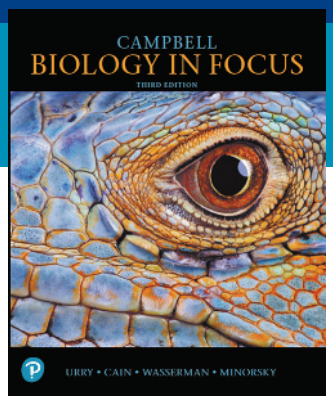
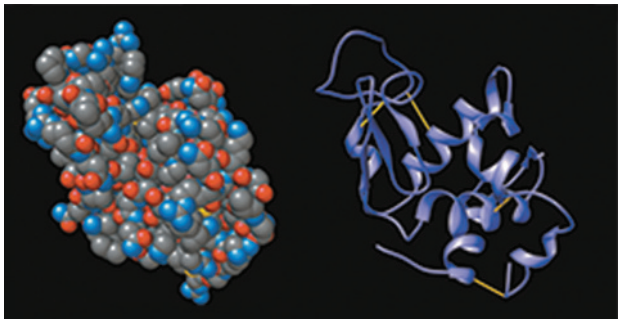
Focus on Core Concepts and Skills

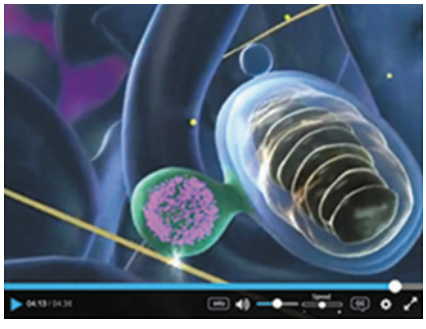


Campbell Biology in Focus, Third Edition, is designed to help students master the fundamental **content** and scientific **skills** they need as college biology majors. Here is an overview of the features of the Third Edition:

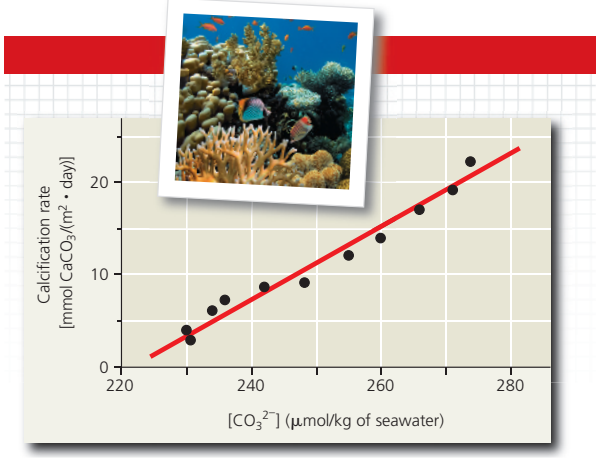
- **Visualizing Figures and Visual Skills Questions** Build the skills needed to interpret diagrams and models in biology (pp. xii–xiii).



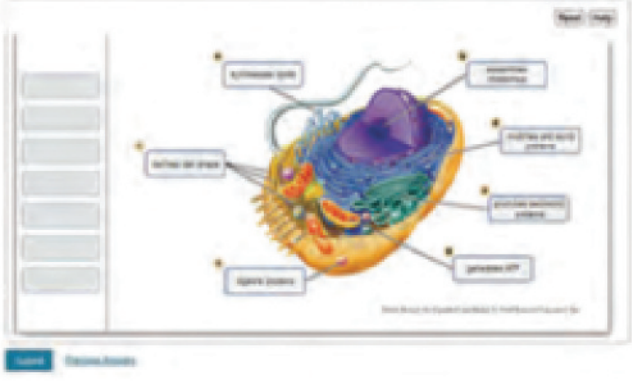
- **Student Success with Mastering™ Biology** Succeed in biology by using the eText, Study Area, and Dynamic Study Modules (pp. xviii–xix).



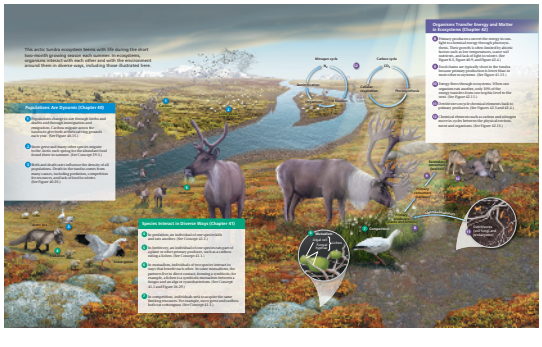
- **Scientific Skills and Problem-Solving Exercises** Use real data to build key skills needed for biology (pp. xiv–xv).



- **Personalized Coaching in Mastering Biology** Master concepts with tutorials that provide hints and feedback (pp. xx–xxi).



- **Make Connections Figures and Questions** See the big picture of biology by integrating content from different chapters (pp. xvi–xvii).



- **Active Learning** Enliven class time and increase student learning with the Ready-to-Go Teaching Modules (p. xxii).

Focus on Visual Skills

NEW! Visualizing Figures teach students how to interpret diagrams and models in biology.

▼ **Figure 3.20 Visualizing Proteins**

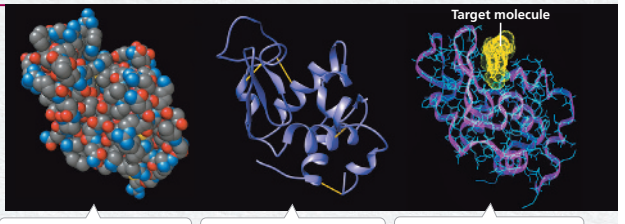
Proteins can be represented in different ways, depending on the goal of the illustration.

Structural Models

Using data from structural studies of proteins, computers can generate various types of models. Each model emphasizes a different aspect of the protein's structure, but no model can show what a protein actually looks like. These three models depict lysozyme, a protein in tears and saliva that helps prevent infection by binding to target molecules on bacteria.

1. In which model is it easiest to follow the polypeptide backbone?

Instructors: The tutorial "Molecular Model: Lysozyme," in which students rotate 3-D models of lysozyme, can be assigned in **Mastering Biology**.



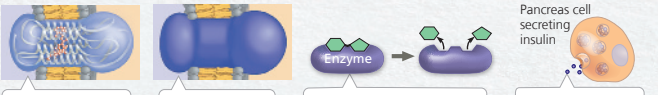
Space-filling model: Emphasizes the overall globular shape. Shows all the atoms of the protein (except hydrogen), which are color-coded: gray = carbon, red = oxygen, blue = nitrogen, and yellow = sulfur.

Ribbon model: Shows only the polypeptide backbone, emphasizing how it folds and coils to form a 3-D shape, in this case stabilized by disulfide bridges (yellow lines).

Wireframe model (blue): Shows the polypeptide backbone with side chains extending from it. A ribbon model (purple) is superimposed on the wireframe model. The bacterial target molecule (yellow) is bound.

Simplified Diagrams

It isn't always necessary to use a detailed computer model; simplified diagrams are useful when the focus of the figure is on the function of the protein, not the structure.



A transparent shape is drawn around the contours of a ribbon model of the protein rhodopsin, showing the shape of the molecule as well as some internal details.

When structural details are not needed, a solid shape can be used.

A simple shape is used here to represent a generic enzyme because the diagram focuses on enzyme action in general.

Sometimes a protein is represented simply as a dot, as shown here for insulin.

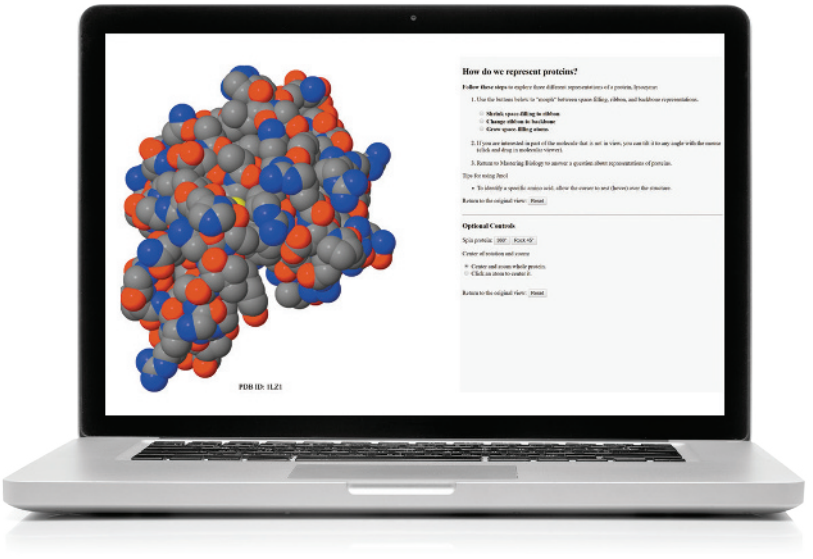
2. Draw a simple version of lysozyme that shows its overall shape, based on the molecular models in the top section of the figure.

3. Why is it unnecessary to show the actual shape of insulin here?

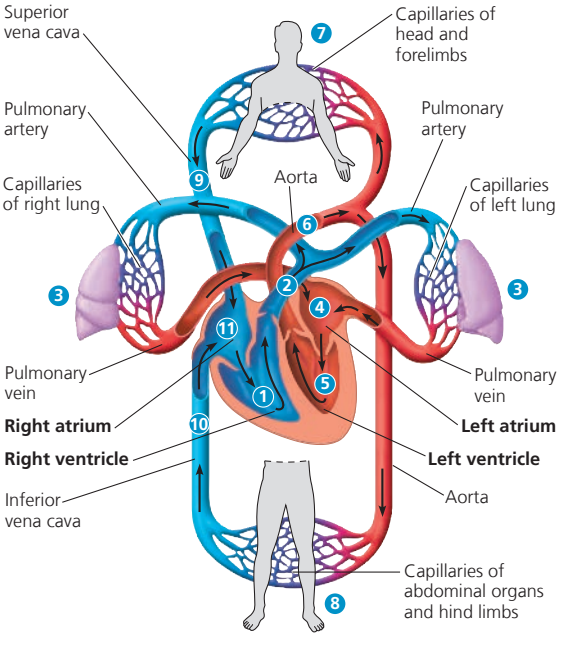
Embedded **questions** give students practice applying **visual skills** as they read the figure. ◀

NEW! Assignable activities in **Mastering Biology** support each Visualizing Figure.

▼

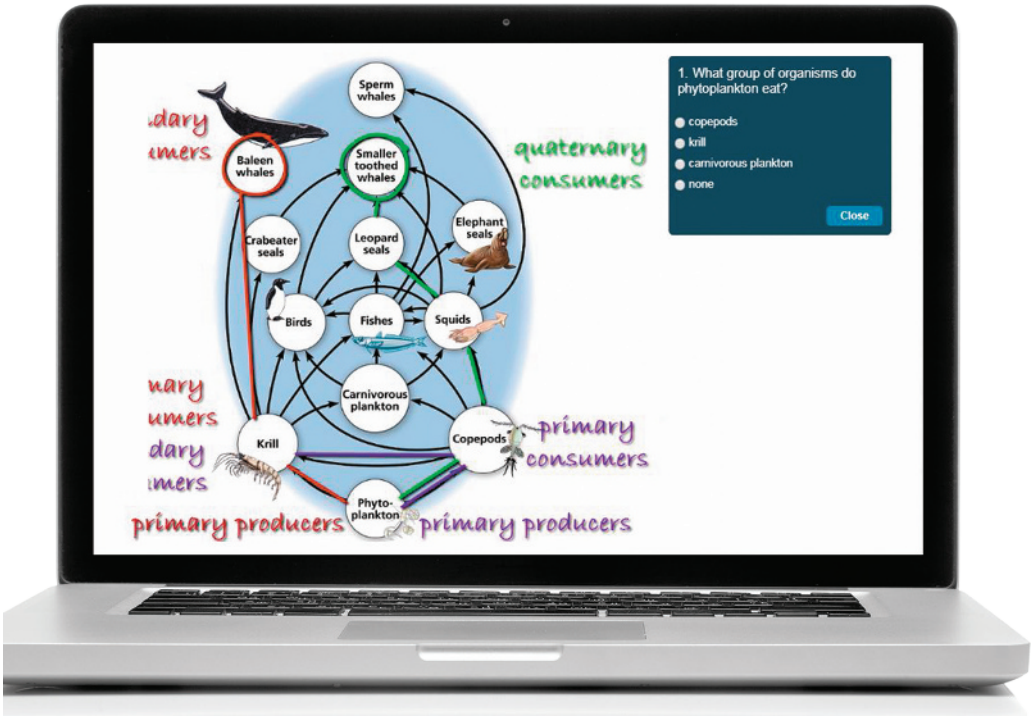


NEW! Visual Skills Questions give students practice interpreting illustrations and photos in the text. ▶

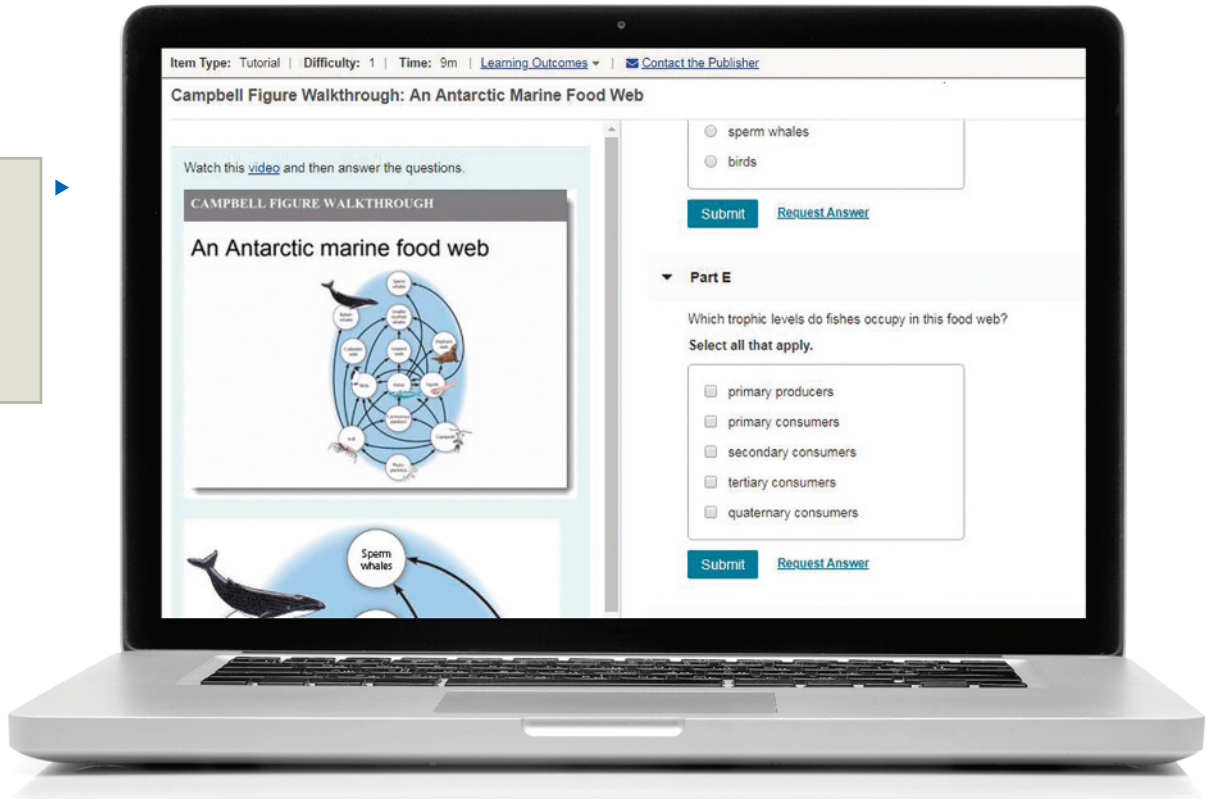


VISUAL SKILLS *If you trace the path of a molecule of carbon dioxide that starts in an arteriole in the right thumb and leaves the body in exhaled air, what is the minimum number of capillary beds the molecule encountered? Explain.*

NEW! Figure Walkthroughs guide students through key figures with narrated explanations and figure markups that reinforce important points.



NEW! The Figure Walkthroughs can also be **assigned** in **Mastering Biology** with higher-level questions.



Focus on Scientific Skills and Problem Solving

Scientific Skills Exercises use real data to build key skills needed for biology, including data analysis, graphing, experimental design, and math skills.

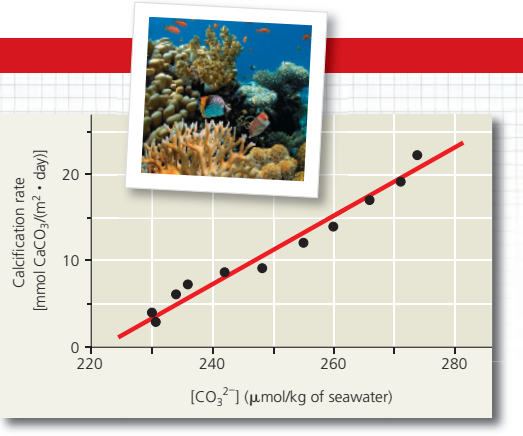
Scientific Skills Exercise

Interpreting a Scatter Plot with a Regression Line

How Does the Carbonate Ion Concentration of Seawater Affect the Calcification Rate of a Coral Reef? Scientists predict that acidification of the ocean due to higher levels of atmospheric CO_2 will lower the concentration of dissolved carbonate ions, which living corals use to build calcium carbonate reef structures. In this exercise, you will analyze data from a controlled experiment that examined the effect of carbonate ion concentration ($[CO_3^{2-}]$) on calcium carbonate deposition, a process called calcification.

How the Experiment Was Done For several years, scientists conducted research on ocean acidification using a large coral reef aquarium at Biosphere 2 in Arizona. They measured the rate of calcification by the reef organisms and examined how the calcification rate changed with differing amounts of dissolved carbonate ions in the seawater.

Data from the Experiment The black data points in the graph form a scatter plot. The red line, known as a linear regression line, is the best-fitting straight line for these points. These data are from one set of experiments, in which the pH, temperature, and calcium ion concentration of the seawater were held constant.



Data from C. Langdon et al., Effect of calcium carbonate saturation state on the calcification rate of an experimental coral reef, *Global Biogeochemical Cycles* 14:639–654 (2000).

INTERPRET THE DATA

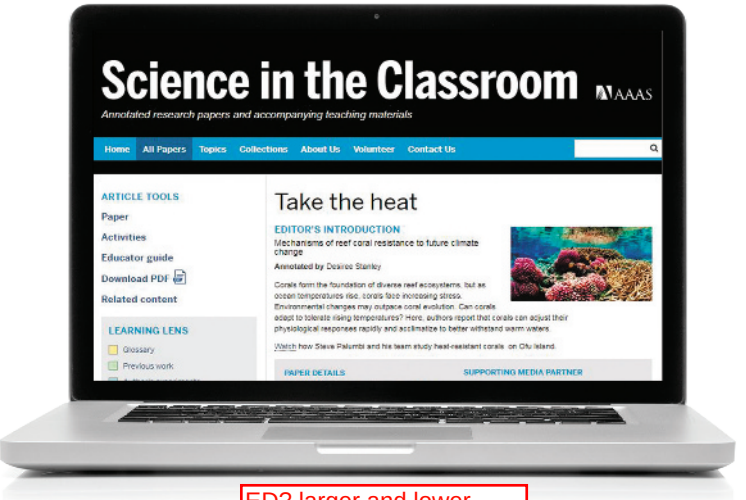
1. When presented with a graph, first determine what each axis represents. **(a)** In words, what is shown on the *x*-axis? (Include the units.) **(b)** What is on the *y*-axis? **(c)** Which variable is the independent variable—the one that was *manipulated* by the researchers? **(d)** Which is the dependent variable—the one that responded to the treatment, which was *measured* by the researchers? (For additional information about graphs, see the Scientific Skills Review in Appendix F.)
2. Based on the data shown in the graph, describe in words the relationship between carbonate ion concentration and calcification rate.
3. If the seawater CO_3^{2-} concentration is 270 μmol/kg, estimate the rate of calcification and how many days it would take 1 square meter of reef to accumulate 30 mmol of $CaCO_3$.
4. **(a)** Which step of the process in Figure 2.25 is measured in this experiment? **(b)** Are the results of this experiment consistent with the hypothesis that increased atmospheric $[CO_2]$ will slow the growth of coral reefs? Why or why not?

Instructors: A version of this Scientific Skills Exercise can be assigned in **Mastering Biology**.

NEW! 24 chapters contain links to papers from *Science* on the **AAAS Science in the Classroom** website, where the papers are annotated to aid student comprehension.

Explore Scientific Papers with Science in the Classroom AAAS
How are some coral reefs responding to climate change?
Go to "Take the Heat" at www.scienceintheclassroom.org.
Instructors: Questions can be assigned in **Mastering Biology**.

The gray surround s/b the same blue as the background to Chapter Review pages in text —PS



ED? larger and lower image? —PS

NEW! Problem-Solving Exercises guide students in applying scientific skills and intepreting real data in the context of solving a real-world problem.

Problem-Solving Exercise

In this exercise, you will investigate whether a piece of salmon has been fraudulently labeled.

Your Approach The principle guiding your investigation is that DNA sequences from within a species or from closely related species are more similar to each other than are sequences from more distantly related species.

Your Data You've been sold a piece of salmon labeled as coho salmon (*Oncorhynchus kisutch*). To see whether your fish was labeled correctly, you will compare a short DNA sequence from your sample to standard sequences from the same gene for three salmon species. The sequences are:

Sample labeled as *O. kisutch* (coho salmon)	5′-CGGCACCGCCCTAAGTCTCT-3′
Standard sequences: Sequence for *O. kisutch* (coho salmon)	5′-AGGCACCGCCCTAAGTCTAC-3′
Standard sequences: Sequence for *O. keta* (chum salmon)	5′-AGGCACCGCCCTGAGCCTAC-3′
Standard sequences: Sequence for *Salmo salar* (Atlantic salmon)	5′-CGGCACCGCCCTAAGTCTCT-3′

Your Analysis

1. Circle any bases in the standard sequences that do not match the sequence from your fish sample.
2. How many bases differ between **(a)** *O. kisutch* and your fish sample? **(b)** *O. keta* and the sample? **(c)** *S. salar* and the sample?
3. For each standard, what percentage of its bases are identical to your sample?
4. Based on these data alone, state a hypothesis for the species identity of your sample. What is your reasoning?

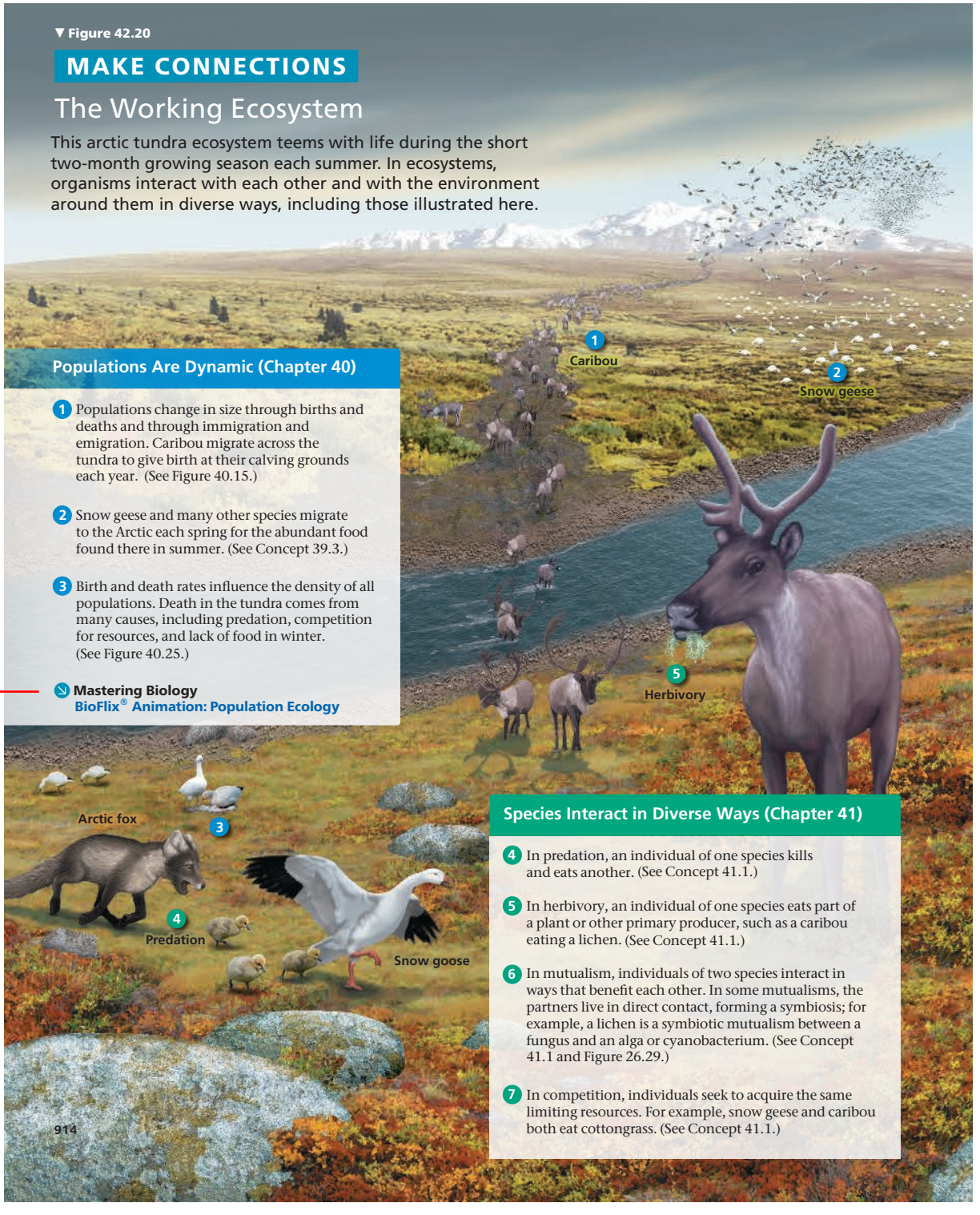
Instructors: A version of this Problem-Solving Exercise can be assigned in Chapter 3 of **Mastering Biology**. A more extensive investigation is in Chapter 20 of **Mastering Biology**.

CHAPTER 3 CARBON AND THE MOLECULAR DIVERSITY OF LIFE 71

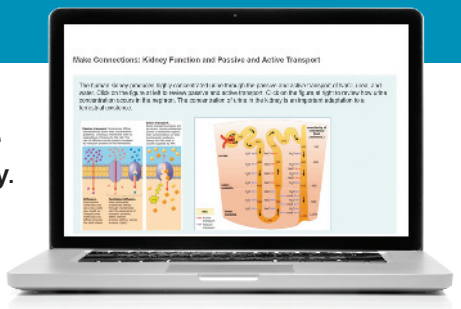
- Scientific Skills Exercises, Problem-Solving Exercises **(NEW!)**, and AAAS Science in the Classroom articles **(NEW!)** are all **assignable** through **Mastering Biology**.

Focus on Making Connections

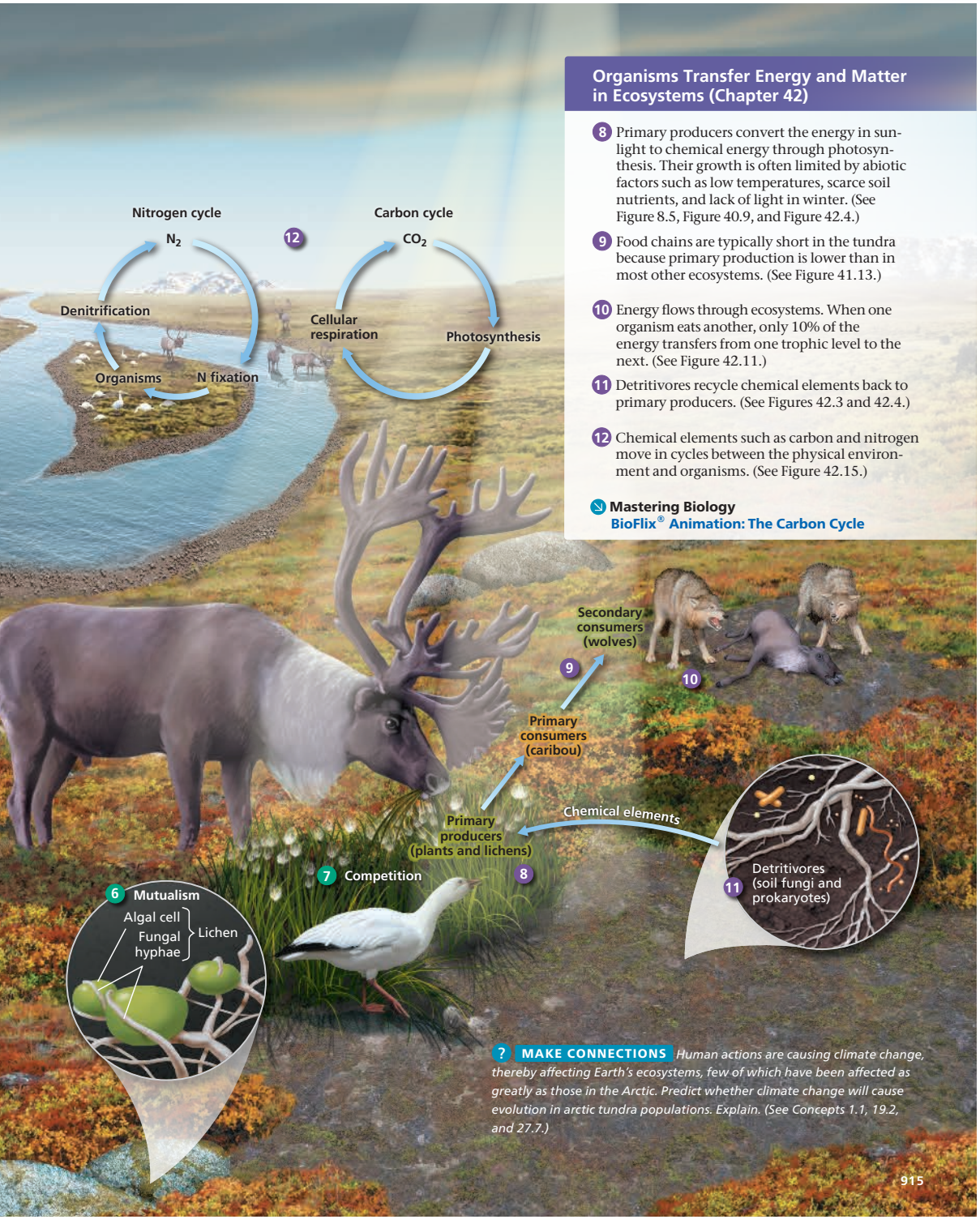
Ten **Make Connections Figures** pull together content from different chapters, providing a visual representation of "big picture" relationships.



NEW! Media references in the text direct students to digital content in the **Mastering Biology** eText and Study Area.



▶ **Make Connections Tutorials** are **assignable** in **Mastering Biology**.



Organisms Transfer Energy and Matter in Ecosystems (Chapter 42)

8 Primary producers convert the energy in sunlight to chemical energy through photosynthesis. Their growth is often limited by abiotic factors such as low temperatures, scarce soil nutrients, and lack of light in winter. (See Figure 8.5, Figure 40.9, and Figure 42.4.)

9 Food chains are typically short in the tundra because primary production is lower than in most other ecosystems. (See Figure 41.13.)

10 Energy flows through ecosystems. When one organism eats another, only 10% of the energy transfers from one trophic level to the next. (See Figure 42.11.)

11 Detritivores recycle chemical elements back to primary producers. (See Figures 42.3 and 42.4.)

12 Chemical elements such as carbon and nitrogen move in cycles between the physical environment and organisms. (See Figure 42.15.)

Mastering Biology
BioFlix® Animation: The Carbon Cycle

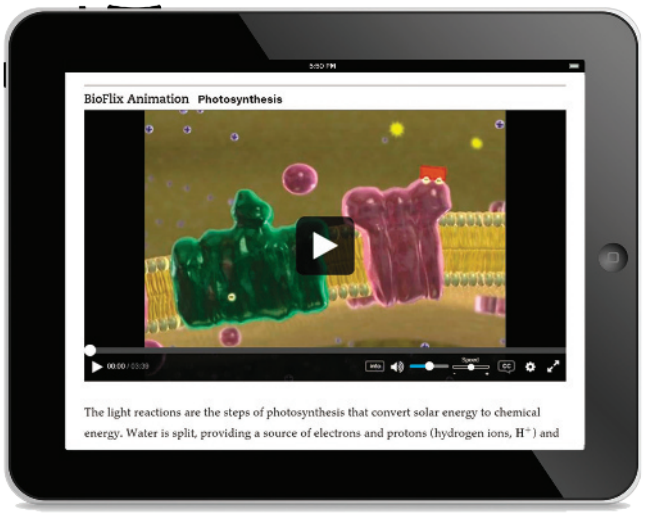
◀ **Make Connections Questions** in every chapter ask students to relate content to material presented earlier in the course.

Focus on Student Success with **Mastering Biology**

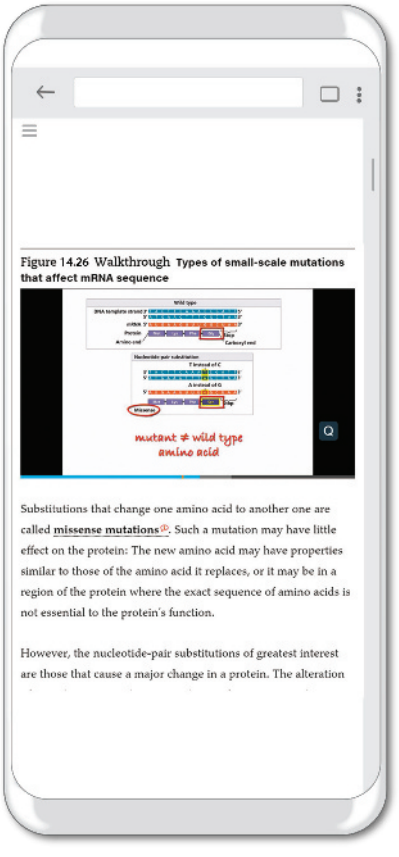
NEW! The **eText** includes over 450 **Videos, Animations,** and **Figure Walkthroughs** integrated into the digital text, plus **Get Ready for This Chapter Questions**, **Vocab Self-Quizzes**, and **Practice Tests**.

▼ Videos

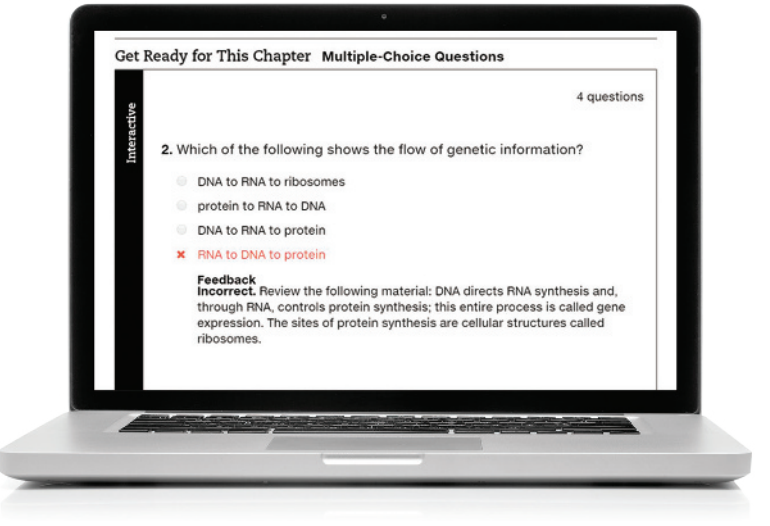
▼ Animations



▼ Figure Walkthroughs



▼ Get Ready for This Chapter Questions



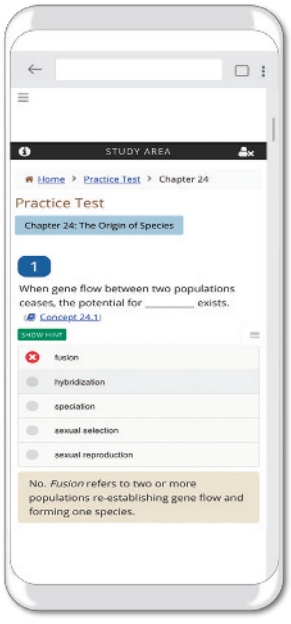
NEW! Additional eText features include:

- Instructor and student note-taking; notes can be shared
- Highlighting
- Bookmarking
- Search
- Links to Glossary terms
- Accessible (screen-reader ready)
- The Pearson eText mobile app can be downloaded from the Apple App Store or Google Play. Includes offline access.

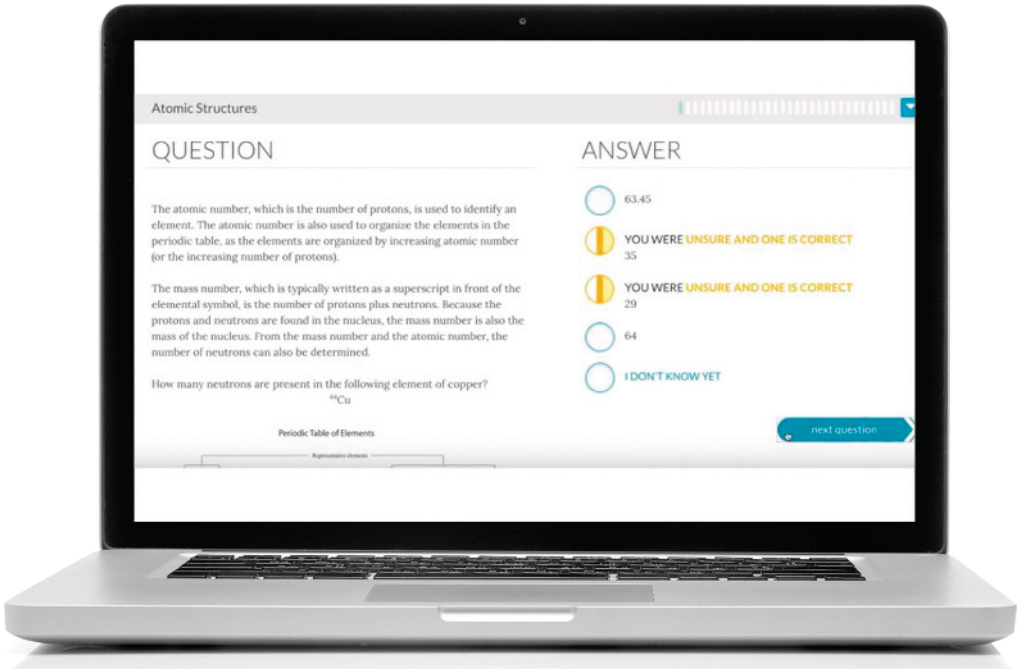
Students who prefer to read a print book can watch videos and animations and test themselves in the **Study Area** as they read.

▼ Animations and Videos

▼ Practice Tests



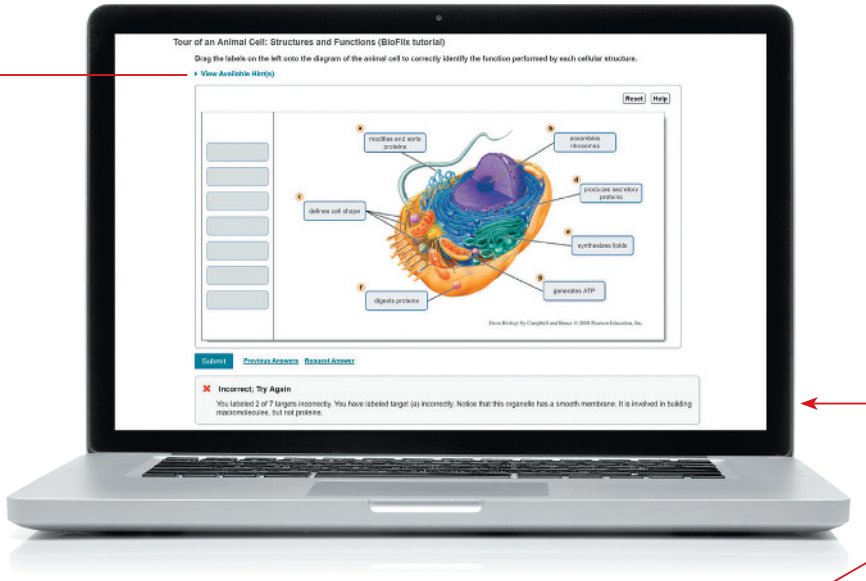
Dynamic Study Modules allow students to test, learn, and retest until they achieve mastery of the content.



▲

NEW! The eText, Study Area, and Dynamic Study Modules can be accessed from any **computer, tablet, or smartphone**.

Focus on Personalized Coaching in Mastering Biology



Instructors can assign self-paced **Mastering Biology tutorials** that provide students with individualized coaching with specific hints and feedback on the toughest topics in the course.

If a student gets stuck...

1. Specific **wrong-answer feedback** appears in the gray feedback box.

2. **Hints** coach the student to the correct response.

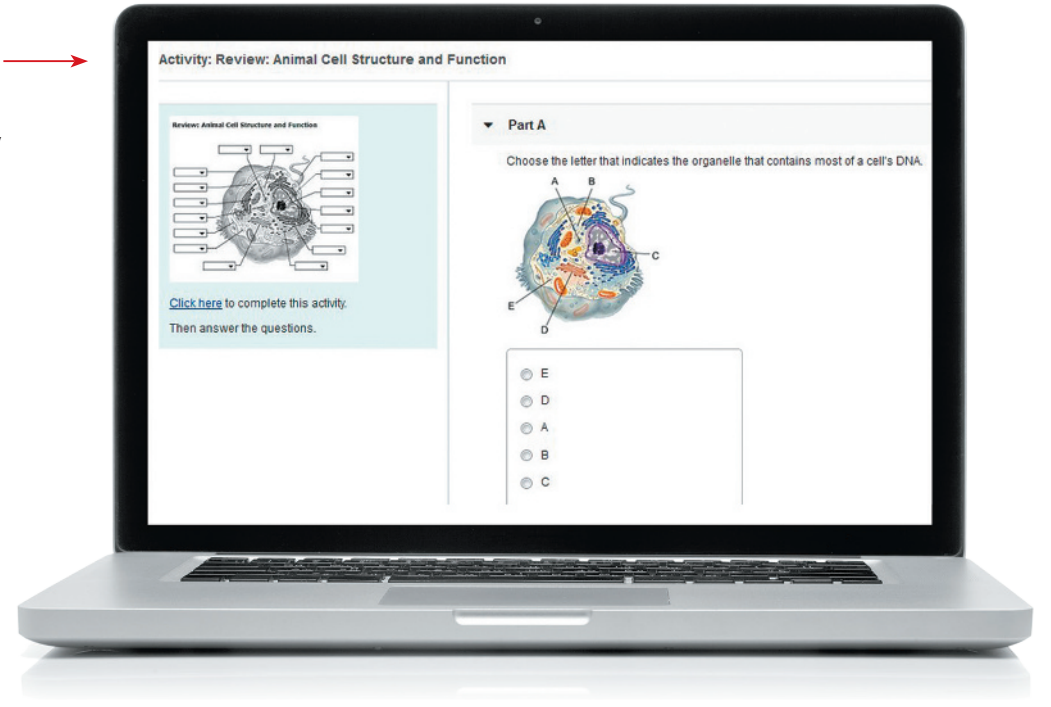
Hint 1. Structure and function of cell organelles

The structure of each organelle in a eukaryotic cell makes it very well-suited for the task it performs. Some examples are described here.

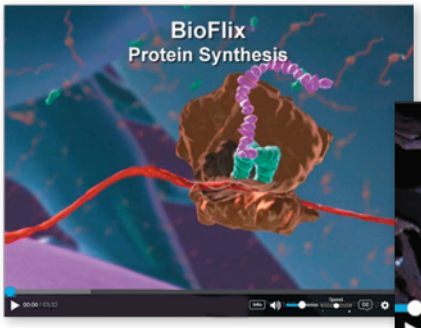
- **Rough endoplasmic reticulum**: This organelle plays an important role in the synthesis of secretory proteins. The outer surfaces of rough ER are studded with ribosomes, the sites where proteins are made. As a protein chain grows from a bound ribosome, it is threaded through a pore in the ER membrane. Once inside, protein folding occurs.
- **Golgi apparatus**: The Golgi is composed of a series of flattened membranous discs called cisternae. Each cisterna forms an enclosed space that houses a distinct set of enzymes used to process proteins in a sequential manner as they are prepared for transport to different sites.
- **Mitochondria**: The inner membrane of a mitochondrion has extensive infoldings, which greatly increase the surface area available for key reactions in the energy-producing processes of cellular respiration.

Hint 2. Which organelles are involved in protein secretion?

3. Optional **Adaptive Follow-Up Assignments** provide additional coaching and practice as needed, continuously adapting to each student's needs.



▼ **Mastering Biology** offers thousands of tutorials, activities, and questions that can be assigned as homework. A few examples are shown below.



▲

NEW! Grants in the Galápagos Videos filmed by Peter and Rosemary Grant come with assignable activities in **Mastering Biology**.

BioFlix Tutorials use 3-D, movie quality animations and coaching exercises to help students master tough topics outside of class. Animations are also available in the eText and Study Area and can be shown in class.

EXPANDED! HHMI BioInteractive Short Films, documentary-quality movies from the Howard Hughes Medical Institute, engage students in topics from the discovery of the double helix to evolution, with assignable questions.

▼ **NEW! Early Alerts** provide instructors with valuable insights into student performance through a new dashboard in **Mastering Biology**.

Focus on Active Learning

Ready-to-Go Teaching Modules help instructors efficiently make use of the best teaching tools before, during, and after class.

With the Ready-to-Go Teaching Modules, instructors can easily incorporate **active learning** into their courses using suggested activity ideas and questions.

NEW! We've added five more teaching modules. All the modules can be accessed through the Instructor Resources area of **Mastering Biology**.

- **Videos** demonstrate how the activities can be used in class.

- **Learning Catalytics™** allows students to use their smartphone, tablet, or laptop to respond to questions in class. Visit learningcatalytics.com.

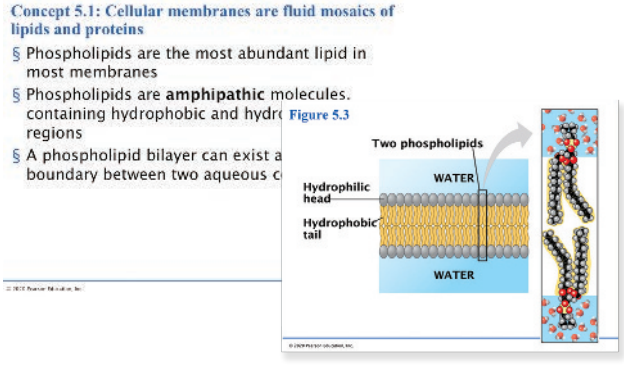
More Instructor Resources

The Instructor Resources Area of Mastering Biology

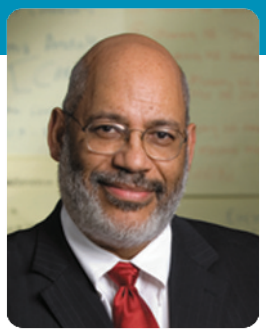
- **5 NEW!** Ready-to-Go Teaching Modules help instructors efficiently make use of the available teaching tools for the toughest topics. Before-class assignments, in-class activities, and after-class assignments are provided for ease of use. Instructors can incorporate active learning into their course with the suggested activity ideas and clicker questions or Learning Catalytics questions.
- Editable figures (art and photos) and tables from the text in PowerPoint®
- PowerPoint Lecture Presentations for each chapter with lecture notes, editable figures (art and photos), tables, and links to animations and videos
- Accessible PowerPoint Lecture Presentations with alt text for every image; students can access alt text with a screen reader if needed.
- JPEG images, including labeled and unlabeled art, photos from the text, and extra photos
- Clicker Questions in PowerPoint
- **EXPANDED!** 450+ instructor animations and videos, including BioFlix® 3-D Animations, HHMI Videos and Animations, ABC News Videos, and much more
- Test Bank questions in TestGen® software and Microsoft® Word. This invaluable resource contains over 4,500 questions, including scenario-based questions and art, graph, and data interpretation questions. **NEW!** Every image has alt text, which students can access with a screen reader if needed.
- **NEW! Mastering Biology** Item Library Reference Guide: An at-a-glance reference to assignable resources
- **NEW!** Statistics Worksheets for Biology
- Instructor Answers to Scientific Skills Exercises, Problem-Solving Exercises, Interpret the Data questions, and essay questions; includes rubric and tips for grading short-answer essays
- Instructor Guides for Supplements: Instructor Guide for *Practicing Biology: A Student Workbook*; Instructor Guide for *Biological Inquiry: A Workbook of Investigative Cases*; Answer Key for *Inquiry in Action: Interpreting Scientific Papers; Investigating Biology Lab Prep Guide*; and *Investigating Biology* Lab Data Tables

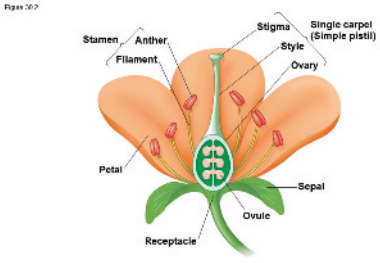
Learning Management Systems

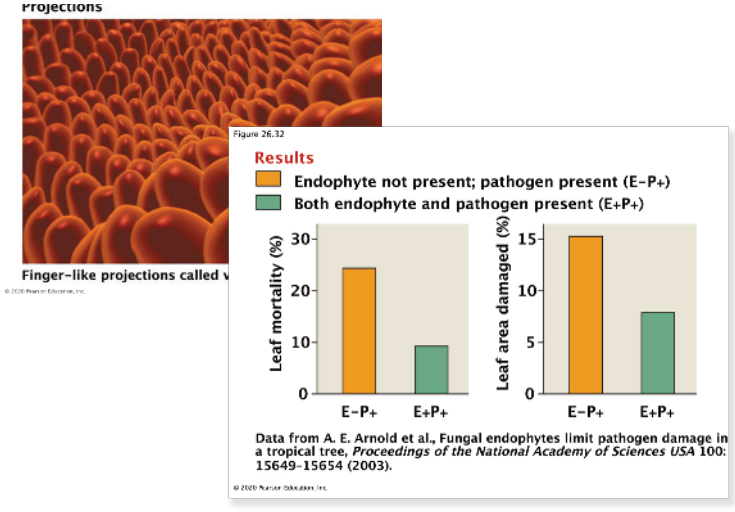
Integration with various learning management systems is available for **Mastering Biology**. Contact your sales representative for details.



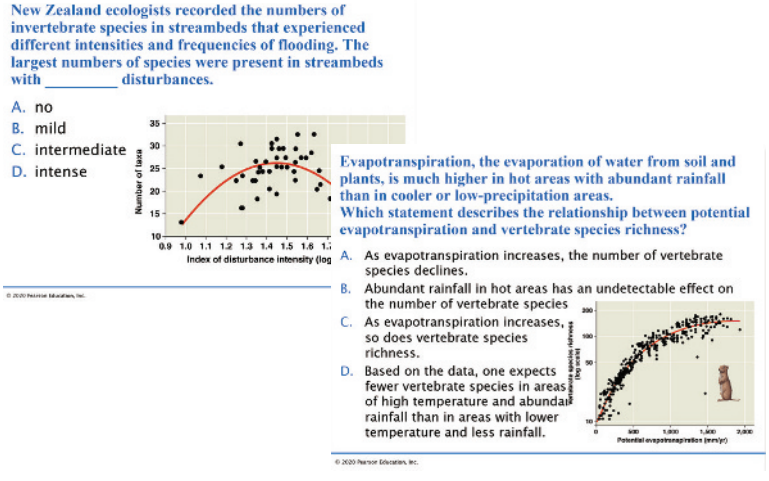
▲ **Customizable PowerPoint Lectures** provide a jumpstart for instruction.







▲ **All of the art, graphs, and photos from the text** are provided with enlarged, customizable labels. More than 1,600 photos from the text and other sources are included.



▲ **Clicker Questions** can be used to stimulate effective classroom discussions (for use with or without clickers).

Preface

The eye of the iguana (*Iguana iguana*) that gazes attentively from the cover of this book has a suite of evolutionary adaptations that give it excellent color vision and long-distance vision, helping the iguana find food and avoid predators. The iguana's remarkable eye is an apt metaphor for our goal in writing this text: to focus with high intensity on the core concepts that introductory biology students need to master to build a solid foundation in biology.

The current explosion of biological information, while exhilarating in its scope, poses a significant challenge—how best to teach a subject that is constantly expanding. In particular, instructors have become increasingly concerned that their students are overwhelmed by an excessive volume of detail and are losing sight of the big ideas in biology. In response to this challenge, various groups of biologists have initiated efforts to refine and, in some cases, redesign the introductory biology course. In particular, the report *Vision and Change in Undergraduate Biology Education: A Call to Action** advocates focusing course material and instruction on key ideas while transforming the classroom through active learning and scientific inquiry. Many instructors have embraced such approaches and have changed how they teach. Cutting back on the amount of detail they present, they focus on core biological concepts, explore select examples, and engage in a rich variety of active learning exercises.

We were inspired by these ongoing changes in biology education to write *Campbell Biology in Focus,* a shorter textbook that has been received with widespread excitement by instructors. Guided by their feedback, we have honed the Third Edition so that it does an even better job of helping students explore the key questions, approaches, and ideas of modern biology.

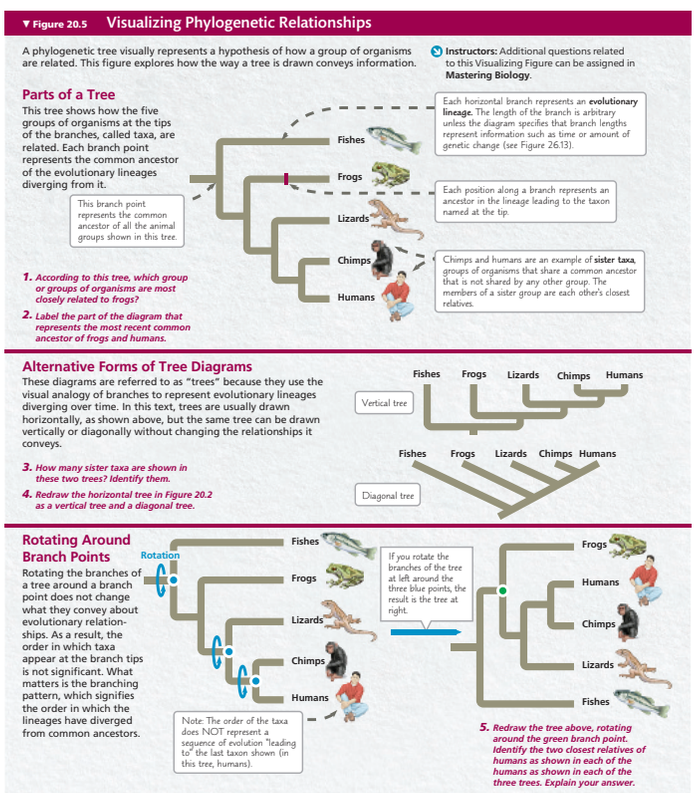
New to This Edition

Our goals for the Third Edition include:

- **increasing visual literacy** through new figures, questions, and exercises that build students' skills in understanding and creating visual representations of biological structures and processes
- giving students the opportunity to **practice scientific skills** by applying scientific skills to **real-world problems**
- **integrating text and media** to engage, guide, and inform students in an active process of inquiry and learning
- **supporting instructors** by providing teaching modules with tools and materials for introducing, teaching, and assessing important and often challenging topics

Our starting point, as always, was our commitment to crafting text and visuals that are accurate, are current, and reflect our passion for teaching biology. Here we provide an overview of the new features that we have developed for the Third Edition. We invite you to explore pages xi–xxii for more information and examples.

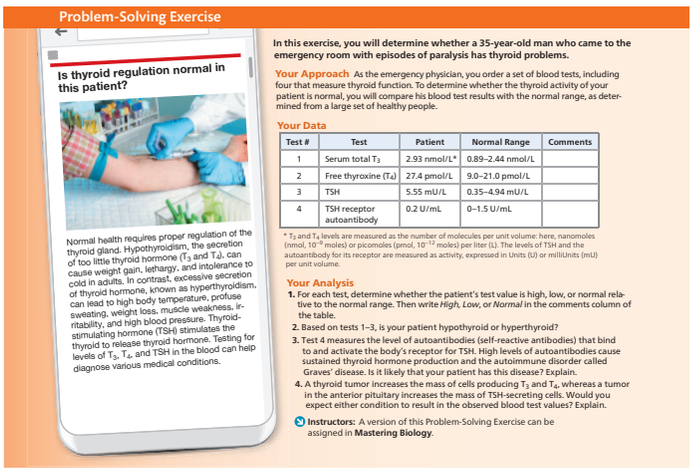
- **NEW! Visualizing Figures** and **Visual Skills Questions** help students practice interpreting and creating visual representations in biology. The Visualizing Figures have embedded questions that guide students in exploring how



* Copyright 2011 American Association for the Advancement of Science. See also *Vision and Change in Undergraduate Biology Education: Chronicling Change, Inspiring the Future* (copyright 2015 American Association for the Advancement of Science) and *Vision and Change in Undergraduate Biology Education: Unpacking a Movement and Sharing Lessons Learned* (copyright 2018 American Association for the Advancement of Science). For more information, see www.visionandchange.org.

diagrams, photographs, and models represent and reflect biological systems and processes. Assignable questions are also available in **Mastering Biology** that allow students to practice the visual skills addressed in these figures.

- **NEW! Problem-Solving Exercises** challenge students to apply scientific skills and interpret data in solving engaging real-world problems. Problem-Solving Exercises can also be assigned and automatically graded in **Mastering Biology**.



Problem-Solving Exercise

Is thyroid regulation normal in this patient?

Normal health requires proper regulation of the thyroid gland. Hypothyroidism, the secretion of too little thyroid hormone (T_3 and T_4), can cause weight gain, lethargy, and intolerance to cold in adults. In contrast, excessive secretion of thyroid hormone, known as hyperthyroidism, can lead to high body temperature, profuse sweating, weight loss, muscle weakness, irritability, and high blood pressure. Thyroid-stimulating hormone (TSH) stimulates the thyroid to release thyroid hormone. Testing for levels of T_3, T_4, and TSH in the blood can help diagnose various medical conditions.

In this exercise, you will determine whether a 35-year-old man who came to the emergency room with episodes of paralysis has thyroid problems.

Your Approach As the emergency physician, you order a set of blood tests, including four that measure thyroid function. To determine whether the thyroid activity of your patient is normal, you will compare his blood test results with the normal range, as determined from a large set of healthy people.

Your Data

Test #	Test	Patient	Normal Range	Comments
1	Serum total T_3	2.93 nmol/L*	0.89–2.44 nmol/L	
2	Free thyroxine (T_4)	27.4 pmol/L	9.0–21.0 pmol/L	
3	TSH	5.55 mU/L	0.35–4.94 mU/L	
4	TSH receptor autoantibody	0.2 U/mL	0–1.5 U/mL	

* T_3 and T_4 levels are measured as the number of molecules per unit volume: here, nanomoles (nmol, 10^{-9} moles) or picomoles (pmol, 10^{-12} moles) per liter (L). The levels of TSH and the autoantibody for its receptor are measured as activity, expressed in Units (U) or milliUnits (mU) per unit volume.

Your Analysis

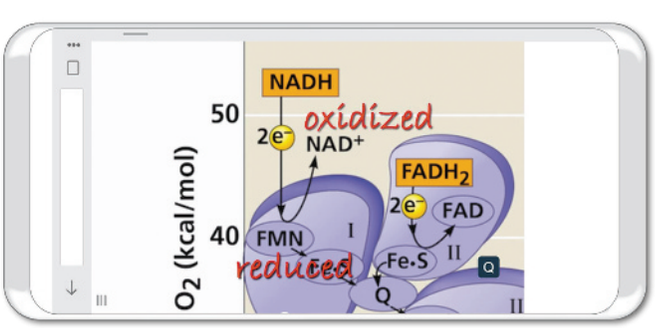
1. For each test, determine whether the patient's test value is high, low, or normal relative to the normal range. Then write *High*, *Low*, or *Normal* in the comments column of the table.
2. Based on tests 1–3, is your patient hypothyroid or hyperthyroid?
3. Test 4 measures the level of autoantibodies (self-reactive antibodies) that bind to and activate the body's receptor for TSH. High levels of autoantibodies cause sustained thyroid hormone production and the autoimmune disorder called Graves' disease. Is it likely that your patient has this disease? Explain.
4. A thyroid tumor increases the mass of cells producing T_3 and T_4, whereas a tumor in the anterior pituitary increases the mass of TSH-secreting cells. Would you expect either condition to result in the observed blood test values? Explain.

Instructors: A version of this Problem-Solving Exercise can be assigned in **Mastering Biology**.

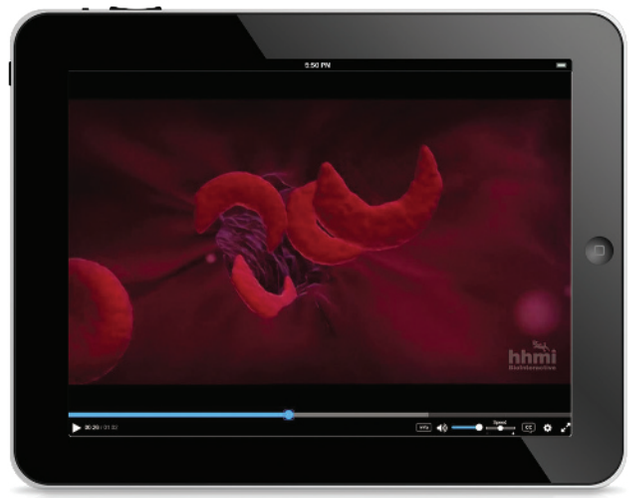
- **NEW! Integrated text and media**: Media references in the printed book direct students to a wealth of online self-study resources available to them in the **Mastering Biology eText** or **Study Area:**

  Mastering Biology
  BioFlix® Animation: Protein Synthesis

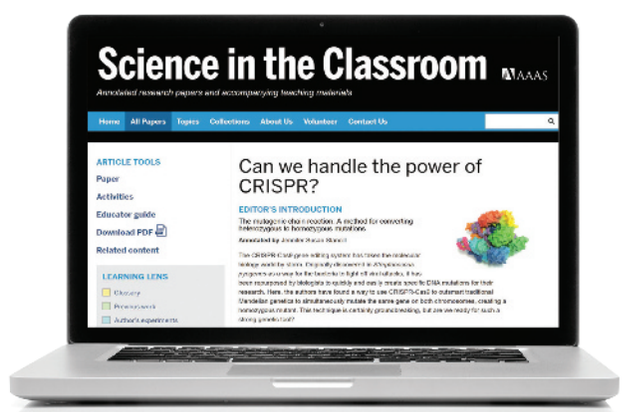
- **NEW! Get Ready for This Chapter** online questions provide a quick check of student understanding of the background information needed to learn a new chapter's content, with feedback to bolster their preparation.
- **NEW! Figure Walkthroughs** guide students through key figures with narrated explanations and figure markups that reinforce important points. Check students' understanding with assignable questions in **Mastering Biology**.



- **EXPANDED!** More than **450 animations** and **videos** bring biology to life in the Mastering Biology eText, Study Area, Instructor Resources, and Item Library. These include **BioFlix® 3-D Animations** and resources from **HHMI BioInteractive**.



- **NEW! Mastering Biology** includes automatically graded assignments with links to annotated research papers from *Science* on the **AAAS Science in the Classroom** website.



- **FIVE NEW! Ready-to-Go Teaching Modules** provide instructors with active learning exercises and assessment questions to use in class, plus **Mastering Biology** assignments that can be assigned before and after class. The Third Edition includes five new modules for a total of 15 modules.
- **EXPANDED!** The impact of **climate change** at all levels of the biological hierarchy has been expanded throughout the text, starting with a new chapter opener and Figure 2.21 in Chapter 2 and continuing with new figures and increased coverage of climate change in Chapters 22, 40, and 42.
- As in each new edition of *Campbell Biology in Focus*, the Third Edition incorporates **new content**, which is summarized on pages ~~viii~~ x. Content updates reflect rapid, current changes in technology and knowledge in the fields of genomics, gene-editing technology (CRISPR), evolutionary biology, microbiology, and more.