

GLOBAL
EDITION



Biology

Life on Earth

WITH PHYSIOLOGY

ELEVENTH EDITION

Teresa Audesirk • Gerald Audesirk • Bruce E. Byers

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BIOLOGY

LIFE ON EARTH WITH PHYSIOLOGY

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They are now emeritus professors of biology at the University of Colorado Denver, where they taught introductory biology and neurobiology from 1982 through 2006. In their research, funded primarily by the National Institutes of Health, they investigated the mechanisms by which neurons are harmed by low levels of environmental pollutants and protected by estrogen.

Terry and Gerry are long-time members of many conservation organizations and share a deep appreciation of nature and of the outdoors. They enjoy hiking in the Rockies, walking and horseback riding near their home outside Steamboat Springs, and singing in the community chorus. Keeping up with the amazing and endless stream of new discoveries in biology provides them with a continuing source of fascination and stimulation. They are delighted that their daughter Heather has become a teacher and is inspiring a new generation of students with her love of chemistry.

BRUCE E. BYERS is a Midwesterner transplanted to the hills of western Massachusetts, where he is a professor in the biology department at the University of Massachusetts Amherst. He has been a member of the faculty at UMass (where he also completed his doctoral degree) since 1993. Bruce teaches courses in evolution, ornithology, and animal behavior, and does research on the function and evolution of bird vocalizations.



*With love to Jack, Lori,
and Heather and in
loving memory of Eve
and Joe*

— T. A. & G. A.

*In memory of
Bob Byers, a biologist
at heart.*

—B. E. B.

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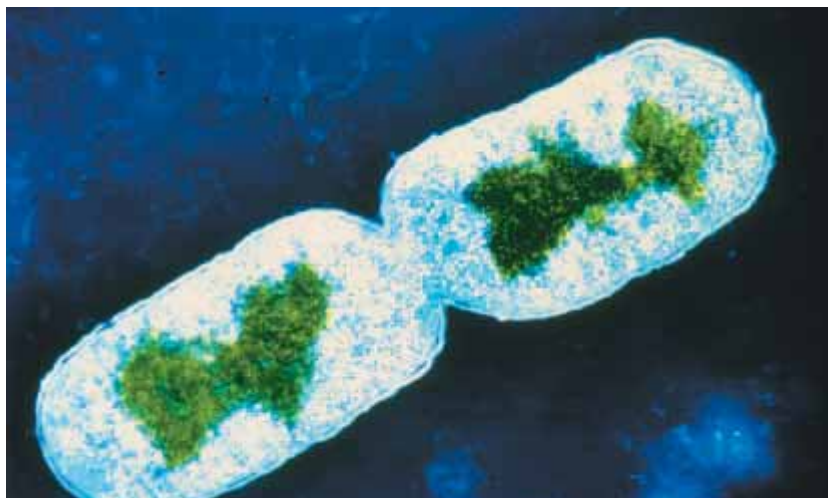
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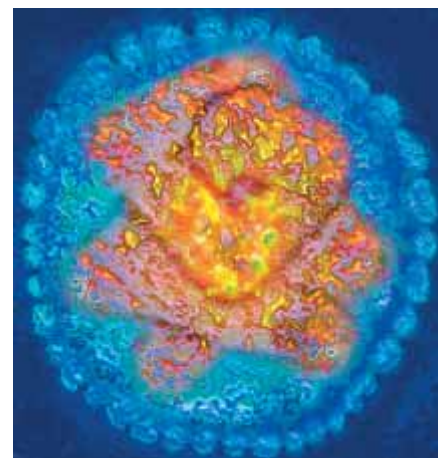
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PREFACE

THE CASE FOR SCIENTIFIC LITERACY

Climate change, biofuels versus food and forests, bioengineering, stem cells in medicine, potential flu pandemics, the plight of polar bears and pandas, human population growth and sustainability: these are just some of the very real, urgent, and interrelated concerns sweeping our increasingly connected human societies. The Internet places a wealth of information—and a flood of misinformation—at our fingertips. Never have scientifically literate students been more important to humanity’s future. As educators, we feel humbled before this massive challenge. As authors, we feel hopeful that the Eleventh Edition of *Biology: Life on Earth* will help lead introductory biology students along paths to understanding.

Scientific literacy requires a foundation of factual knowledge that provides a solid and accurate cognitive framework into which new information can be integrated. But more importantly, it endows people with the mental tools to separate the wealth of data from the morass of misinformation. Scientifically literate citizens are better able to evaluate facts and to make informed choices in both their personal lives and the political arena.

This Eleventh Edition of *Biology: Life on Earth* continues our tradition of:

- Helping instructors present biological information in a way that will foster scientific literacy among their students.
- Helping to inspire students with a sense of wonder about the natural world, fostering an attitude of inquiry and a keen appreciation for the knowledge gained through science.
- Helping students to recognize the importance of what they are learning to their future roles in our rapidly-changing world.

WHAT’S NEW IN THIS EDITION?

Each new edition gives the authors a fresh opportunity to ponder: “What can we do better?” With extensive help from reviewers, development editors, and our coauthors, we’ve answered this question with the following changes organized around three major goals:

Highlight an Inquiry-Driven Approach to Learning

- **Probing questions at the end of the extensively revised “Case Study Continued” segments** help students anticipate what they will learn.
- **Three unique question types in essays and figure captions** encourage students to think critically about the content: “Think Critically” questions focus on solving

problems, thinking about scientific data, or evaluating a hypothesis; “Evaluate This” questions ask students to interpret or draw conclusions from a hypothetical scenario; and “Consider This” questions invite students to form an opinion or pose an argument for or against an issue, based on valid scientific information. Answers to “Think Critically” and “Evaluate This” questions are included in the back of the book; hints for “Consider This” questions are included on MasteringBiology.

- **New multiple choice questions at the end of every chapter** address students’ recall and comprehension and help them prepare for tests.

Create Connections for Students

- **“Health Watch” essays often include an “Evaluate This” question**, encouraging students to connect health topics to practical, real-world examples.
- **“Threads of Life” themes** in pertinent chapters weave together what may otherwise appear to be unrelated fields within the uniquely diverse science of biology. These threads—identified in our list of changes by chapter below—are the unifying theme of *Evolution*, the exploding science of *Biotechnology*, our increasing recognition of the impacts of *Climate Change*, and our emerging understanding of the importance of *Microbiomes* throughout the living world.
- **Dozens of entirely new and revised figures** illustrate concepts more clearly and engagingly than ever before. For example, negative feedback cycles are now illustrated in a consistent manner that allows students to instantly recognize the chain of events and relate it to negative feedback events in other chapters.

Encourage Critical Thinking

- **New “How Do We Know That?” essays** show students the process of science in a simple way, emphasizing the process and method to what scientists do. Essays go into the details of experiments, highlighting exciting technology and data. “How Do We Know That?” features include “Think Critically” or “Consider This” questions, encouraging students to analyze data or engage with the topics presented in the essay.
- **“Earth Watch” essays include more data.** Students will find more examples of real scientific data in the form of graphs and tables; the data are accompanied by “Think Critically” questions that challenge students to interpret the data, fostering increased understanding of how science is communicated.

In addition, **mitosis and meiosis are now covered in separate chapters** (Chapters 9 and 10, respectively), so students gain a stronger foundational understanding of some of the toughest topics in biology.

BIOLOGY: LIFE ON EARTH, ELEVENTH EDITION

... Is Organized Clearly and Uniformly

Navigational aids help students explore each chapter. An important goal of this organization is to present biology as a hierarchy of closely interrelated concepts rather than as a compendium of independent topics.

- Major sections are introduced as broad questions that stimulate students to think about the material to follow; subheadings are statements that summarize their specific content.
- A “Summary of Key Concepts” section ends each chapter, providing a concise, efficient review of the chapter’s major topics.

... Engages and Motivates Students

Scientific literacy cannot be imposed on students—they must actively participate in acquiring the necessary information and skills. To be inspired to accomplish this, they must first recognize that biology is about their own lives. For example, we help students acquire a basic understanding and appreciation of how their own bodies function by including information about diet and weight, cancer, and lower back pain.

We fervently hope that students who use this text will come to see their world through keener eyes. For example, they will perceive forests, fields, and ponds as vibrant and interconnected ecosystems brimming with diverse life-forms rather than as mundane features of their everyday surroundings. If we have done our job, students will also gain the interest, insight, and information they need to look at how humanity has intervened in the natural world. If they ask the question, “Is this activity sustainable?” and then use their new knowledge and critical thinking skills to seek some answers, we can be optimistic about the future.

In support of these goals, the Eleventh Edition has updated features that make Biology more engaging and accessible.

- **Case Studies** Each chapter opens with an attention-grabbing “Case Study” that highlights topics of emerging relevance in today’s world. Case Studies, including “Unstable Atoms Unleashed” (Chapter 2), “New Parts for Human Bodies” (Chapter 4), and “Unwelcome Dinner Guests” (Chapter 20), are based on news events, personal interest stories, or particularly fascinating biological topics. “Case Study Continued” segments weave the topic throughout the chapter, whereas “Case Study Revisited” completes the chapter, exploring the topic further in light of the information presented.

- **Boxed Essays** Four categories of essays enliven this text. “Earth Watch” essays explore pressing environmental issues; “Health Watch” essays cover important or intriguing medical topics; “How Do We Know That?” essays explain how scientific knowledge is acquired; and “In Greater Depth” essays make this text versatile for in-depth levels of instruction.
- **“Have You Ever Wondered” Questions** These popular features continue to demystify common and intriguing questions, showing the application of biology in the real world.
- **End-of-Chapter Questions** The questions that conclude each chapter allow students to review the material in different formats—multiple choice, fill-in-the-blank, and essay—that help them to study and test what they have learned. Answers to the multiple choice and fill-in-the-blank questions are included in the back of the book. Answers or hints for the essay questions are included on MasteringBiology.
- **Key Terms and a Complete Glossary** Boldfaced key terms are defined clearly within the text as they are introduced. These terms are also listed at the end of each chapter, providing users with a quick reference to the chapter’s important vocabulary. The glossary, carefully written by the authors, provides exceptionally complete definitions for all key terms, as well as for many other important biological terms.

... Is a Comprehensive Learning Package

The Eleventh Edition of *Biology: Life on Earth* is a complete learning package, providing updated and innovative teaching aids for instructors and learning aids for students.

CHAPTER-BY-CHAPTER SUMMARY OF IMPORTANT CHANGES

Following the revision of chapters in response to reviews by instructors and experts, the text and artwork were carefully reviewed by each of the other two authors and the development editors. The coauthors provided valuable insights to one another, integrating the chapters more thoroughly, improving consistency between chapters, and explaining complex concepts more clearly. Our development editors brought trained eyes for order and detail to our work, helping us make the writing even more student-friendly. Following this intense scrutiny, each initial revision underwent a second, sometimes extensive revision. Specific changes include the following:

- **Chapter 1: An Introduction to Life on Earth** includes an entirely updated Case Study to reflect the recent Ebola epidemic. A new “Have You Ever Wondered: Why Scientists Study Obscure Organisms?” highlights unforeseen benefits that have emerged from investigating different organisms. Our *Evolution* “Thread of Life” is emphasized throughout and *Climate Change* is noted in the context of evolution.

UNIT 1 The Life of the Cell

- **Chapter 2: Atoms, Molecules, and Life** offers improved coverage of the unique properties of water. The essay “How Do We Know That? Radioactive Revelations” includes new PET images. The essay “Health Watch: Free Radicals—Friends and Foes?” incorporates new findings on antioxidant supplements. Figures 2-1, 2-2, 2-3, 2-4, 2-5, and 2-6 have been revised for greater clarity and consistency.
- **Chapter 3: Biological Molecules** now covers lipids last, because they are distinct in their structural diversity and in not forming polymers. The discussion of protein structure and intrinsically disordered proteins has been extensively revised. The “Health Watch” essay on trans fats and cholesterol has been extensively updated and rewritten, as has the “Have You Ever Wondered” essay on hair structure. Figures 3-1 and 3-3 and Table 3-2 have undergone major revisions.
- **Chapter 4: Cell Structure and Function** features an entirely new Case Study supporting our *Biotechnology* thread. There is new art for relative sizes as well as enhanced coverage and new art of the extracellular matrix and cytoskeleton (Figures 4-1, 4-6, and 4-7, respectively). Prokaryotic cells are now covered before eukaryotic cells. A new “Earth Watch” essay discusses the environmental impact of raising livestock and the culturing of cow muscle in the lab. “Have You Ever Wondered” has been revised and introduces our *Microbiome* thread.
- **Chapter 5: Cell Membrane Structure and Function** includes upgraded figures of the plasma membrane (Figure 5-1), phospholipids (Figure 5-2), membrane receptors (Figure 5-3), osmosis (Figure 5-6), and surface/volume relationship (Figure 5-13). Added micrographs illustrate cell junctions (Figure 5-14). The “How Do We Know That?” essay on aquaporins has been updated and now includes a data figure. Membrane fluidity has now been incorporated into a “Health Watch” essay, and there is a new “Have You Ever Wondered” essay describing how antibiotics destroy bacteria and supporting our *Evolution* thread.
- **Chapter 6: Energy Flow in the Life of a Cell** includes an updated Case Study, as well as revised art of coupled reactions (Figure 6-7), feedback inhibition (Figure 6-12), and regenerative braking (Figure E6-1). There are new images for entropy (Figure 6-3), activation energy (Figure 6-5b), and food preservation (Figure 6-14). Our explanation of the second law of thermodynamics now uses the phrase “isolated system.” The section on solar energy incorporates the *Climate Change* thread. The revised “Health Watch” essay on lactose intolerance supports our *Evolution* thread and a revised “Have You Ever Wondered” about glowing plants supports our *Biotechnology* thread.
- **Chapter 7: Capturing Solar Energy: Photosynthesis** has a revised and updated Case Study, a new overview figure (Figure 7-1), and a chloroplast micrograph added to the figure illustrating photosynthetic structures (Figure 7-3). Figures describing energy transfer in the light reactions (Figure 7-7) and the C_4 and CAM pathways (Figures E7-1 and E7-2) have been significantly improved. The section The Calvin Cycle Captures Carbon Dioxide incorporates the *Biotechnology* thread. The “Earth Watch” essay on biofuels has been updated and supports our *Climate Change* thread.
- **Chapter 8: Harvesting Energy: Glycolysis and Cellular Respiration** features an entirely new Case Study on the use of mitochondrial DNA in the identification of King Richard III of England. The essay “Health Watch: How Can You Get Fat by Eating Sugar?” has new art showing the conversion of sugar to fat. A micrograph of the mitochondrion has been added to Figure 8-4; the electron transport chain in Figure 8-6 has been redrawn; a new Figure 8-8 illustrates energy extraction from foods; and a new Table 8-1 summarizes glucose breakdown.

UNIT 2 Inheritance

- **Chapter 9: Cellular Reproduction** now covers only mitotic cell division and the control of the cell cycle; meiotic cell division and its importance in sexual reproduction are discussed in Chapter 10. Chapter 9 opens with a new Case Study describing the potential of stem cell therapy for healing injuries. Figure 9-2 illustrates the two important properties of stem cells: self-renewal and the ability of their daughter cells to differentiate into multiple cell types. Cloning is briefly introduced as a technology-based form of asexual reproduction, continuing the *Evolution* thread.
- **Chapter 10: Meiosis: The Basis of Sexual Reproduction** begins with a new Case Study, which illustrates how the genetic variability produced by meiosis can be strikingly visible in everyday life. Descriptions of disorders such as Down syndrome and Turner syndrome have been moved into this chapter. A new “How Do We Know That?” essay describes hypotheses and experiments that explore selective forces that may favor the evolution of sexual reproduction, continuing the *Evolution* thread.
- **Chapter 11: Patterns of Inheritance** now includes photos in Figure 11-21, showing how the world looks to color-deficient people—highly accurate images, as verified by the color-deficient author. The “Have You Ever Wondered” essay on the inheritance of body size in dogs includes new information.
- **Chapter 12: DNA: The Molecule of Heredity** now features a streamlined description of the seminal Hershey-Chase experiment in “How Do We Know That? DNA Is the Hereditary Molecule.”

- **Chapter 13: Gene Expression and Regulation** contains a revised and updated “Health Watch” essay on epigenetic control of gene expression.
- **Chapter 14: Biotechnology** begins with a new Case Study. The entire chapter has been updated with current information, including recently developed methods for using single-nucleotide polymorphisms to provide information on physical characteristics of both living and ancient humans; possible applications of biotechnology in environmental bioengineering; and using DNA microarrays to diagnose both inherited disorders and infectious diseases. The “How Do We Know That?” essay on prenatal genetic screening asks the students to use their knowledge of forensic DNA and prenatal testing in a simulated paternity case.

UNIT 3 Evolution and Diversity of Life

- **Chapter 15: Principles of Evolution** includes a largely new “How Do We Know That?” essay describing some of the evidence that led Darwin to formulate his theory. The section on evidence of natural selection in the wild includes a new example. “Earth Watch: People Promote High-Speed Evolution” supports our *Climate Change* thread.
- **Chapter 16: How Populations Evolve** includes a revised explanation of how population size affects genetic drift, with a new accompanying figure (Figure 16-5). The “In Greater Depth” essay includes a new figure to aid visualization of the Hardy–Weinberg principle. The section on mutation has been updated to reflect the latest research on mutation rates. A new “Health Watch” essay describes a Darwinian approach to thinking about cancer.
- **Chapter 17: The Origin of Species** presents a new Case Study about the discovery of new species. New, data-based graphics have been added to “Earth Watch: Why Preserve Biodiversity?” and “How Do We Know That? Seeking the Secrets of the Sea.”
- **Chapter 18: The History of Life** includes a new Case Study about how our newfound ability to recover and sequence ancient (fossil) DNA provides insight into evolutionary history. We include updated information on fossils found since the previous edition. All dates have been updated to reflect the latest Geological Society revisions of the geological time scale. The human evolution section now contains information about *Homo floresiensis*. There is a new photo of a protist with an algal endosymbiont (Figure 18-6); new photos of early hominin tools (Figure 18-15); and a new artist’s conception of a Carboniferous landscape (Figure 18-8).
- **Chapter 19: Systematics: Seeking Order Amid Diversity** includes a new “Have You Ever Wondered” essay about using systematics to estimate how long ago humans began to wear clothing. The account of current views on taxonomic ranks has been streamlined. Text and figures in “In Greater Depth: Phylogenetic Trees” have been revised for increased clarity.
- **Chapter 20: The Diversity of Prokaryotes and Viruses** presents a revised section on prokaryotic systematics that now includes descriptions of some specific clades. A new Table 20-1 summarizes the differences between Archaea and Bacteria. The chapter includes new descriptions of photosynthetic and subterranean bacteria. “Health Watch: Is Your Body’s Ecosystem Healthy?” supports our *Microbiome* thread.
- **Chapter 21: The Diversity of Protists** includes a new “Health Watch” essay about diseases caused by protists. The sections on brown algae and red algae now include information on foods derived from those organisms. The description of chlorophytes has been revised to reflect improved understanding of the group’s phylogeny, and the section also supports our *Biotechnology* thread. The chapter contains new photos of a parabasalid (Figure 21-3), a dinoflagellate (Figure 21-8), and chlorophytes (Figure 21-19).
- **Chapter 22: The Diversity of Plants** includes a new essay, “Health Watch: Green Lifesaver,” about an important antimalarial derived from a plant, highlighting our *Biotechnology* thread. A new figure (Figure 22-3) illustrates some key adaptations for life on land.
- **Chapter 23: The Diversity of Fungi** contains a new essay, “Earth Watch: Killer in the Caves,” which describes a fungal disease that threatens bat populations. The chapter contains new information on an airborne fungal disease of humans, the dangers of toxic mushrooms, and fungi known only from DNA sequences. A new segment on genetically engineered resistance to chestnut blight supports our *Biotechnology* thread.
- **Chapter 24: Animal Diversity I: Invertebrates** includes a new “Earth Watch” essay about coral reef bleaching. “How Do We Know That? The Search for a Sea Monster” focuses on the most recent expedition to search for giant squids. All species counts are updated to reflect the latest numbers from the Catalogue of Life.
- **Chapter 25: Animal Diversity II: Vertebrates** contains a new “Have You Ever Wondered” about shark attacks. The chapter contains new information about hagfish slime and new information about snake digestive physiology. “Earth Watch: Frogs in Peril” has been updated with new information and a new graph. All species counts are updated to reflect the latest numbers from the Catalogue of Life.

UNIT 4 Behavior and Ecology

- **Chapter 26: Animal Behavior** has been extensively revised and updated, including new material and many new figures.
- **Chapter 27: Population Growth and Regulation** opens with a new Case Study on the crash and subsequent regrowth of populations of northern elephant seals. Figure 27-1, illustrating exponential growth, has been revised. Section 27.3 offers a new discussion of life history strategies and their evolution, which also supports our *Evolution* thread. The chapter has been updated with current statistics and figures related to the growth of the human population.
- **Chapter 28: Community Interactions** begins with a new Case Study about endangered Channel Island foxes. Section 28.1 has been expanded to describe the different types of community interactions. Section 28.3 has been extensively revised to describe consumer-prey interactions as a general category that includes all situations in which one organism (the consumer) feeds on another (the prey), and encompasses predation (including herbivory) and parasitism. A new “Have You Ever Wondered” essay explains why rattlesnakes rattle. A new “Health Watch” essay explores how coevolution between parasites and their hosts can produce a range of outcomes, supporting our *Microbiome* thread.
- **Chapter 29: Energy Flow and Nutrient Cycling in Ecosystems** includes updated information on atmospheric carbon dioxide and supports our *Climate Change* thread. A new “How Do We Know That?” essay explores the ways in which scientists monitor Earth’s conditions. The “Health Watch” essay on biological magnification includes a new figure.
- **Chapter 30: Earth’s Diverse Ecosystems** provides a clear explanation of why global average temperature decreases with latitude, including a new illustration in Figure 30-2a. Descriptions of monsoons and the El Niño/Southern Oscillation have been added to Section 30.2.
- **Chapter 31: Conserving Earth’s Biodiversity** opens with a new Case Study of the effects of extirpating, and then reintroducing, wolves in Yellowstone National Park. The description of ecosystem services is now organized into the four categories used by the *Millennium Ecosystem Assessment* and The Economics of Ecosystems and Biodiversity (TEEB). There are new images of rain-forest destruction (Figure 31-4) and wildlife corridors (Figure 31-8).

UNIT 5 Animal Anatomy And Physiology

- **Chapter 32: Homeostasis and the Organization of the Animal Body** includes a major revision of the Case Study on hyperthermia, including a Consider This question supporting our *Climate Change* thread. Figures

illustrating negative feedback (Figure 32-2) and the cell to organ hierarchy (Figure 32-3) have undergone major revisions, and micrographs were added to epithelial cell types (Figure 32-4). A revised “Earth Watch” essay better emphasizes the positive feedback effects of *Climate Change* in the Arctic.

- **Chapter 33: Circulation** opens with an entirely rewritten Case Study about human heart transplants and introduces the *Biotechnology* thread in the Case Study Revisited. Figure 33-3 now shows the human heart within the chest cavity. Figure 33-10, showing red blood cell regulation, has been redrawn.
- **Chapter 34: Respiration** begins with an all new Case Study about athletic training at high altitude, which includes “Continued” sections on respiratory disorders. A new “Have You Ever Wondered” discusses shark swimming and respiration, supported by the rewritten “In Greater Depth: Gills and Gases” covering countercurrent exchange. Our *Evolution* thread is supported by our discussion of two-, three-, and four-chambered vertebrate hearts.
- **Chapter 35: Nutrition and Digestion** includes a new figure to illustrate calorie expenditures in relation to activity and food intake (Figure 35-1), updated USDA recommendations compared with actual diets (Figure 35-6), an illustration of proposed changes in food nutritional information labels (Figure 35-7), and a new figure of peristalsis (Figure 35-16). Micrographs have been added to the small intestine structures (Figure 35-19), and a new figure illustrates negative feedback of leptin on body fat (Figure 35-20). A discussion of bacterial communities in both cow and human digestive tracts highlights our *Microbiome* thread.
- **Chapter 36: The Urinary System** has an extensively rewritten section on the comparative physiology of nitrogenous waste excretion, including a new table (Table 36-1). The terms renal corpuscle, renal capsule, nephron loop, absorption, and secretion are introduced. New illustrations of human nephron structure and function (Figures 36-4 and 36-5) improve clarity, and the negative feedback cycle involving ADH release and water retention has been redrawn (Figure 36-6). The chapter features an updated Case Study and “Health Watch” essay, both of which incorporate our *Biotechnology* thread.
- **Chapter 37: Defenses Against Disease** includes a description of the Ebola virus in “Health Watch: Deadly Emerging Viruses.” The essay “How Do We Know That? Vaccines Can Prevent Infectious Diseases” discusses the benefits of vaccination and asks students to evaluate a graph.
- **Chapter 38: Chemical Control of the Animal Body: The Endocrine System** begins with a new Case Study on Type 2 diabetes. Figure 38-9 has been completely reworked to more clearly illustrate the

interplay between glucagon and insulin in the control of blood glucose. The “Health Watch” essay focuses on commonly abused types of PEDs.

- **Chapter 39: The Nervous System** includes micrographs of neurons and synapses (Figures 39-1 and 39-4, respectively). Figure 39-10 has been revised. We discuss brain lateralization in non-human vertebrates, a fairly constant feature throughout vertebrate *Evolution*. The “Health Watch” essay on addiction now shows PET scans. The “How Do We Know That?” essay on neuroimaging includes exciting new experiments showing that brain activity can be used to reconstruct and recognize specific faces—and informs the students that an undergraduate had the idea for the research.
- **Chapter 40: The Senses** includes a new Section 40.2 on thermoreception. Micrographs have been added to figures showing the structures of the ear (Figure 40-4), retina (Figure 40-7), olfactory epithelium (Figure 40-11), and taste buds (Figure 40-12). A new “Earth Watch” essay describes how noise pollution in the ocean may be impairing communication among whales and incorporates our *Evolution* thread. A new critical thinking question in the “Case Study Revisited” introduces our *Biotechnology* thread.
- **Chapter 41: Action and Support: The Muscles and Skeleton** begins with a substantially rewritten Case Study. Sections 41.1 and 41.2 have been significantly revised. A new “Have You Ever Wondered” compares white and dark meat. A new figure (Figure 41-16) provides data comparing fiber proportions in average people, marathoners, and sprinters; many other figures have been substantially revised.
- **Chapter 42: Animal Reproduction** includes updated information about sexually transmitted diseases, contraception, and in vitro fertilization, including a description of the technology to produce “three-parent” babies, supporting the *Bioengineering* thread. Micrographs of seminiferous tubules and corpus luteum have been added to Figures 42-10 and 42-16, respectively. Figure 42-13, the hormonal control of testosterone secretion and spermatogenesis, has been extensively revised.
- **Chapter 43: Animal Development** now discusses hypotheses that attempt to explain the selective advantages of different forms of aging. “Have You Ever Wondered: Why Childbirth Is So Difficult?” includes a new diagram and new hypotheses and data, supporting our *Evolution* thread.

UNIT 6 Plant Anatomy and Physiology

- **Chapter 44 Plant Anatomy and Nutrient Transport** includes a major revision of the ground and epidermal tissue systems and introduces the

terms *trichomes* and *indeterminate growth*. The section describing root structure and function has been revised. New photos illustrate ground tissue (Figure 44-4) and root nodules (Figure 44-22).

- **Chapter 45 Plant Reproduction and Development** has an updated Case Study describing corpse flower seeds and their dispersers. Revised figures better illustrate seed development (Figure 45-12) and germination (Figure 45-13). A new “How Do We Know That? Tastier Fruits and Veggies are Coming!” explains the new science of marker-assisted selection and supports our *Biotechnology* thread.
- **Chapter 46 Plant Responses to the Environment** includes a new photo showing the effects of gibberellin (Figure 46-1), an extensively revised section on auxin and seed sprouting, and a major revision of Figure 46-3 illustrating the role of auxin in gravitropism. Art illustrating the interconversion of phytochromes now accompanies Table 46-2 describing this phenomenon.

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With gratitude,

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