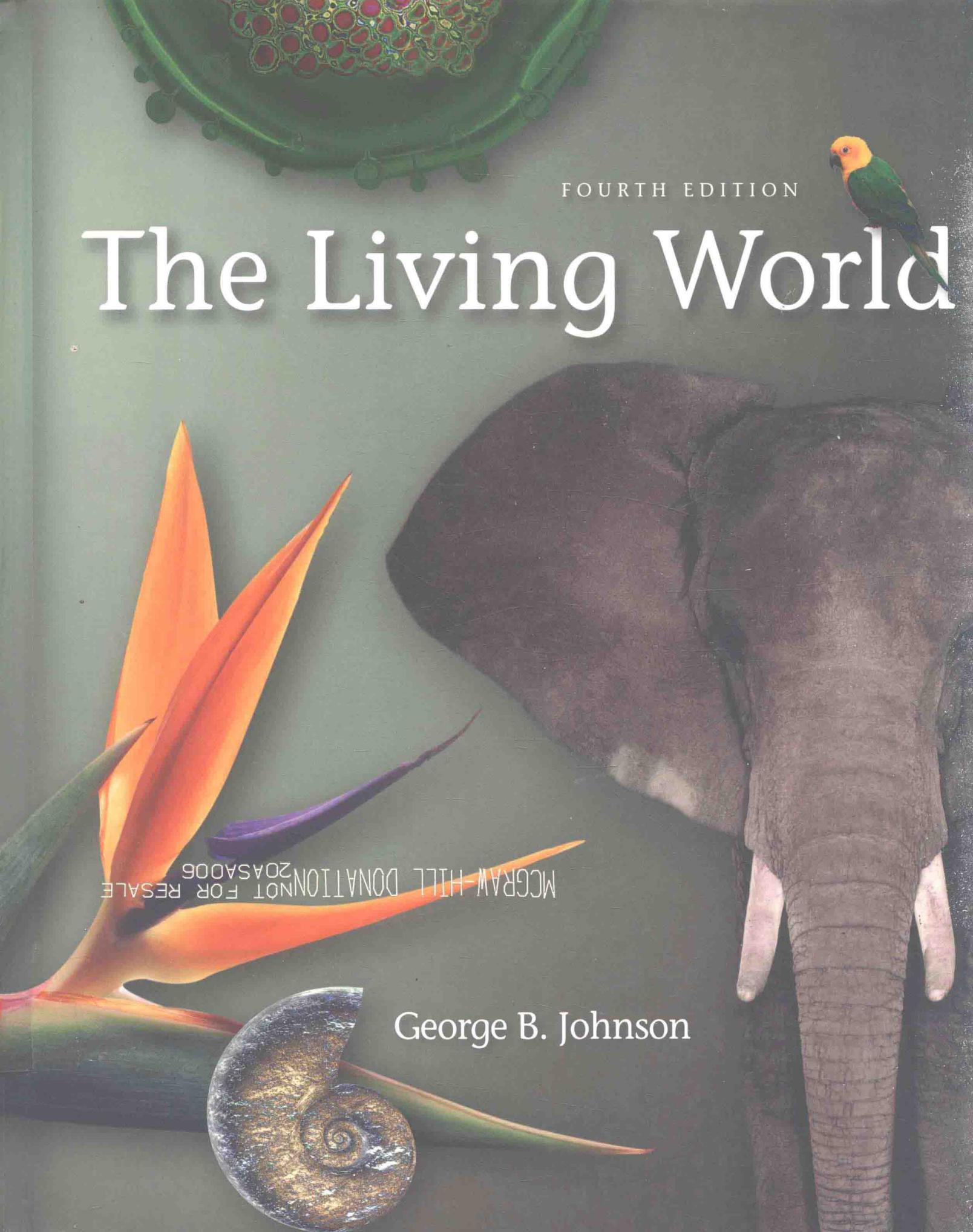

FOURTH EDITION

The Living World

George B. Johnson

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George B. Johnson

Washington University
St. Louis, Missouri

Higher Education

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THE LIVING WORLD, FOURTH EDITION

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Preface

Instructors who have used or reviewed previous editions of *The Living World* will notice some obvious changes with the Fourth Edition, and some that are less evident at first glance. From the cover, artwork, text and design of each page, *The Living World* has undergone a major transformation. Clear writing, engaging analogies and solid science, what I consider to be the hallmarks of this text, are now complemented by additional features that make biology more personal and approachable for the student.

How I Came to Write This Text

I have been teaching biology to college freshmen in Washington University classrooms for over thirty years, and my writing of *The Living World* is a product of that long educational journey. I first put finger to keyboard in 1995, several years after having been assigned the teaching of nonmajors biology in my department. My initial experience teaching biology to nonmajors had been discouraging. While my students were bright and very interested in biology, they were put off by the flood of information, and particularly by the mass of unfamiliar terminology. When you don't know what the words mean, it's easy to slip into thinking that the subject matter is difficult, when actually the ideas are simple, easy to grasp, and fun to consider.

The available textbooks weren't much help. They had lots of pretty pictures, but were dense in content and terminology. In large measure, this reflected the fact that these texts had been cobbled together from longer majors texts—chopping out material to shorten the book had produced choppy chapters that were difficult for my students to follow, and way too hard. A wall of terminology and detail stood between my students and the ideas that form the core of biology.

So I decided to write my own book. I had already written a successful majors text with my friend Peter Raven, but in writing a nonmajors biology text I promised myself I would not repeat the fundamental mistake I had seen in other texts. Rather than prepare another "cut down majors text," I set out to write a whole new book from scratch, based on my experience in the classroom and aimed squarely at nonmajors students.

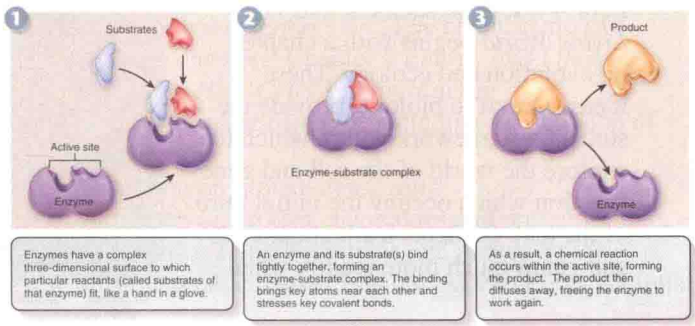
Writing *The Living World* was one of the most enjoyable experiences of my life. Organizing lectures for the classroom for thirty years had taught me that biology is at its core a set of ideas, and if students can master these ideas, the rest comes easy to them. So I set out to write a text that focused on concepts rather than terminology and information, a book that would be easy for students to learn from. Sorting out how best to teach each key idea was for me both challenging and an enormous amount of fun.

What Sets This Text Apart

Those who have not used or reviewed previous editions will want to know how this book differs from others.

Writing Style

1. *Using Analogies.* I tried to write *The Living World* in an informal, friendly way, to engage as well as to teach. My principal tools to counteract the tendency of new terminology to intimidate wary students were analogies, relating the matter at hand to things we all know. As science, analogies are not exact, trading precision for clarity, but the classroom has taught me that if I do my job right, the key idea is not compromised by the analogy I use to explain it, but rather revealed.
2. *Trimming Away Detail.* A second barrier stands between students and biology, and that is the mass of information typically presented in an introductory biology text. To make the ideas of biology more accessible to students, I attempted to address ideas and concepts rather than detailed information, trying to teach *how* things work and *why* things happen the way they do rather than merely naming parts or giving information.
3. *Focusing on Key Processes.* However clearly it is written, there is no way a text can avoid the fact that some processes like photosynthesis and the Krebs cycle are complex. To aid in a student's learning of complex ideas, I have prepared special "This is how it works" Process Boxes for some four dozen important processes that students encounter in introductory



biology. Each of these Process Boxes walks the student through a complex process, one step at a time, so that the central idea is not lost in the details.

4. *Creating Educated Citizens.* In writing *The Living World,* I endeavored in the first edition, and in each subsequent edition, to relate what the student is learning to the biology each student ought to know to live as an informed citizen in the twenty-first century. In the Fourth Edition, I have devoted an entire section to "The New Biology," with a full chapter on gene technology and the impact of genetic engineering on agriculture and medicine, another chapter on the new science of genomics and how it is altering our views of taxonomy, and yet another on the revolutionary new developments in cell technology that offer such medical promise. There are few chapters in the text where these advances have not had an impact.

Chapter Organization

I have made an effort to organize this text according to what was most successful in my own classroom. These decisions have created important differences between this text and its competitors.

1. *Centered Around the Learning Module.* I wrote *The Living World* to fit one and two-page spreads, so that each learning module begins with a new heading on the upper left-hand page and ends with a summary statement at the bottom of the right-hand page. I believe this format makes it easier for students to understand how the chapter content fits together conceptually, and the feedback I have received from our many reviewers seems to support that belief. This method of content organization also allows instructors to customize the text to their courses, as they can clearly point out which modules will be included in lecture.
2. *Clearer Teaching of Photosynthesis.* I have deliberately combined photosynthesis and cellular respiration into a single chapter in *The Living World,* not because metabolism is unimportant, but because teaching this difficult material in the classroom has taught me that students more easily grasp the complex metabolic activities of organisms when they explore photosynthesis and cellular respiration together, the many similarities of the two processes revealing their underlying unity.
3. *Beginning with Evolution and Ecology.* It is no accident that *The Living World* begins with a chapter on evolution and ecology. These ideas, central to biology, provide the student a framework within which to explore the world of the cell and gene function which occupy the initial third of the text. Students learn about cells and genes much more readily when they are presented in an evolutionary context, as biology rather than as molecular machinery.
4. *Presenting biological diversity as a story.* In traditional texts, evolution and diversity are taught as separate subjects. In *The Living World,* Evolution and Diversity are no longer treated as separate sections of the text. I have chosen instead to combine these areas into one continuous narrative, presenting biological diversity as an evolutionary journey. It is a lot more fun to teach this way, and students learn a great deal more, too.

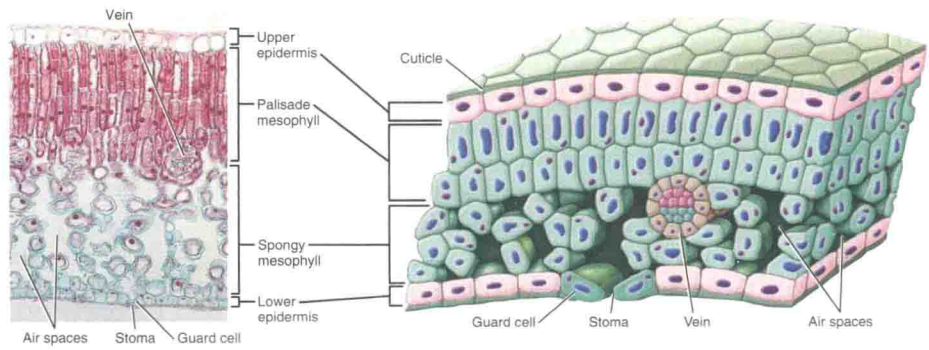
What's New This Edition

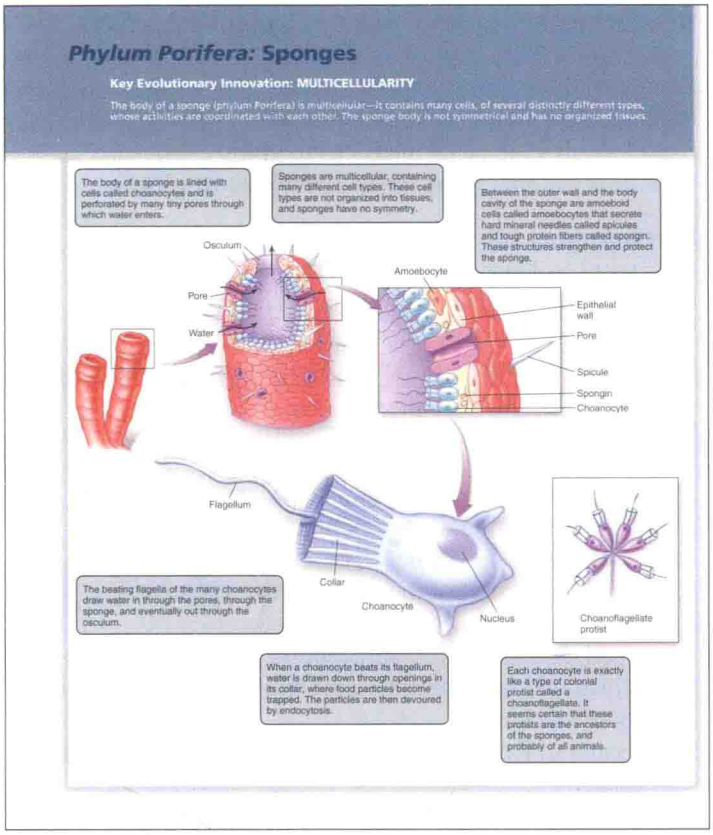
A quick look through the Fourth Edition will reveal many changes to the look and feel of this text. These changes came about because of feedback I received from many users and reviewers and through a series of focus groups held by my editors at McGraw-Hill with instructors across the country. At these meetings instructors spoke of their desire for an up-to-date text with an art program that was attractive but most importantly instructional, pages that were beautiful but still accurate and easy to navigate, and features that made the science relevant and approachable for nonmajors students. I have made a great effort to respond to that feedback, and am quite happy with the result.

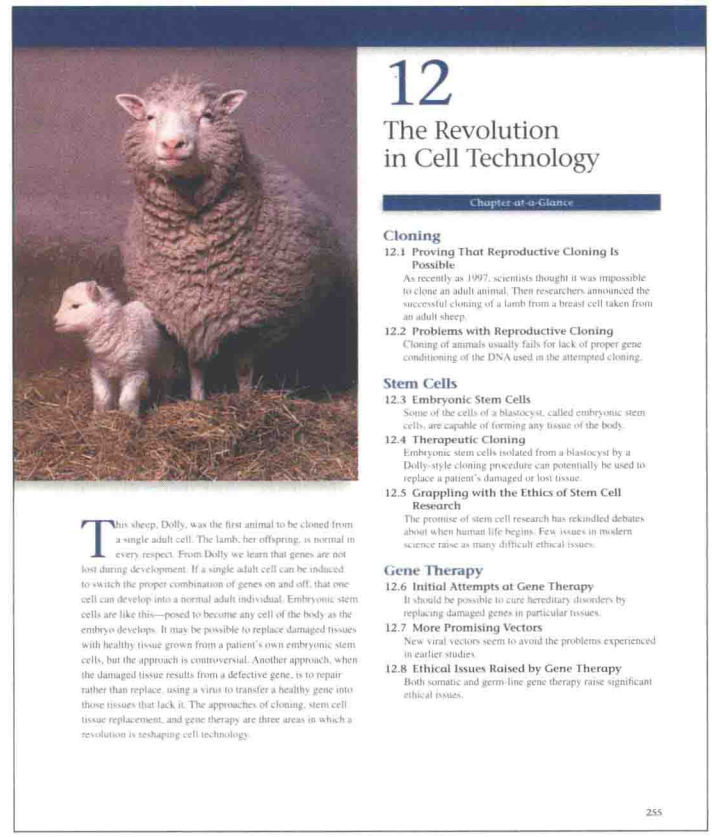
New Art

The first introduction of the student to idealized representations of plant and animal cells is particularly important in a nonmajors' text, because the beginning student must make a mental reference to that cell throughout his or her biology course, as important cellular processes and the cell's landscape are referenced again and again. For that reason I have put a great deal of thought into those representations, to remove as many areas for student misconception and confusion as possible. The resulting illustrations, seen on pages 78 and 79, are both instructive and attractive and are examples of the many changes I have made in the art in the Fourth Edition.

- **Combination Figures** These figures combine a photo or micrograph with a line drawing, to make the connection between conceptual art and what the student may encounter in a lab (see Figure 19.18 A leaf in cross section, page 395).







- **Phylum Facts** These figures summarize the key characteristics of each of the major phyla within the animal kingdom (see figure 21.39 Phylum Porifera: Sponges, page 431).
- **Process Boxes** This "how it works" feature provides a step-by-step description that walks the student through a compact summary of an important concept (see figure 5.6 How enzymes work, page 105).
- **Illustrated Tables** The inclusion of figures within many of the tables in the text now makes it easier for students to understand the information at a glance, and helps remind the student of key structures or processes (see table 27.1 Cells of the Immune System, page 589).
- **Biochemistry Pathway Icons** Found in the discussions of respiration and photosynthesis, these icons help students follow complex metabolic processes by highlighting the step currently under discussion (see figure 6.12 The Calvin cycle, page 123).

New Chapters

Gene technology is revolutionizing agriculture, providing medicine with powerful diagnostic tools, and revamping the criminal justice system. The fledgling science of genomics is reshaping the evolutionary trees that determine how we name and classify the world's creatures. Advances in cell technology now permit the cloning of farm animals, and may soon lead to cures for juvenile diabetes and Parkinson's. It is here, where advances in biology meet public awareness, that a student's interest in biology is most acute, where there is the greatest need for education and the greatest opportunity for learning. Many of the content changes in this edition of *The Living World* are in direct response to that opportunity.

New chapter 12, "The Revolution in Cell Technology," contains up-to-date treatments of cloning, stem cells, and gene therapy. These topics are important for all informed citizens to understand, as government policies and medical practices are being established on this information.

New chapter 33, "Behavior and the Environment," focuses on how natural selection has guided the evolution of animal behavior, and the often profound ecological consequences.

Thoroughly Updated Content

Part 1 The Study of Life

New section: Four Theories Unify Biology as a Science
Expanded discussion of adaptive radiation, focusing on one example, Darwin's finches

Part 2 The Living Cell

Divided the previous *Energy and Life* chapter into two separate chapters: Chapter 5 *Energy and Life* and Chapter 6 *How Cells Acquire Energy*
New section: Visualizing Cells, including a discussion of microscopy
New discussion on protein denaturing
New discussion on protein chaperones and protein folding
New introduction to photosystems and photosynthesis
New illustrated table: How Cells Use ATP to Power Cellular Work

Part 3 The Continuity of Life
New section explaining how genes influence traits
New section of Mendelian genetics problems
New discussion of how small RNAs regulate gene expression
New overview of protein synthesis
Expanded discussion of the differences between homologues and sister chromatids
Expanded discussion of "What is Cancer?"
Expanded discussion of the importance of generating genetic diversity
Expanded discussion of DNA replication
Expanded discussion of genetic counseling

Part 4 The New Biology
New chapter *The Revolution in Cell Technology* that contains information on cloning, stem cells, and gene therapy
Expanded section on measuring the risks of GM crops
Expanded discussion of producing recombinant DNA
Expanded discussion of uses for a cloned gene
New illustrated table summarizing genetically modified crops
New section: Comparing Genomes of Different Organisms
New discussion of genomic sequence of Y chromosome
New illustrated table summarizing information on sequenced eukaryotic genomes

Part 5 The Evolution and Diversity of Life
New section: A general introduction to evolution
Revised discussion of Hardy-Weinberg, with the equation analyzed step-by-step
New Featured Reading: Evolution's Critics
New section: The Pace of Evolution
New section: The Origin of the First Cells
New section: The Ecological Role of Fungi
New Featured Reading: "Has Life Evolved Elsewhere?"
New Featured Reading: "Prions and Mad Cow Disease"
New discussion of origin of nucleus and endoplasmic reticulum
New discussion of chytrids, a fourth phylum of fungi
Expanded discussion of viral diseases

Part 6 Plant Life
New section: Plant Evolution, including a molecular phylogenetic tree
Expanded discussion of carbohydrate transport
New section: Asexual Reproduction
Expanded discussion of flowers to include wind pollinated flowers and aquatic plants
Expanded discussion of flower-insect coevolution
Expanded discussion of fruit
Expanded discussion of ground tissue
Expanded discussion of absorbing minerals and water from the soil

Part 7 Evolution of Animal Life
New section: The Animal Family Tree, discussing the traditional vs. molecular approaches
New section: "Evo-Devo" and the Roots of the Animal Family Tree
Expanded discussion of echinoderms
Expanded discussion of chordate characteristics
Expanded discussion of mammalian groups
New information on the hominid evolutionary tree

Part 8 Animal Life
New section: Treating Blocked Coronary Arteries
New section: Antibodies in Medical Diagnosis
New section: Sexually Transmitted Diseases
Expanded discussions of delay hypersensitivity and immune surveillance
Expanded discussion of blood pressure
Expanded discussion of the nerve impulse
Expanded discussion of the limbic system
Expanded discussion of steroid hormone function
Expanded discussion of negative feedback loops
Expanded discussion of the reproductive cycle
Expanded discussion of vertebrate teeth
Expanded discussion of contraception
New illustrated table summarizing the innovations in animal body design
New Featured Reading on the link between diabetes and obesity
New Featured Reading on the search for an effective AIDS vaccine
New Featured Reading on aging

Part 9 The Living Environment
New chapter: *Animal Behavior*
New section: Coevolution of Predator and Prey
New section: Solving Environmental Problems
New section on Loss of Biodiversity
Expanded section on global warming
Expanded section on declining population growth
Expanded discussion of other chemicals that are cycled through ecosystems
Expanded discussion of La Niña
Expanded discussion of hydrothermal vent systems
Expanded discussion of other biomes
Expanded discussion of succession
Expanded discussion of niches and their overlap
Expanded discussion of coevolution

End of Chapter Pedagogy

I have revised the end-of-chapter content to focus on student review and self-evaluation. Features of this section include an extensive chapter summary and three assessment tools: Self-Test, multiple choice questions; Visual Understanding, questions based on art from the chapter; and Challenge Questions, critical thinking questions. Answers for the Self-Test questions are provided in the back of the text, while extended answers for all of the end-of-chapter questions can be found on the text-specific website.

Relevance

Throughout the book, I have written new full-page boxed readings to make connections to the everyday world: *A Closer Look* essays examine important new advances in biology; *Science In Action* essays focus on how scientific analysis is carried out; and *Author's Corner* essays take a more personal view of how science relates to our everyday lives.

Current issues are of great interest to many students of introductory biology. In a new end-of-chapter element called *Exploring Current Issues* I provide these students with ways to explore the issues raised in the chapter in more depth. These include references to articles from scientific publications on topics of interest, links to articles written by me which expand on these topics, and videos of lectures on these topics presented by me to my students at Washington University in my course "Biology and Society."

Author's Corner

How Tropical Lizards Climb Vertical Walls

Science is most fun when it tickles your imagination. This is particularly true when you see something you know just can't be true. A few years ago, my wife, Barbara, and I were on a tropical vacation, and I was lying on the bed when a little lizard walked up the wall beside me and across the ceiling, stopping right over my head and looking down at me.

This was no special effect, no trick with mirrors. I was seeing it with my own eyes, real as day, right there above me. The lizard, a green gecko about the size of a toothbrush, stood upside down on the ceiling and seemed to laugh at me for several minutes before trotting over to the far wall and down.

How did my gecko perform this gripping feat? Investigators have puzzled over the adhesive properties of geckos for decades. What force prevented gravity from dropping the gecko on my nose?

The most reasonable hypothesis seemed suction—salamanders feet from suction cups that let them climb walls, so maybe geckos do too. The way to test this is to see if the feet adhere in a vacuum, with no air to create suction. Salamander feet don't adhere, but gecko feet do. It's not suction.

How about friction? Cockroaches climb using tiny hooks that grapple onto irregularities in the surface, much as rock climbers use crampons. Geckos, however, happily run up walls of smooth polished glass that no cockroach can climb. It's not friction.

Electrostatic attraction? Clothes in a dryer stick together because of electrical charges created by their rubbing together. You can stop this by adding a "static remover" that is itself heavily ionized. But a gecko's feet still adhere in ionized air. It's not electrostatic attraction.

Could it be glue? Many insects use adhesive secretions from glands in their feet to aid climbing. But there are no gland cells in gecko feet, no secreted chemical. It's not glue.

There was one tantalizing clue, however, the kind that experimenters love. Gecko feet seem to get stickier on surfaces with highly ordered molecules. This suggests that geckos are tapping directly into the molecular structure of the surfaces they walk on!

Tracking down this clue, Robert Full of the University of California, Berkeley, and his research team took a closer look at gecko feet. Geckos have rows of tiny hairs on the bottoms of their feet, like the bristles of a toothbrush. There are about half a million of these hairs on each foot, pointed toward the heel.

When you look at these hairs under a microscope, the end of each hair is divided into between 400 and 1,000 fine projections, the projections sticking out from the tip like tiny stiff brushes.

When a gecko takes a step, it drives the sole of its foot into the surface and pushes it backwards. This shoves the forest of tips directly against the surface. The atoms of each gecko tip become closely engaged with the atoms of the surface, and that is the force that defies gravity. When two atoms approach each other very closely—closer than the diameter of an atom—a subtle nuclear attraction called "Van der Waals forces" comes into play. These forces are individually very weak, but when lots of atoms add their little bits, the sum can add up to quite a lot.

Full and his team used microelectrical mechanical sensors (originally designed to be used with atomic force microscopes) to measure the force exerted by a single hair removed from a gecko's foot. It was 200 micronewtons, a tiny force but stupendous for a single hair. Enough to hold up an ant. A million hairs could support a small child. My little gecko, ceiling-walking with 2 million of them, could have carried an 80-pound backpack—talk about being overengineered!

If they stick that well, how do geckos ever come unstuck? For a gecko's foot to stick, each hair projection must butt up squarely against the surface, so the hair's individual atoms can come into play. Tipped past a critical angle—30 degrees—the attractive forces between hair and surface atoms weaken to nothing. The trick is to tip the feet hairs until the projections let go. Geckos release their feet by curling up each toe and peeling it off, sort of like undoing velcro.

Now I can laugh with my little gecko friend, should I see it again, for I know its secret.

CHAPTER 1 THE CHEMISTRY OF LIFE 49

Overview of Changes to *The Living World, Fourth Edition*

Enhanced Art and Photo Program All pieces of art were revised for content and style. All photos were enhanced for better printing quality and clearer presentation. Page design was updated to facilitate text flow and optimize space.

Fully Updated Cell and Genetics Chapters In addition to discussing important advances, sections were added at the request of reviewers to provide students with even more background information and more detailed explanations to help first-time biologists make connections between concepts.

New Chapter "The Revolution in Cell Technology" This new chapter provides students with fundamental information on frequently debated topics such as cloning, stem cells, and gene therapy, topics that will only become more prominent issues in their lifetimes.

New Boxed Readings I have written three types of boxed readings for this edition: *A Closer Look* essays take closer looks at important new advances in biology; *Science In Action* essays focus on how scientific analysis is carried out; and *Author's Corner* essays take a more personal view of how science relates to our everyday lives.

Fully Updated Evolution and Diversity Chapters New RNA and genomic information is causing us to reconsider previously assumed relationships between organisms. New sections throughout the text address this new knowledge.

New Chapter "Animal Behavior" This new chapter focuses on how natural selection has guided the evolution of animal behavior, as well as the often profound ecological consequences.

New End-of-Chapter Assessment New end of chapter summaries and assessment questions provide students with more help in mastering chapter concepts. New questions include: Self-Test, multiple choice questions; Visual Understanding, questions based on art from the chapter; and Challenge Questions, critical thinking questions.

Exploring Current Issues This new section references articles from scientific publications on topics that are of interest to students, and articles or lectures created by me, found on the Online Learning Center, which expand on topics found within the chapter.

New and Expanded Discussions Throughout All chapters were revised and updated. A complete list of changes can be found in the Information Center on the Online Learning Center.

Teaching and Learning Supplements

McGraw-Hill offers various tools and technology products to support *Biology.* Students can order supplemental study materials by contacting their local bookstore or by calling 800-262-4729. Instructors can obtain teaching aids by calling the Customer Service Department at 800-338-3987, visiting our website at www.mhhe.com/biology, or contacting their local McGraw-Hill sales representative.

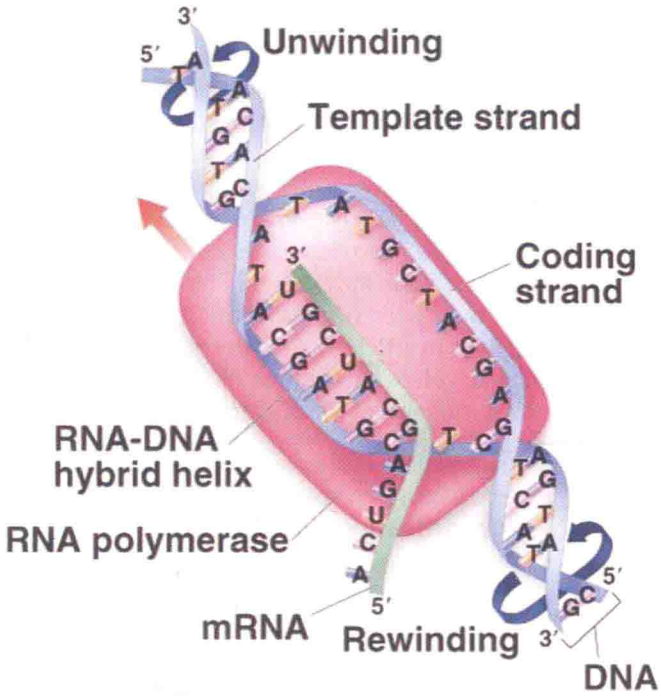
For The Instructor:

Digital Content Manager CD-ROM

This multimedia collection of visual resources allows instructors to 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 material. The digital assets on this cross-platform CD-ROM include:

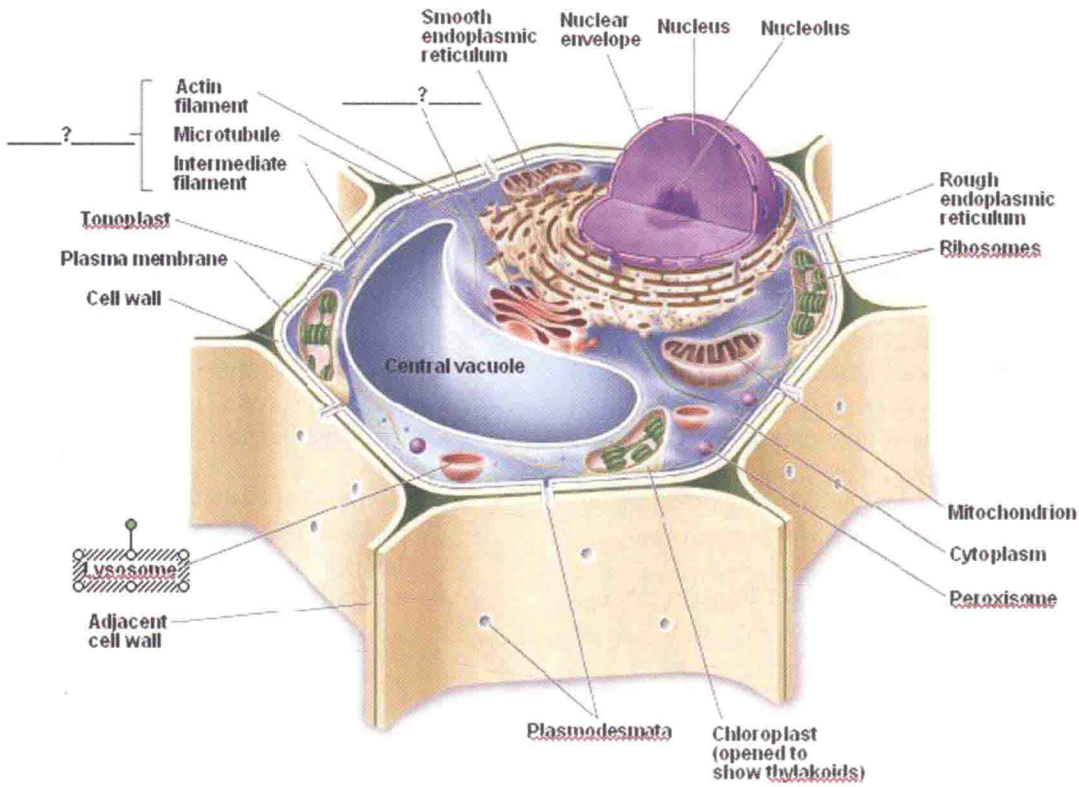
Art Library Color-enhanced, digital files of all illustrations in the book, plus the same art saved in unlabeled and gray scale versions, can be readily incorporated into lecture presentations, exams, or custom-made classroom materials. Upsized labels make the images appropriate for use in large lecture halls.

Art Library with upsized labels



TextEdit Art Library Every line art piece is placed into a PowerPoint presentation that allows the user to revise and/or move or delete labels as desired for creation of customized presentations and/or for testing purposes.

TextEdit Art Library with modified labels



Active Art Library Active Art consists of art files that have been converted to a format that allows the artwork to be edited inside of PowerPoint. Each piece can be broken down to its core elements, grouped or ungrouped, and edited to create customized illustrations.

Animations Library Full color presentations of key biological processes have been brought to life via animation. These animations offer flexibility for instructors and were designed to be used in lecture. Instructors can pause, rewind, fast forward, and turn the audio off or on to create dynamic lecture presentations. The animations are now also available with Spanish narration and text.

PowerPoint Lecture Outlines These ready-made presentations combine art and lecture notes for each of the 34 chapters of the book. The presentations can be used as they are, or can be customized to reflect your preferred lecture topics and organization.

PowerPoint Outlines The art photos and tables for each chapter are inserted into blank PowerPoint presentations to which you can add your own notes.

Photo Library Like the Art Library, digital files of all photographs from the book are available.

Table Library Every table that appears in the book is provided in electronic form.

Additional Photo Library Over 700 photos, not found in *The Living World,* are available for use in creating lecture presentations.

Biology Digitized Videos DVD

This collection of videos features 75 video clips of biological concepts that can only be fully understood in motion. Excellent for introducing lecture topics, the videos are catalogued by main subject areas for easy location of desired topics.

Alex the African Grey Parrot correctly answers complex questions in a video segment that vividly introduces the subject of animal cognition and behavior.

Instructor's Testing and Resource CD-ROM

The cross-platform CD-ROM contains the Instructor's Manual and Test Item File, both available in Word and PDF formats. The manual contains chapter outlines, learning objectives, key terms, lecture suggestions, additional critical thinking questions, and sources for visual resources. The Test Bank offers questions that can be used for homework assignments or the preparation of exams. The computerized test bank allows the user to quickly create customized exams. Instructors can search questions by topic, format, or difficulty level; edit existing questions or add new ones; and scramble questions and answer keys for multiple versions of the same test.

Transparencies

A set of 700 transparency overheads includes every piece of line art and table in the text. The images are printed with better visibility and contrast than ever before, and labels are large and bold for clear projection.

Online Learning Center
www.mhhe.com/tlw4

Instructor's resources at this site include access to online laboratories, case studies, news feeds, Course Integration Guide, and Instructor's Manual.

Course Delivery Systems

With help from our partners, WebCT, Blackboard, TopClass, eCollege, and other course management systems, instructors can take complete control over their course content. These course cartridges also provide online testing and powerful student tracking features. *The Living World* Online Learning Center is available within all of these platforms.

For the Student:

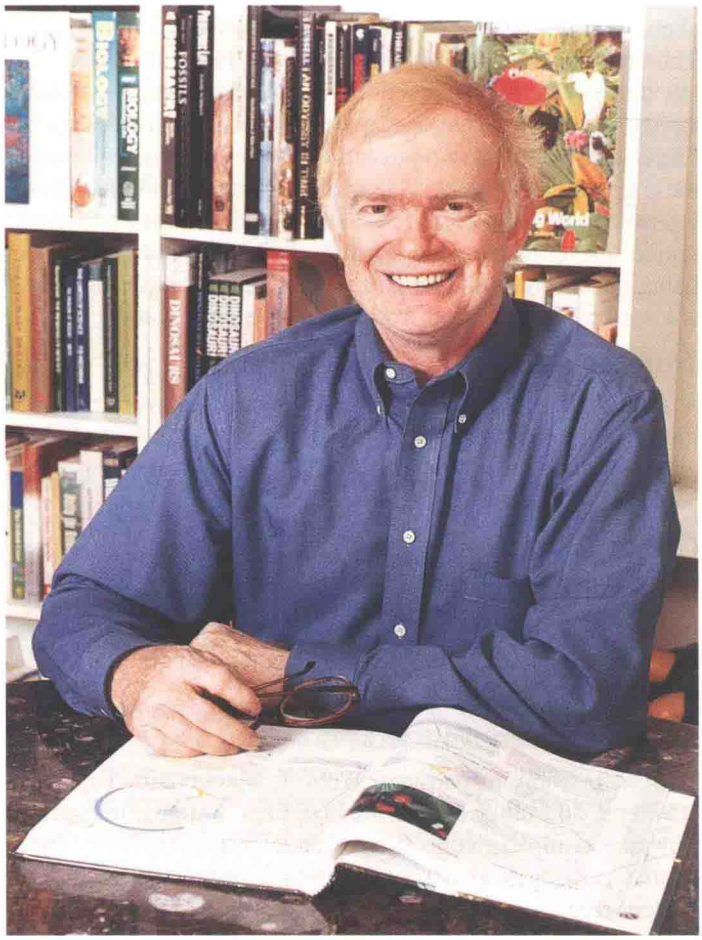
Online Learning Center
www.mhhe.com/tlw4

The site includes quizzes for each chapter, animations, interactive activities, and answers to questions from the text. Turn to the inside cover of the text to learn more about the exciting features provided for students through the enhanced *The Living World* Online Learning Center.

Student Study Guide

This student resource contains activities and questions to help reinforce chapter concepts. The guide provides students with tips and strategies for mastering the chapter content, concept outlines, key terms, and sample quizzes.

Acknowledgements



Every author labors on the shoulders of many others. When I first set out to write a textbook, I had no idea how much work remained to be done after I had finished writing. An army of editors, spelling and grammar checkers, photo researchers, and artists assembles the final manuscript, and another even larger army transforms this manuscript into a bound book. I cannot begin to thank them all. Tom Lyon and Anne Winch were my editorial team, the people I worked with every day; their boss, Kent Peterson, put out any fires I created out of excess enthusiasm or sheer pig-headedness. Jodi Rhomberg spearheaded the production team, balancing many balls in the air. The new art program was done by Imagineering. They did a superb job, despite my occasionally breathing fire down their necks. When the manuscript was ready and the art finished, the book went to Carlisle Communications, where another team headed by Cindy Sweeney went to work to prepare the book for printing, with Jodi Gaherty expertly composing the pages into learning modules. My own longtime developmental editors and right arms Megan Jackman and Liz Sievers have again played an invaluable role in overseeing every detail of a complex revision. Their intelligence and perseverance continue to play a major role in the quality of this book. I would also like to thank JodyLee Estrada Duek of Pima Community College, who provided end-of-chapter questions, and Jennifer Warner of the University of North Carolina-Charlotte, who contributed the Additional Resources for the *Exploring Current Issues* feature. Last but not least, I would like to extend a special thanks to Michael Lange, the editor-in-chief at McGraw-Hill, for his continued strong support of this project.

Reviewers

Over twenty years of authoring have taught me the great value of reviewers in improving my texts. My colleagues around the country have provided numerous suggestions on how to improve this fourth edition. Many teachers and students using the previous edition have also suggsted ways to improve it. Even teachers who chose not to adopt the previous edition often drew my attention to something they did not like. All of these instructors and students have much to teach me, pointing out ways to improve presentation, clarify explanations, and add or expand on important topics. The instructors listed below provided detailed comments. I have tried to listen carefully to all of you. Every one of you has my heartfelt thanks.

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Guided Tour

Instructive Art Program

The core of every biology textbook is its art program, and George Johnson has worked hard to create a dynamic program of full-color illustrations and photographs that support and further clarify the text explanations. Brilliantly rendered and meticulously reviewed for accuracy and consistency, the carefully conceived illustrations and accompanying photos provide concrete, visual reinforcement of the topics discussed throughout the text.

Process Boxes

Process Boxes break down complex processes into a series of smaller steps, allowing you to track the key occurrences and learn them as you go.

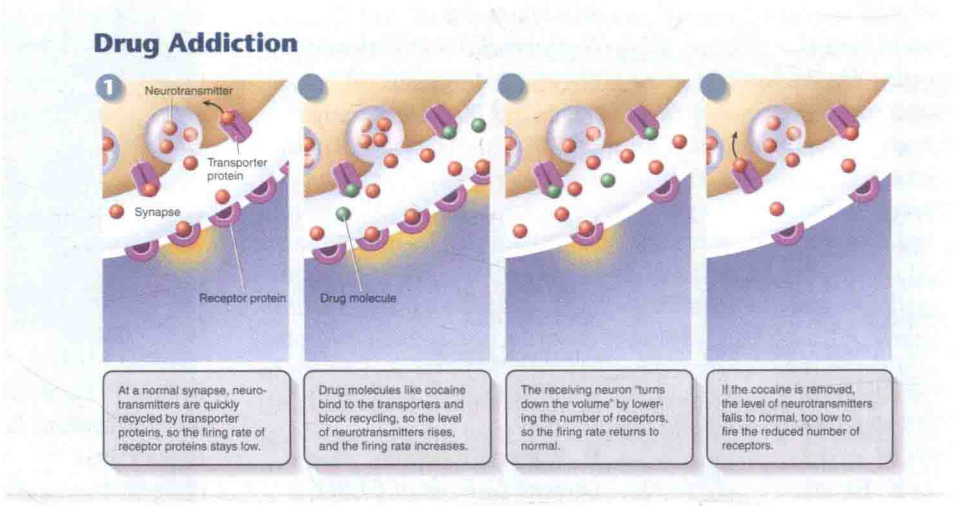


Figure 28.10 How drug addiction works.

Phylum Facts

These figures summarize the key characteristics of each of the major phyla within the animal kingdom.

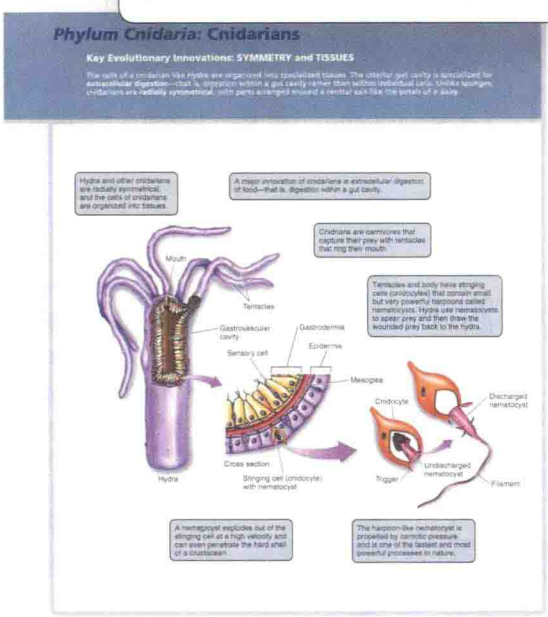


TABLE 17.1 FUNGI

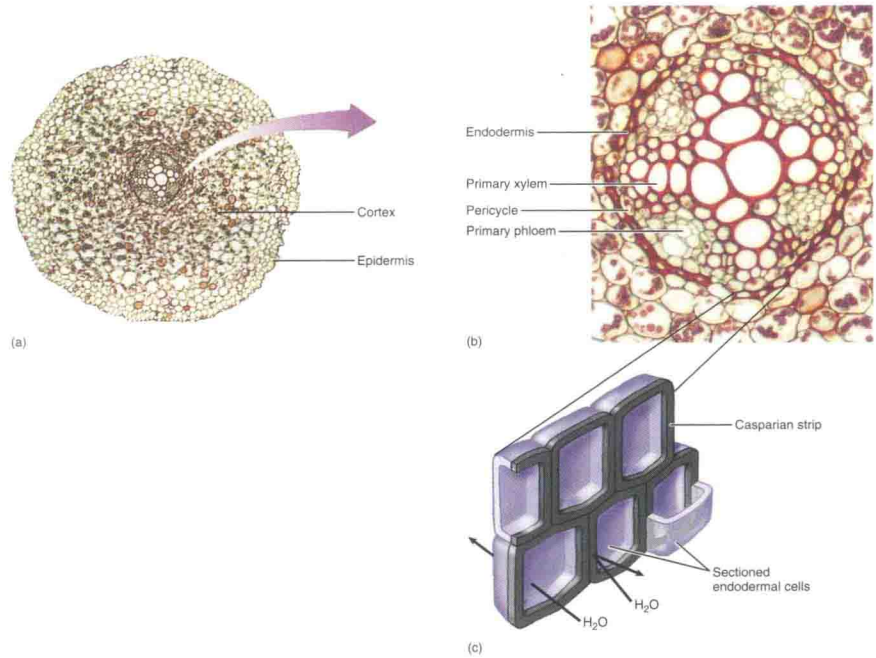
Phylum	Typical Examples	Key Characteristics	Approximate Number of Living Species
Zygomycota	*Rhizopus* (black bread mold)	Develop sexually and asexually; multinucleate hyphae lack septa, except for reproductive structures; fusion of hyphae leads directly to formation of a zygote, in which meiosis occurs just before it germinates	1,050
Ascomycota	Yeasts, truffles, morels	Develop by sexual means; ascospores are formed inside a sac called an ascus; asexual reproduction is also common	32,000
Basidiomycota	Mushrooms, toadstools, rusts	Develop by sexual means; basidiospores are borne on club-shaped structures called basidia; the terminal hyphal cell that produces spores is called a basidium; asexual reproduction occurs occasionally	22,000
Chytridiomycota	*Allomyces*	Produce flagellated gametes (zoospores); predominately aquatic, some freshwater and some marine, oldest group of fungi	1,500
Imperfect fungi (not a phylum)	*Aspergillus*, *Penicillium*	Sexual reproduction has not been observed; most are thought to be ascomycetes that have lost the ability to reproduce sexually	17,000

Illustrated Tables

The inclusion of figures within many of the tables in the text now make it easier for you to understand the table information at a glance, and helps remind you of key structures or processes.

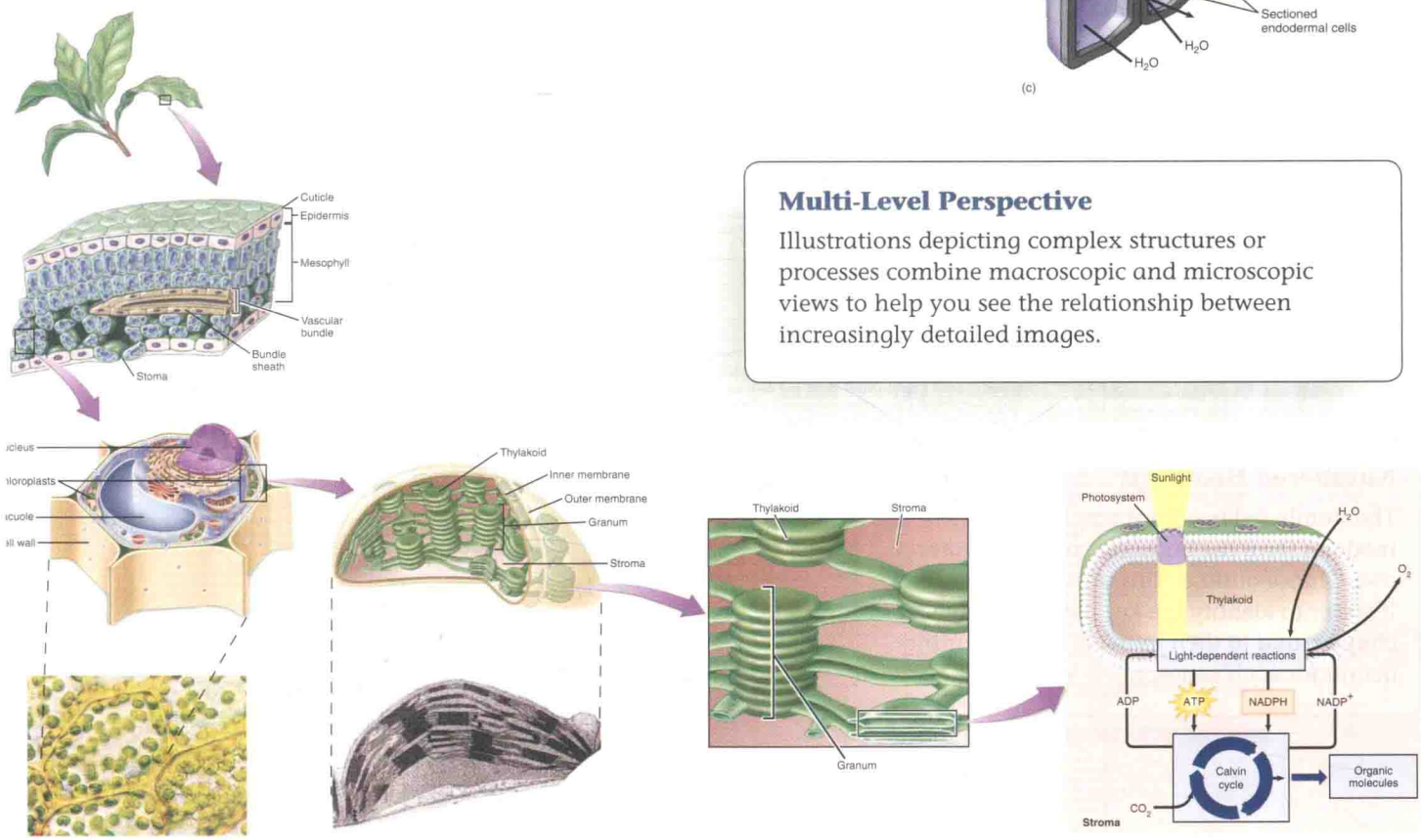
Combination Figures

Line drawings are often combined with photographs to facilitate visualization of structures.



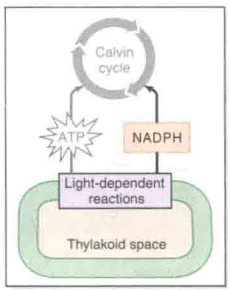
Multi-Level Perspective

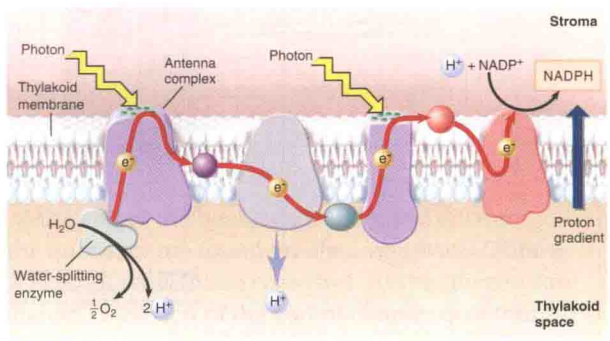
Illustrations depicting complex structures or processes combine macroscopic and microscopic views to help you see the relationship between increasingly detailed images.



Biochemistry Pathway Icons

These icons are paired with more detailed illustrations to assist you in keeping the big picture in mind when learning complex metabolic processes. The icon highlights which step the main illustration represents, and where that step occurs in the complete process.





The Learning System

This text is designed to help you learn in a systematic fashion. Simple facts are the building blocks for developing explanations of more complex concepts. The text discussion is presented within a supporting framework of learning aids that help organize studying, reinforce learning, and promote problem-solving skills.

14

How We Name Living Things

Chapter-at-a-Glance

The Classification of Organisms

14.1 The Invention of the Linnaean System
Biologists name organisms using a two-word "binomial" system.

14.2 Species Names
Every kind of organism is assigned a unique Latin name.

14.3 Higher Categories
The higher groups into which an organism is placed reveal a great deal about the organism.

14.4 What Is a Species?
Species are groups of similar organisms. Animal species tend not to interbreed with individuals of other species, while plants often do so.

Inferring Phylogeny

14.5 How to Build a Family Tree
Traditional and cladistic interpretations of an organism's evolutionary history differ in the emphasis they place on key traits.

In 1799, the skin of a most unusual animal was sent to England by Captain John Hunter, governor of the British penal colony in New South Wales (Australia). Covered in soft fur, it was less than two feet long. As it had mammary glands with which to suckle its y... a mammal, but in other ways it seemed very... Males have internal testes, and females hav... and reproductive tract opening called a clo... reptiles do, and like reptilian eggs, the yolk... egg does not divide. It thus seemed a confu... mammalian and reptilian traits. Adding to t... its appearance: It has a tail not unlike that o... not unlike that of a duck, and webbed feet!... had mixed together body parts at random—

Chapter-at-a-Glance

Each chapter begins with an outline that gives you an overview of the content contained within that chapter. Reviewing the outline before reading the chapter will help focus your attention on the major concepts you should take away from the chapter.

Numbered Headings

The numbered headings employed in the modules form the backbone of the Chapter-at-a-Glance outline. This consistency makes it easier to identify the key concepts for each chapter, and to then manage the supporting details for each concept.

14.2 Species Names

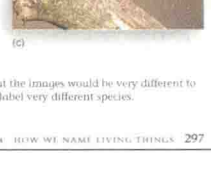
A group of organisms at a particular level in a classification system is called a **taxon** (plural, **taxa**), and the branch of biology that identifies and names such groups of organisms is called **taxonomy.** Taxonomists are in a real sense detectives, biologists who must use clues of appearance and behavior to ...organisms. ...among taxonomists through... ...sms can have the same name. ...ored, a language spoken by no ...e names. Because the scientific ...me anywhere in the world, this ...d precise way of communicat... ...particular biologist is Chinese, ...his is a great improvement over ...ich often vary from one place to ...ure 14.2, corn in Europe refers to the plant Americans call wheat; a bear is a large placental omnivore in the United States but a koala (a vegetarian marsupial) in Australia; and a robin is a very different bird in Europe and North America.

By convention, the first word of the binomial name is the genus to which the organism belongs. This word is always capitalized. The second word, called the *epithet*, refers to the particular species and is not capitalized. The two words together are called the **scientific name,** or species name, and are written in italics. The system of naming animals, plants, and other organisms established by Linnaeus has served the science of biology well for nearly 250 years.

14.2 By convention, the first part of a binomial species name identifies the genus to which the species belongs, and the second part distinguishes that particular species from other species in the genus.

(a)

(b)



(c)

Figure 14.2 Common names make poor labels.
The common names corn (*a*), bear (*b*), and robin (*c*) bring clear images to our minds (photos on *top*), but the images would be very different to someone living in Europe or Australia (photos on *bottom*). There, the same common names are used to label very different species.

CHAPTER 14 HOW WE NAME LIVING THINGS 297

Section Summaries

Each module ends with a summary intended to reinforce the key concepts from that section. Reviewing the summary after reading the section will indicate whether you learned the main ideas presented in the module.

Modular Format

Each page or two-page spread in *The Living World* is organized as an independent module, with its own numbered heading at the top of the left-hand page, and a highlighted summary at the bottom of the right-hand page. This system organizes the information in the chapter within a clear conceptual framework, which in turn helps you learn and retain the material.

20.3 Fruit

During seed formation, the flower ovary begins to develop into fruit. The evolution of flowers was key to the success and diversification of the angiosperms. But of equal importance to angiosperm success has been the evolution of these fruits in response to their modes of dispersal. Fruits form in many ways and exhibit a wide array of modes of specialization.

Three layers of ovary wall can have distinct fates and account for the diversity of fruit types, from fleshy to dry and hard. There are three main kinds of fleshy fruits (figure 20.5): berries, drupes, and pomes. In *berries*—such as grapes, tomatoes, and peppers—which are typically many-seeded, the inner layers of the ovary wall are fleshy. In *drupes*—peaches, olives, plums, and cherries—the inner layer of the fruit is stony and adheres tightly to a single seed. In *pomes*—apples and pears—the fleshy portion of the fruit forms from the ovary, which is embedded in the receptacle (the swollen end of the flower stem that holds the petals and sepals).

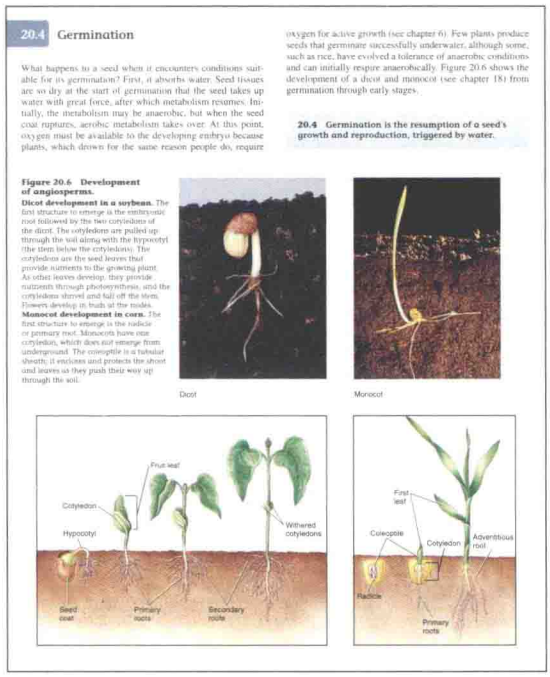
Fruits that have fleshy coverings, often black, bright blue, or red, are normally dispersed by birds and other vertebrates (figure 20.5d). By feeding on these fruits, the birds and other animals carry seeds from place to place before excreting the seeds as solid waste. The seeds, not harmed by the animal digestive system, thus are transferred from one suitable habitat to another. Other fruits that are dispersed by wind (figure 20.5e), or by attaching themselves to the fur of mammals or the feathers of birds (figure 20.5f), are called dry fruits because they lack the fleshy tissue of edible fruits. Still other fruits, such as those of mangroves, coconuts, and certain other plants that characteristically occur on or near beaches, swamps, or other bodies of water, are regularly spread from place to place by water.

20.3 Fruits are specialized to achieve widespread dispersal by wind, by water, by attachment to animals, or, in the case of fleshy fruits, by being eaten.

(a) Berries (b) Drupes (c) Pomes

(d) Eaten by animals (e) Dispersed by wind (f) Dispersed by attaching to animals

Figure 20.5 Types of fruits and common modes of dispersion.
(a) Tomatoes are a type of fleshy fruit called berries that have multiple seeds. (b) Peaches are a type of fleshy fruit called drupes that contain a single large seed. (c) Apples are a type of fleshy fruit that contains multiple seeds. (d) The bright red berries of this honeysuckle, *Lonicera*, are highly attractive to birds. Birds may carry the berry seeds either internally or stuck to their feet for great distances. (e) The seeds of this dandelion, *Taraxacum officinale*, are enclosed in a dry fruit with a "parachute" structure that aids its dispersal by wind. (f) The spiny fruits of this cocklebur, *Xanthium strumarium*, adhere readily to any passing animal.



20.4 Germination

What happens to a seed when it encounters conditions suitable for its germination? First, it absorbs water. Seed tissues are so dry at the start of germination that the seed takes up water with great force, after which metabolism resumes. Initially, the metabolism may be anaerobic, but when the seed coat ruptures, aerobic metabolism takes over. At this point, oxygen must be available to the developing embryo because plants, which drown for the same reason people do, require oxygen for active growth (see chapter 6). Few plants produce seeds that germinate successfully underwater, although some, such as rice, have evolved a tolerance of anaerobic conditions and can initially respire anaerobically. Figure 20.6 shows the development of a dicot and monocot (see chapter 18) from germination through early stages.

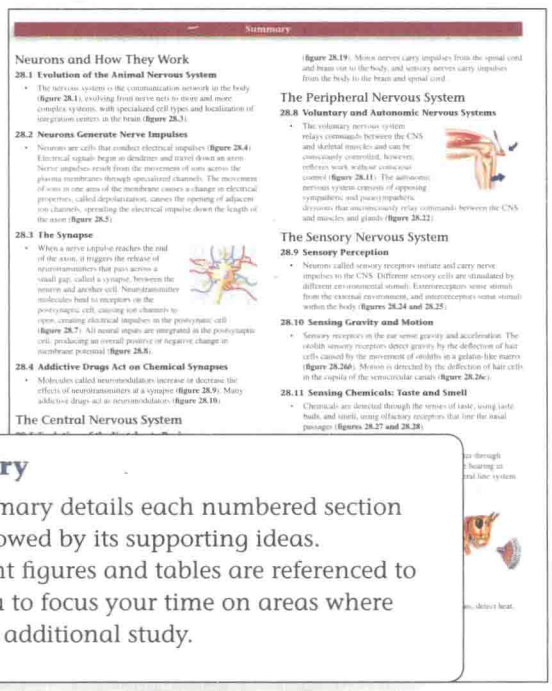
20.4 Germination is the resumption of a seed's growth and reproduction, triggered by water.

Figure 20.6 Development of angiosperms.
Dicot development in a soybean. The first structure to emerge is the embryonic root followed by the two cotyledons of the dicot. The cotyledons are pulled up through the soil along with the hypocotyl (the stem below the cotyledons). The cotyledons are the seed leaves that provide nutrients to the growing plant. As other leaves develop, they provide nutrients through photosynthesis, and the cotyledons shrivel and fall off the stem. Flowers develop at buds at the nodes.
Monocot development in corn. The first structure to emerge is the radicle or primary root. Monocots have one cotyledon, which does not emerge from underground. The coleoptile is a tubular sheath; it encloses and protects the shoot and leaves as they push their way up through the soil.

Dicot Monocot

Fruit leaf
Cotyledon
Hypocotyl
Withered cotyledons
Seed coat
Primary roots
Secondary roots

First leaf
Coleoptile
Cotyledon
Adventitious root
Radicle
Primary roots



Summary

Neurons and How They Work

28.1 Evolution of the Animal Nervous System

- The nervous system is the communication network in the body (**figure 28.1**), evolving from nerve nets to more and more complex systems, with specialized cell types and localization of integration centers in the brain (**figure 28.3**).

28.2 Neurons Generate Nerve Impulses

- Neurons are cells that conduct electrical impulses (**figure 28.4**). Electrical signals begin at dendrites and travel down an axon. Nerve impulses result from the movement of ions across the plasma membranes through specialized channels. The movement of ions in one area of the membrane causes a change in electrical properties, called depolarization, causes the opening of adjacent ion channels, spreading the electrical impulse down the length of the axon (**figure 28.5**).

28.3 The Synapse

- When a nerve impulse reaches the end of the axon, it triggers the release of neurotransmitters that pass across a small gap, called a synapse, between the neuron and another cell. Neurotransmitter molecules bind to receptors on the postsynaptic cell, causing ion channels to open, creating electrical impulses in the postsynaptic cell (**figure 28.7**). All neural inputs are integrated in the postsynaptic cell, producing an overall positive or negative change in membrane potential (**figure 28.8**).

28.4 Addictive Drugs Act on Chemical Synapses

- Molecules called neuromodulators increase or decrease the effects of neurotransmitters at a synapse (**figure 28.9**). Many addictive drugs act as neuromodulators (**figure 28.10**).

The Central Nervous System

(**figure 28.19**). Motor nerves carry impulses from the spinal cord and brain out to the body, and sensory nerves carry impulses from the body to the brain and spinal cord.

The Peripheral Nervous System

28.8 Voluntary and Autonomic Nervous Systems

- The voluntary nervous system relays commands between the CNS and skeletal muscles and can be consciously controlled; however, reflexes work without conscious control (**figure 28.11**). The autonomic nervous system consists of opposing sympathetic and parasympathetic divisions that unconsciously relay commands between the CNS and muscles and glands (**figure 28.12**).

The Sensory Nervous System

28.9 Sensory Perception

- Neurons called sensory receptors initiate and carry nerve impulses to the CNS. Different sensory cells are stimulated by different environmental stimuli. Exteroceptors sense stimuli from the external environment, and interoceptors sense stimuli within the body (**figures 28.24 and 28.25**).

28.10 Sensing Gravity and Motion

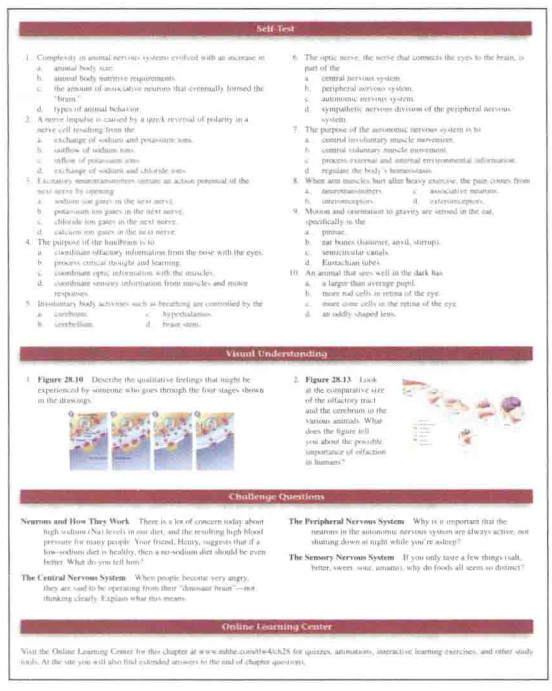
- Sensory receptors in the ear sense gravity and acceleration. The otolith sensory receptors detect gravity by the deflection of hair cells caused by the movement of otoliths in a gelatin-like matrix (**figure 28.26b**). Motion is detected by the deflection of hair cells in the cupula of the semicircular canals (**figure 28.26c**).

28.11 Sensing Chemicals: Taste and Smell

- Chemicals are detected through the senses of taste, using taste buds, and smell, using olfactory receptors that line the nasal passages (**figures 28.27 and 28.28**).

Summary

The Summary details each numbered section head followed by its supporting ideas. Significant figures and tables are referenced to allow you to focus your time on areas where you need additional study.



Self-Test

1. Complexity in animal nervous systems evolved with an increase in
   a. animal body size.
   b. animal body nutritive requirements.
   c. the amount of associative neurons that eventually formed the "brains."
   d. types of animal behavior.
2. A nerve impulse is caused by a quick reversal of polarity in a nerve cell resulting from the
   a. exchange of sodium and potassium ions.
   b. outflow of sodium ions.
   c. inflow of potassium ions.
   d. exchange of sodium and chloride ions.
3. Excitatory neurotransmitters initiate an action potential of the next nerve by opening
   a. sodium ion gates in the next nerve.
   b. potassium ion gates in the next nerve.
   c. chloride ion gates in the next nerve.
   d. calcium ion gates in the next nerve.
4. The purpose of the hindbrain is to
   a. coordinate olfactory information from the nose with the eyes.
   b. process critical thought and learning.
   c. coordinate optic information with the muscles.
   d. coordinate sensory information from muscles and motor responses.
5. Involuntary body activities such as breathing are controlled by the
   a. cerebrum. c. hypothalamus.
   b. cerebellum. d. brain stem.
6. The optic nerve, the nerve that connects the eyes to the brain, is part of the
   a. central nervous system.
   b. peripheral nervous system.
   c. autonomic nervous system.
   d. sympathetic nervous division of the peripheral nervous system.
7. The purpose of the autonomic nervous system is to
   a. control involuntary muscle movement.
   b. control voluntary muscle movement.
   c. process external and internal environmental information.
   d. regulate the body's homeostasis.
8. When arm muscles hurt after heavy exercise, the pain comes from
   a. neurotransmitters. c. associative neurons.
   b. interoceptors. d. exteroceptors.
9. Motion and orientation to gravity are sensed in the ear, specifically in the
   a. pinnae.
   b. ear bones (hammer, anvil, stirrup).
   c. semicircular canals.
   d. Eustachian tubes.
10. An animal that sees well in the dark has
    a. a larger than average pupil.
    b. more rod cells in retina of the eye.
    c. more cone cells in the retina of the eye.
    d. an oddly shaped lens.

Visual Understanding

1. **Figure 28.10** Describe the qualitative feelings that might be experienced by someone who goes through the four stages shown in the drawings.

2. **Figure 28.13** Look at the comparative size of the olfactory tract and the cerebrum in the various animals. What does the figure tell you about the possible importance of olfaction in humans?

Challenge Questions

Neurons and How They Work There is a lot of concern today about high sodium (Na) levels in our diet, and the resulting high blood pressure for many people. Your friend, Henry, suggests that if a low-sodium diet is healthy, then a no-sodium diet should be even better. What do you tell him?

The Central Nervous System When people become very angry, they are said to be operating from their "dinosaur brain"—not thinking clearly. Explain what this means.

The Peripheral Nervous System Why is it important that the neurons in the autonomic nervous system are always active, not shutting down at night while you're asleep?

The Sensory Nervous System If you only taste a few things (salt, bitter, sweet, sour, umami), why do foods all seem so distinct?

Online Learning Center

Visit the Online Learning Center for this chapter at www.mhhe.com/tlw4/ch28 for quizzes, animations, interactive learning exercises, and other study tools. At the site you will also find extended answers to the end of chapter questions.

End-of-chapter Questions

Each chapter concludes with a set of questions designed to test your knowledge of the content, including multiple choice questions, illustration-based questions, and application questions. Answers to the multiple choice questions are in a section at the end of the book, while extended answers for all of the questions are found on *The Living World* Online Learning Center at www.mhhe.com/tlw4. At the site you can take an interactive version of the end-of-chapter quiz that provides you with instructional feedback.

NEW! Boxed Readings

Author's Corner

Where Are All My Socks Going?–page 12
All my life, as far back as I can remember, I have been losing socks. Not pairs of socks, mind you, but single socks ...

How Tropical Lizards Climb Vertical Walls–page 49
Science is most fun when it tickles your imagination. This is particularly true when you see something you know just can't be true ...

Fad Diets and Impossible Dreams–page 131
The much discussed Atkin's diet was the fad diet I tried. As a scientist I should have known better, but so many people seemed to use it ...

Biodiversity Behind Bars–page 303
When I was seven, I knew with a searing certainty that no person, no animal should have to live caged, peering out behind bars at a free world it cannot reach. And I acted on that certainty ...

Evolution of the Family Dog–page 481
I first suspected that Boswell would have a short life when he bit my wife on our nuptial bed ...

Running Improperly Provides a Painful Lesson in the Biology of Bones and Muscles–page 519
Any mention I make of my running in a race only evokes screams of laughter from my daughters, and an arch look from my wife. Memory is cruelest when it is accurate ...

Science in Action

Evolution Repeats Itself in Caribbean Lizards–page 29
Darwin would have been puzzled at the average American's reluctance to accept his theory of evolution ...

The Case of the Dying Racehorse Foals–page 47
In real life, it is sometimes difficult to tell the difference between scientific investigation and good detective work. In the spring of the year 2000, scientists were called in to solve a mystery that Sherlock Holmes would have enjoyed ...

The Search for an Effective AIDS Vaccine Looks More Promising–page 603
Since the AIDS epidemic burst upon us in 1981, scientists have feverishly sought a vaccine to protect people from this deadly and incurable disease ...

Why You Age and Cancer Cells Don't–page 672
The oldest documented living person, Marie-Louise Febronie Meilleur of Ontario, Canada, reached the age of 117 years in 1997. The tantalizing possibility of long life that she represents is one reason why there is such interest in the aging process—if we knew enough about it, perhaps we could slow it ...

The Great Pigeon Race Disaster of 1997 Suggests an Answer to an Enduring Mystery–page 741
A homing pigeon released hundreds of miles from where it lives, at a location it has never seen, will unerringly set out on a bee line homeward, flying through darkness and storm at speeds that often average 50 miles per hour ...

A Closer Look

Membrane Defects Can Cause Disease–page 76
The year 1993 marked an important milestone in the treatment of human disease ...

The Energy Cycle–page 125
The energy-capturing metabolisms of the chloroplasts studied in this section of the chapter and the mitochondria studied in the chapter's next section are intimately related ...

Metabolic Efficiency and the Length of Food Chains–page 133
In the earth's ecosystems, the organisms that carry out photosynthesis are often consumed as food by other organisms ...

Why Sex?–page 163
Not all reproduction is sexual. In asexual reproduction, an individual inherits all of it chromosomes from a single parent ...

Does Environment Affect I.Q.?–page 181
The influence of environment on the expression of genetic traits is especially hard to study when a number of different genes affect the trait. Nowhere has this difficulty led to more controversy than in studies of I.Q. scores ...

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Our view of the differences between the sexes has recently undergone a radical revision ...

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The story of when human life begins has a checkered past ...

Evolution's Critics–page 291
The theory that life on earth arose spontaneously and evolved into the forms living today is accepted by most, but not all, biologists ...

Has Life Evolved Elsewhere?–page 315
We should not overlook the possibility that life processes might have evolved in different ways on other planets ...

Prions and Mad Cow Disease–page 325
For decades scientists have been fascinated by a peculiar group of fatal brain diseases ...

Closing in On the Long-Sought Link Between Diabetes and Obesity–page 557
We Americans love to eat, but in 2004 the Centers for Disease Control and Prevention released a report suggesting we are eating ourselves into a diabetes epidemic ...

Invasion of the Killer Bees–page 709
One of the harshest lessons of environmental biology is that the unexpected does happen ...

The Global Decline in Amphibians–page 759
Sometimes important things happen, right under our eyes, without anyone noticing ...