# Biology

## Science for Life

**WITH PHYSIOLOGY**

FIFTH EDITION


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University of Minnesota–Duluth

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# About the Authors


**Colleen Belk** and **Virginia Borden Maier** collaborated on teaching biology to non-majors for over a decade at the University of Minnesota–Duluth. This collaboration has continued for an additional decade through Virginia's move to St. John Fisher College in Rochester, New York, and has been enhanced by their differing but complementary areas of expertise. In addition to the non-majors course, Colleen Belk teaches general biology for majors, genetics, cell biology, and molecular biology courses. Virginia Borden Maier teaches general biology for majors, evolutionary biology, zoology, plant biology, ecology, and conservation biology courses.

After several somewhat painful attempts at teaching the breadth of biology to non-majors in a single semester, the two authors came to the conclusion that they needed to find a better way. They realized that their students were more engaged when they understood how biology directly affected their lives. Colleen and Virginia began to structure their lectures around stories they knew would interest students. When they began letting the story drive the science, they immediately noticed a difference in student engagement and willingness to work harder at learning biology. Not only has this approach increased student understanding, but it has also increased the authors' enjoyment in teaching the course—presenting students with fascinating stories infused with biological concepts is simply a lot more fun.

# Preface

## To the Student

Is it acceptable to clone humans? When does human life begin? What should be done about our warming planet? Who owns living organisms? What are our responsibilities toward endangered species? Having taught this course for nearly 40 combined years, we understand that no amount of knowledge alone will provide satisfactory answers to these questions. Addressing them requires the development of a scientific literacy that surpasses the rote memorization of facts. To make decisions that are individually, socially, and ecologically responsible, you must not only understand some fundamental principles of biology but also be able to use this knowledge as a tool to help you analyze ethical and moral issues involving biology. This is the aim of this textbook.

To help you understand biology and apply your knowledge to an ever-expanding suite of issues, we have structured each chapter of *Biology: Science for Life* around a compelling story in which biology plays an integral role. Through the story you not only will learn the relevant biological principles but also will see how science can be used to help answer complex questions. As you learn to apply the strategies modeled by the text, you will also be developing your critical thinking skills.

Even though you may not be planning to be a practicing biologist, well-developed critical thinking skills will enable you to make better decisions about issues that affect your own life and form well-reasoned, fact-based opinions about personal, social, and ecological issues.

## To the Instructor

You are probably all too aware that teaching non-majors students is very different from teaching biology majors. You know that most of these students will never take another formal science course; therefore, your course may be the last chance for these students to appreciate how biology is woven throughout the fabric of their lives and to develop a deep understanding of the process of science. You recognize the importance of engaging non-majors because you know that these students will one day be voting on issues of scientific importance, holding positions of power in the community, serving on juries, and making health care decisions for themselves and their families. This text is designed to help you reach your goals.

By now, most non-majors biology instructors are aware that this book differs from other books in that we use a compelling storyline woven throughout the entire chapter to garner student interest. Once we draw students in, we keep them engaged by returning to the storyline again and again until the end of the chapter, when students should be able to form their own data-driven opinions about each topic. Storylines are skillfully crafted to allow the same depth and breadth of coverage as any non-majors biology text.

Our experience has taught us that students will not remember as many facts as we hope they will, but they can and do remember how to apply the scientific method to novel questions involving biology, and they can retain a strong appreciation for how science differs from other methods of understanding the world. To ensure our students leave our course with the ability to critically evaluate information they may come across, this text focuses heavily on process of science, providing opportunities for students to practice applying the scientific method and analyze data at every opportunity.

### New to the Fifth Edition

The positive feedback obtained in previous editions assured us that presenting science alongside a story works for students and instructors alike. In the fifth edition, we have added two new features and several reorganized chapters. We also updated storylines and continued to improve popular features from previous editions as well as our supplements.

### New Features: Working with Data and Sounds Right, But Is It?

In this edition, we have added new **Working with Data** questions to select figures within each chapter. Students are asked questions that guide them in how to carefully and critically analyze and interpret data in graphical, tabular, or written form. Each chapter contains at least one of these critical data analysis questions. In Chapter 6, for example, students are asked to evaluate a graph showing the cancer risks associated with smoking.

A new end-of-chapter feature, **Sounds Right, But Is It?**, addresses common misconceptions we know that our own students often have. In Chapter 4, for example, the misconception deals with whether use of laxatives can cause permanent weight loss. To help students identify

and discard such misconceptions, the description of the misconception is followed by guided inquiry questions, which lead students through a careful analysis of the reliability of the misconception, using the biological concepts from the chapter covered.

## Updated Physiology Coverage and New Chapter

Content in physiology chapters has been significantly reorganized to address concerns from instructors that too much material was covered in too few chapters; what was once covered in two chapters is now spread over three. **Chapter 17** now focuses only on tissues and organs, while the new **Chapter 18** uses a discussion of the biology of the digestive and urinary systems as a way to help students understand the biological and safety consequences of binge drinking.

## Revised Unit One Coverage

Because we have found that our students need more practice analyzing pseudoscientific information they come across, we are using **Chapter 2** of the book to build on Chapter 1's introduction to the scientific method. There, students will use their newly acquired skills to learn about life and evolution in analyzing whether zombies as they are portrayed in popular culture are "alive" and whether humans are evolutionarily progressing to become higher beings. They will learn basic biochemistry while determining whether the Bermuda Triangle is a site of massive ship and plane disappearances, whether ingesting sugar causes hyperactivity, and whether tryptophan in turkey does make people tired.

## Updated Storylines

Our chapter on cellular respiration and body weight (**Chapter 4)** incorporates new meta-data showing that being underweight is less healthy than being overweight and the health consequences of being overweight start at higher weights than once thought. Our chapter on global warming and photosynthesis (**Chapter 5**) is updated to reflect the continued global changes resulting from this process. The cell division chapter (**Chapter 6**) helps students understand the biology of differently acquired cancers using the examples of the very public battles fought by celebrities like Angelina Jolie. The protein synthesis chapter (**Chapter 9**) has been updated to reflect current developments in pet and human cloning as well as so-called genetic pharming practices.

Our review of biological diversity (**Chapter 13**) now examines the question of humanity's supposed superiority over other species. The skeletal, endocrine, and muscular system coverage (**Chapter 21**) revolves around the 2014 inclusion of women's ski jumping as an Olympic sport for the first time, and the chapter on the nervous system has been revised to focus on the phenomenon of students sharing non-prescribed ADD meds with each other (**Chapter 23**).

## Improved Pedagogy

With the previous editions, we focused on improving flexibility for instructors via **A Closer Look** chapter subsections; these are now streamlined and better identified within the text. Our popular **Roots to Remember** feature that helps students build their scientific vocabulary is now integrated into the chapter itself; students can find definitions for these terms as they occur. Features that help students assess their understanding within the chapter—**Stop and Stretch** and **Visualize This** questions—have been expanded and updated in nearly every chapter. Many **Savvy Reader** essays, found in every chapter and meant to develop students as better consumers of popular media, have been updated as well.

# Supplements and Media

For the fifth edition, we've undertaken a significant revision and updating of the complete supplements package. Judi Roux EdD, a talented college instructor with years of classroom experience in non-majors biology and colleague of Colleen Belk at the University of Minnesota, Duluth, has undertaken authoring these innovative new items. We think you will find that the supplements she developed are brimming with ideas for how to reach this particular population of students. In addition to a completely revamped Instructor's Manual (for use in traditional lectures as well as flipped classrooms) and a test bank, we also provide slides, animation, and videos to enrich instruction efforts. Available online, the *Biology: Science for Life with Physiology* resources are easy to navigate and support a variety of learning and teaching styles. Judi Roux authored not only the Instructor Guide, MasteringBiology Quiz and Test Items, but the PowerPoint lectures as well.

New features in MasteringBiology include interactive concept maps and Working with Data exercises for each chapter. And our **Learning Outcomes** continue to provide support to students and instructors by organizing the chapter summary and tagging questions and activities within MasteringBiology and other ancillary material.

We believe you will find that the design and format of this text and its supplements will help you meet the challenge of helping students both succeed in your course and develop science skills—for life.

We look forward to learning about your experience with *Biology: Science for Life with Physiology*, *Fifth Edition.*

# Compelling Stories Highlight the Relevance of Biology to Everyday Life

**Each chapter weaves a compelling story based on a current issue or hot topic that presents, explains, and demystifies biological concepts, examples, and applications.**

CHAPTER 18 **Binge Drinking**

A student is turning 21.



## ▲ UPDATED!

**Six thoroughly revised storylines** have been added to the Fifth Edition to highlight the relevance of biology concepts to everyday life, along with one entirely new storyline:

- **Chapter 2:** Science Fiction, Bad Science, and Pseudoscience
- **Chapter 4:** Body Weight and Health
- **Chapter 13:** The Greatest Species on Earth?
- **NEW CHAPTER! Chapter 18:** Binge Drinking*
- **Chapter 19:** Clearing the Air*
- **Chapter 21:** Human Sex Differences*
- **Chapter 23:** Study Drugs*

* Chapters 17–25 are included in the expanded version of the text that includes coverage of animal and plant anatomy and physiology.

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**NEW! Storyline PPTs** help instructors incorporate the stories into their lectures with videos and pre-made lectures.

# The Digestive and Urinary Systems

It's Saturday night and Malik is hosting a surprise party to celebrate the 21st birthday of his friend Lin. Lin is several years younger than Malik. She lived with Malik's family, sharing a room with his younger sister, for 2 years when she was a high school exchange student. Now an international student attending college in the United States, Lin has had almost no experience with alcohol. Malik knows that Lin is eagerly anticipating this birthday and that she is planning to drink at least a little alcohol. Because he feels as protective of Lin as he does his little sister, Malik wants to help Lin learn how to enjoy the benefits of alcohol consumption while limiting the negative consequences that can also occur.

**Malik is worried about his friend Lin.**

**He does not want her alcohol consumption to place her at risk of overdose ...**

Some of Malik's concerns about negative consequences are based on situations he has witnessed and others on information he came across while writing a paper on alcohol abuse for a health class he took last semester.

A student who lived on Malik's dorm floor freshman year broke his ankle when he tripped while running from the police to avoid an underage consumption ticket. His chemistry lab partner broke her nose when she was riding with an intoxicated driver whose car hit a tree on a snow-covered road. While working on the paper for his health class, he came across a government website that indicated over 30,000 students required medical treatment for alcohol poisoning last year and he does not want this to happen to Lin. He also worries about the high rate of sexual assault on college campuses. He does not want Lin to become one of the 20% of female students who will be sexually assaulted while in college.

Malik wants to develop a plan for convincing Lin, a pre-med biology major, that drinking too much is bad for her body, an argument he thinks she may find credible. Because he has heard that eating food before drinking might help absorb some of the alcohol and that alcohol consumption causes dehydration, he plans to focus his efforts on the effects of drinking on the digestive and urinary systems.

**... or jeopardize her safety.**

◀ NEW!

**Chapter 18*** covers the digestive and urinary systems, which were previously part of the chapters on the cardiovascular and respiratory systems. This new chapter presents this material in a more manageable format for instructors and students.

and alcohol is broken down and absorbed across the intestinal wall and into the bloodstream. When alcohol relaxes muscles involved with peristalsis, food spends more time in the digestive tract than normal and this increased exposure to digestive enzymes can cause diarrhea.

Malik has heard that it is good to eat a large meal before drinking. This is because the presence of food in the stomach causes the pyloric sphincter to remain closed. Since the stomach does not absorb alcohol as readily as the small intestine, preventing the alcohol from reaching the small intestine can slow the rate at which it reaches the blood stream. Therefore, Malik plans to take Lin out to eat before the birthday party.

Many of the digestive enzymes used in the small intestine are produced by an organ called the **pancreas.** Secretions from the pancreas neutralize stomach

▲ **The story is revisited** throughout the chapter. ▶ In these examples, the story narrative provides an opportunity for students to learn about the digestive system as they follow a student's experience with binge drinking.

wastes including urea and various ions. During urine **excretion,** urine leaves the kidneys and flows to the bladder.

Alcohol is a diuretic, which means that it promotes the formation of urine and increases the volume of urine that is released from the bladder, a process called **micturation.** Coupling the increased volume of urine produced with the deadening of awareness of the need to urinate that goes with intoxication can result in a very full bladder. Even though micturition is typically under conscious control, an intoxicated person that passes out before emptying the bladder may end up urinating on himself. In this case, the body overrides the conscious control of micturition to prevent a potentially lethal bladder rupture.

Alcohol is a depressant, slowing down brain function and altering perceptions, reflexes and balance, and causing slurred speech. In an attempt to prevent the depressant effects of intoxication, some of Malik's friends mix alcohol with energy drinks. Malik will recommend to Lin that she does not do this because Lin should develop an awareness of when to stop drinking. This is harder to do if the depressant effects of intoxication are, in part, masked by the stimulant effects of the energy drink.

In addition to managing wastes, the urinary system also plays an important role in regulating blood volume, acidity, and salt balance. The kidneys regulate

# Learn and Practice Science and Literacy Skills

**Building upon the popular features of previous editions, the Fifth Edition of *Biology: Science for Life* helps students develop scientific thinking skills for a lifetime of critically evaluating scientific—and pseudoscientific—information.**

NEW!

**Sounds Right, But Is It?** activities are located at the end of each chapter and challenge students to answer a series of questions that address common biology-related misconceptions.

SOUNDS RIGHT **BUT IS IT?**

A couple with two boys is considering having another child. While they are grateful to be fertile and to have had two healthy boys, they do think it would be fun to have a girl. In investigating their odds, they came across some data on sibships, or groups of siblings with the same parents. The study they saw showed that three-fourths of sibships of three contain members of both genders versus containing all boys or all girls. The couple now believes that their next child will very likely be a girl.

**If a couple has two boys, the odds are higher than normal that their next child will be a girl.**

Sounds right, but it isn't.

1. The probabilities of independent events, that is, events not affected by previous events, are multiplied to determine their combined probability. For example, when you flip a coin twice, the outcome of the second flip is independent of the outcome of the first flip. Therefore, the likelihood of flipping heads twice is one-half times one-half or one-fourth. What is the likelihood of flipping heads three times in a row?
2. Each fertilization of an egg by a sperm is an independent event. What is the probability that a couple will have three boys in a row?
3. The total probabilities of related independent events equal one. This means that the probability that a couple with three kids will have some outcome aside from three boys is seven-eighths. Describe, in terms of gender, what those sibships could contain.
4. While it is true that in sibships with three children seven-eighths would have at least one girl, how is looking at all the possible sibships that could be produced when there are three children different than the scenario outlined above?
5. Consider your answers to questions 1–4 and explain why the original statement bolded above sounds right, but isn't.

**Sounds Right, But Is It?** misconceptions include:

- "If a product is clinically proven to do what it advertises, that means it will work for you." —Chapter 1
- "The use of tanning beds is not only safe, it improves health." —Chapter 6
- "If a couple has two boys, the odds are higher than normal that their next child will be a girl." —Chapter 8
- "The human eye is too complex to have evolved by chance from nothing." —Chapter 11
- "There is always a chance that a brain-dead person will make a full recovery." —Chapter 17*
- "The number of vaccinations given to modern children is too much for the average immune system to handle." —Chapter 20*

…and more!

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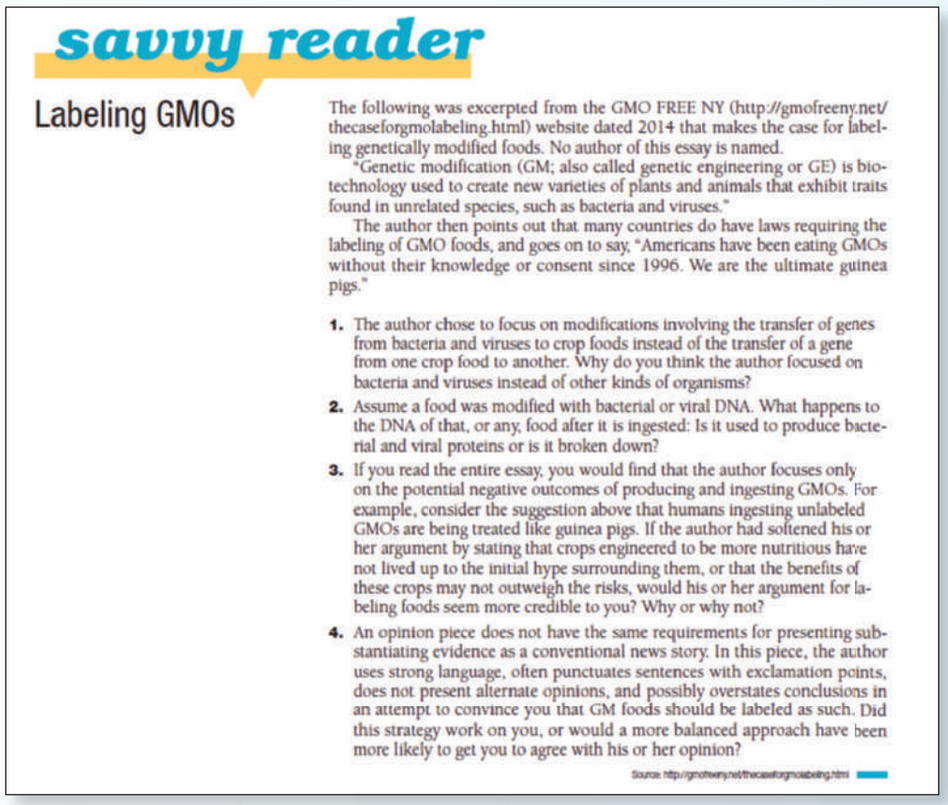
**NEW! Sounds Right, But Is It?** questions in the text are also available for in-class activities using Learning Catalytics.

* Chapters 17–25 are included in the expanded version of the text that includes coverage of animal and plant anatomy and physiology.

**Savvy Reader** activities in each chapter investigate a short excerpt from a variety of current news sources relating to discussions in the main chapter narrative. Critical thinking questions help students evaluate scientific information and data presented in the media.



savvy reader

## Labeling GMOs

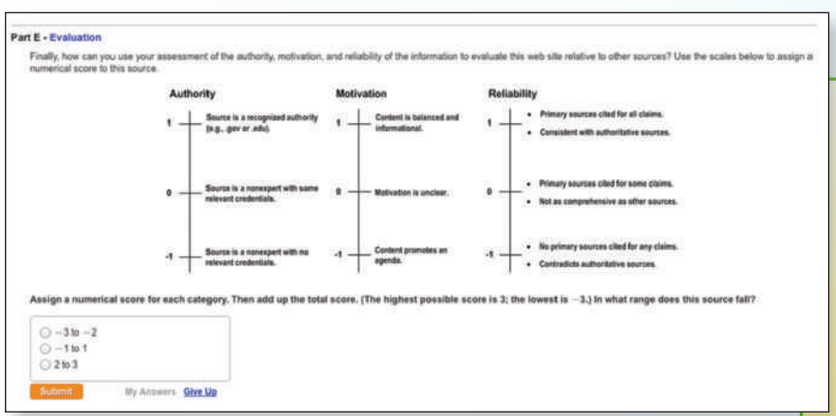
The following was excerpted from the GMO FREE NY (http://gmofreeny.net/thecaseforgmolabeling.html) website dated 2014 that makes the case for labeling genetically modified foods. No author of this essay is named.

"Genetic modification (GM; also called genetic engineering or GE) is biotechnology used to create new varieties of plants and animals that exhibit traits found in unrelated species, such as bacteria and viruses."

The author then points out that many countries do have laws requiring the labeling of GMO foods, and goes on to say, "Americans have been eating GMOs without their knowledge or consent since 1996. We are the ultimate guinea pigs."

1. The author chose to focus on modifications involving the transfer of genes from bacteria and viruses to crop foods instead of the transfer of a gene from one crop food to another. Why do you think the author focused on bacteria and viruses instead of other kinds of organisms?
2. Assume a food was modified with bacterial or viral DNA. What happens to the DNA of that, or any, food after it is ingested: Is it used to produce bacterial and viral proteins or is it broken down?
3. If you read the entire essay, you would find that the author focuses only on the potential negative outcomes of producing and ingesting GMOs. For example, consider the suggestion above that humans ingesting unlabeled GMOs are being treated like guinea pigs. If the author had softened his or her argument by stating that crops engineered to be more nutritious have not lived up to the initial hype surrounding them, or that the benefits of these crops may not outweigh the risks, would his or her argument for labeling foods seem more credible to you? Why or why not?
4. An opinion piece does not have the same requirements for presenting substantiating evidence as a conventional news story. In this piece, the author uses strong language, often punctuates sentences with exclamation points, does not present alternate opinions, and possibly overstates conclusions in an attempt to convince you that GM foods should be labeled as such. Did this strategy work on you, or would a more balanced approach have been more likely to get you to agree with his or her opinion?

Source: http://gmofreeny.net/thecaseforgmolabeling.html



Part E - Evaluation

Finally, how can you use your assessment of the authority, motivation, and reliability of the information to evaluate this web site relative to other sources? Use the scales below to assign a numerical score to this source.

| | Authority | Motivation | Reliability |
|---|---|---|---|
| 1 | Source is a recognized authority (e.g., .gov or .edu). | Content is balanced and informational. | • Primary sources cited for all claims.<br>• Consistent with authoritative sources. |
| 0 | Source is a nonexpert with some relevant credentials. | Motivation is unclear. | • Primary sources cited for some claims.<br>• Not as comprehensive as other sources. |
| -1 | Source is a nonexpert with no relevant credentials. | Content promotes an agenda. | • No primary sources cited for any claims.<br>• Contradicts authoritative sources. |

Assign a numerical score for each category. Then add up the total score. (The highest possible score is 3; the lowest is −3.) In what range does this source fall?

- −3 to −2
- −1 to 1
- 2 to 3

Submit My Answers Give Up

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**NEW! Savvy Reader: Evaluating Sources** activities ask students to examine a website, article, or video with a critical eye on the sources and methods used to convey information.

# Engage with Data and Visual Information

**The hallmark illustration style of previous editions has been enhanced in the Fifth Edition with new pedagogy to help students interpret data and other visual information.**

### Working with Data

**Is the cancer risk associated with smoking and drinking additive or multiplicative? Explain your answer.**

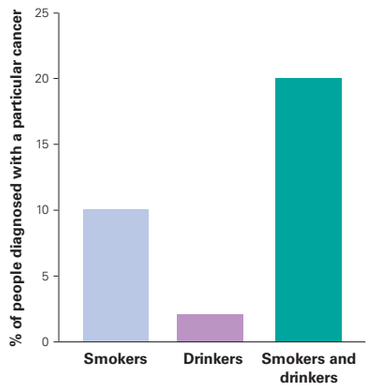


**FIGURE 6.2 Alcohol and tobacco are synergists.** Smoking cigarettes while drinking is an unhealthy practice.

### Working with Data

**The line looks relatively flat from 8000 B.C.E. to 1500 B.C.E., though the population doubled four times in that period. Was the population growing exponentially at this time?**

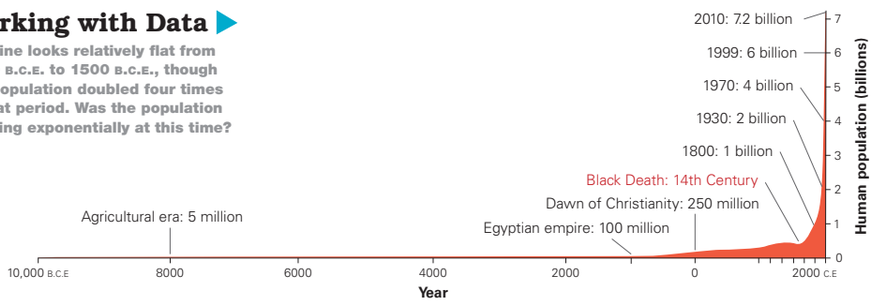


**FIGURE 14.3 Exponential growth.** The number of people on Earth grew relatively slowly until the eighteenth century. The rapid growth since then has occurred in proportion to the total, causing a J-shaped curve.

NEW!

**Working with Data** questions have been added to the figure legends of selected graphs, tables, or figures, and challenge students to closely interpret the data.

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**NEW! Working with Data** assignments are available for each chapter and ask students to analyze and apply their knowledge of biology to a graph or a set of data.

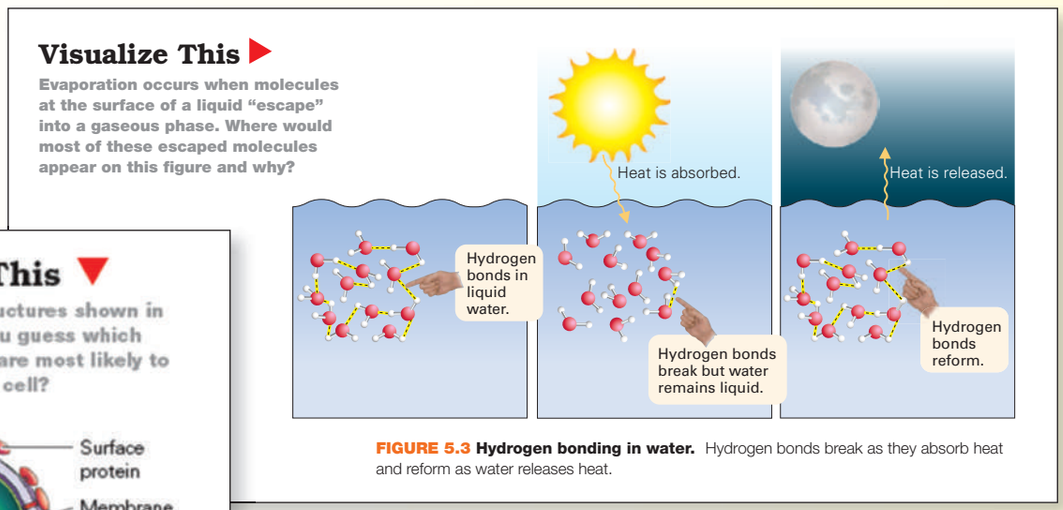



**FIGURE 5.3 Hydrogen bonding in water.** Hydrogen bonds break as they absorb heat and reform as water releases heat.

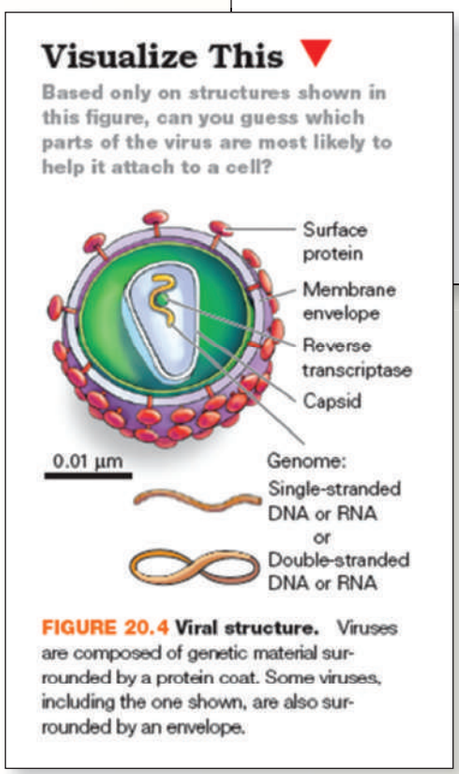
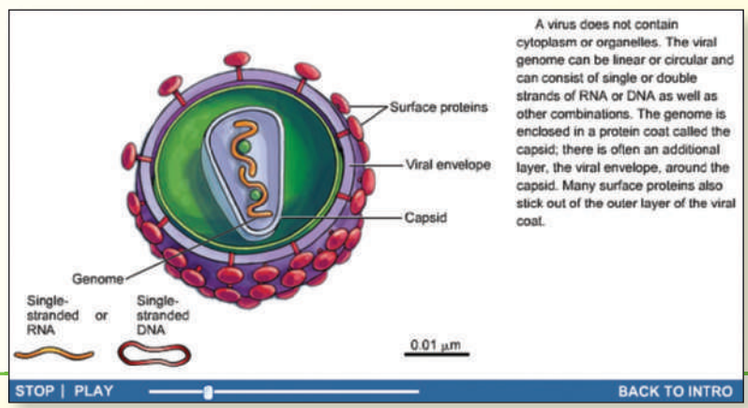



**FIGURE 20.4 Viral structure.** Viruses are composed of genetic material surrounded by a protein coat. Some viruses, including the one shown, are also surrounded by an envelope.

## EXPANDED!

**Visualize This** questions within selected figure legends encourage students to look more closely at figures to more fully understand their content.

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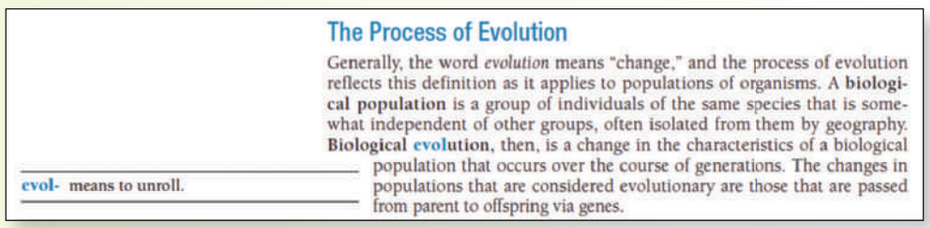
**Narrated Animations** of selected figures from the text can be assigned in MasteringBiology as activities with assessment questions that include answer-specific feedback and hints.

# Tools to Learn and Visualize Key Concepts

**Colleen Belk and Virginia Borden Maier incorporate many classroom-tested teaching techniques into the Fifth Edition prose and illustrations, making it easier for students to learn and remember unfamiliar biology concepts.**



### The Process of Evolution

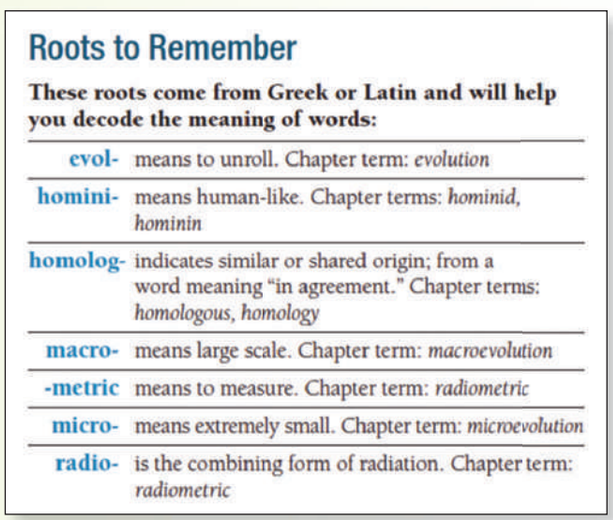
Generally, the word *evolution* means "change," and the process of evolution reflects this definition as it applies to populations of organisms. A **biological population** is a group of individuals of the same species that is somewhat independent of other groups, often isolated from them by geography. **Biological evolution**, then, is a change in the characteristics of a biological population that occurs over the course of generations. The changes in populations that are considered evolutionary are those that are passed from parent to offspring via genes.

**evol-** means to unroll.

NEW! ▲

**Roots to Remember** references have been added in context within chapter discussions to help students learn the language of biology using word roots.

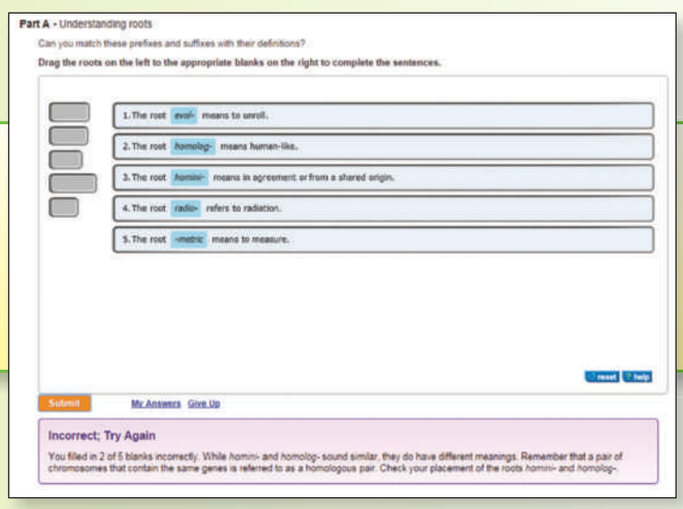
**A Roots to Remember summary** ▶ is also provided at the end of each chapter for quick reference.



### Roots to Remember

**These roots come from Greek or Latin and will help you decode the meaning of words:**

| | |
|---|---|
| **evol-** | means to unroll. Chapter term: *evolution* |
| **homini-** | means human-like. Chapter terms: *hominid, hominin* |
| **homolog-** | indicates similar or shared origin; from a word meaning "in agreement." Chapter terms: *homologous, homology* |
| **macro-** | means large scale. Chapter term: *macroevolution* |
| **-metric** | means to measure. Chapter term: *radiometric* |
| **micro-** | means extremely small. Chapter term: *microevolution* |
| **radio-** | is the combining form of radiation. Chapter term: *radiometric* |



Part A - Understanding roots

Can you match these prefixes and suffixes with their definitions?

Drag the roots on the left to the appropriate blanks on the right to complete the sentences.

1. The root evol- means to unroll.
2. The root homolog- means human-like.
3. The root homini- means in agreement or from a shared origin.
4. The root radio- refers to radiation.
5. The root -metric means to measure.

reset help

Submit My Answers Give Up

Incorrect; Try Again

You filled in 2 of 5 blanks incorrectly. While homini- and homolog- sound similar, they do have different meanings. Remember that a pair of chromosomes that contain the same genes is referred to as a homologous pair. Check your placement of the roots homini- and homolog-.

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**Roots to Remember** coaching activities provide a fun, interactive way to learn word roots.

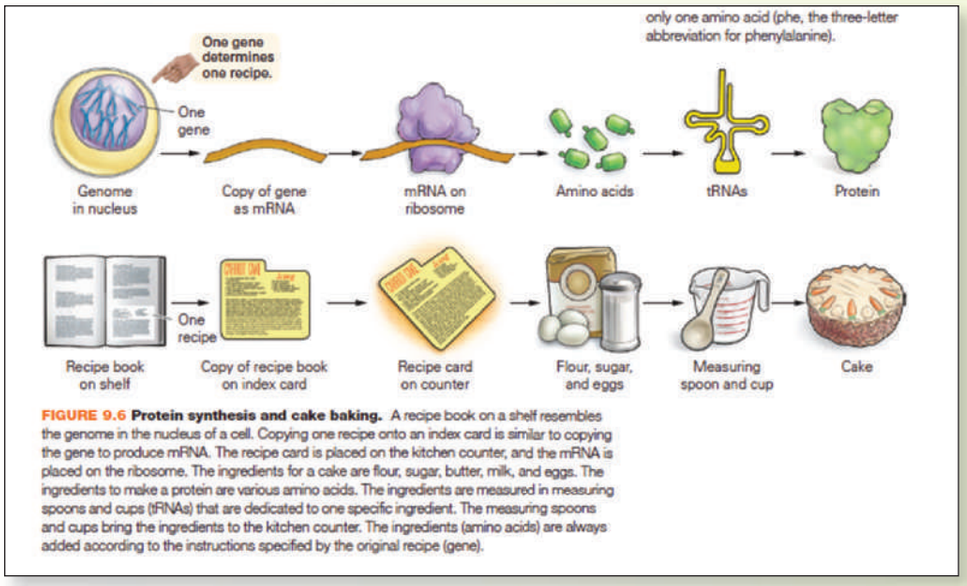



**FIGURE 9.6 Protein synthesis and cake baking.** A recipe book on a shelf resembles the genome in the nucleus of a cell. Copying one recipe onto an index card is similar to copying the gene to produce mRNA. The recipe card is placed on the kitchen counter, and the mRNA is placed on the ribosome. The ingredients for a cake are flour, sugar, butter, milk, and eggs. The ingredients to make a protein are various amino acids. The ingredients are measured in measuring spoons and cups (tRNAs) that are dedicated to one specific ingredient. The measuring spoons and cups bring the ingredients to the kitchen counter. The ingredients (amino acids) are always added according to the instructions specified by the original recipe (gene).

**Unique Visual Analogies** compare abstract science with familiar objects and experiences to help students grasp complex biology concepts.

**Illustrated Tables** organize information in one place and provide easy visual references to compare and contrast.

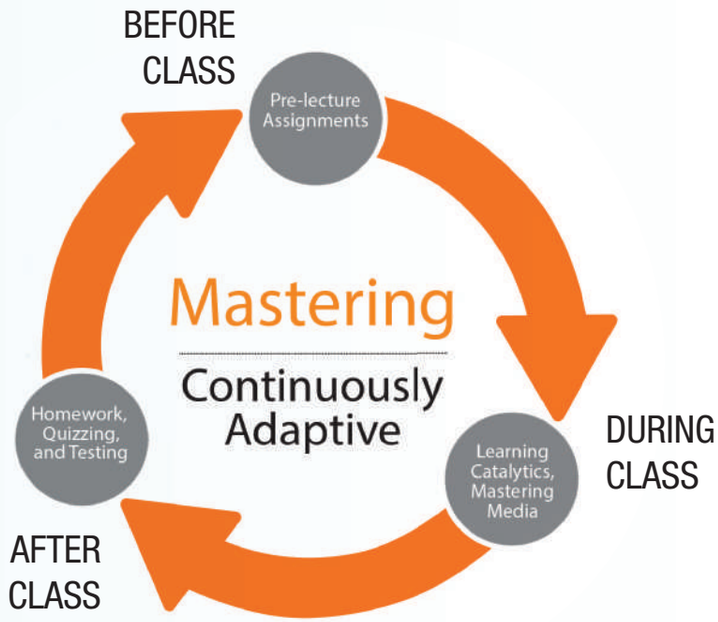
**TABLE 7.2 To what extent is IQ heritable? A summary of various estimates of IQ heritability, their shortcomings, and the problems with using them to understand the role of genes in determining an individual's potential intelligence.**

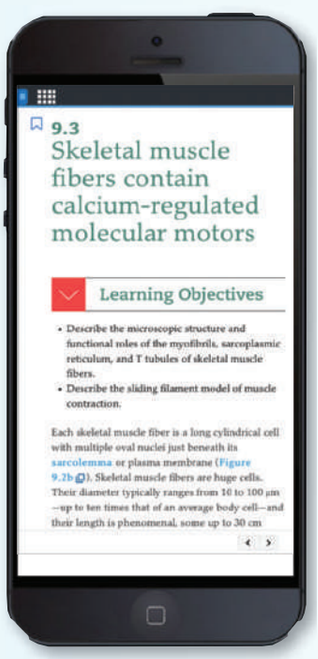
| Method of Measurement | Estimated Percentage of Phenotype Determined by Genes | Warnings When Interpreting This Result | Warnings That Apply to All Measurements of Heritability |
|---|---|---|---|
| Correlation between parents' IQ and children's IQ in a population | 42% | When parents and children live together, a correlation can't rule out environmental influence. | • Heritability values are specific to the populations for which they were measured.<br>• High heritability for a trait does not mean that the trait will not respond to a change in the environment.<br>• Heritability is a measure of a population, not an individual. |
| Natural experiment comparing IQ in pairs of identical twins versus nonidentical twins | 52% | Because identical twins are treated as more alike than nonidentical twins the heritability value could be an overestimate. | |
| Natural experiment comparing IQ of identical twins raised apart versus nonidentical twins raised apart | 72% | Small sample size may skew results. | |

# Support For Your Students Anytime, Anywhere

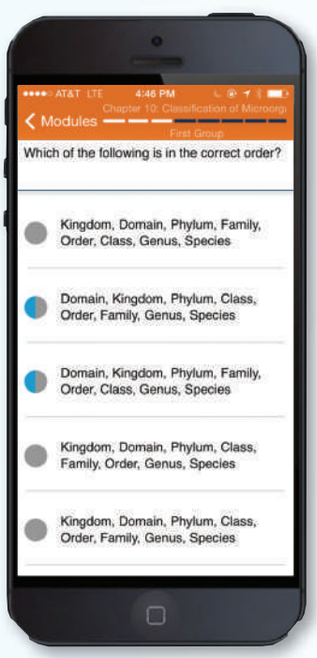
MasteringBiology®

**is an online homework, tutorial, and assessment program that helps you quickly master biology concepts and skills. Self-paced tutorials provide immediate wrong-answer feedback and hints to help keep you on track to succeed in the course.**




**eText 2.0**




**Dynamic Study Modules**

## BEFORE CLASS

### NEW!

**eText 2.0** Allow your students to access their text anytime, anywhere.

- Now available on Smartphones and Tablets.
- Seamlessly integrated digital and media resources.
- Fully accessible (screen-reader ready).
- Configurable reading settings, including resizable type and night reading mode.
- Instructor and student note-taking, highlighting, bookmarking and search.

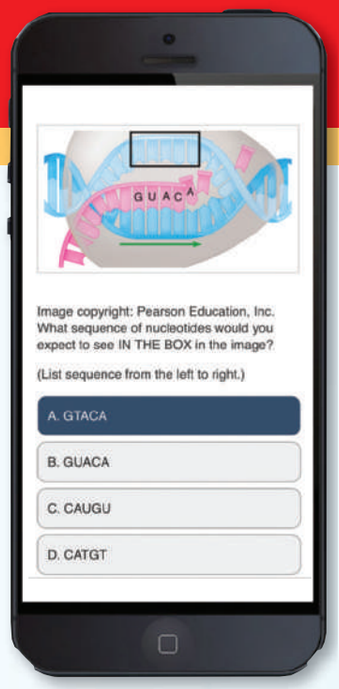
### NEW!

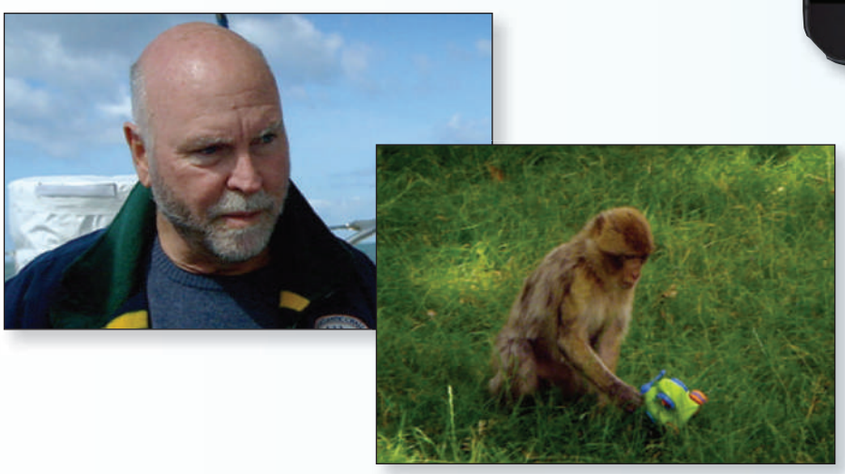
**Dynamic Study Modules** help students acquire, retain, and recall information faster and more efficiently than ever before. These convenient practice questions and detailed review explanations can be accessed using a smartphone, tablet, or computer.

# DURING CLASS

## NEW!

**Learning Catalytics** is an assessment and classroom activity system that works with any web-enabled device and facilitates collaboration with your classmates. Your MasteringBiology subscription with eText includes access to Learning Catalytics.



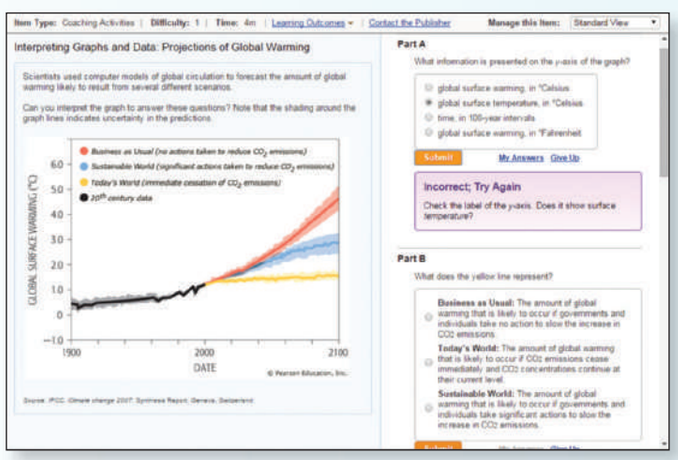
## NEW!

**Everyday Biology Videos** briefly explore interesting and relevant biology topics that relate to concepts in the course. These 20 videos, produced by the BBC, can be shown in class or assigned as homework in MasteringBiology.

# AFTER CLASS

**A wide range of question types and activities** are available for homework assignments, including the following **NEW** assignment options for the Fifth Edition:

- **Interactive Storyline Activities** tie the storyline of the chapter to key science concepts.
- **Working with Data questions** require you to analyze and apply your knowledge of biology to a graph or set of data.
- **Savvy Reader Evaluating Media activities** challenge you to evaluate various information from websites, articles, and videos.



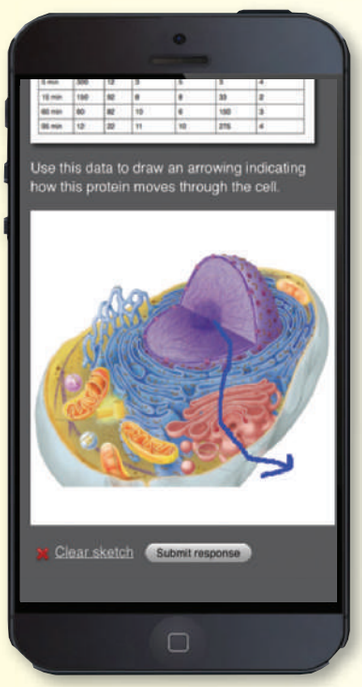
# New Resources for Flipped Classrooms and More

**New resources save valuable time both during course prep and during class.**

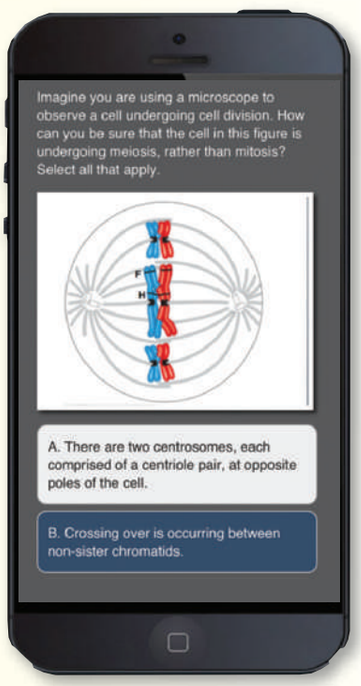
NEW!

**Learning Catalytics** is a "bring your own device" assessment and classroom activity system that expands the possibilities for student engagement. Using Learning Catalytics, instructors can deliver a wide range of auto-gradable or open-ended questions that test content knowledge and build critical thinking skills. Eighteen different answer types provide great flexibility, including:

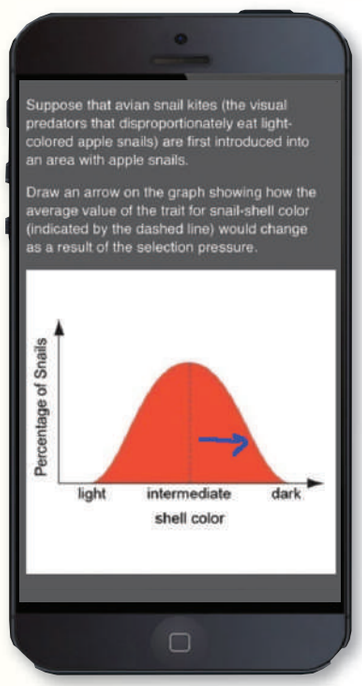
SKETCH/DIRECTION




MANY CHOICE




REGION

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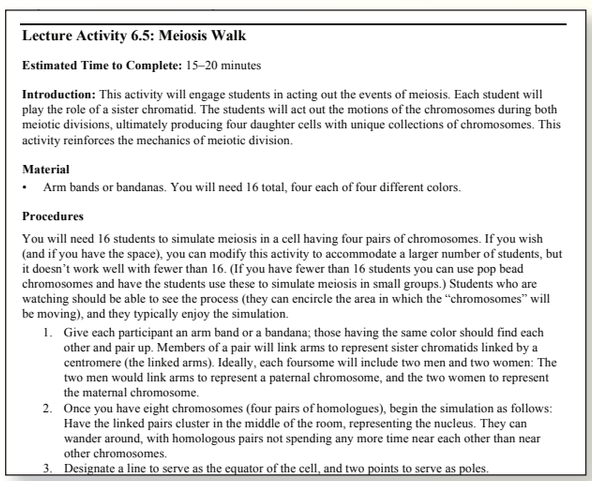
MasteringBiology users may select from Pearson's library of Learning Catalytics questions, including two **NEW** types of questions developed from the **Stop and Stretch** and **Sounds Right, But Is It?** questions in the Fifth Edition of *Biology: Science for Life.*

NEW!

**"Flipped Classroom" Instructor's Manual** includes many activities that have been tested by Colleen Belk, Virginia Borden Maier, and their colleagues in their own classes. Each text chapter is supplemented with a selection of in-class activities, suggestions for student "pre-work" outside of class, media references, and more. In addition, teaching tip videos by the authors are available in MasteringBiology.



**Lecture Activity 6.5: Meiosis Walk**

**Estimated Time to Complete:** 15–20 minutes

**Introduction:** This activity will engage students in acting out the events of meiosis. Each student will play the role of a sister chromatid. The students will act out the motions of the chromosomes during both meiotic divisions, ultimately producing four daughter cells with unique collections of chromosomes. This activity reinforces the mechanics of meiotic division.

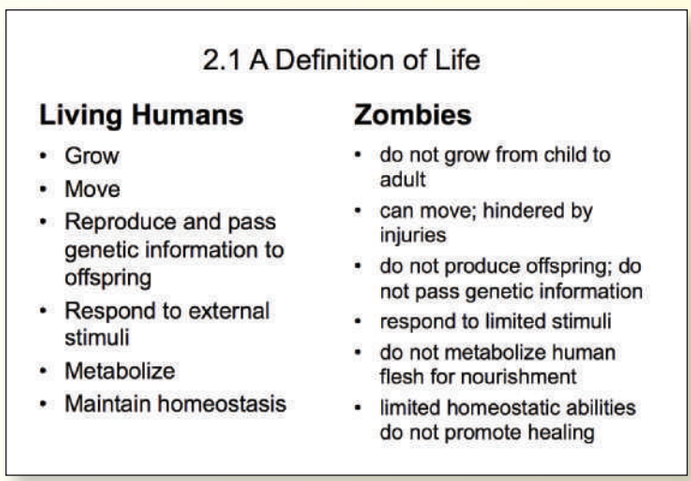
**Material**

- Arm bands or bandanas. You will need 16 total, four each of four different colors.

**Procedures**

You will need 16 students to simulate meiosis in a cell having four pairs of chromosomes. If you wish (and if you have the space), you can modify this activity to accommodate a larger number of students, but it doesn't work well with fewer than 16. (If you have fewer than 16 students you can use pop bead chromosomes and have the students use these to simulate meiosis in small groups.) Students who are watching should be able to see the process (they can encircle the area in which the "chromosomes" will be moving), and they typically enjoy the simulation.

1. Give each participant an arm band or a bandana; those having the same color should find each other and pair up. Members of a pair will link arms to represent sister chromatids linked by a centromere (the linked arms). Ideally, each foursome will include two men and two women: The two men would link arms to represent a paternal chromosome, and the two women to represent the maternal chromosome.
2. Once you have eight chromosomes (four pairs of homologues), begin the simulation as follows: Have the linked pairs cluster in the middle of the room, representing the nucleus. They can wander around, with homologous pairs not spending any more time near each other than near other chromosomes.
3. Designate a line to serve as the equator of the cell, and two points to serve as poles.



2.1 A Definition of Life

| Living Humans | Zombies |
|---|---|
| • Grow | • do not grow from child to adult |
| • Move | • can move; hindered by injuries |
| • Reproduce and pass genetic information to offspring | • do not produce offspring; do not pass genetic information |
| • Respond to external stimuli | • respond to limited stimuli |
| • Metabolize | • do not metabolize human flesh for nourishment |
| • Maintain homeostasis | • limited homeostatic abilities do not promote healing |

NEW!

**Storyline PPTs** for instructors allow easy integration of the stories into lecture. The PPT presentations include integrated story examples and video launcher segments to engage students.

MasteringBiology®

These valuable resources are available to adopting instructors and can be downloaded from the Instructor Resources area of MasteringBiology.

# Acknowledgments

## Reviewers

Each chapter of this book was thoroughly reviewed several times as it moved through the development process. Reviewers were chosen on the basis of their demonstrated talent and dedication in the classroom. Many of these reviewers are already trying various approaches to actively engage students in lectures and to raise the scientific literacy and critical thinking skills among their students. Their passion for teaching and commitment to their students were evident throughout this process. These devoted individuals scrupulously checked each chapter for scientific accuracy, readability, and coverage level.

All of these reviewers provided thoughtful, insightful feedback, which improved the text significantly. Their efforts reflect their deep commitment to teaching nonmajors and improving the scientific literacy of all students. We are very thankful for their contributions.

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## The Book Team

We feel blessed to be able to work with Star MacKenzie, our editor for the last three editions, and our new development editor Leata Holloway. Both of these women are insightful, funny, kind, and generous with their time. Their commitment to producing an excellent book that meets the needs of students and instructors is unrivaled in the industry.

This book is dedicated to our families, friends, and colleagues who have supported us over the years. Having loving families, great friends, and a supportive work environment has enabled us to make this heartfelt contribution to non-majors biology education.

COLLEEN BELK AND
VIRGINIA BORDEN MAIER

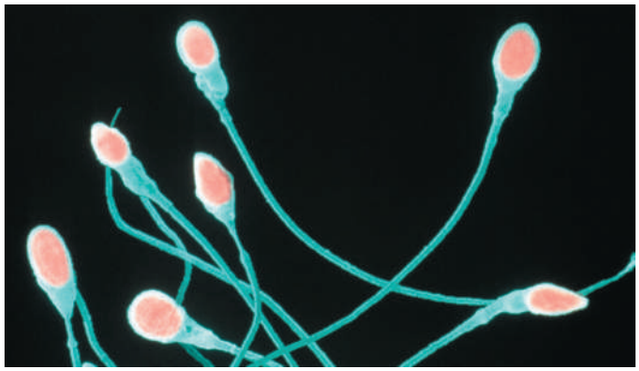
*"Because science, told as a story, can intrigue and inform the non-scientific minds among us, it has the potential to bridge the two cultures into which civilization is split—the sciences and the humanities. For educators, stories are an exciting way to draw young minds into the scientific culture."*

—E.O. WILSON

# Brief Contents

# Contents





UNIT FIVE

# Animal Structure and Function