

TWELFTH EDITION

CAMPBELL

# BIOLOGY

URRY • CAIN • WASSERMAN  
MINORSKY • ORR



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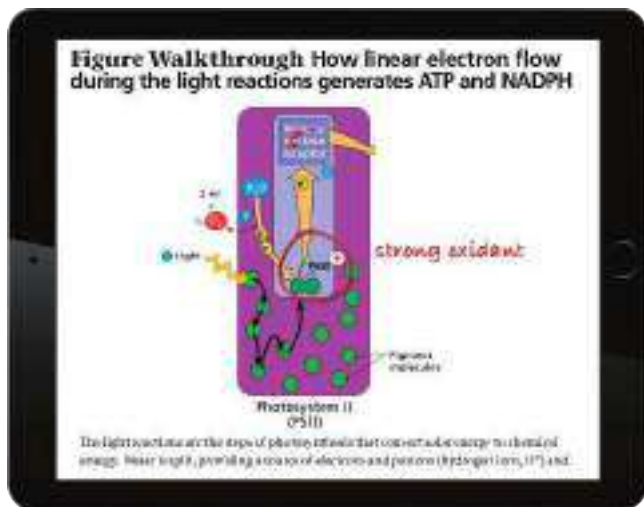
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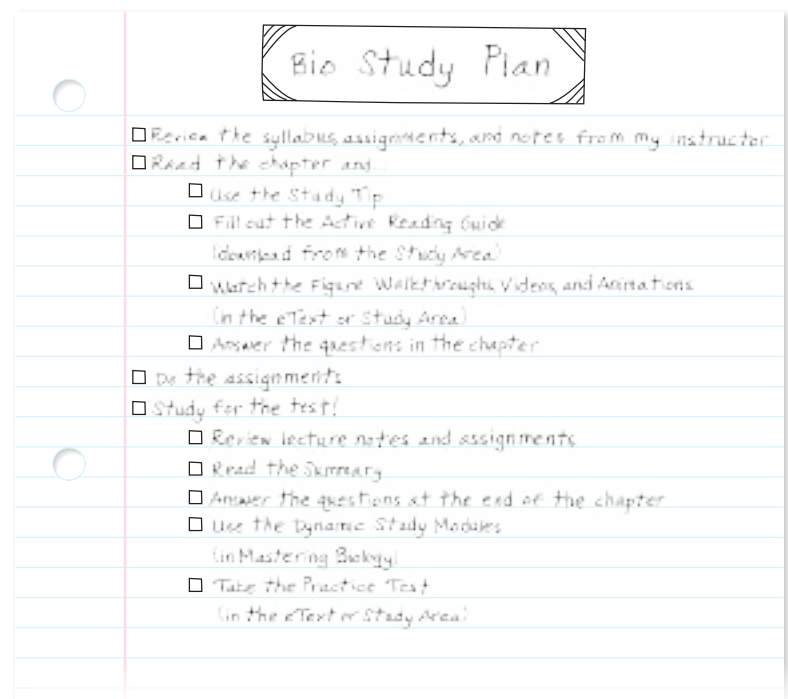
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# CAMPBELL BIOLOGY

TWELFTH EDITION



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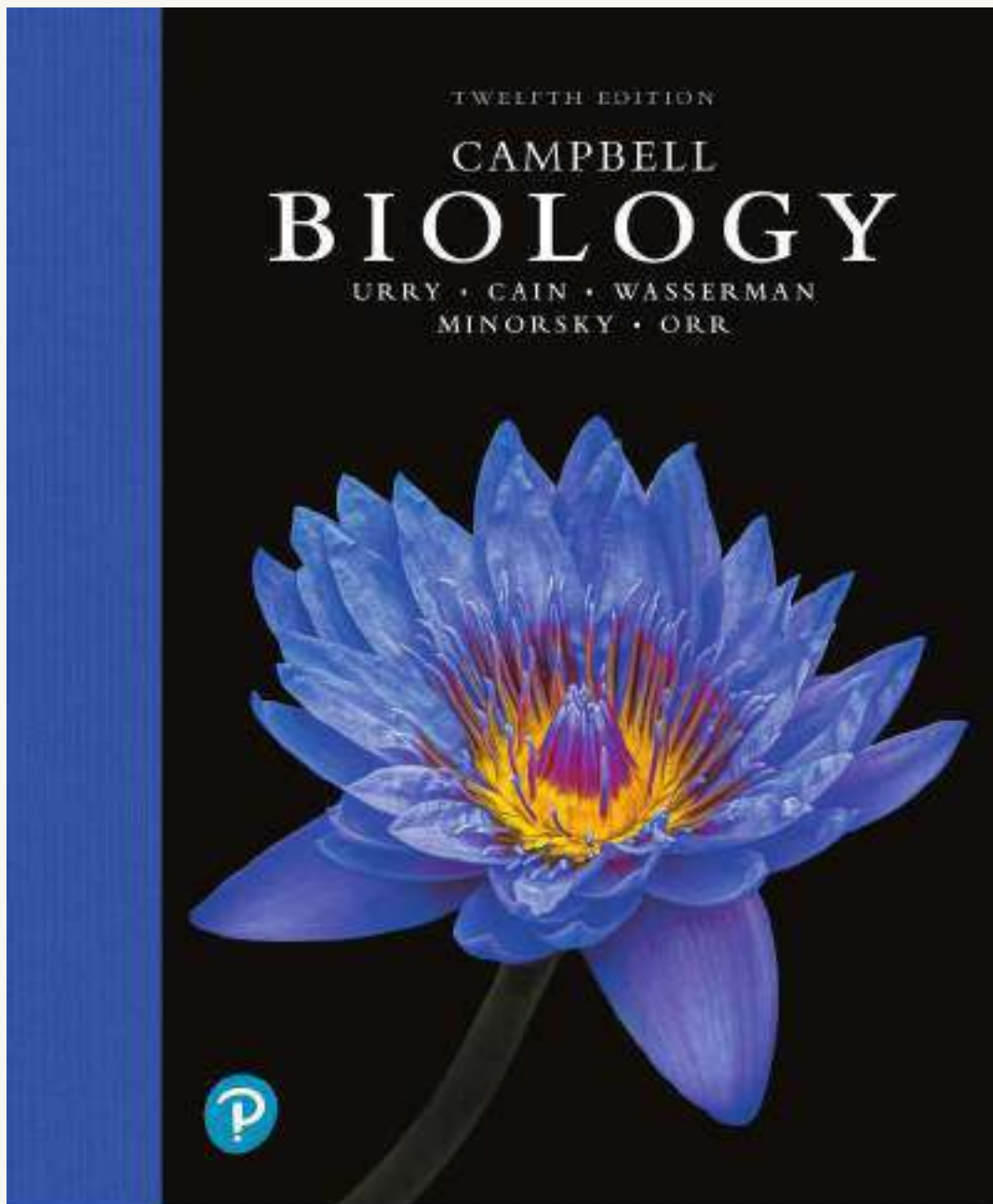


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***Campbell Biology, 12th Edition***, delivers an authoritative, accurate, current, and pedagogically innovative experience that helps students make connections so they learn and understand biology. This edition presents new, engaging visual and digital resources that meet demonstrated student needs.



# A New Visual Experience for Every Chapter

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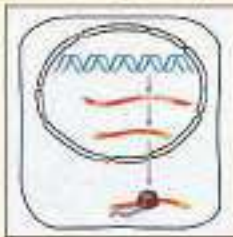
## 17 Gene Expression: From Gene to Protein

### KEY CONCEPTS

- 17.1 Genes specify proteins via transcription and translation. p. 236
- 17.2 Transcription is the DNA-directed synthesis of RNA. A Closer Look p. 242
- 17.3 Eukaryotic cells modify RNA after transcription. p. 245
- 17.4 Translation is the RNA-directed synthesis of a polypeptide. A Closer Look p. 267
- 17.5 Mutations of one or a few nucleotides can affect protein structure and function. p. 357

### Study Tip

**Make a visual study guide:** Sketch the process shown below, and add labels and details as you read the chapter. (In this exercise, assume all processes take place in a eukaryotic cell.)



### Go to Mastering Biology

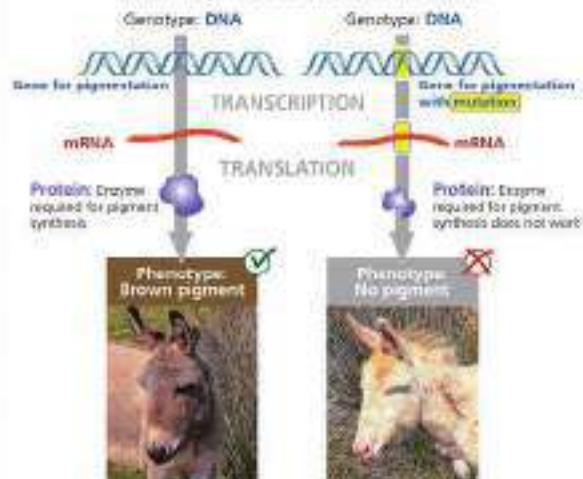
- For Students (in eText and Study Area)**
- Get Ready for Chapter 17
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  - Figure 17.27 Walkthrough: Types of Small-Scale Mutations that Affect mRNA Sequence
- For Instructors to Assign (in the Library)**
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  - Tutorial: CRISPR: A Revolution in Genome Editing
- Ready-to-Go Teaching Module (in Instructor Resources)**
- Gene Expression: Mutations (Concept 17.5)



**Figure 17.1** A population of albino donkeys grazes on vegetation on the hillside of Assiniboia, an Italian island. Several centuries ago, a recessive mutation that disables pigment synthesis arose in the DNA of one donkey and was passed down through the generations. Inbreeding has resulted in a large number of homozygous albino donkeys living on the island today.

### How can one change in DNA result in such a dramatic change in appearance?

Proteins are the link between genotype and phenotype. Gene expression is the process by which DNA directs the synthesis of proteins.



335

**NEW! A Visual Overview** helps students start with the big picture.

# 39 Plant Responses to Internal and External Signals

## KEY CONCEPTS

- 39.1 Signal transduction pathways link signal reception to response p. 841
- 39.2 Plants use chemicals to communicate p. 846
- 39.3 Responses to light are critical for plant success p. 850
- 39.4 Plants respond to a wide variety of stimuli other than light p. 861
- 39.5 Plants respond to attacks by pathogens and herbivores p. 868

### Study Tip

**Make a table:** As you read the chapter, add specific examples for each of the general categories of responses shown in the diagram.

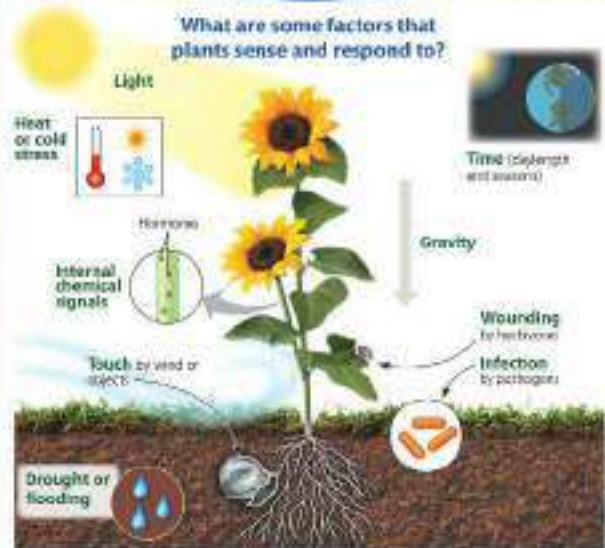
Factor	Example of plant response
Light	Seed germination in response to red light

### Go to Mastering Biology

- For Students** (in eText and Study Area)
- Get Ready for Chapter 39
  - Video: Gravitropism
  - Video: Mimosa leaves
- For Instructors to Assign** (in Item Library)
- Activity: Leaf Abscission
  - Activity: Plant Hormones



**Figure 39.5** Sunflowers track the sun from east to west each day. After sunset, they reverse direction, facing the direction of the next sunrise. By facing the sun during the day, the floral heads become warmer and release greater amounts of chemicals that attract pollinators. Light is just one of the many factors to which a plant responds.

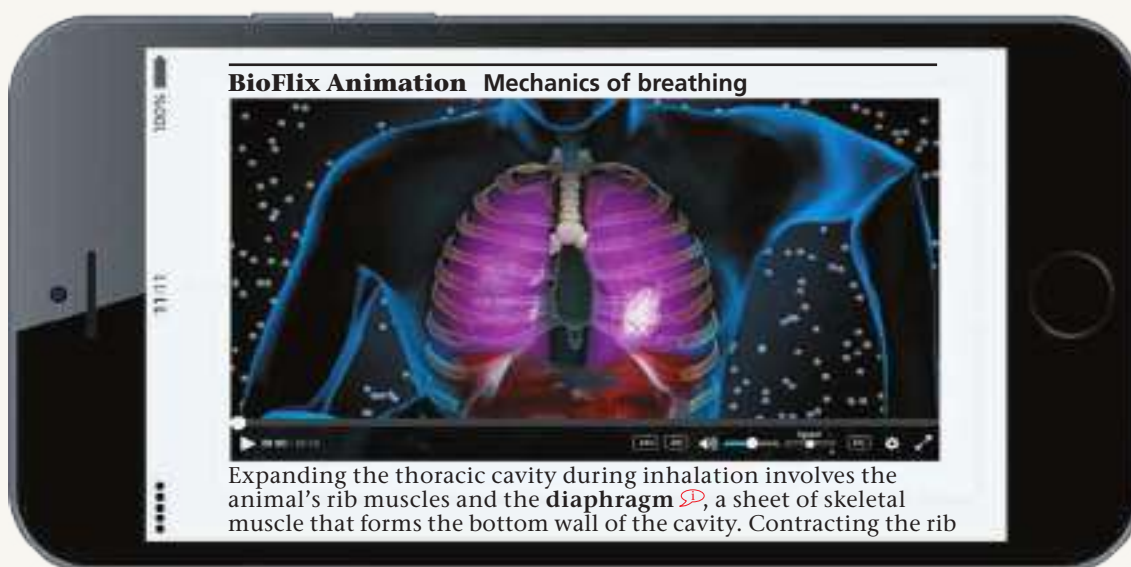


**NEW! A Study Tip** provides an activity for students to help them organize and learn the information in the chapter.

**NEW! Key Mastering Biology resources** are highlighted for students and instructors.

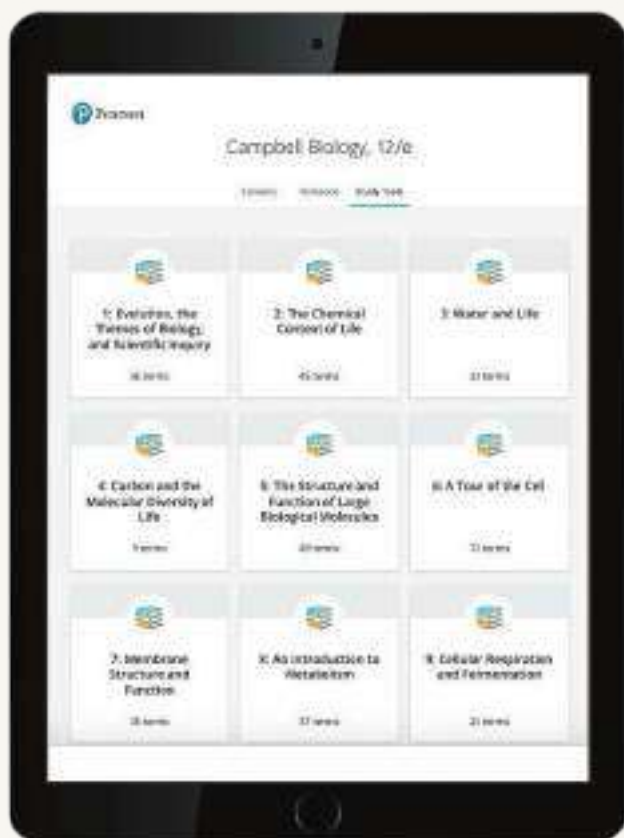
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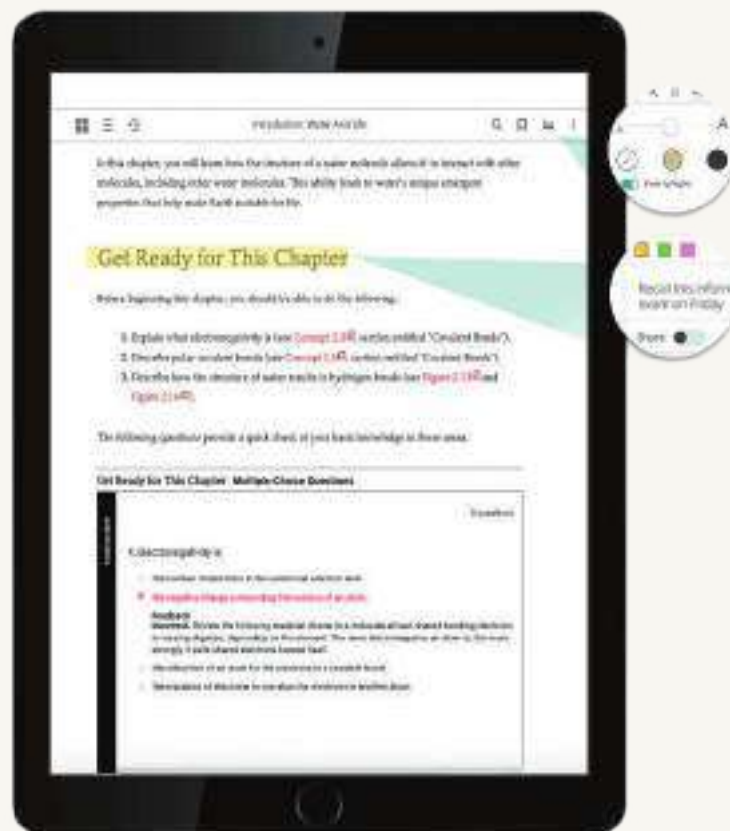


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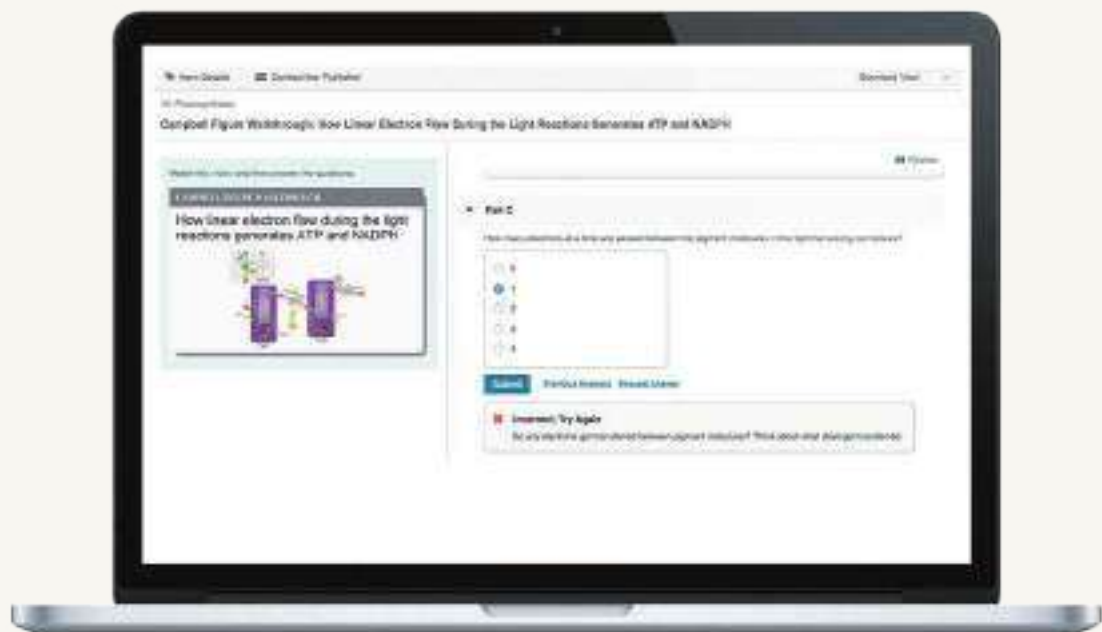
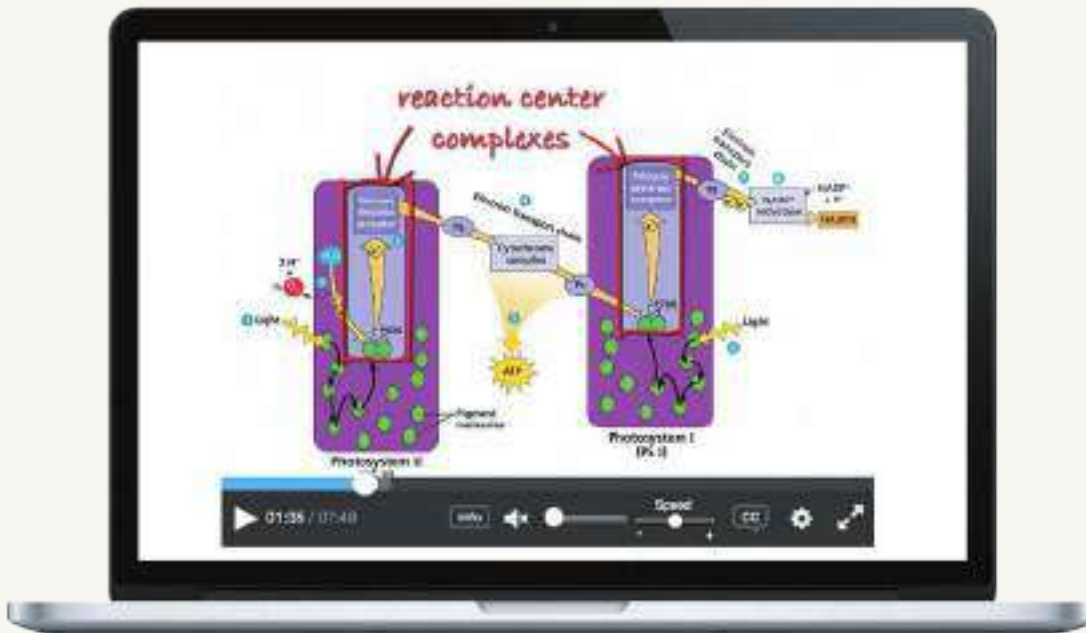


The Pearson eText app is available for download in the app store for approved devices.



# Bringing Innovative Art to Life

**NEW!** An expanded collection of **Figure Walkthroughs** guide students through key figures with narrated explanations and figure mark-ups that reinforce important points. **These are embedded in the eText and available for assignment in Mastering Biology.**



# Giving Students the Tools They Need to Succeed

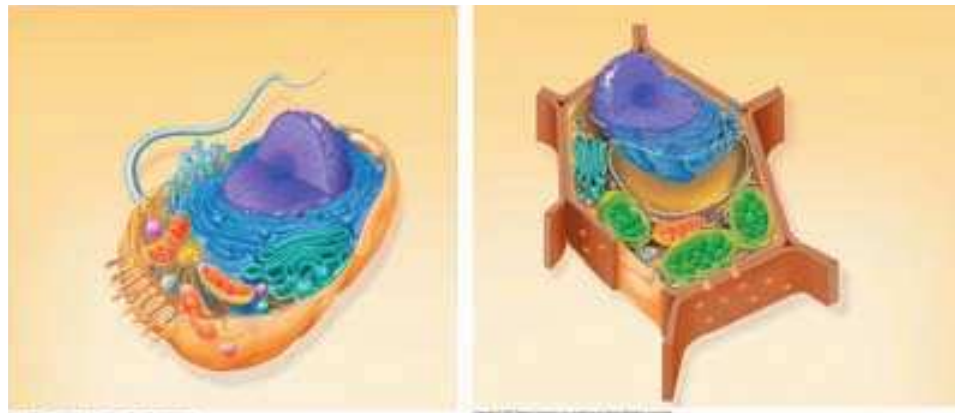
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**NEW! Science in the Classroom** presents annotated journal articles from the **American Association for the Advancement of Science (AAAS)** and makes reading and understanding primary literature easier for students. The articles include assessments in Mastering Biology, allowing instructors to assign the journal articles.

**NEW! Active Reading Guides** support students in actively reading their biology text. Students can download the worksheets from the Study Area in Mastering Biology.

35. On these diagrams of plant and animal cells, label each organelle and give a brief statement of its function.



*Concept 6.6 The cytoskeleton is a network of fibers that organizes structures and activities in the cell*

36. What is the cytoskeleton?
37. What are the three roles of the cytoskeleton?
38. There are three main types of fibers that make up the cytoskeleton. Name them.
39. *Microtubules* are hollow rods made of a globular protein called tubulin. Each tubulin protein is a dimer made of two subunits. These are easily assembled and disassembled. What are four functions of microtubules?

# Make Connections Across Multiple Concepts

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

▼ Figure 44.17

## MAKE CONNECTIONS

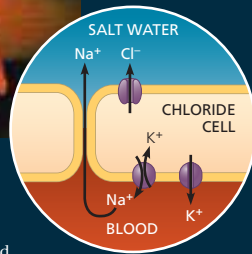
### Ion Movement and Gradients

The transport of ions across the plasma membrane of a cell is a fundamental activity of all animals, and indeed of all living things. By generating ion gradients, ion transport provides the potential energy that powers processes ranging from an organism’s regulation of salts and gases in internal fluids to its perception of and locomotion through its environment.



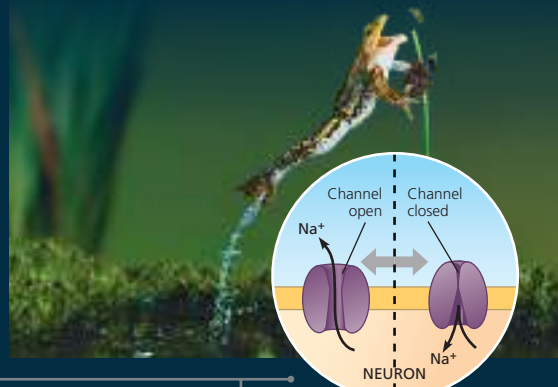
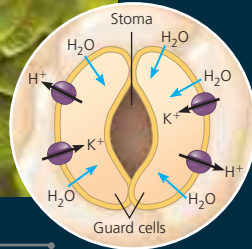
#### Osmoregulation

In marine bony fishes, ion gradients drive secretion of salt (NaCl), a process essential to avoid dehydration. Within gills, the pumps, cotransporters, and channels of specialized chloride cells function together to drive salt from the blood across the gill epithelium and into the surrounding salt water. (See Figure 44.3.)



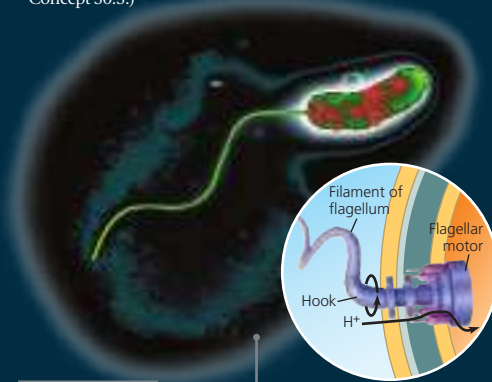
#### Gas Exchange

Ion gradients provide the basis for the opening of a plant stoma by surrounding guard cells. Active transport of  $H^+$  out of a guard cell generates a voltage (membrane potential) that drives inward movement of  $K^+$ . This uptake of  $K^+$  by guard cells triggers an osmotic influx of water that changes cell shape, bowing the guard cells outward and thereby opening the stoma. (See Concept 36.4.)



#### Information Processing

In neurons, transmission of information as nerve impulses is made possible by the opening and closing of channels selective for sodium or other ions. These signals enable nervous systems to receive and process input and to direct appropriate output, such as this leap of a frog capturing prey. (See Concept 48.3 and Concept 50.5.)



#### Locomotion

A gradient of  $H^+$  powers the bacterial flagellum. An electron transport chain generates this gradient, establishing a higher concentration of  $H^+$  outside the bacterial cell. Protons reentering the cell provide a force that causes the flagellar motor to rotate. The rotating motor turns the curved hook, causing the attached filament to propel the cell. (See Concept 9.4 and Figure 27.7.)

#### MAKE CONNECTIONS

Explain why the set of forces driving ion movement across the plasma membrane of a cell is described as an electrochemical (electrical and chemical) gradient (see Concept 7.4).

➔ Mastering Biology BioFlix® Animation: Membrane Transport

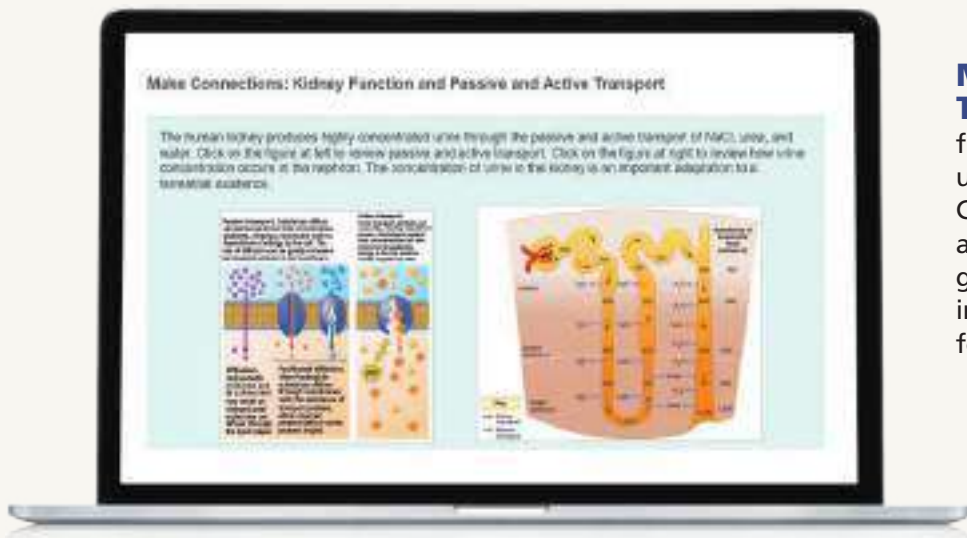
## Make Connections

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

### CONCEPT CHECK 24.2

1. Summarize key differences between allopatric and sympatric speciation. Which type of speciation is more common, and why?
2. Describe two mechanisms that can decrease gene flow in sympatric populations, thereby making sympatric speciation more likely to occur.
3. **WHAT IF?** Is allopatric speciation more likely to occur on an island close to a mainland or on a more isolated island of the same size? Explain your prediction.
4. **MAKE CONNECTIONS** Review the process of meiosis in Figure 13.8. Describe how an error during meiosis could lead to polyploidy.

*For suggested answers, see Appendix A.*



## Make Connections Tutorials

connect content from two different chapters using art from the book. Make Connections Tutorials are assignable and automatically graded in Mastering Biology and include answer-specific feedback for students.

# Develop Scientific Skills

**Scientific Skills Exercise**

## Analyzing Polypeptide Sequence Data

**Are Rhesus Monkeys or Gibbons More Closely Related to Humans?** In this exercise, you will look at amino acid sequence data for the  $\beta$ -globin polypeptide chain of hemoglobin, often called  $\beta$ -globin. You will then interpret the data to hypothesize whether the monkey or the gibbon is more closely related to humans.

**How Such Experiments Are Done** Researchers can isolate the polypeptide of interest from an organism and then determine the amino acid sequence. More frequently, the DNA of the relevant gene is sequenced, and the amino acid sequence of the polypeptide is deduced from the DNA sequence of its gene.

**Data from the Experiments** In the data below, the letters give the sequence of the 146 amino acids in  $\beta$ -globin from humans.

Human, monkey, and gibbon sequences are aligned so that their amino acids are in the same columns. Because a complete sequence would not fit on one line here, the sequences are divided into three segments: amino acids 1–50, 51–100, and 101–146. The sequences for the three different species are aligned so that you can compare them easily. For example, you can see that for all three species, the first amino acid is a V (valine) and the 100th amino acid is H (histidine).

**INTERPRET THE DATA**

- Scan the monkey and gibbon sequences, letter by letter, finding any amino acids that do not match the human sequence. (a) How many amino acids differ between the monkey and the human sequence? (b) Between the gibbon and human?
- For each nonhuman species, what percent of its amino acids are identical to the human sequence of  $\beta$ -globin?
- Based on these data alone, write a hypothesis for which of these two species is more closely related to humans. What is your reasoning?
- What other evidence could you use to support your hypothesis?

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

Species	Alignment of Amino Acid Sequences of $\beta$ -globin
Human	1 VHLTPEDDA VTALAGKRII BENGQELSR LLVYPNTR FFEFGRLST
Monkey	1 VHLTFEDDA VTTLAGKRII BENGQELSR LLVYPNTR FFEFGRLSS
Gibbon	1 VHLTFEDDA VTALAGKRII BENGQELSR LLVYPNTR FFEFGRLST
Human	51 PDAMGKPY IAKGKIVLGA FSGIARLEK LKSTFAQLSE LKCEALVDFP
Monkey	51 PDAMGKPY IAKGKIVLGA FSGIARLEK LKSTFAQLSE LKCEALVDFP
Gibbon	51 PDAMGKPY IAKGKIVLGA FSGIARLEK LKSTFAQLSE LKCEALVDFP
Human	101 EHFELDRI VDAIARFQ ETPPYSAF QKRYGVWA LAKRIK
Monkey	101 EHFELDRI VDAIARFQ ETPPYSAF QKRYGVWA LAKRIK
Gibbon	101 EHFELDRI VDAIARFQ ETPPYSAF QKRYGVWA LAKRIK

Data from Madigan, M.D. (2006) *Life: the science of biology* (7th ed.) Sunderland, MA: Sinauer Associates, Inc. 1320–1321. <http://www.masteringbiology.com>


**Scientific Skills Exercises** in every chapter of the text use real data to build key skills needed for biology, including data analysis, graphing, experimental design, and math skills. Each exercise is also available as an automatically graded assignment in *Mastering Biology* with answer-specific feedback for students.

**Problem-Solving Exercises** guide students in applying scientific skills and interpreting real data in the context of solving a real-world problem. A version of each Problem-Solving Exercise can also be assigned in *Mastering Biology*.

**PROBLEM-SOLVING EXERCISE**

### Can declining amphibian populations be saved by a vaccine?

Amphibian populations are declining rapidly worldwide. The fungus *Batrachochytrium dendrobatidis* (*Bd*) has contributed to this decline: This pathogen causes severe skin infections in many amphibian species, leading to massive die-offs. Efforts to save amphibians from *Bd* have had limited success, and there is little evidence that frogs and other amphibians have acquired resistance to *Bd* on their own.



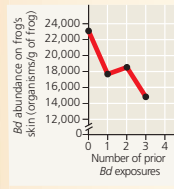
Yellow-legged frogs (*Rana muscosa*) in California killed by *Bd* infection

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

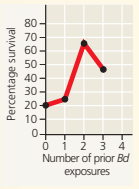
In this exercise, you will investigate whether amphibians can acquire resistance to the fungal pathogen *Bd*.

**Your Approach** The principle guiding your investigation is that prior exposure to a pathogen can enable amphibians to acquire immunological resistance to that pathogen. To see whether this occurs after exposure to *Bd*, you will analyze data on acquired resistance in Cuban tree frogs (*Osteopilus septentrionalis*).

**Your Data** To create variation in number of prior exposures to *Bd*, Cuban tree frogs were exposed to *Bd* and cleared of their infection (using heat treatments) from zero to three times; frogs with no prior exposures are referred to as "naive." Researchers then exposed frogs to *Bd* and measured mean abundance of *Bd* on the frog's skin, frog survival, and abundance of lymphocytes (a type of white blood cell involved in the vertebrate immune response).



*Bd* abundance on frog's skin (organisms per g of frog)



Percentage survival

Number of prior <i>Bd</i> exposures	Thousands of lymphocytes per g of frog
0	134
1	240
2	244
3	227

**Your Analysis**

- Describe and interpret the results shown in the figure.
- (a) Graph the data in the table. (b) Based on these data, develop a hypothesis that explains the results discussed in question 1.
- Breeding populations of amphibian species threatened by *Bd* have been established in captivity. In addition, evidence suggests that Cuban tree frogs can acquire resistance after exposure to dead *Bd*. Based on this information and your answers to questions 1 and 2, suggest a strategy for repopulating regions decimated by *Bd*.