

Committed to Excellence

With the release of the tenth edition, Raven & Johnson's *Biology* enters a new era. This edition provides an unmatched comprehensive text fully integrated with state-of-the-art digital resources. The material in the text is organized around learning outcomes keyed to major biological concepts, which provide a framework for understanding the ever-expanding universe of biological knowledge. An inquiry-based approach with robust, adaptive tools for discovery and assessment in both text and digital resources provide the intellectual challenge needed to promote student critical thinking and ensure academic success. A major strength of this hallmark tenth edition is assessment across multiple levels of Bloom's taxonomy that develops critical thinking and problem solving skill in addition to comprehensive factual knowledge. McGraw-Hill's Connect® platform offers a powerful suite of online tools including LearnSmart™ that adapts to student needs over time. The adaptive learning system helps students learn faster, study efficiently, and retain more knowledge of key concepts.

The tenth edition continues our tradition of providing the student with clear learning paths that emphasize data analysis and quantitative reasoning. Embedded eBook resources allow just-in-time exploration of major themes like evolution from directly within the eBook. Additional embedded eBook resources link to asides that delve more deeply into quantitative aspects.

The author team is experienced and fully committed to student learning and producing the best possible text for both students and faculty. Lead author Kenneth Mason (University of Iowa) has taught majors biology for more than 20 years at three major public universities. Jonathan Losos (Harvard University), a leading evolutionary biology researcher, has taught both undergraduate and graduate courses in biology for 20 years. Susan Rundell Singer (Carleton College) is a 26-year veteran science educator deeply involved in science education policy on a national level. As a team, we continually strive to improve the text by integrating the latest cognitive and best practices research with methods that are known to positively affect learning. We have multiple features that are focused on scientific inquiry, including an increased quantitative emphasis in the Scientific Thinking features. We continue to use the concise, accessible, and engaging writing style of past editions while maintaining the clear emphasis on evolution and scientific inquiry that have made this a leading textbook of choice for majors biology students. Our emphasis on evolution combined with integrated cell and molecular biology and genomics offers our readers a student-friendly text that is modern and well balanced.

The tenth edition continues to employ the aesthetically stunning art program that the Raven and Johnson *Biology* text is known for. Complex topics are represented clearly

and succinctly, helping students to build the mental models needed to understanding biology.

Insights into the diversity of life that are provided by molecular tools have led to a reorganization of these topics in the tenth edition. This entire unit reflects the most current research on eukaryotic phylogenies, blending molecular, morphological, and development viewpoints. Nuclear reprogramming in stem cells, gene expression, and the importance of small RNAs in gene regulation continue to shape our treatment of these topics. These are just a few examples of the many changes in the tenth edition of *Biology* that provide students with scientifically accurate context, historical perspective, and relevant supporting details essential to a modern understanding of life science.

As the pace of scientific discovery continues to provide new insights into the foundation of life on Earth, our author team will continue to use every means possible to ensure students are as prepared as possible to engage in biological topics. Our goal now, as it has always been, is to ensure your success.

Our Consistent Themes

It is important to have consistent themes that organize and unify a text. A number of themes are used throughout the book to unify the broad-ranging material that makes up modern biology. This begins with the primary goal of this textbook to provide a comprehensive understanding of evolutionary theory and the scientific basis for this view. We use an experimental framework combining both historical and contemporary research examples to help students appreciate the progressive and integrated nature of science.

Biology Is Based on an Understanding of Evolution

When Peter Raven and George Johnson began work on *Biology* in 1982 they set out to write a text that presented biology the way they taught in their classrooms—as the product of evolution. We bear in mind always that all biology “only makes sense in the light of evolution”; so this text is enhanced by a consistent evolutionary theme that is woven throughout the text, and we have enhanced this theme in the tenth edition.

The enhanced evolutionary thread can be found in obvious examples such as the two chapters on molecular evolution, but can also be seen throughout the text. As each section considers the current state of knowledge, the “what” of biological phenomena, they also consider how each system may have arisen by evolution, the “where it came from” of biological phenomena.

We added an explicit phylogenetic perspective to the understanding of animal form and function. This is most

obvious in the numerous figures containing phylogenies in the form and function chapters. The diversity material is supported by the most up-to-date approach to phylogenies of both animals and plants. Together these current approaches add even more evolutionary support to a text that set the standard for the integration of evolution in biology. Our approach allows evolution to be dealt with in the context in which it is relevant. The material throughout this book is considered not only in terms of present structure and function, but how that structure and function may have arisen via evolution by natural selection.

The emphasis on evolution is expanded in the eBook. Because a textbook limits content to a specific length, examples or additional information related to evolution cannot always be included in the printed book. The digital environment lifts these restrictions and has allowed us the opportunity to include interesting and instructional evolution material in the eBook. The topics that are supported by additional examples and information on the evolutionary aspects of a concept are highlighted with the inclusion of an “evolution” icon in the text. This icon is associated with a link in the eBook that reveals this additional material.

Biology Uses the Methods of Scientific Inquiry

Another unifying theme within the text is that knowledge arises from experimental work that moves us progressively forward. The use of historical and experimental approaches throughout allow the student not only to see where the field is now, but more importantly, how we arrived here. The incredible expansion of knowledge in biology has created challenges for authors in deciding what content to keep, and to what level an introductory text should strive. We have tried to keep as much historical context as possible and to provide this within an experimental framework consistently throughout the text.

We use a variety of approaches to expose the student to scientific inquiry. We use our Scientific Thinking figures to walk through an experiment and its implications. These figures always use material that is relevant to the story being told. Data are also provided throughout the text, and our new **Data Analysis questions** ask students to interpret these data. Students are also provided with **Inquiry questions** to stimulate critical thinking about the material throughout the book. The Data Analysis questions deal directly with data in figures or the text, while the Inquiry questions are more conceptual. This combination will allow the student experience in interpreting data, and lead the student to question the material in the text as well. Embedded eBook resources allow just-in-time exploration of quantitative aspects of the science. Quantitative Asides present in the eBook are indicated with a “quantitative” icon in the text. This icon in the eBook links to



asides that delve more deeply into quantitative aspects of the topic under discussion.

Biology Is an Integrative Science

The explosion of molecular information has reverberated throughout all areas of biological study. Scientists are increasingly able to describe complicated processes in terms of the interaction of specific molecules, and this knowledge of life at the molecular level has illuminated relationships that were previously unknown. Using this cutting-edge information, we more strongly connect the different areas of biology in this edition.

One example of this integration concerns the structure and function of biological molecules—an emphasis of modern biology. This edition brings that focus to the entire book, using this as a theme to weave together the different aspects of content material with a modern perspective. Given the enormous amount of information that has accumulated in recent years, this emphasis on structure and function provides a necessary thread integrating these new perspectives into the fabric of the traditional biology text.

Although all current biology texts have added a genomics chapter, our text was one of the first to do so. This chapter has been updated, and we have an additional chapter on the evolution of genomes. More importantly, the results from the analysis of genomes and the proteomes they encode are presented throughout the book wherever this information is relevant. This allows a more modern perspective throughout the book rather than limiting it to a few chapters. Examples, for instance, can be found in the diversity chapters, where classification of some organisms were updated based on new findings revealed by molecular techniques.

This systems approach to biology also shows up at the level of chapter organization. We introduce genomes in the genetics section in the context of learning about DNA and genomics. We then come back to this topic with an entire chapter at the end of the evolution unit where we look at the evolution of genomes, followed by a chapter on the evolution of development, which leads into our unit on the diversity of organisms.

We're excited about the tenth edition of this quality textbook providing a learning path for a new generation of students. All of us have extensive experience teaching undergraduate biology, and we've used this knowledge as a guide in producing a text that is up to date, beautifully illustrated, and pedagogically sound for the student. We've also worked to provide clear explicit learning outcomes, and more closely integrate the text with its media support materials to provide instructors with an excellent complement to their teaching.

Ken Mason, Jonathan Losos, Susan Rundell Singer

Cutting Edge Science

Changes to the Tenth Edition

Part I: The Molecular Basis of Life

The material in this section does not change much with time. However, we have updated it to make it more friendly to the student. The Learning Outcomes have been analyzed and rewritten both for clarity and to increase linkage between Learning Outcomes and assessment in both the end-of-chapter material and online content.

In chapter 3, the material on nucleic acids has been rewritten to make it more modern. Our view of the role of RNA in particular has changed hugely in the last decade, and this introduction to these molecules has been rewritten to reflect this. Also in chapter 3 is the first Evolutionary Aside for the eBook.

Part II: Biology of the Cell

The Learning Outcomes have been analyzed and rewritten both for clarity and to increase linkage between Learning Outcomes and assessment in both end-of-chapter material and online content. Data Analysis questions were added, and some Evolutionary Aside and Quantitative Asides for the eBook were also included.

Chapter 4—New material on prokaryotic cytoskeleton was added. Material on the nuclear pore was updated and a new figure added to show our current view of this structure. The role of chromatin structure in gene expression is introduced earlier, and material on the ER and Golgi has been updated to present the most current view of these important organelles. The material on cell-to-cell connections has been updated and also given a more evolutionary perspective.

Chapter 5—Material on lipid rafts was reconsidered, and material on sphingolipids was added. These important lipids are often ignored, despite their importance in the nervous system of vertebrates. This material also includes a new figure of sphingolipids.

Chapter 7—The introduction to glycolysis was rewritten for clarity. This includes better integration of text and figures. The Krebs cycle overview figure was simplified, as was the explanatory text for greater clarity. The section on theoretical energy yield from chemiosmosis was completely rewritten to bring it up to the view of modern chemistry.

Chapter 9—The discussion of GPCR was updated to take into account new genetic data on their distribution. A new section on small ras-like G proteins was added, including a new figure showing their action. This both illustrates their importance in the control of cell division, and clarifies their connection to signaling by growth factors.

Chapter 10—Content on chromosome structure was updated and material on the behavior of chromosomes was rewritten for clarity. A figure from chapter 9 on role of growth factors was combined with a figure from chapter 10 for greater clarity and to reduce redundancy.

Part III: Genetic and Molecular Biology

The overall organization of this section remains the same. We have retained the split of transmission genetics into two chapters as it has proved successful for students.

Content changes in the molecular genetics portion of this section continue to update material that is the most rapidly changing in the entire book. We also continue to refine the idea that RNA plays a much greater role now than appreciated in the past. The more modern view of RNA continues to be under appreciated in introductory textbooks. New material continues to be put into historical context for greater student understanding. The Learning Outcomes have been analyzed and rewritten both for clarity and to increase linkage between learning outcomes and assessment in both the end-of-chapter material and online content. Data Analysis questions were added, and some Evolutionary Asides and Quantitative Asides for the eBook were also included.

Chapter 11—The behavior of chromosomes during meiosis was rewritten for clarity. This subject is one that causes great confusion for students, and two graphics—one figure and one in-text graphic—were updated to complement the new textual discussion. This section is now much easier for students to both appreciate the complex behavior of meiotic chromosomes, but also the molecular basis for this behavior.

Chapter 15—The definition of genes as one-gene/one-polypeptide was revised for clarity. The complexity of eukaryotic initiation is given greater appreciation. The idea of promoter-proximal pausing is introduced. This allows for a clearer view by students of the nature of the extensive transcription observed by whole-genome scans.

Chapter 16—Introductory material on the control of gene expression has been rewritten to reflect recent data and a more modern view of this control. Some material on DNA binding proteins was rewritten for clarity. The section on postranscriptional control has been rewritten again as it is one of the most rapidly changing areas. This material is now on stronger conceptual ground.

Chapter 17—The chapter has been reorganized and revised to focus on biological concepts related to biotechnology, rather than using techniques as the organizational structure. Polymerase chain reaction is now clearly linked to student's prior learning about DNA replication. DNA sequencing was moved to chapter 18, which focuses on genomes so sequencing of single genes to entire genomes is explained in a coherent and cohesive way. Instead of a generic section on DNA analysis, a section on "Storing and Sorting DNA Fragments" has been introduced, followed by a section titled "Analyzing and Creating DNA Differences." We have revised the DNA fingerprinting section to include short tandem repeats. The applications sections have been updated to include, for example, sections on marker assisted breeding and transgenic salmon.

Chapter 18—A comprehensive approach to sequencing at all scales has been developed to frame the genomics chapter. A "Genes to Proteins" section also scales from

individual genes and proteins to genomes and proteins. The section includes text and art explaining the yeast two-hybrid assay. A new section on comparing genomes has been added that provides the foundation for the comparative genomics in the Genome Evolution chapter placed after the principles of evolution. Text and artwork exploring genomic insights into human migration are now integrated into chapter 18.

Chapter 19—The material on nuclear reprogramming was rewritten for both clarity and to incorporate new data in this exciting area. New information on induced pluripotent stem cells is presented along with a better historical timeline of this topic. This is both of general interest to students, and is a source of controversy and misinformation. All material on plant development that was not used for direct comparisons to animals was removed or moved to chapter 41.

Part IV: Evolution

The evolution chapters were updated with new examples. A strong emphasis on the role of experimental approaches to studying evolutionary phenomena has been maintained and enhanced.

Chapter 20—This chapter has been reorganized to consolidate the discussion of selection acting on discrete and continuously distributed populations, before discussing the interaction among different evolutionary forces, which now is discussed toward the end of the chapter.

Chapter 21—The examples in chapter 21 have been updated in several important ways. First, research published in 2012 indicates that studies on selection on peppered moths by Kettlewell were completely correct in showing that bird predation favors those moths that contrasted their background. This section has been revised to clarify this previously controversial point. In addition, new data points on the decrease in the prevalence of black moths in recent years have been added, continuing to demonstrate that as air pollution has been alleviated, peppered moths are increasing in frequency. Material on dating the fossil record was moved to chapter 26. The discussion of the difference between “theory” and “hypothesis” in scientific terminology has been expanded.

Chapter 22—The discussion of hybrid inviability was expanded. The discussion of character displacement was enhanced with a detailed case study of stickleback fishes in northwestern lakes. The discussion of speciation and extinction through time has been moved to chapter 26 and chapter 59.

Chapter 23—Terminology concerning cladistic analysis and phylogenetic systematics was clarified. The example of using phylogenetic information to understand the spread of HIV from monkeys and apes to humans has been updated to reflect new discoveries.

Chapter 24—The increased number of sequenced genomes allowed us to increase the emphasis on comparative

genomics informing our understanding of evolution, as represented in the new figure 24.1. The entire chapter was reorganized to present genome evolution in a conceptual rather than topical way, as reflected in the new section heads. New findings on the rapid rate of plant genome evolution are analyzed, as are the implications of additional primate sequences. A new section on how comparative genomics informs conservation biology was added.

Chapter 25—The seven sections in the previous edition have been consolidated into four sections focusing on core concepts in the evolution of development. The fully reorganized chapter now provides a more coherent and current overview of the maturing field of evolution of development. The chapter now emphasizes evolution of developmental patterns, how single-gene changes can alter form, and different ways to evolve the same structure. A new Scientific Thinking figure guides students through the research on how *Tbx4* and *Tbx 5* were co-opted for vertebrate limb development (figure 25.6). The role of *Hox* genes in digit development has been added, along with a supporting figure (figure 25.7). Our case study on the evolution of the eye has been updated, informed by new data on jellyfish and exemplified by the addition of figure 25.15.

Part V: Diversity of Life on Earth

You will notice some significant reorganization of material in Part V from the ninth edition.

Chapter 26—This is a new chapter for our tenth edition that sets the stage for the unit on Diversity of Life on Earth. This chapter focuses on the origins and diversity of life, beginning with an introduction to deep time. Understanding deep time is essential for student understanding of the origins and evidence for early life. “Earth’s Changing Systems” presents our understanding of how Earth system changes have affected life and how life has affected Earth systems. The chapter then investigates the major innovations in the evolution of life, a springboard for the rest of the unit. New artwork supports student understanding of deep time and the changes that have occurred in Earth systems and life forms over geological time.

Chapter 27—New material has been added on the 2009 H1N1 pandemic. Material on bacteriophage life cycles was rewritten, and now is used as an example of a simple virus life cycle.

Chapter 28—Material on the origin of life that opened this chapter in the previous edition was moved to chapter 26 where all such material has been consolidated. A new introduction was written that looks at the history of the study of microbiology in brief.

Chapter 29—Reorganization of this chapter was guided by the newest phylogenies for the protists. The green algae presentation, including life cycles, was moved from the plant diversity chapter to the protist chapter in this

edition to provide greater clarity about the algae in general for students.

Chapters 30 and 31—The Green Plant chapter in the ninth edition has been replaced with a chapter on Seedless Plants and a chapter on Seed Plants. This allowed us to move the information on the diversity of fruit and flower structure from the plant unit to the diversity unit where it is more appropriate. This approach reduces redundancy between the two units and keeps students focused on the most relevant concepts for understanding plant diversity.

Chapters 33–35—These chapters have been reorganized to reflect current understanding of phylogenetic relationships. In particular chapter 33 now discusses an overview of animal diversity and evolution, as well as the most basal members of animal phylogeny. Chapter 34 covers protostomes and chapter 35 covers deuterostomes.

Part VI: Plant Form and Function

This unit was reorganized at the chapter level in this edition. The Vegetative Plant Development chapter in the ninth edition was eliminated. Plant reproduction and development were consolidated in a single, coherent chapter 41. Information on the diversity of flowers and fruit was modified and integrated into the unit on diversity.

Chapter 37—Figure 37.2 was modified for clarity. To help students better understand mass flow, figure 37.19 was expanded to pull out details about critical events at both sources and sinks.

Chapter 41—A substantial reorganization of this chapter resulted in the incorporation of embryo development and germination into this chapter, following the section on pollination. To streamline the chapter, several figures addressing determination for flowering and the three-dimensional axes of embryo development were eliminated. The restructuring maintains student focus on what is truly core in understanding plant reproduction and development at the level of introductory biology.

Part VII: Animal Form and Function

The organizational changes made in the ninth edition have been maintained. This gives the student a system-level organization that is enhanced by the presentation of material that is both cellular and molecular in focus, and that puts this material into an evolutionary context. The Learning Outcomes have been analyzed and rewritten both for clarity and to increase linkage between Learning Outcomes and assessment in both

the end-of-chapter material and online content. Data Analysis questions were added, and some Evolutionary Asides and Quantitative Asides for the eBook were also included.

Chapter 43—The material on the generation of a resting potential was rewritten for clarity. These changes emphasize membrane permeability and the role of ion channels. This provides a strong framework to understand how ion channels also function in graded and action potentials.

Chapter 50—This chapter was reorganized to make a more logical flow of topics. The section on nitrogenous wastes was moved up from section 4 to section 2. This places information on nitrogenous wastes immediately after the concept of osmoregulation, and consolidates all of the material on how various animals achieve this.

Chapter 51—The introduction and the material on innate immunity has been rewritten for clarity and to emphasize the connections between innate and adaptive immunity.

Chapter 52—The material on the development of the follicle has been updated to reflect a more accurate description of developmental timing.

Part VIII: Ecology and Behavior

This unit is rich in eBook Evolutionary Asides, for example, a number of case studies of the evolutionary significance of animal behavior are presented in chapter 54. In chapter 59, eBook Evolutionary Asides have been included exploring extinction through time, the evolutionary significance of biological “hot spots,” and the evolutionary response of populations to overfishing. Befitting the nature of ecological science, the chapters are now also replete with Data Analysis questions accompanying the many graphical illustrations.

Chapter 55—The information on human population growth was updated using current statistics.

Chapter 56—The discussion of the definition of a biological community was revised.

Chapter 58—The information on human impacts on the environment and global warming was updated using the most current information available. New material discussing ocean acidification was added.

Chapter 59—Chapter 59 considers conservation biology, emphasizing the causes of species endangerment and what can be done. The information about species extinctions, including mass extinction (moved from chapter 22), was updated.