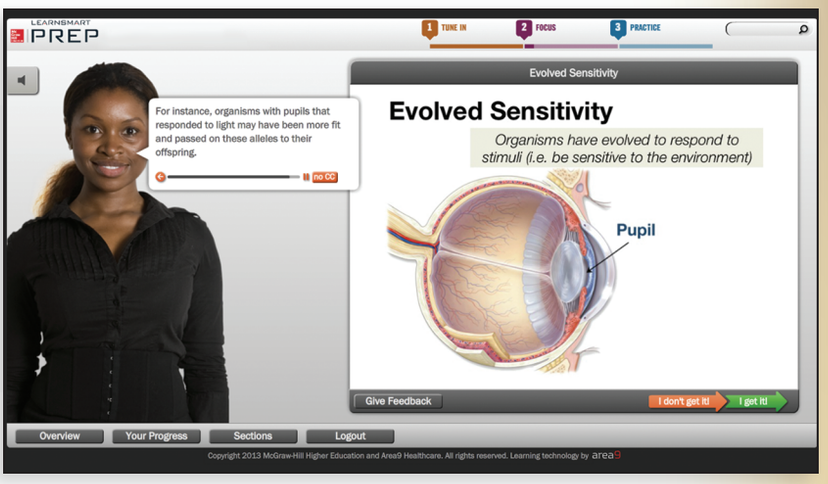
LEARNSMART PREP™

LearnSmart Prep quickly and efficiently prepares students for a college level course. Prep uses a set of diagnostic questions to help identify what a student knows and doesn't know. It then provides a unique learning plan focused on helping the student master the basic skills and concepts he or she needs the most before entering the classroom.



LEARNSMART LABS™

LearnSmart Labs is a super-adaptive simulated lab experience that brings meaningful scientific exploration to students. Through a series of adaptive questions, LearnSmart Labs identifies a student's knowledge gaps and provides resources to quickly and efficiently close those gaps. Once the student has mastered the necessary basic skills and concepts, they engage in a highly realistic simulated lab experience that allows for mistakes and the execution of the scientific method.

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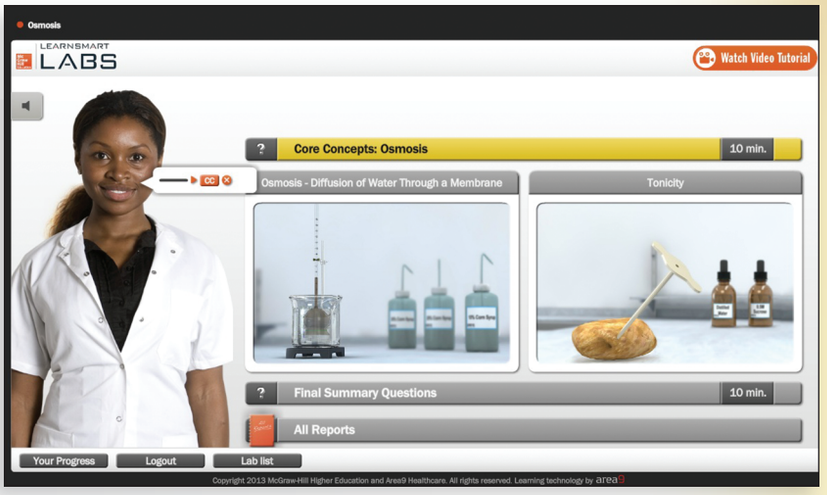

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Detailed List of Content Changes

Chapter 1 Biology, The Study of Life Section 1.2 (pages 6-7) was rewritten to help students follow the experiment under discussion and Figure 1.2 was revised to allow students to see at a glance the results of the scientific study.

UNIT 1 Organisms Are Composed of Cell

Chapter 2 Basic Chemistry of Cells The application "The Harmful Effects of Acid Rain" was rewritten to stress the detrimental effects of an abnormal pH on organisms and inanimate structures. **Chapter 3 Organic Molecules of Cells** New introductory photos strikingly reveal relevancy of chemistry to our lives. In section 3.7, a new figure better compares the structure of various amino acids and the discussion directly progresses from amino acids to protein structure. **Chapter 4 Structure and Function of Cells** Figure 4.4B was redone to show the connection between the nuclear envelope and the endoplasmic reticulum. Table 4.11, a summary of the organelles, is now a better study tool for students. **Chapter 5 Dynamic Activities of Cells** This chapter was reorganized to position the plasma membrane discussion after the cell chapter and the study of enzymes prior to the photosynthesis chapter. **Chapter 6 Pathways of Photosynthesis** In section 6.10, modes of photosynthesis was rewritten to clarify and improve accuracy and a new table summarizes this section. **Chapter 7 Pathways of Cellular Respiration** was reorganized into two major sections to emphasize that glycolysis occurs outside the mitochondria.

UNIT 2 Genes Control the Traits of Organisms

Chapter 8 Cellular Reproduction This new chapter, devoted solely to the cell cycle and mitosis, aids student comprehension and better highlights the connection between the cell cycle and cancer. **Chapter 9 Sexual Reproduction** The process of meiosis is clearly explained in this new chapter which emphasizes how meiosis contributes to evolution by producing variations. Chromosome anomalies in section 9.7 illustrate how nondisjunction during meiosis results in human syndromes. **Chapter 11 Molecular Biology of Inheritance** A new section (11.9) dramatically illustrates the connection between genetic and chromosomal mutations and other human syndromes. **Chapter 12 Regulation of Gene Activity** This chapter emphasizes the important role of repetitive DNA in gene regulation and a new application (12B) summarizes the influence of epigenetic inheritance on the phenotype. **Chapter 13 Biotechnology and Genomics** Genomics is an expanding field in biology and the text recognizes this by better explaining the importance of functional and comparative genomics, proteomics, and bioinformatics in sections 13.10–13.12.

UNIT 3 Organisms Are Related and Adapted to Their Environment

Chapter 14 Evidence of Evolution The new title for this chapter emphasizes that Darwin presented evidence for evolution and that more evidence continues to accumulate. A dramatic new illustration (Fig. 14.6) shows how the altered activity of *Hox* genes can contribute to evolution of morphology. **Chapter 16 The Evolutionary History of Life on Earth** The contribution of molecular genetics to recognizing species is exemplified in a new application, "DNA Barcoding of Life." **Chapter 17 Evolution of Microbial Life** Figure 17.6 which outlines the origin of the first cell is better integrated into the text and later the discussion of autotrophic bacteria is much improved. **Chapter 19 Evolution of Plants and Fungi** In section 19.8 the text suggests that a symbiotic relationship between fungi and plants contributed to the ability of plants to invade land. **Chapter 20 Evolution of Animals** In section 20.11, student interest in echinoderms is promoted by new photos and section 20.14 discusses and illustrates how amphibians evolved from lobe-finned fishes. **Chapter 21 Evolution of Humans** Section 21.4 includes recent finds in South Africa that question whether Lucy gave rise to humans. An expanded Neandertal section (21.5) addresses the question of whether humans interbred with Neandertals.

UNIT 4 Plants are Homeostatic

Chapter 22 Plant Organization and Homeostasis The section "Homeostatic Mechanisms of Plants" was rewritten to sharpen the presentation. **Chapter 23 Transport and Nutrition in Plants** Figures 23.1B and C are colorful additions to the chapter that better describe the structure of xylem and phloem. A relevant application "Plants Can Clean Up Toxic Messes" was rewritten to feature poplar trees and mustard plants. **Chapter 24 Control of Growth and Responses in Plants** In section 24.9, phytochrome structure and function was updated to emphasize its importance to plant physiology.

UNIT 5 Animals Are Homeostatic

Chapter 26 Animal Organization and Homeostasis The application "UV Rays: Too Much or Too Little?" is a new relevant addition to the chapter. **Chapter 29 Locomotion and Support Systems** New section 29.2 highlights the similar functions of a crayfish exoskeleton and a mammalian endoskeleton. A new application (29D) compares the structure and function of fast- and slow-twitch muscle fibers. **Chapter 30 Circulation and Cardiovascular Systems** This chapter has two relevant applications: "How to Prevent Cardiovascular Disease" was revised and the application "What to Know When Giving Blood" is new. **Chapter 31 Lymph Transport and Immunity** The application "Evolution of the Immune System" highlights that macrophages may have evolved from amoebas. **Chapter 34 Osmoregulation and Excretion** Several revised illustrations will make it easier for students to trace the path of urine and learn the functions of kidney tubules. **Chapter 35 Coordination by Hormone Signaling** The section "Hormones affect cellular metabolism" was rewritten to bring the principles of hormone action into sharper focus. The application "Fish Gills and Parathyroid Glands" gives evidence that the parathyroid glands evolved from a pharyngeal pouch.

UNIT 6 Organisms Live in Ecosystems

Chapter 37 Population Ecology The application "Sustainability of the U.S. Population" was revised to reflect recent demographic statistics. **Chapter 38 Behavioral Ecology** A comparative approach based on evolution is now used to discuss sexual selection in an expanded section. **Chapter 39 Community and Ecosystem Ecology** The discussion of ecological succession is much improved by showing appropriate stages in Glacier Bay, Alaska. **Chapter 41 Conservation Biology** A new application explores the efforts to restore the floodplain along the Illinois River in keeping with sustainable principles.

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