

The Living World

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

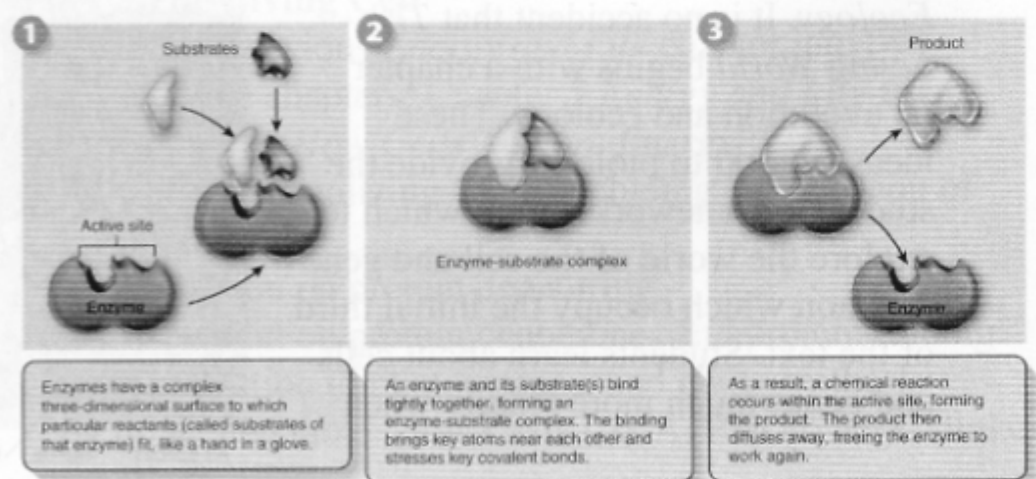
best to teach each key idea was for me both challenging and an enormous amount of fun.

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.

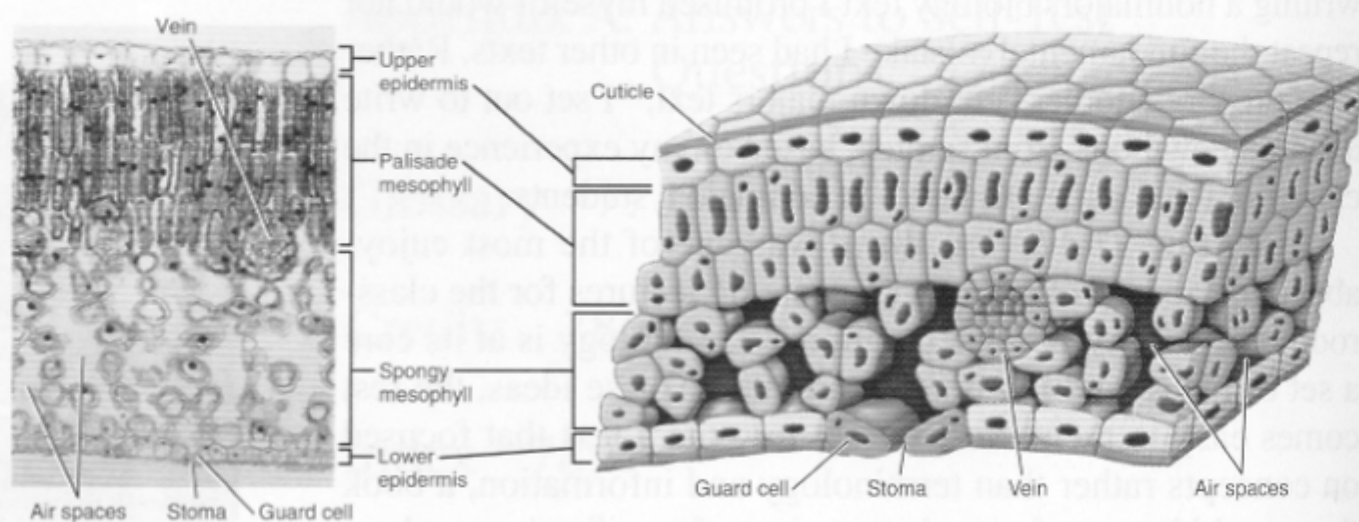
What's New This Edition

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.

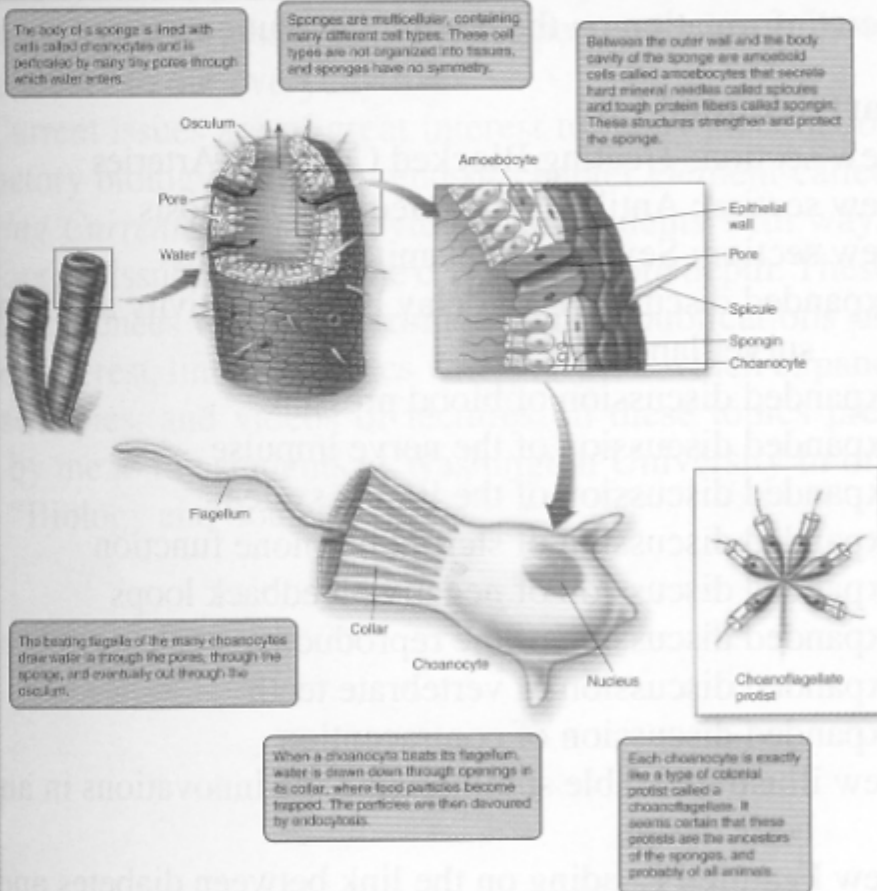
- **Combination Figures** These figures combine a photo or micrograph with a line drawing, to make the connection between conceptual art and what the student may encounter in a lab (see Figure 19.18 A leaf in cross section, page 395).



Phylum Porifera: Sponges

Key Evolutionary Innovation: MULTICELLULARITY

The body of a sponge (phylum Porifera) is multicellular—it contains many cells, of several distinctly different types, whose activities are coordinated with each other. The sponge body is not symmetrical and has no organized tissues.



- **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

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The Revolution in Cell Technology

Chapter at a Glance

Cloning

12.1 Proving That Reproductive Cloning Is Possible

As recently as 1997, scientists thought it was impossible to clone an adult animal. Then researchers announced the successful cloning of a lamb from a breast cell taken from an adult sheep.

12.2 Problems with Reproductive Cloning

Cloning of animals usually fails for lack of proper gene conditioning of the DNA used in the attempted cloning.

Stem Cells

12.3 Embryonic Stem Cells

Some of the cells of a blastocyst, called embryonic stem cells, are capable of forming any tissue of the body.

12.4 Therapeutic Cloning

Embryonic stem cells isolated from a blastocyst by a Dolly-style cloning procedure can potentially be used to replace a patient’s damaged or lost tissue.

12.5 Grappling with the Ethics of Stem Cell Research

The promise of stem cell research has rekindled debates about when human life begins. Few issues in modern science raise as many difficult ethical issues.

Gene Therapy

12.6 Initial Attempts at Gene Therapy

It should be possible to cure hereditary disorders by replacing damaged genes in particular tissues.

12.7 More Promising Vectors

New viral vectors seem to avoid the problems experienced in earlier studies.

12.8 Ethical Issues Raised by Gene Therapy

Both somatic and germ-line gene therapy raise significant ethical issues.



This sheep, Dolly, was the first animal to be cloned from a single adult cell. The lamb, her offspring, is normal in every respect. From Dolly we learn that genes are not lost during development. If a single adult cell can be induced to switch the proper combination of genes on and off, that one cell can develop into a normal adult individual. Embryonic stem cells are like this—poised to become any cell of the body as the embryo develops. It may be possible to replace damaged tissues with healthy tissue grown from a patient’s own embryonic stem cells, but the approach is controversial. Another approach, when the damaged tissue results from a defective gene, is to repair rather than replace, using a virus to transfer a healthy gene into those tissues that lack it. The approaches of cloning, stem cell tissue replacement, and gene therapy are three areas in which a revolution is reshaping cell technology.

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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 tottering 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 form 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 into 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 chemicals. 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.

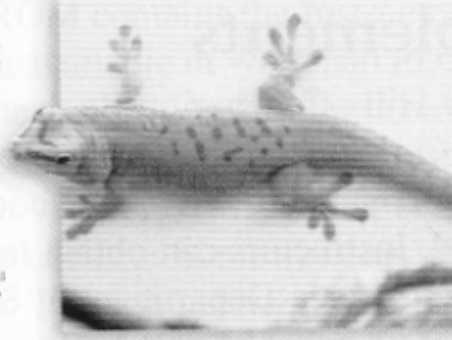
When a gecko takes a step, it drives the side of its foot into the surface and pushes it backwards. This shows the forest of tips directly against the surface. The atoms of each gecko tip become closely engaged with the atoms of the surface, and that is the force that defies gravity. When two atoms approach 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 microneutons, 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 hairs' individual atoms can come into play. Tipped past a critical angle—90 degrees—the attractive forces between hair and surface atoms weaken to nothing. The trick is to tip the foot 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.

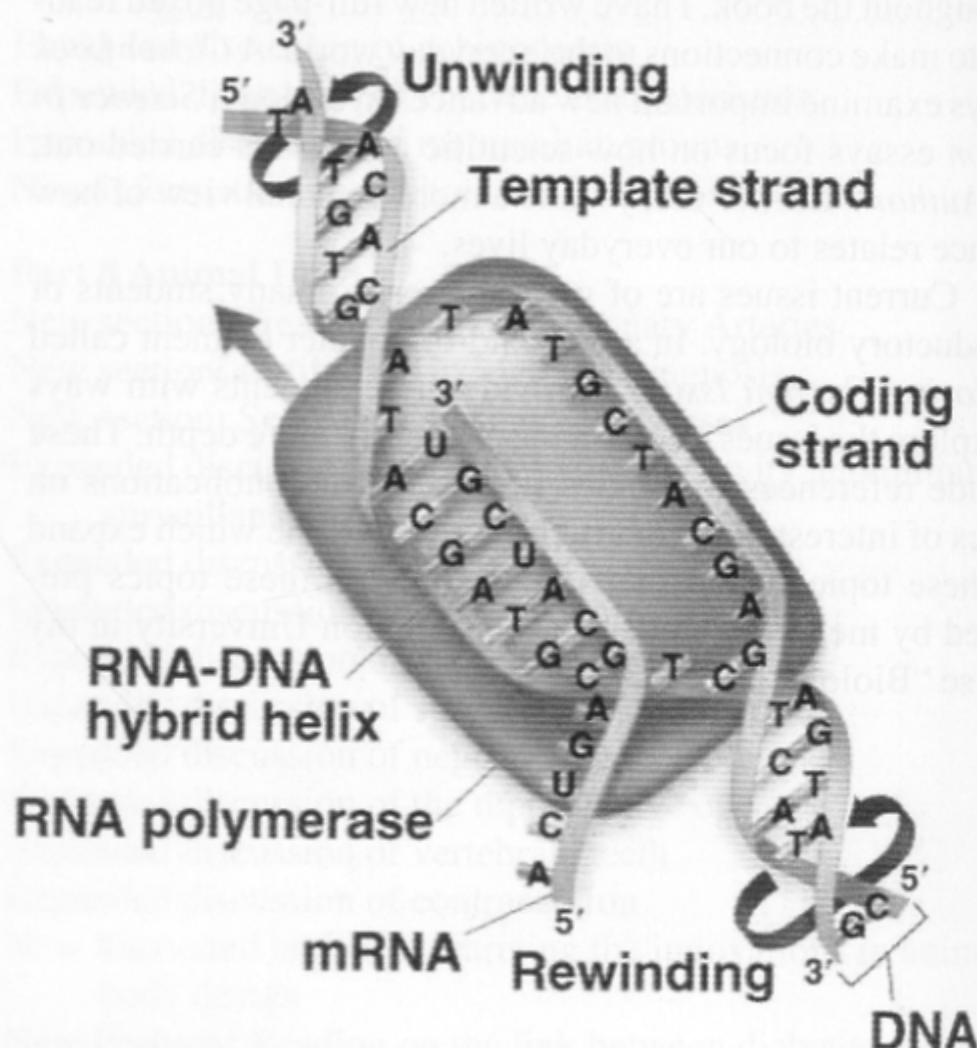
For The Instructor:

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:

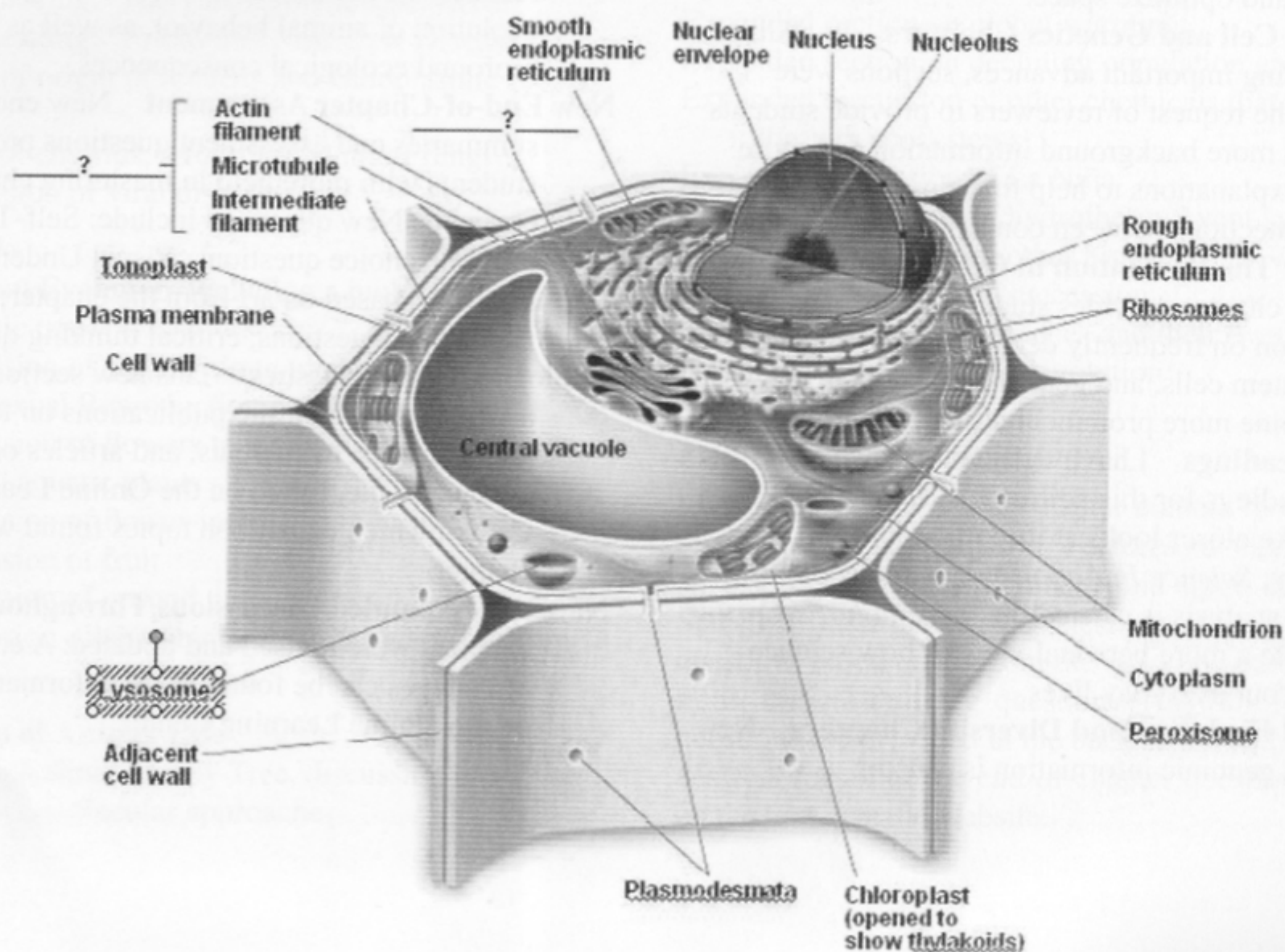
Art Library Color-enhanced, digital files of all illustrations in the book, plus the same art saved in unlabeled and gray scale versions, can be readily incorporated into lecture presentations, exams, or custom-made classroom materials. Upsized labels make the images appropriate for use in large lecture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