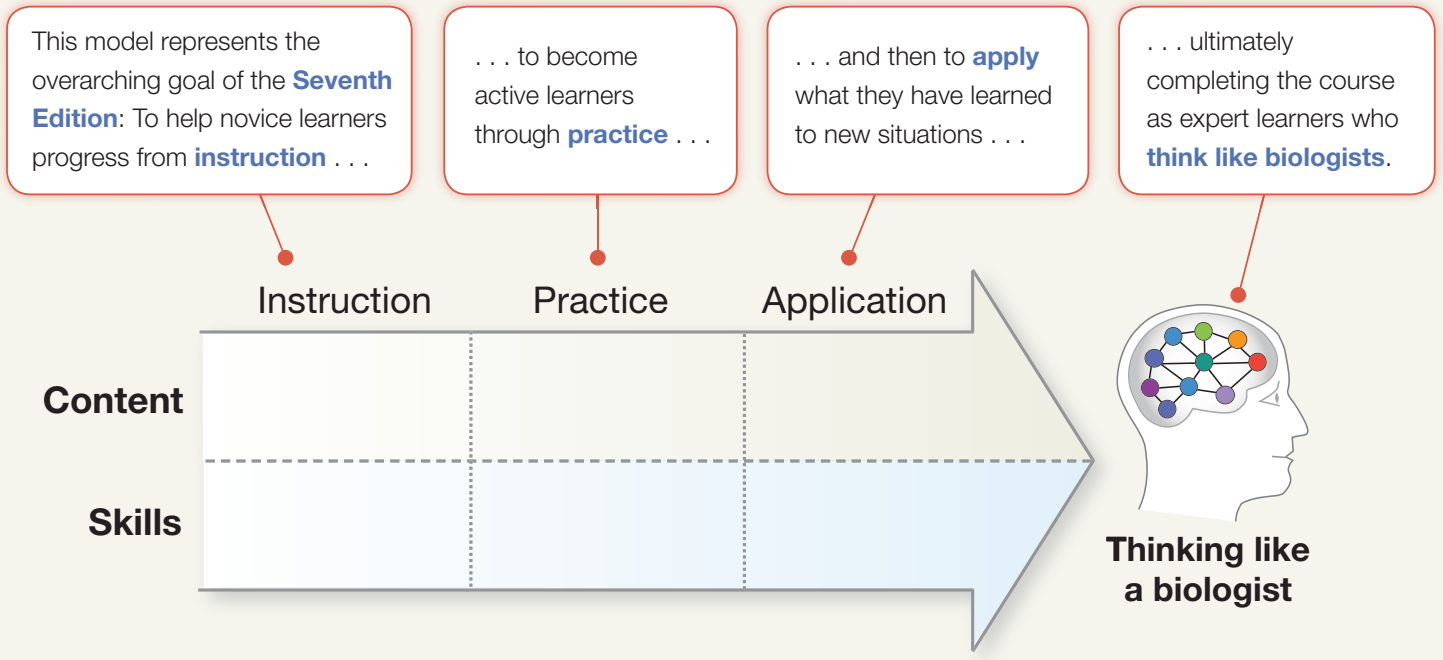
Discover Biology, Develop Skills, and Make Connections

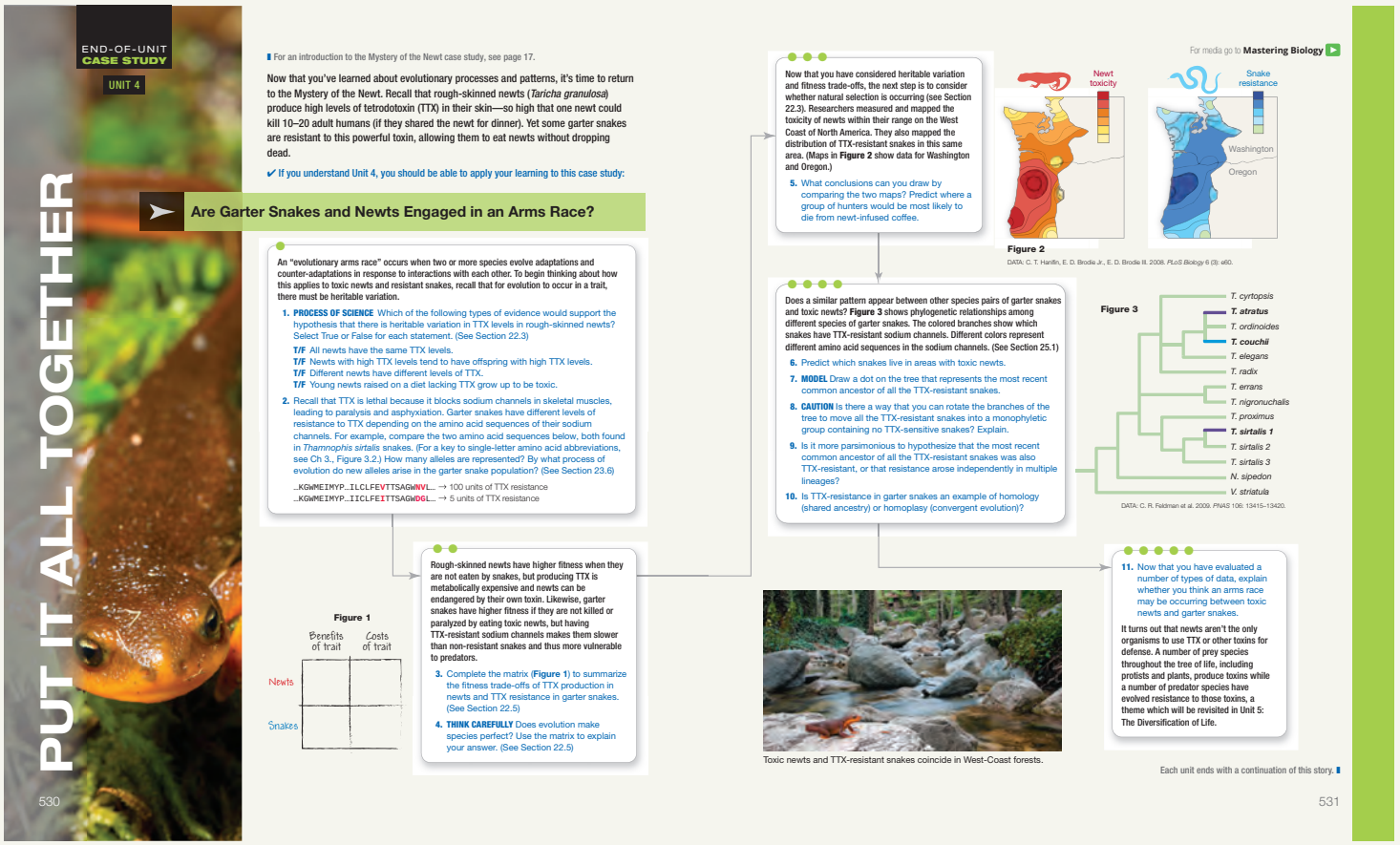
Since it's trailblazing First Edition, *Biological Sciences* has delivered numerous biology teaching innovations that emphasize higher-order thinking skills and conceptual understanding rather than an encyclopedic grasp of what is known about biology. Central to this shift is a student-centered approach that provides support for mastering core content and developing skills that help students learn and practice biology.



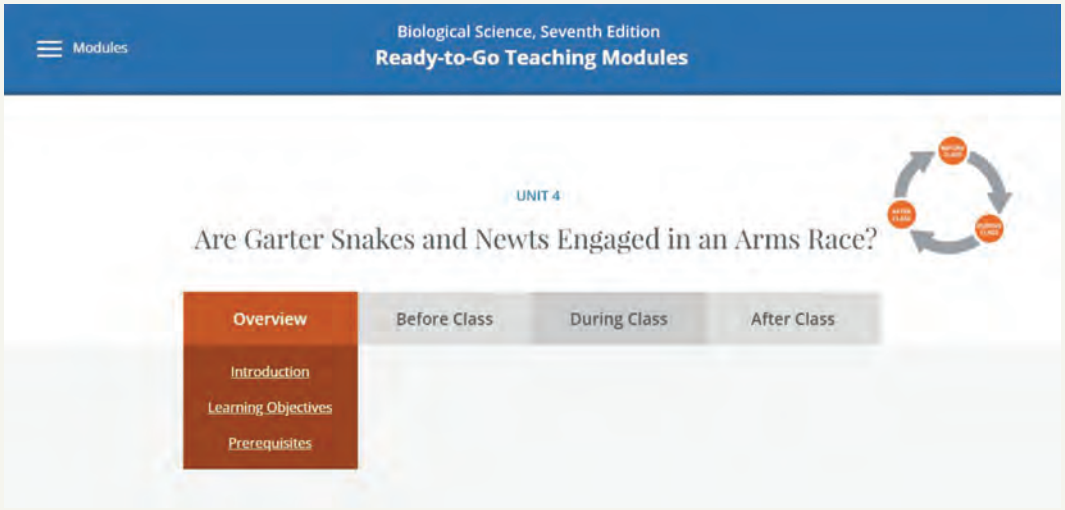
Pearson

Making Connections Through

NEW Integrative End of Unit Case Study is introduced following Chapter 1. Each unit concludes with a 2-page spread that continues the story, guiding students through an exploration of key biological elements and scientific data. A unifying story about the evolutionary arms race between newts and garter snakes unfolds to illustrate how biology concepts and the various sub-disciplines of biology are connected across multiple levels from molecules, cells, and genetics to evolution and diversity, physiology, and ecology. Materials in Mastering Biology support in-class and out-of-class activities.



Every Chapter and Unit



NEW The **End-of-Unit Case Studies** are supported by **Ready-to-Go Teaching Modules** in Mastering Biology that provide pre- and post-class assignments as well as a wealth of ideas for in-class activities. These resources will help enliven your class time and provide students with opportunities to apply what they are learning.

Updated **"Put It All Together" Case Studies** appear at the end of every chapter and provide a sample of contemporary biology research in action. Each case study poses questions that help students connect what they learn in class with current, real-world biology research. At least one question requires students to analyze real data or apply quantitative skills.

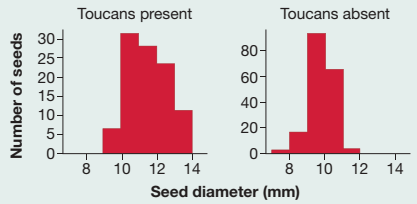
✓PUT IT ALL TOGETHER: Case Study

Are toucans important to tropical forests?

Human activities are causing the fragmentation of the Brazilian Atlantic rain forest. One result is that toucans have become extinct or nearly extinct in some of the forest fragments. Does the absence of toucans affect the forest?

11. Toucans disperse seeds of key forest species such as juçara palms by eating the fruit and defecating the seeds in new locations, sometimes more than a kilometer away. If there are no toucans, is the genetic diversity of palms likely to increase or decrease within forest fragments? Why?
a. increase (due to increased genetic drift)
b. decrease (due to decreased gene flow)
c. decrease (due to decreased mutation rate)
d. decrease (due to decreased natural selection)

12. **QUANTITATIVE** Toucans can eat fruits with large seeds because their large bills can open wide. Most other birds in the same forest can only eat small seeds. Ecologist Mauro Galetti and his colleagues measured the seed sizes of palms in forest fragments with and without toucans. The graphs show two of the forest populations they studied. What is the take-home message of the data?



Source: M. Galetti, R. Guevara, and M. C. Côrtes, et al. 2013. *Science* 340: 1086–1090.

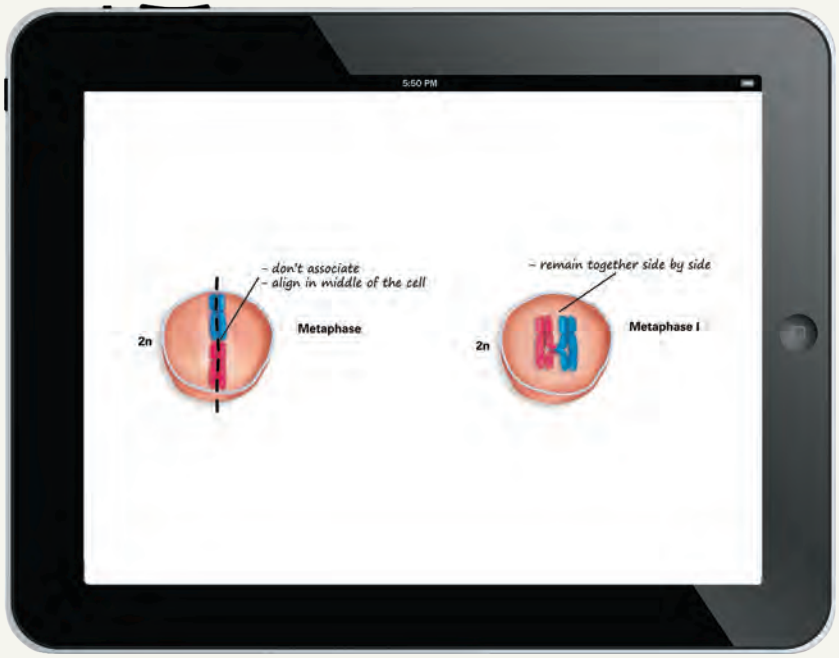
13. Do these data illustrate directional, stabilizing, disruptive, or balancing selection? Justify your answer in terms of fitness.

14. Large seeds carry more resources than small seeds and tend to have a higher rate of survival, especially after being dispersed by a bird. Predict how the local extinction of toucans will affect the palm population over time.

15. **PROCESS OF SCIENCE** The data in the graphs are from two of the 22 forest fragments studied by the researchers: 7 with toucans present, 15 with toucans absent. Why do you think the researchers bothered to study so many forest fragments?

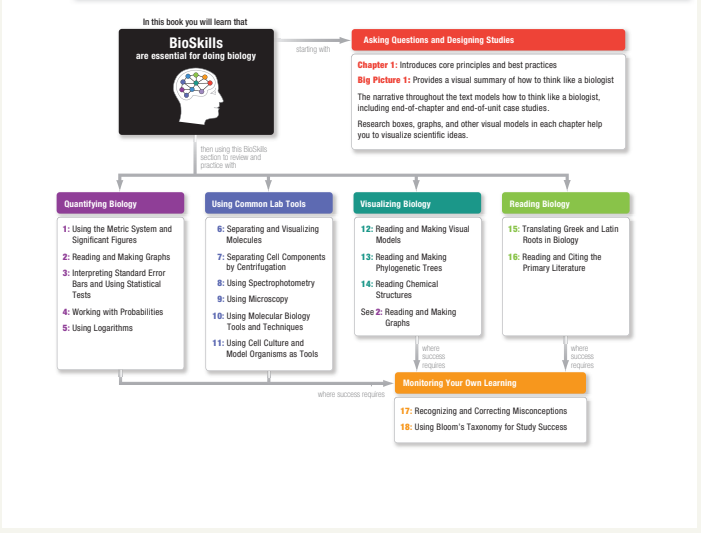
16. **SOCIETY** If you were a journalist covering this story, how could you use data from this study to respond to the following social media post? "Evolution is a slow process. Humans do not cause evolution in other organisms."

Developing Skills with

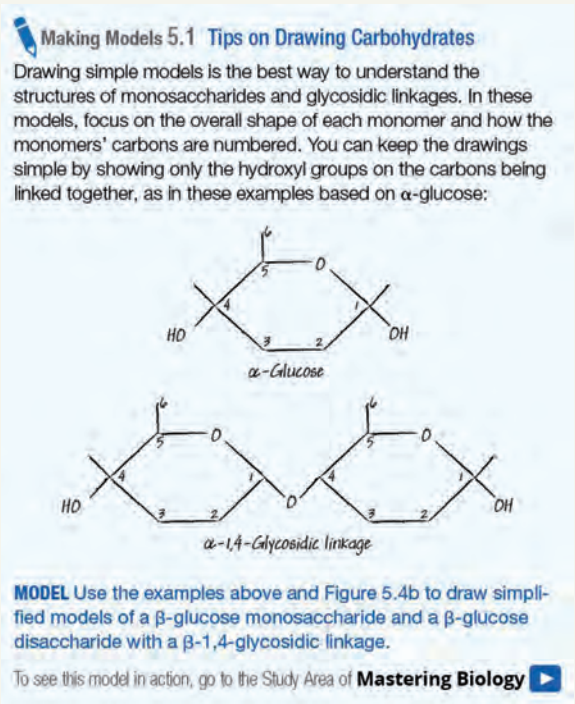


NEW 24 Interactive Figures with Walkthrough Videos help students develop skills to interpret figures, as well as develop a better understanding of key concepts. Figure Walkthrough Videos are embedded in Pearson eText for viewing at the initial point of learning and also assignable in Mastering with questions that help students practice working with visuals.

The **BioSkills** reference section appears between Chapters 1 and 2, drawing attention to key skills students need to succeed in biology. This compendium of easy-to-find reference material supports skill development throughout the course. Each BioSkill includes practice exercises in the book, questions in the Study Area of Mastering, and assignable, skill-reinforcing activities in Mastering.



Interactive and Engaging Content



Making Models 5.1 Tips on Drawing Carbohydrates

Drawing simple models is the best way to understand the structures of monosaccharides and glycosidic linkages. In these models, focus on the overall shape of each monomer and how the monomers' carbons are numbered. You can keep the drawings simple by showing only the hydroxyl groups on the carbons being linked together, as in these examples based on α-glucose:

MODEL Use the examples above and Figure 5.4b to draw simplified models of a β-glucose monosaccharide and a β-glucose disaccharide with a β-1,4-glycosidic linkage.

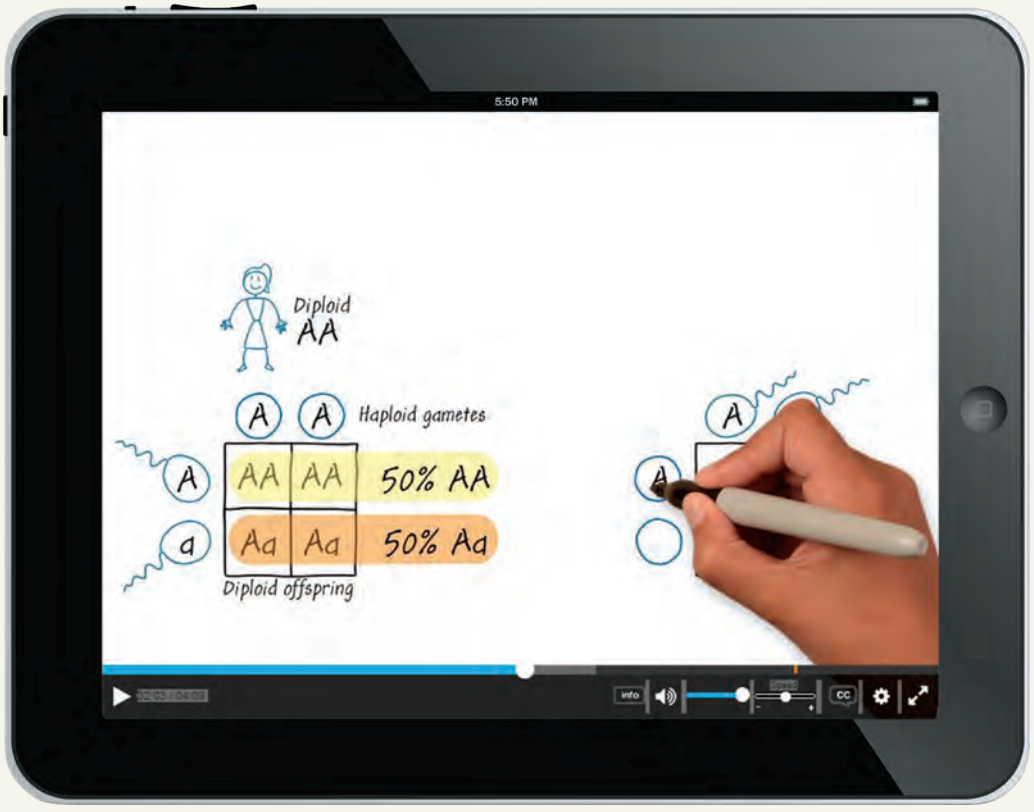
To see this model in action, go to the Study Area of **Mastering Biology**

Making Models boxes explicitly teach students how to use visual models to learn and do biology. 45 boxes throughout the book guide students in deepening their understanding of modeling and of biology concepts. Making Models are also available for self-study in the Study Area and assignable with questions in Mastering.

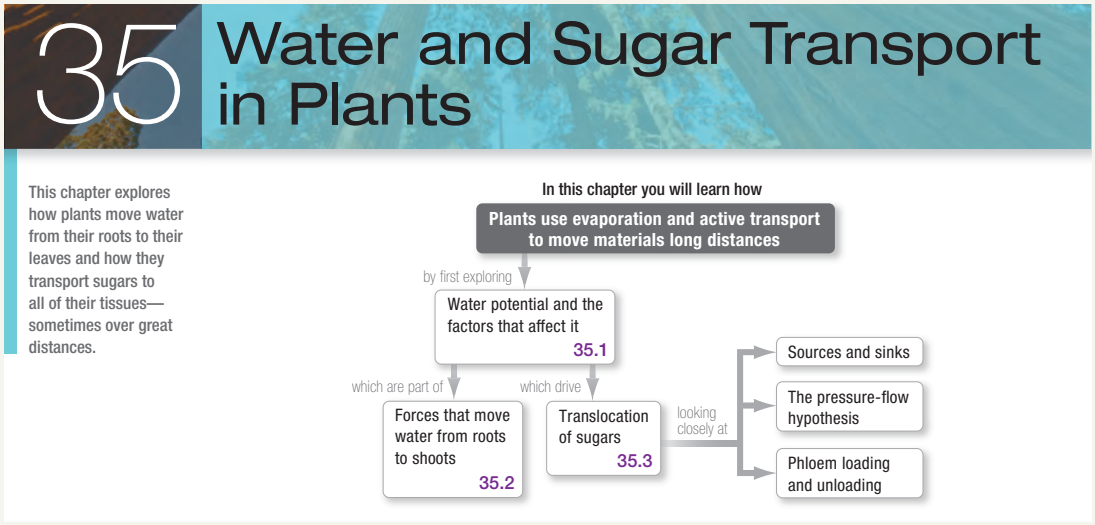
3 NEW Making Models boxes are:

- Ch. 5: Tips on Drawing Carbohydrates
- Ch. 40: Tips on Drawing Arrows
- Ch. 48: Tips on Drawing Immune System Processes

Dynamic whiteboard videos support each **Making Models** box, bringing the modeling activity to life and helping students better understand how to interpret and build models. The videos are embedded in the eText, available in the Study Area, and assignable as homework in Mastering Biology.

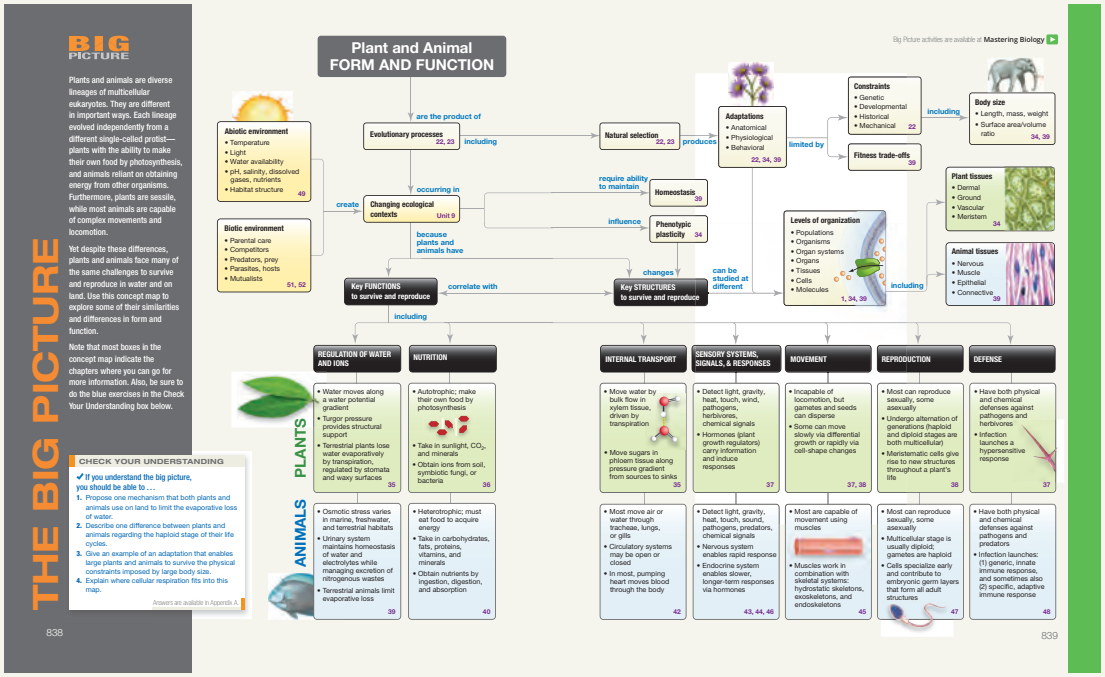


Guiding Students to Learning



Unique **Chapter-Opening Road-maps** set the table for learning by visually grouping and organizing information to help students anticipate key ideas as well as recognize meaningful relationships and connections that are explored in the chapter that follows.

Big Picture Concept Maps help students review key ideas. Words and visuals are integrated in these 2-page spreads to help students synthesize information about challenging topics that span multiple chapters or units. Accompanying question sets encourage students to analyze important patterns within each Big Picture. Mastering Biology provides related mapping activities and questions to help students work on higher order problems.



and Increasing Engagement

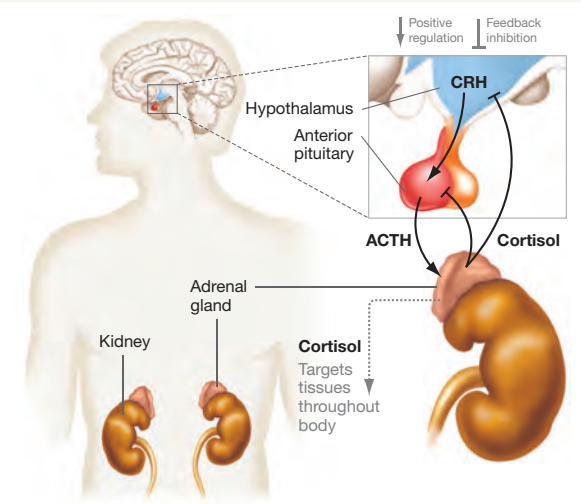


Figure 46.14 **The Interaction between Cortisol, ACTH, and CRH Is an Example of Negative Feedback.**

✔ **PROCESS OF SCIENCE** Use the figure to devise a test for adrenal failure in humans.

Hallmark **Blue-Thread** questions throughout the text encourage students to engage with content, think like biologists, and monitor their learning. There are a variety of question types throughout the text to help students retrieve and apply information and practice skills at all cognitive levels of Bloom's taxonomy.

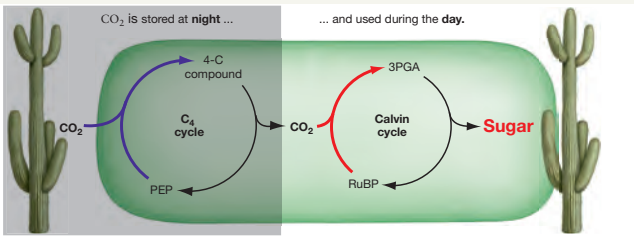


Figure 10.25 **In CAM Plants, Carbon Fixation Occurs at Night and the Calvin Cycle Occurs during the Day.**

✔ At what part of the day would there be the highest concentration of four-carbon organic acids in the vacuoles of CAM plants?

Hear from every student with **Learning Catalytics**. Utilizing a variety of question types, students recall ideas, apply concepts, and develop critical-thinking skills. Students respond using smartphones, tablets, or laptops. Responses are monitored in real-time and allow you to see what your students do—and don't—understand. Instructors can create their own questions, draw from community content, or access Pearson's library of question clusters. Focused on key topics, the clusters consist of 2-5 questions about a single data set or scenario.

Multiple Levels of Assessment

24.1 How Are Species Defined and Identified?

If your friend tells you she's planning to study polar bears and grizzly bears for her summer research project, you'd likely know that these animals are distinct species. But what if your friend is going to compare forest elephants and savanna elephants of Africa? Are they the same species or two di" erent species?

After you complete this section, you should be able to . . .

- Compare mechanisms of reproductive isolation.
- Compare the advantages and disadvantages of different species concepts.

Evolutionary biologists have been wrangling with the definition of species for decades—how can you reliably distinguish two or more species of bears, elephants, or bacteria in the field or fossil record? Although there is no single, universal answer, scientists do agree there is a distinction between the *general definition* of a species and the criteria used in the *practical identification* of species in particular cases.

NEW Learning Objectives at the beginning of every section make it clear what fundamental content students should expect to learn and how they should be able to apply that knowledge.

Check Your Understanding Questions at the end of every section are tightly aligned to the learning objectives for the section.

CHECK YOUR UNDERSTANDING

✔ If you understood this section, you should be able to . . .

1. Predict which mechanism of reproductive isolation played a role in trumpeter speciation in the Amazon basin. Note: Trumpeters cannot fly across large rivers.
2. Determine which species concept(s) could be used to identify the number of trumpeter species in the Amazon.

Answers are available in Appendix A.

Steps to Building Understanding

Each chapter ends with three groups of questions that build in difficulty

✔ TEST YOUR KNOWLEDGE

Begin by testing your basic knowledge of new information.

✔ TEST YOUR UNDERSTANDING

Once you're confident with the basics, demonstrate your deeper understanding of the material.

✔ TEST YOUR PROBLEM-SOLVING SKILLS

Work towards mastery of the content by answering questions that challenge you at the highest level of competency.

End-of-Chapter Questions are organized in three levels–Test Your Knowledge, Test Your Understanding, and Test Your Problem-Solving Skills–so students can build from lower- to higher-order cognitive levels of assessment.

Help Students Learn and Practice

Blue Thread questions, throughout the text and figures, help students gauge their learning.

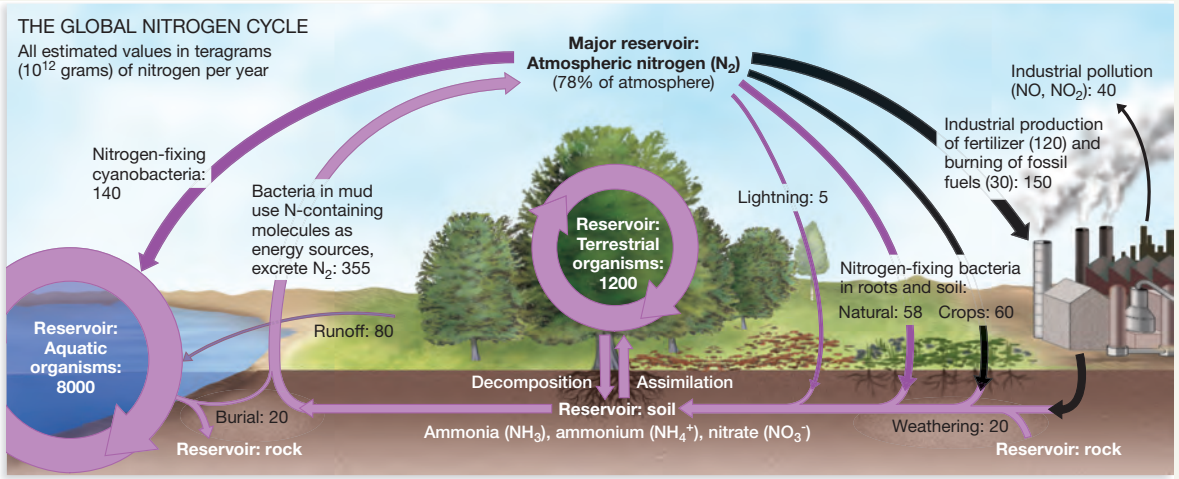


Figure 53.15 The Global Nitrogen Cycle. Nitrogen enters ecosystems as ammonia or nitrate via fixation from atmospheric nitrogen. It is exported in runoff and as nitrogen gas given off by bacteria.

DATA: D. Fowler et al. 2013. *Philosophical Transactions of the Royal Society B* 368 (1621): 20130165.

✓ **QUANTITATIVE** Calculate the percentage of total nitrogen fixation (all downward-pointing arrows) that is caused by human activities (black arrows).

Chapter Assessment Grids help instructors quickly identify suitable assessment questions in the text according to learning outcomes, Bloom's taxonomy level, core concepts and core competencies discussed in the *Vision and Change in Undergraduate Biology Education* report, and when, applicable, common misconceptions.

BLOOMS TAXONOMY RANKING

"Blue Thread" questions, including end-of-chapter problems, are ranked according to **Bloom's taxonomy** and are assignable in Mastering Biology.

LEARNING OUTCOMES

Each question is tagged to a publisher-provided **Learning Outcome**. Instructors may also track their own Learning Outcomes using Mastering Biology.

MISCONCEPTIONS

When applicable, **common student misconceptions** are addressed and identified with targeted questions.

VISION & CHANGE CORE CONCEPTS

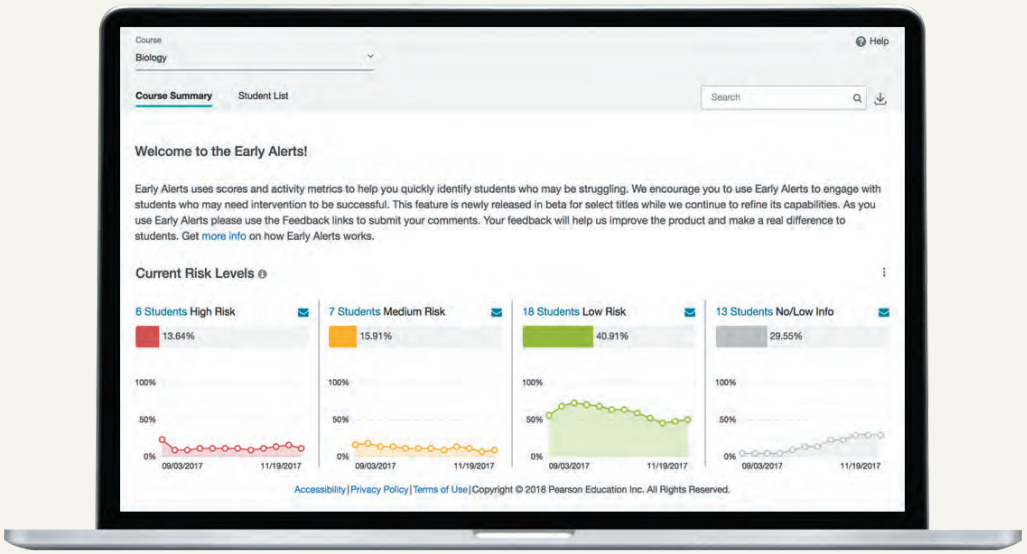
Each question that covers a **Core Concept** from the *Vision and Change in Undergraduate Biology Education* report is noted in the chapter assessment grid and in Mastering Biology.

VISION & CHANGE CORE COMPETENCIES

Core Competencies from the *Vision and Change in Undergraduate Biology Education* report are indicated in the chapter assessment grid and in Mastering Biology.

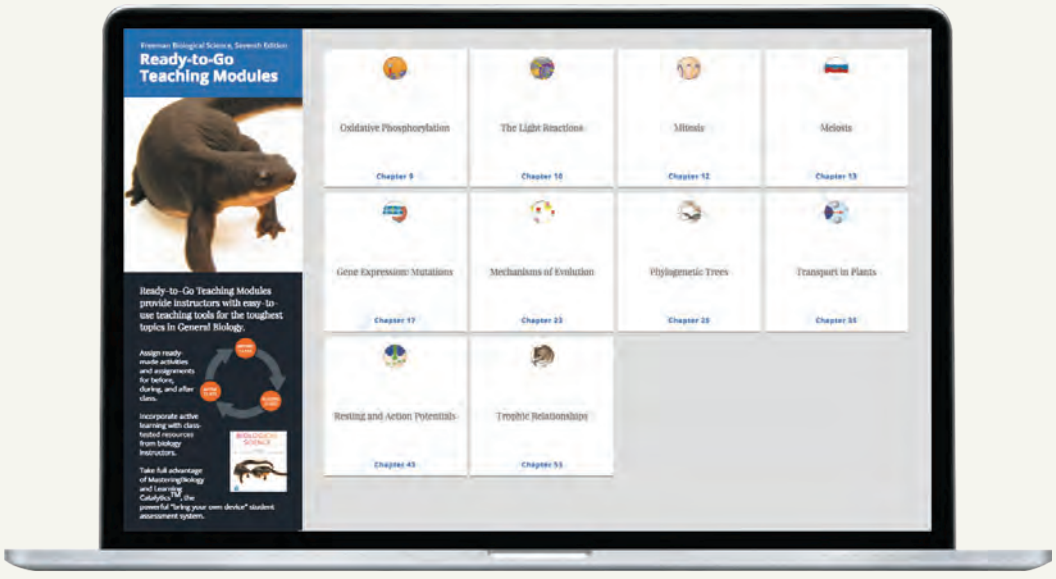
Succeeding with Mastering Biology

Mastering Biology is the teaching and learning platform that empowers you to reach every student. By combining trusted author content with digital tools developed to engage students and emulate the office-hour experience, Mastering personalizes learning and improves results for each student.

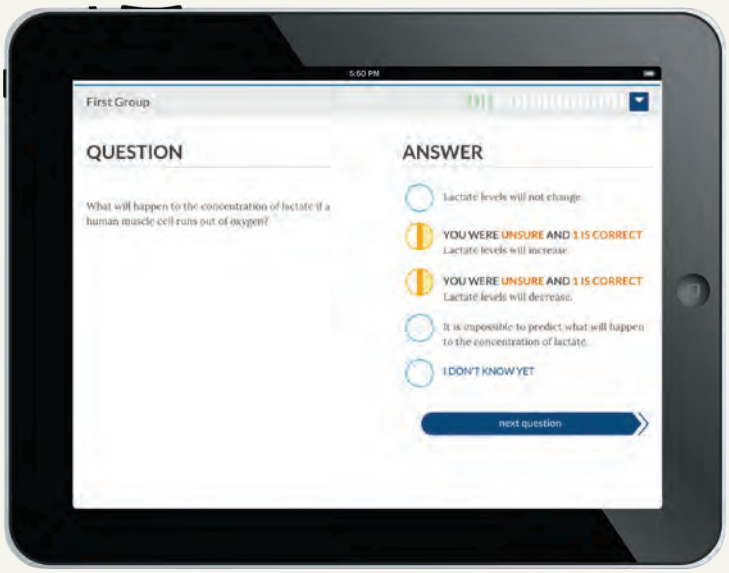


NEW Early Alerts in Mastering Biology uses scores and behavioral data to help instructors identify individual students at risk of not performing well in the course. This insight enables instructors to provide informed feedback and support at the moment struggling students need it so they can stay—and succeed—in the course.

Ready-To-Go Teaching Modules offer prepared teaching tools for use before, during, and after class, including ideas for in-class active learning. The modules incorporate the best that the text, Mastering Biology, and Learning Catalytics have to offer and can be accessed through the Instructor Resources area of Mastering Biology.



Personalizing Learning and the Classroom

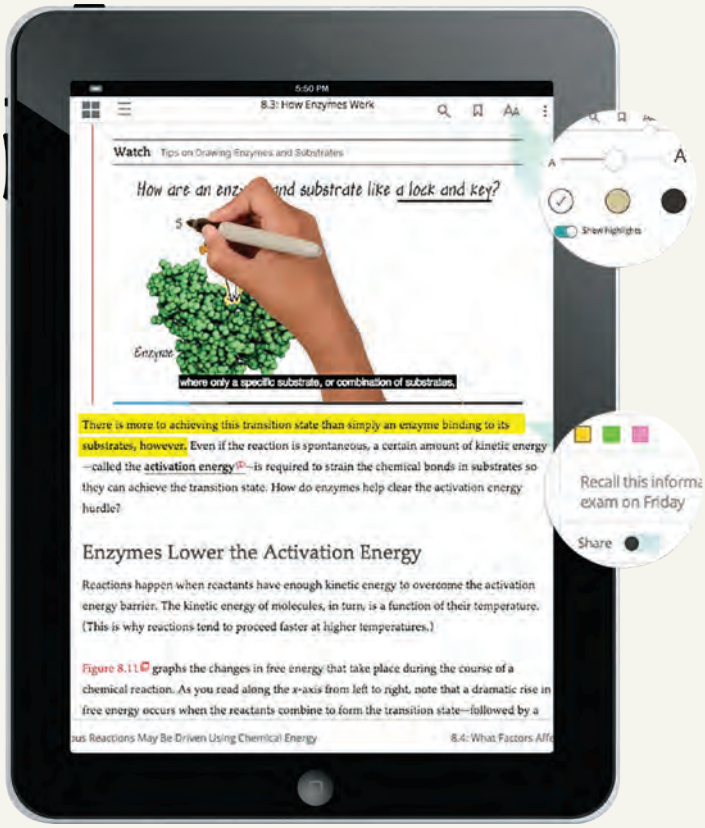


Dynamic Study Modules, based on the latest developments in cognitive science, adapt to student performance in real time to help students study course topics. As a result, students build the confidence they need to deepen their understanding, participate meaningfully, and perform better—in and out of class. Available on smartphones, tablets, and computers.

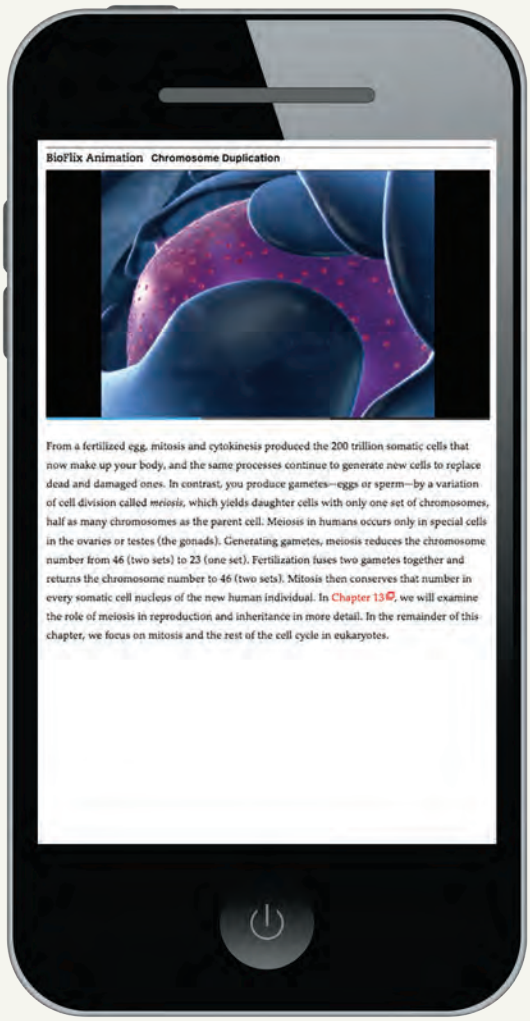
Adaptive Follow-Up Assignments provide each student with targeted question sets that address the specific concepts and skills he or she struggled with in the original homework assignment.

Additional Mastering Resources include: BioFlix, GraphIt! activities, HHMI videos, animations, concept maps, new tutorials, and many other tools to engage students and bring concepts to life. Available for self-study and assignment.

A Whole New Learning Experience with Pearson eText



NEW Pearson eText is a simple-to-use, mobile-optimized, personalized reading experience. It allows students to easily highlight, take notes, and review key vocabulary all in one place. Instructors can share notes from their eText with students to help focus student attention on important ideas.



The **7th edition eText** is accessible on computers, tablets, and smart phones. To engage students, it includes embedded multimedia carefully selected or created to support key ideas in the text, including 45 Making Models videos, 25 Figure Walkthrough videos, 12 interactive graphs, and over 150 additional animations and videos.

Preface to Instructors

Since its inception, *Biological Science*'s unique emphasis on the process of scientific discovery and guiding students to think like biologists has placed this book at the forefront of change in the way we teach biology. The Seventh Edition embraces this legacy and continues to exemplify the principles outlined in the *Vision and Change in Undergraduate Biology Education* report. As in previous editions, the cutting-edge biology in the Seventh Edition is pitched at exactly the right level for introductory students and is as accurate and exciting as ever for instructors and students alike. New findings from education research about ways to increase student engagement in the learning process continue to inform and inspire the coauthor team. The Seventh Edition introduces novel approaches that will allow instructors to attain an appropriate blend of both content and skill development in the classroom. Innovative features new to this edition offer students even more opportunities to actively apply concepts in new situations; evaluate experimental design, hypotheses, and data; synthesize results; and make and interpret models. For instructors, additional resources are provided to help align course activities and learning goals with their assessment strategies.

Core Values

In the Seventh Edition, the coauthor team has strived to extend the vision and maintain the core values of *Biological Science*—to provide a book and online resources for dedicated instructors who embrace the challenge of helping students achieve higher levels of learning, and to provide a book that helps students each step of the way in learning to think like scientists, regardless of their starting point in the process. The Seventh Edition provides tools to help students build their cognitive mastery in both transferrable skills and biology content—to learn at the level called for by the National Academy of Sciences, the Howard Hughes Medical Institute, the American Association of Medical Academies, and the National Science Foundation. Reports such as *Biology 2010, Scientific Foundations for Future Physicians*, and *Vision and Change* all place a premium on fundamental skills and concepts as well as connecting core ideas across all levels of biology.

What's New in This Edition

Many of the new or expanded features in the Seventh Edition are designed to seamlessly intertwine delivery of cutting-edge biology content with development of students' skills in data analysis and quantitative model-based reasoning, in an engaging and relevant way. Students will receive initial instruction in biology content and transferrable skills, followed by opportunities for lots of practice in applying knowledge and skills to new contexts. The ultimate goal is for students to learn to construct their own knowledge and think like biologists.

- **Integrative End-of-Unit Case Study** Introduced in Chapter 1 and then revisited throughout the book, the end-of-unit case study "Mystery of the Newt" features a cliff-hanger tale of poisonous newts and resistant garter snakes. The unfolding story illustrates how biology concepts and the various subdisciplines of biology (genetics, evolution, physiology, ecology, etc.) are connected across multiple levels from molecules and cells to ecology and evolution. Each unit concludes with a two-page spread that focuses on contemporary biological elements and poses questions relevant to the unit and the case study. By highlighting the practice of science, we hope to encourage students to envision themselves as scientists. The end-of-unit case study is supported by Ready-to-Go teaching modules with instructional resources that include in-class clicker questions and activities and related Mastering™ Biology questions for pre- and post-class assignments to promote critical thinking and student engagement in the classroom.
- **Interactive Figure Walk-through Videos** Twenty-five figure walk-through videos have been added throughout the text to help students with unpacking complex figures and to cultivate better engagement with the text and other scientific sources. The videos will help students to better understand quantitative and modeling skills, as well as key concepts, by breaking down the information in figures step-by-step. Interactive figures are embedded in Pearson's new and engaging eText for practice at the initial point of learning and included in assignable Mastering Biology activities to help students practice working with visuals.
- **Three New Making Models Boxes** Reports like *Vision and Change* cite the importance of developing model-based reasoning skills. To help attain this goal, Making Models boxes were introduced in the Sixth Edition to explicitly teach students how to use visual models in learning and doing biology. In the Seventh Edition, three new Making Models boxes have been added: Tips on Drawing Carbohydrates (Ch. 5); Tips on Drawing Arrows (Ch. 40); and Tips on Drawing Immune System Processes (Ch. 48). Each Making Models box has three components: instruction in interpreting or creating a specific type of model, an example of that type of model, and an application question so that students can immediately practice their skills. Additionally, whiteboard-style videos allow students to watch and interact with a dynamic presentation of modeling. These videos are embedded in the eText, accessible in the Study Area of Mastering Biology, and integrated in assignable Mastering Biology activities that test students' understanding of models. Lastly, there are test bank questions aligned with the Making Models activities.
- **Enhanced Interactive eText** New and expanded features in the Seventh Edition have been designed not only to enhance

the print text but also to make full use of the new, embedded Pearson eText platform. The eText presents over 250 videos and animations that have been carefully selected to support content in the text. Resources include whiteboard Making Models videos, interactive Figure Walk-through videos, HHMI Biointeractive videos, and BioFlix® Animations and Tutorials that engage students, help them learn, guide them in completing assignments, and bring biology to life.

- **In-Text Learning Objectives** To help students navigate content, a Learning Objective now appears at the beginning of each section of a chapter. Each Learning Objective makes it clear up front what fundamental content students should expect to learn in a particular section and what they should be able to do with what they've learned.
- **Key New Content** Introduced in the Sixth Edition, end-of-chapter Put It All Together case studies engage students by asking them to connect what they've learned in the chapter to an example of contemporary, relevant research. New case studies have been added that are updated for more recent developments, relevancy, and alignment with chapter content: Ch 30: "Why aren't comb jellies the most diverse animals on Earth?; Ch 31: "How could you count all the bees, beetles, and butterflies in one forest?; and Ch. 33: "How does Zika virus cause birth defects?" Also new to the Seventh Edition is a heavily revised Chapter 20, which includes expanded coverage of CRISPR-Cas gene editing and synthetic biology. In addition, coverage of climate change and other human impacts, as an important context for biological systems, is woven throughout relevant chapters, especially in the ecology unit. There is also an increased emphasis on systems biology and big data; for example, in the ecology unit students explore social networks and community networks.
- **Expanded Assessment Matrix** Introduced in the Sixth Edition, an assessment matrix for each chapter identifies for instructors how each question is related to learning objectives, Bloom's level, common misconceptions, and *Vision and Change* core concepts and competencies. New to the Seventh Edition, all in-text and test bank questions are integrated and tightly aligned to two levels of learning objectives: broader "big picture" objectives and more granular supporting objectives. We hope this tool will assist instructors in selecting the most appropriate assessment items to align with the goals of their course.

Hallmark Features of the Text

While we are excited to introduce the new features of the Seventh Edition, we are committed to strengthening the hallmark features that make this book unique.

- **Road Maps** Each chapter opens with a concept map that visually groups and organizes information to help students anticipate key ideas as well as recognize meaningful relationships and connections among ideas.
- **Big Picture Spreads** While the Road Maps help students look forward as they engage with a chapter, Big Picture concept maps, typically found at the end of a unit, help students review content. Words and visuals are integrated to help students synthesize information about challenging topics that span multiple chapters or units. Related activities are available in Mastering Biology to help students work on higher-order problems while synthesizing key ideas.
- **BioSkills** Instructors recognize that biology students need to develop foundational science skills in addition to content knowledge. Since the Third Edition, *Biological Science* has provided a unique, robust set of materials and activities to guide students who need extra help with the skills emphasized in the book. The BioSkills materials reside between Chapters 1 and 2 to emphasize their importance as a resource for success in doing biology, and to make it easier for students to access them throughout the course. The BioSkills are presented in five broad categories: Quantifying Biology, Using Common Lab Tools, Visualizing Biology, Reading Biology, and Monitoring Your Own Learning. BioSkills include practice questions, are cross-referenced throughout the text, and can be assigned online in Mastering Biology.
- **Opportunities for Practice** "Blue Thread" questions, integrated throughout the text, are designed to help students identify what they do and do not understand. Students are encouraged to think like biologists and practice engaging with content at a higher level. The idea is that if students really understand a piece of information or a concept, they should be able to do something with it. As in the Sixth Edition, all questions in the text are assigned a Bloom's taxonomy level to help both students and instructors understand whether a question requires higher-order or lower-order cognitive skills. A substantial proportion of questions are higher order. In addition, skill-based question tags help students and instructors identify opportunities to practice key skills. Questions are tagged to indicate the following: *Process of Science* questions explore the application of the scientific process; *Model* questions ask students to interpret or construct visual models; *Society* questions explore the relationship between science and society; *Quantitative* questions help students perform quantitative analysis and use mathematical reasoning; and *Think Carefully* questions address topics that students often have common misconceptions about, and the answers to these questions include information that addresses the misconception.
  - **In-text "You Should Be Able To" questions** These questions focus on topics and concepts that professors and students have identified as most key or difficult in each chapter.
  - **Caption questions and exercises** Students are challenged to examine the information in a figure or table critically—not just absorb it.
  - **Check Your Understanding boxes** One to three tasks are presented that students should be able to complete in order to demonstrate a mastery of learning objectives.
  - **End-of-chapter questions** Questions are organized in three levels: Test Your Knowledge, Test Your Understanding, and Test Your Problem-Solving Skills—so students can build from lower- to higher-order cognitive levels of assessment.

- **Put It All Together Case Studies** Case studies added in the Sixth Edition briefly introduce contemporary biology research in action, followed by questions that ask students to apply the chapter's content and skills to the research topic. Instructor resources include clicker questions to give instructors the opportunity to use the case studies as discussion prompts in the classroom. An enduring feature of this text is its emphasis on experimental evidence—on teaching how we know what we know. The case studies expand this emphasis, requiring students to evaluate real data and to see how ongoing scientific research is related to core biological ideas.
- **Focus on Real Data** Students now have expanded opportunities to develop skills in working with real data from the primary literature. Sources of the data presented in research boxes, graphs, end-of-chapter case studies, and the end-of-unit case studies are cited to model good practice for students and to provide a resource for students and instructors who wish to evaluate the original data more deeply.
- **Illustrated Summary Tables** The art program is enhanced by illustrated summary tables that deliver content in a streamlined way and facilitate comparison and analysis by students. Photographic summary tables in Unit 5, for instance, illustrate the diversity of life. These tables make subject areas more accessible to visual learners and reinforce a chapter's key concepts.

Integration of Media

The textbook continues to be supported by Mastering Biology, the most powerful online homework, tutorial, and assessment system available. Tutorials follow the Socratic method, coaching students to the correct answer by offering feedback specific to a student's errors or misconceptions as well as supplying hints that students can access if they get stuck. Instructors can associate content with publisher-provided learning outcomes or create their own. Highlights include the following:

- **eText** The new eText provides an engaging learning experience for students. We have integrated over 250 videos and animations, including Making Models videos, Interactive Figure Walk-through videos, BioFlix animations, and data visualizations. The eText is accessible on computers, tablets, and smart phones.
- **Interactive Figure Walk-through Videos** Twenty-five figures that students find challenging to interpret are now enhanced with brief videos that break down the art and provide explanatory narration to help students better understand key concepts and to develop critical thinking skills. The videos are in the eText and included in assignable activities in Mastering Biology that allow students to apply what they've learned.
- **Making Models Activities** Forty-six whiteboard videos bring the Making Models feature from the book to life to help students develop their visual modeling skills. The videos are in the Study Area and are also included in assignable activities that allow students to practice modeling and apply their understanding to new situations.
- **Case Study Questions** Put It All Together case study questions from the end of each chapter are assignable in Mastering Biology.
- **Solve It Tutorials** These activities allow students to act like scientists in simulated investigations. Each tutorial presents an interesting, real-world question that students will answer by analyzing and interpreting data.
- **Experimental Inquiry Tutorials** The call to teach students about the process of science has never been louder. To support such teaching, there are 10 interactive tutorials on classic scientific experiments—ranging from Meselson–Stahl on DNA replication to the Grants' work on Galápagos finches and Connell's work on competition. Students who use these tutorials should be better prepared to think critically about experimental design and evaluate the wider implications of the data—preparing them to do the work of real scientists in the future.
- **BioFlix Animations and Tutorials** BioFlix are movie-quality, 3-D animations that focus on the most difficult core topics and are accompanied by in-depth, online tutorials that provide hints and feedback to guide student learning. Eighteen BioFlix animations and tutorials tackle topics such as meiosis, mitosis, DNA replication, photosynthesis, homeostasis, and the carbon cycle.
- **HHMI BioInteractive Short Films Activities** Documentary-quality movies from HHMI are available in Mastering Biology with assignable questions to make sure students understand key ideas.
- **Galápagos Evolution Video Activities** These incredible videos, filmed on the Galápagos Islands by Peter and Rosemary Grant, bring to life the dynamic evolutionary processes that have an impact on Darwin's finches on Daphne Major Island. Six videos explore important concepts and data from the Grants' field research, and assignable activities keep students focused on the important take-home points.
- **GraphIt! Activities** These activities use real data to help students explore important topics while developing skills to read, interpret, and create graphs.
- **End-of-Chapter Questions** A broad range of end-of-chapter questions are available to assign in Mastering Biology.
- **Blue Thread Questions** Over 500 questions based on the Blue Thread questions in the textbook are assignable in Mastering Biology.
- **Big Picture Concept Map Tutorials** An engaging concept mapping tool is the basis for highly interactive, challenging concept map activities based on the Big Picture figures in the textbook. Students build their own concept maps, which are automatically graded, and then answer questions to make sure they understand key ideas and make important connections.
- **BioSkills Activities** Activities based on the BioSkills content in the textbook are assignable in Mastering Biology, including activities to support the new BioSkills.
- **Reading Quiz Questions** Every chapter includes reading quiz questions that can be assigned to ensure students read

the textbook and understand the basics. These quizzes are perfect as a pre-lecture assignment to get students into the content before class, allowing instructors to use class time more effectively.

In addition, a few tools are of particular help to busy instructors.

- **Ready-to-Go Teaching Modules** Based on key topics that students struggle with, these modules provide instructors with assignments to use before class, in class, and after class. New modules will support the integrative end-of-unit case study about newts to help instructors engage students with a range of activities for in class and outside of class.
- **Early Alerts** A powerful algorithm looks at student performance and behavior to help identify struggling students as early as possible in the course. Instructors are notified and can easily e-mail students from the Early Alerts dashboard to offer additional help to get students back on track.
- **Vision and Change Filters** All content in Mastering Biology is tagged to the *Vision and Change* core concepts and core competencies, so instructors can identify assessment items in every chapter that are related to *Vision and Change*. Instructors can also sort items by the learning outcomes for this book.

Serving a Community of Teachers

All members of the coauthor team are motivated by a deep commitment to students and to supporting the efforts of dedicated teachers. Our passion in life is doing and teaching biology. At various points along our diverse paths, we have been inspired by our own teachers when we were students, and now we are inspired by our colleagues as we strive to become even better teacher-scholars. In the tradition of all previous editions of *Biological Science*, we have tried to infuse this textbook with the spirit and practice of evidence-based teaching. We welcome your comments, suggestions, and questions.

Content Highlights of the Seventh Edition

Chapter 1 Biology—The Study of Life The new title and reorganized sections reflect a greater emphasis on the theme of five characteristics of life, within a framework of three unifying theories: the cell theory, the theory of evolution, and the chromosome theory of inheritance. Coverage of "life requires energy" is expanded to include more examples of energy acquisition and use and emphasize its importance in the diversification of life.

Chapter 2 Water and Carbon—The Chemical Basis of Life Macromolecules are now introduced in this chapter to provide flexibility in how instructors organize their presentation of content in Unit 1. The description of thermodynamic systems is expanded, including a new figure that illustrates the types of systems based on the exchange of energy and matter with the surrounding environment. To sharpen the focus on foundational concepts that support other chapters in the unit, coverage of the models for chemical evolution is condensed.

Chapter 3 Protein Structure and Function The presentation of how electron sharing gives peptide bonds characteristics similar to double bonds is improved. Discussion of molecular chaperones is expanded, and a new figure illustrates their role in the protein folding process. New assessment questions reinforce student understanding of peptide bonds, how proteins fold into different tertiary structures, and the relationship between protein structure and function.

Chapter 4 Nucleic Acids and the RNA World The description of DNA secondary structure and the accompanying figures are updated to include the concept of base stacking and more accurately represent the geometry of nitrogenous bases relative to the sugar–phosphate backbone. The varied functional roles of RNA are now discussed with reference to the Central Dogma, which is introduced in Chapter 1. A new figure illustrates how tertiary structures are formed from secondary structures in RNA.

Chapter 5 An Introduction to Carbohydrates The introduction of monosaccharides is revised to emphasize how variations in the ring structure of the same monosaccharide will have profound functional consequences. A new Making Models figure is included to help students identify the effect of the ring structure on glycosidic linkages between monosaccharides. Several new questions in the text address how carbohydrate structure is related to function of the polymers.

Chapter 6 Lipids, Membranes, and the First Cells A new figure illustrates how the chemical bonds within fatty acids are responsible for the large amount of potential energy stored in fats. The discussion of selective permeability in membranes is streamlined to emphasize the impact of solute polarity, size, and charge. The section on facilitated diffusion is reorganized, and differences between how channel proteins and carrier proteins participate in this process are clarified.

Chapter 7 Inside the Cell Figures of generalized animal and plant cells are replaced with new and vibrant illustrations to represent the diversity of organelle structures. References to the central dogma, introduced in Chapter 1, are included when describing the functions of the nucleoid, ribosome, and nuclear envelope. A new figure shows how cytosolic proteins are imported into the nucleus after being experimentally modified to include a nuclear localization signal. The research box is replaced with a new one that demonstrates how the secretory pathway was identified using a pulse–chase assay. The description of mitochondrial structure is expanded to include the existence of dynamic networks that undergo fusion and fission between these organelles. Discussion of lysosomes and recycling is clarified and includes a new section on autophagy.

Chapter 8 Energy and Enzymes—An Introduction to Metabolism A new figure illustrates the concept of entropy. Discussion of how temperature and concentration affect chemical reactions is expanded, and the research box includes new data and a description of how the "iodine clock" experiment was performed. The discussion of how enzymes affect chemical reactions is reorganized to emphasize the relationship between catalyzed and uncatalyzed reactions.

Chapter 9 Cellular Respiration and Fermentation The discussion of pyruvate oxidation and the citric acid cycle is revised to improve clarity. Figures illustrating electron transport are updated to clearly show how electrons are transferred to ubiquinone via both complexes I and II, and illustrations in the research box are improved to clearly show the coupling of electron transport and oxidative phosphorylation. A revised figure comparing cellular respiration and fermentation emphasizes how these pathways are related in terms of regenerating electron carriers. Discussion of uncoupling proteins, and how they affect electron transport and oxidative phosphorylation efficiency, is expanded.

Chapter 10 Photosynthesis The revised introduction to the light-capturing reactions and Calvin cycle places greater emphasis on the interdependence of these two pathways. The role of proteins in organizing and tuning pigments in light-harvesting complexes is expanded. Material on carbon fixation and the reduction of sugars is reorganized to emphasize their distinct roles and clarify the relationship between C_3 and C_4 pathways.

Chapter 11 Cell–Cell Interactions The chapter opening image is replaced with a vibrant fluorescent micrograph that represents the chapter's key concepts regarding intercellular connections. The introduction of plant and animal fiber composites is reorganized to streamline discussion of animal extracellular matrix (ECM) and intercellular connections. The figure on animal cell ECM is supplemented with a new illustration on the assembly of collagen proteins into fibrils. Discussion of second messengers is expanded to emphasize their roles in diversification and amplification of intracellular signals.

Chapter 12 The Cell Cycle Centrosome replication and participation in forming the mitotic spindle is now included in the

discussion of mitosis. The summary table is revised to include microtubules and microtubule motor proteins as structures involved in mitosis. A new section on the discovery of proteins responsible for M-phase-promoting factor (MPF) activity is added, including a new research box on the expression of cyclins in the cell cycle that illustrates how scientists distinguish between correlation and causation. The introduction to the G1 checkpoint is revised to clarify how Rb and E2F are regulated.

Chapter 13 Meiosis Figures are updated to more accurately show how chiasma are maintained throughout metaphase I of meiosis. Discussion of human aneuploid conditions is expanded, and sections of the chapter are streamlined for a sharper focus on essential content: for example, by reducing the discussion of details of synapsis and crossing over during meiosis I.

Chapter 14 Mendel and the Gene Coverage of epistasis is included, and material on gene linkage is expanded. Revisions to improve clarity and understanding were made to the research box; to discussions of quantitative inheritance and multiple alleles; and to the figures showing the genotypes and phenotypes of the ABO blood group and quantitative inheritance.

Chapter 15 DNA and the Gene—Synthesis and Repair The description of the polarity of DNA strands and how the antiparallel nature of DNA leads to a lagging strand and challenges in DNA replication is now more student friendly. The content and figures are updated throughout: for example, by clarifying the sliding clamp's relationship to DNA polymerase, discussing the role of DNA helicase in nucleotide excision repair, and showing an exonuclease site in DNA polymerases that is distinct from the active site for polymerization.

Chapter 16 How Genes Work New assessment questions are provided to enhance student understanding of the central dogma of molecular biology. The description of how the genetic code was cracked is expanded. Updated content includes a new figure on chromosome structural alterations and their functional consequences.

Chapter 17 Transcription, RNA Processing, and Translation Content is updated, including new findings on the prevalence of coupled transcription and translation in bacteria; modifications to the figure on splicing to better illustrate how the spliceosome assembles; enhanced discussion on the need for accuracy of aminoacyl tRNA synthetases; and new information on translation elongation factors, the role of GTP in elongation, and termination of transcription in bacteria.

Chapter 18 Control of Gene Expression in Bacteria A broader view of gene expression in bacteria is provided, including use of the CAP protein in *lac* operon regulation as an example of positive control, new coverage of the *trp* operon, and increased coverage of global gene regulation. Figures are updated for clarity, and a new figure on the SOS regulon is added.

Chapter 19 Control of Gene Expression in Eukaryotes Sections were reordered to improve understanding and logical flow. Coverage of epigenetic inheritance and RNA interference is expanded. Extensive updates to the figures and accompanying text better illustrate key concepts, such as how promoter-proximal elements and enhancers are composed of multiple regulatory sequences; how base-pair projections in major and minor grooves of DNA helix can be recognized by transcription factors; the number of alternative splicing possibilities for a single gene; and how RISC binds and separates double-stranded RNA. A new summary table highlights the components of transcriptional regulation.

Chapter 20 The Molecular Revolution—Biotechnology, Genomics, and New Frontiers This chapter is extensively revised to reflect the rapid advances in biotechnology. Highlights include extensive coverage of CRISPR-Cas genome editing, including applications in agriculture and gene drives; many new examples of the applications of biotechnology across all areas of the chapter; expanded coverage of Next-Gen sequencing, GMOs, RNA-seq, and gene therapy; a new section on synthetic biology; and a reorganization of the chapter to present techniques first, followed by insights gained from these new methodologies and finally by coverage of emerging areas in biology.

Chapter 21 Genes, Development, and Evolution Chapter sections are reorganized and updated to improve comprehension and flow, and they now move up an organizational ladder from single cell properties to organizing multiple cells to creating the body plan and finally to the link between development and evolution. New figures illustrate the stem cell concept, the creation of induced pluripotent stem cells, and the genetic regulatory cascades in *Drosophila* development.

Chapter 22 Evolution by Natural Selection More structure and practice are provided for students in the section on evidence of evolution. The mockingbird phylogeny is replaced with a finch phylogeny to align with the finch case study. Content is updated, for example, by including reference to CRISPR technology, new data on pesticide and herbicide resistance, and organisms experiencing climate change. The summary table on common misconceptions is enlarged to help students identify and modify their conceptions of evolution.

Chapter 23 Evolutionary Processes The introduction to the Hardy–Weinberg principle is more student friendly, including a sea turtle example comparing alleles, genotypes, and phenotypes; an aligned new figure of the gene pool concept; and an aligned new figure helping students bridge the use of Punnett squares in Mendelian genetics and their use in understanding the calculations of the Hardy–Weinberg principle. A few examples have been either updated or replaced to align with examples used in other chapters (e.g., finches and whitefish). Discussion of sexual selection is revised to be more culturally sensitive to stereotypes in human gender identity and sexual orientation.

Chapter 24 Speciation A new figure offers a friendly introduction to the topic of speciation. Mechanisms of reproductive isolation are reformatted in an illustrated summary table, followed by application questions to give students more practice. The seaside sparrow case study is replaced by an expanded case study on the number of elephant species and includes a research box. The apple maggot fly case study is replaced with a case study on sympatric speciation in killer whales. New whitefish data on fusion is added to align with the new disruptive selection example used in Chapter 23.

Chapter 25 Phylogenies and the History of Life Chapter structure is clarified, explaining how phylogenetics and fossil evidence can be used in combination or separately to reveal insights about the history of life. The phylogenetics section is streamlined and updated. Dates and events in the history of life are updated.

Discussion of the Cretaceous extinction is updated to include evidence of volcanism in the Deccan Traps, including a new figure that supplies geological context for the continental configuration at that time. Discussion of the sixth extinction is expanded, including new data showing current extinction rates for vertebrates.

Chapter 26 Bacteria and Archaea The list of key terms is expanded to help students navigate content. Discussion of microbial communities is enhanced, including a new figure on human microbiomes. New figures illustrating DNA transfer by transformation and transduction are included, along with accompanying text to clarify these processes.

Chapter 27 Diversification of Eukaryotes Although protists are still the primary focus, the title is changed to reflect the evolutionary emphasis of the chapter. To support this evolutionary emphasis, figures are modified to better illustrate morphological diversity and key life-cycle events of protists. A new figure is added to illustrate bioluminescence and its important role in protist defense mechanisms.

Chapter 28 Green Algae and Land Plants Several figures and the accompanying text are modified to emphasize morphological diversity and key life-cycle events of green algae and land plants. A new figure is added that illustrates antheridia and archegonia in seedless vascular plants. The fern life-cycle figure is modified to better show how fern gametophytes facilitate cross-fertilization.

Chapter 29 Fungi The text and some figures are updated and improved to help clarify key concepts related to morphological diversity and key life-cycle events of fungi. The sections on reproductive structures in fungi are streamlined to minimize repetition.

Chapter 30 An Introduction to Animals Revisions include clarifications and updates, such as the removal of *Xenoturbellida* from the deuterostomes; a clearer distinction between germ layers and tissues derived from germ layers; and an addition of the terms "deep homology" and "biradial symmetry." A new case study gives students practice in distinguishing traits that were important to the origin of animal phyla versus traits that were important in the diversification within phyla.

Chapter 31 Protostome Animals More references to ecology are added for context, such as the ecological implications of the water-to-land transition and the increasing threat of extinction to protostomes during the Anthropocene. In addition, a new case study emphasizes sampling methods and measures of diversity in tropical forests.

Chapter 32 Deuterostome Animals *Xenoturbellida* is removed from the deuterostome phylogeny (they are no longer considered deuterostomes). The walk-through of vertebrate evolution includes a new figure showing the homology of placoderm head shields to human skull and jaw, as well as an expanded explanation of the origin of lungs. The human evolution section is updated, including *Homo naledi* and increased evidence of interbreeding among species of *Homo*.

Chapter 33 Viruses New content is included on the decimation of native populations in the Americas during the sixteenth to eighteenth centuries by viral epidemics. Content on different modes of viral replication is expanded. Coverage of the reemergence of Zika virus as a current significant international health problem is included, along with a new case study on how Zika virus causes birth defects.

Chapter 34 Plant Form and Function Several additional key terms are added to expand coverage of fundamental concepts and help students navigate this updated content. Figures are enhanced to help clarify common misconceptions about plant form and function. Discussion of experimental studies on phenotypic plasticity in plants is expanded to give students greater exposure to the process of science.

Chapter 35 Water and Sugar Transport in Plants Figures and accompanying text are modified and improved to help clarify key concepts in water and sugar transport. Previous sections on forces that move water from roots to shoots and features that reduce water loss are streamlined and merged.

Chapter 36 Plant Nutrition The text is updated and streamlined for clarity throughout the chapter to emphasize key concepts in plant nutrition. Students will get more practice at interpreting data with the help of a new research box that addresses the question of whether legumes regulate root nodule development based on nitrogen availability.

Chapter 37 Plant Sensory Systems Figures and accompanying text are enhanced to help clarify key concepts in plant sensory systems. To help engage students in the process of science, discussion of experiments on the relationship between photoperiodism and flowering is expanded. Key terms are added to help students navigate updated content.

Chapter 38 Plant Reproduction and Development Key figures and corresponding text are enhanced to help clarify important concepts in plant reproduction and development. Students will benefit from greater exposure to the process of science and practice with interpreting data thanks to a newly added discussion of experiments on the relationship between flower color and pollinator preference.

Chapter 39 Animal Form and Function The study on reproduction and immune function in crickets has been simplified to better illustrate trade-offs. Content is updated, including a description of the genetic basis of adaptation to high elevation in Tibet and enhanced descriptions of the composition of connective tissues, bone, and cartilage. The treatment of epithelia has been expanded with an updated figure that shows simple and stratified epithelia side by side. The mathematical explanation of surface-area-to-volume ratio is simplified to clarify this concept. A new figure shows homeostatic thermoregulation in dogs.

Chapter 40 Animal Water and Electrolyte Balance A new Making Models box shows tips for modeling osmoregulatory challenges and solutions faced by animals. A new figure compares osmoregulation in marine bony fishes and osmoconformation in marine cartilaginous fishes. The sections on marine and freshwater fishes are combined to better compare osmoregulation in the two groups. In addition to filtration and reabsorption in the kidney, secretion of substances into the nephron is now briefly discussed.

Chapter 41 Animal Nutrition Further detail is added on the actions of digestive enzymes in humans, including clarification of the function of lingual lipase; introduction of gastric lipase; clarification of carbohydrate digestion by salivary amylase and pancreatic amylase; introduction of brush border enzymes for digestion of disaccharides and dipeptides; and standardization of the name "enteropeptidase." Information on how fat-soluble and

water-soluble vitamins are absorbed is included. A new section covers the human gut microbiome.

Chapter 42 Animal Gas Exchange and Circulation The section on insect tracheae is revised for clarity. A brief discussion of oxygen-carrying pigments other than hemoglobin is added. New material and a new research box are added discussing the special anatomy of the alligator heart. Discussion of the mechanism by which blood pressure drops as blood moves away from the heart is revised to clarify key concepts.

Chapter 43 Animal Nervous Systems Discussion of how the resting membrane potential is established is clarified. Coverage of the peripheral nervous system is expanded, specifically on the autonomic (sympathetic and parasympathetic) nervous system. Content on the vertebrate brain is augmented by couching the main components (cerebrum, cerebellum, diencephalon, and brainstem) in terms of the three region (forebrain, midbrain, hindbrain) schema from Chapter 32. Discussion on learning and memory is revised to highlight how little scientists actually know about these processes.

Chapter 44 Animal Sensory Systems A brief discussion of touch is now included in the mechanosensation section. A detailed discussion and new figure on the inner ear's sensation of equilibrium are added. The section about the "dark current" associated with stimulation of rods in the eye is revised to describe the process at an appropriate level.

Chapter 45 Animal Movement Language is added throughout to make the chapter more interactive (e.g., put your hand on your biceps and flex it). The figure on muscle cross-bridge cycling is updated to show it as a circular process. The description of cardiac and smooth muscle is expanded, including discussions of autorhythmicity and the reason smooth muscle appears smooth.

Chapter 46 Animal Chemical Communication Coverage of positive feedback is added to complement the discussion of negative feedback. The section on Berthold's discovery of testosterone is updated to affirm that he discovered that chemical signal(s) affect rooster development, although the terms "hormone" and "testosterone" were not coined until many years later. Discussion of hormone receptors is updated and streamlined by removing detail on how the estradiol receptor was discovered and focusing on key content.

Chapter 47 Animal Reproduction and Development The discussion of asexual reproduction in animals is updated to show that it does not always result in clones. For clarity, the process of cell migration during gastrulation is now described as "movement" rather than "migration." The concept of the evolution of viviparity in reptiles and mammals is expanded.

Chapter 48 The Immune System in Animals Content is expanded to help students visualize how innate and adaptive immunity work together, including a new Making Models box, "Tips on Drawing Immune Cells." Updates to coverage of antigen presentation and the activation of B and T cells take a more comparative approach.

Chapter 49 An Introduction to Ecology The introductory section on levels of ecology increases the focus on variables that ecologists measure. Section 49.2 is restructured as a case study on açaí palms, including a new niche model comparing açaí palms and coconut palms; a new summary table comparing variables in the present abiotic, present biotic, past abiotic, and past biotic environments; and a new research box focusing on the effect of climate change on the distribution of açaí palms. The chapter now includes altitude as an abiotic factor, the effect of organisms on climate, and a definition of landscape ecology. Other changes improve clarity and timeliness of information.

Chapter 50 Behavioral Ecology Revisions increase the focus on human behavior, including a new case study on consolation behavior in humans, elephants, and prairie voles. Behaviors are categorized in a summary table representing a continuum between innate and learned behaviors. A new figure shows how behaviors are learned via social networks in bees. The section on optimal foraging includes a new research box that looks at cuttlefish counting behavior and an introduction to game theory. The section on mate choice includes a new summary table on mating strategies, including language that helps students to interpret the complexity of human mate choice and sexual identity in this simplistic framework. There is increased emphasis on the importance of variability in behavior in the context of climate change.

Chapter 51 Population Ecology The chapter includes a new summary table of dispersion patterns with an emphasis on proximate and ultimate causation. Increased emphasis on life-history patterns includes a new figure comparing the life-history patterns of two lizard populations. The section on population dynamics includes a new case study on the crash of the reindeer population on St. Paul island to clarify the common misconception that the human population will gently peak at its carrying capacity, and the hare/lynx research box provides a more accessible data set. The section on human population is updated. Application to conservation biology is now more integrated throughout the chapter.

Chapter 52 Community Ecology Content now includes a new summary table comparing consumption interactions, a new section referencing the hare/lynx data in Chapter 51, a new figure illustrating how mutualists can be generalists or specialists, a new figure of interaction networks to show examples other than food webs, a Making Models box on species richness (brought forward from Chapter 54), a resurrection of Paine's keystone species data (moved from Chapter 32), new data on latitudinal diversity, and increased emphasis throughout on human impacts, including climate change.

Chapter 53 Ecosystems and Global Ecology Updated content includes a new opening image of global CO_2 data, a new figure showing solar-induced fluorescence measured via satellite, a new figure helping students to analyze the productivity pyramid while also understanding the impacts of their food choices, increased emphasis that the greenhouse effect and ozone layer are different phenomena, new reference to the Paris climate agreement, and new reference to ocean deoxygenation.

Chapter 54 Biodiversity and Conservation Content is updated throughout, including a new summary table comparing species, phylogenetic and functional diversity; a revised map showing where global vertebrate biodiversity is highest; an updated map of biodiversity hotspots; an updated data set of the distribution of threats to terrestrial, freshwater, and saltwater ecosystems; the inclusion of disease in the topic of invasive species; and a new map illustrating the principle of "Nature Needs Half" as a conservation goal for a sustainable future.