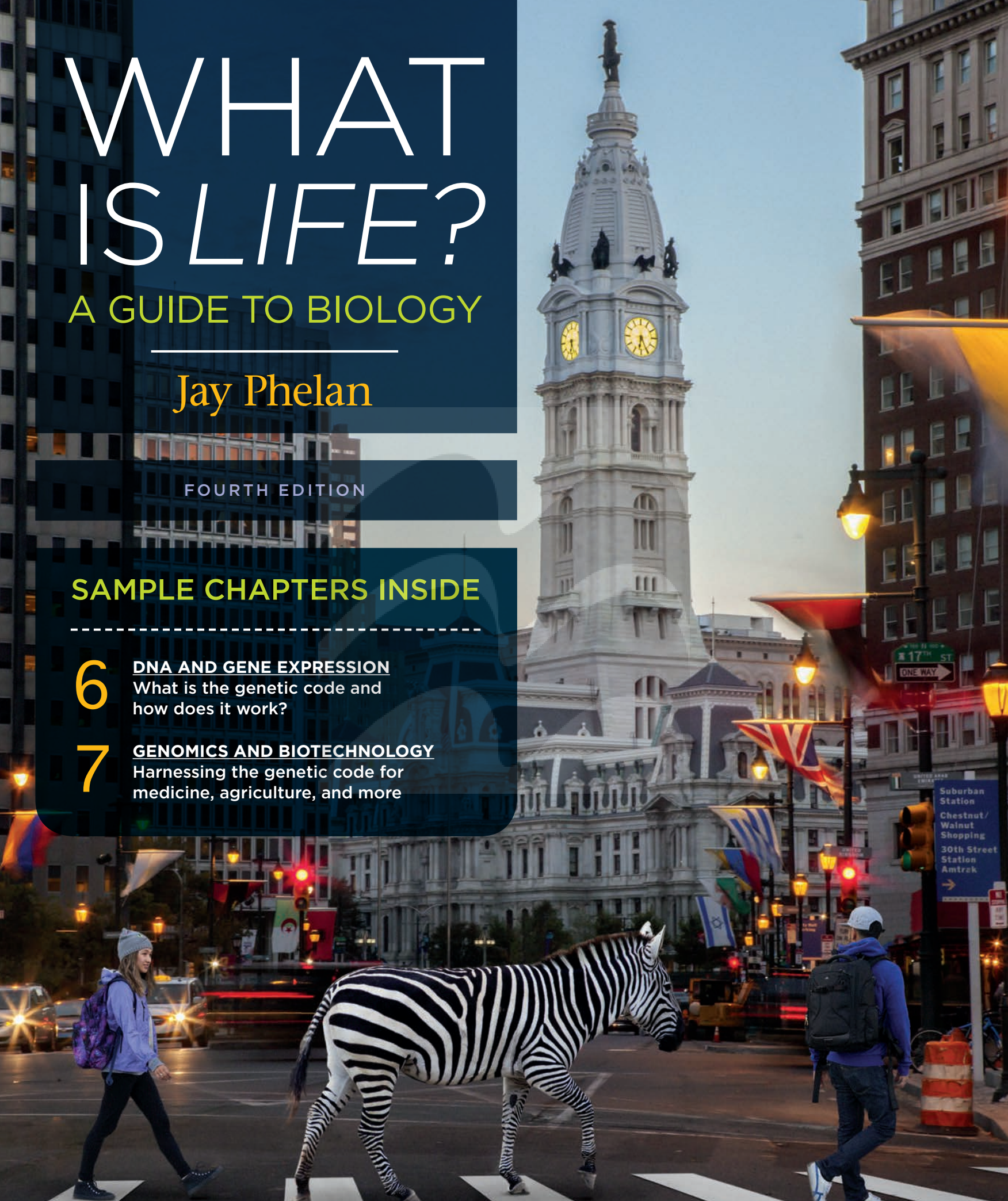
WHAT IS *LIFE?*

A GUIDE TO BIOLOGY

Jay Phelan

FOURTH EDITION



SAMPLE CHAPTERS INSIDE

6 **DNA AND GENE EXPRESSION**
What is the genetic code and how does it work?

7 **GENOMICS AND BIOTECHNOLOGY**
Harnessing the genetic code for medicine, agriculture, and more

FROM THE PREFACE

DEAR READER,

How many days do you wake up to breaking news about a scary-sounding virus, or a potential cause of cancer, or newly identified genes that make you better at math? In a world of easy access to information, it can be difficult to know how much confidence we should have about such reports. My mission is to help you evaluate the sometimes conflicting messages about science topics and science-related issues. In addition, I hope you will understand that ***biology is about you, and it touches every aspect of your life. It's creative. And it's fun.***

In these pages, you'll find an overview of the key themes in biology as well as detailed information about the natural world and its processes. I hope you will find answers to questions you're curious about and will be spurred to ask many more. You'll also find many Red **Q** questions, such as:

- Do megadoses of vitamin C reduce cancer risk?
- An onion has five times as much DNA as a human. Why doesn't that make onions more complex than humans?
- Why doesn't natural selection lead to the production of perfect organisms?
- Why are big, fierce animal species so rare in the world?

The Red **Q**s point toward passages that help uncover the answers. Often, the answer may not be apparent—but look again and think some more.

Within each chapter of *What Is Life?* you'll find a section called **This Is How We Do It**. In these sections we explore the diverse ways that scientists approach problems and how they go about finding answers. Example topics include *Why do we yawn?* and *Does sunscreen use reduce skin cancer risk?*

At the end of each chapter, you'll find a section called **StreetBio: Using evidence to guide decision making in our own lives**. These sections address issues that are particularly practical, such as *How clean is that food you just dropped?*

There's much more to biology than just words. Flip through *What Is Life?* and look at the photographs. Images can inspire and provide an alternative hook for remembering and understanding concepts. They can also challenge you to see ideas in new ways.

You'll also notice brief quotes from a variety of literary sources. It is my hope that as your scientific literacy increases, your experience and appreciation of literature also will be richer.

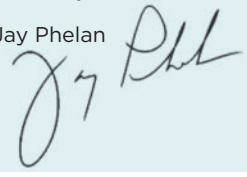
In organizing each chapter, I have broken down the topics into discrete, manageable sections. And at the end of each, I provide a **Take Home Message** that highlights and reinforces the section's most important ideas.

Included at the end of each chapter are summaries as well as multiple-choice and short-answer review questions, plus an exercise called **Graphic Content**. This critical thinking challenge will help you become adept at reading and analyzing visual displays of information, while identifying subtle assumptions, biases, and even manipulations.

This is just a sample of some of the features in *What Is Life?* I hope that you find this book stimulates new ways of thinking about and understanding the world.

Sincerely,

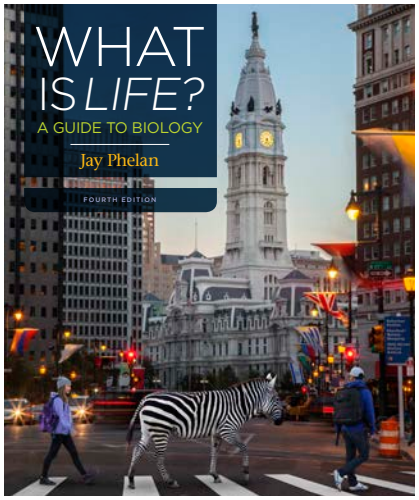
Jay Phelan



P.S. ABOUT THE COVER

I want to convey that biology isn't something that exists far away, separate from our personal lives. Rather, it intersects with our lives and is a central part of our world.

WHAT IS LIFE?
A GUIDE TO BIOLOGY
FOURTH EDITION



JAY PHELAN
University of California, Los Angeles

December 2017 (©2018)

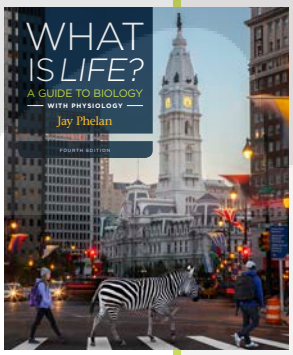
Paperback with LaunchPad 978-1-319-15465-3
Paperback 978-1-319-06545-4
Looseleaf with LaunchPad 978-1-319-15463-9
Looseleaf 978-1-319-10631-7
LaunchPad only 978-1-319-10636-2

IN HIS POPULAR classes and best-selling textbooks, Jay Phelan is a master at captivating non-majors students with both the practical impact and awe-inspiring wonder of biological research. He also knows how to use the study of biology as a context for developing the critical thinking skills and scientific literacy students can draw on through college and beyond.

Phelan's dynamic approach to teaching biology is the driving force behind *What Is Life?*—the most successful new non-majors biology textbook of the millennium. The rigorously updated new edition brings forward the features that made the book a classroom favorite (chapters anchored to intriguing questions about life, spectacular original illustrations, and innovative learning tools) with a more focused and flexible presentation and enhanced art.

And more than ever, this edition seamlessly integrates multimedia resources with the text, with its dedicated version of LaunchPad, Macmillan's breakthrough online course space that brings together an interactive e-Book, all student and instructor media, and a wide range of assessment and course management features.

To request your review copy, contact your local Macmillan Learning representative or visit macmillanlearning.com/learnmorePhelan4e



ALSO AVAILABLE

WHAT IS LIFE?
A Guide to Biology with Physiology
Fourth Edition

Jay Phelan,
University of California, Los Angeles

December 2017 (©2018)

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(The Daily Bruin.)

ABOUT THE AUTHOR

Jay Phelan is a professor at UCLA, where he has taught introductory biology in large lectures for majors and non-majors for 15 years. He received his PhD in evolutionary biology from Harvard in 1995, and his master's and bachelor's degrees from Yale and UCLA. His primary area of research is evolutionary genetics, and his original research has been published in *Evolution*, *Experimental Gerontology*, and the *Journal of Integrative and Comparative Biology*, among others. His research has been featured on *Nightline*, CNN, the BBC, and NPR; in *Science Times* and *Elle*; and in more than a hundred newspapers. He is the recipient of more than a dozen teaching awards. With Terry Burnham, Jay is the coauthor of the international best-seller *Mean Genes: From Sex to Money to Food—Taming Our Primal Instincts*. Written for the general reader, *Mean Genes* explains in simple terms how knowledge of the genetic basis of human nature can empower individuals to lead more satisfying lives. Writing for a nonscientific audience has honed Phelan's writing style to one that is casual and inviting to students while also scientifically precise.

HOW DOES ***WHAT IS LIFE?*** GIVE NON-MAJORS

Brief Sections Make the Material Manageable

Each chapter is broken down into a series of short, accessible sections. This gives instructors flexibility in what they cover and makes the content easier for students to navigate and absorb.

Engaging Examples Showcase Biology in Everyday Life

What Is Life? A Guide to Biology threads fascinating, relevant, contemporary examples of the science throughout each chapter. Jay Phelan expertly uses analogies and interesting examples to inspire students to care about biology.

Intriguing, Often Surprising Q Questions Motivate Readers

Red Q questions spark students' interest and encourage critical thinking. These questions prompt students to consider how biology is a part of their lives and the world around them. Corresponding animations are available in LaunchPad.

5.5–5.11

Photosynthesis uses energy from sunlight to make food.

Large flat water lily leaves intercept sunlight.

5.5 Where does plant matter come from? Photosynthesis: the big picture.

Watching a plant grow over the course of a few years can seem like watching a magic trick. Of course it's not, but the process is nonetheless amazing. Consider that in five years a tree can increase its weight by 150 pounds (68 kg) (FIGURE 5-9). Where does that 150 pounds of new tree come from?

Q When humans grow, the new tissue comes from food we eat. When plants grow, where does the new tissue come from?

Our first guess might be the soil. It's easy enough to weigh the soil in a pot when first planting a tree. Five years later, however, if we weigh the soil again, we find that it has lost less than a pound—nowhere near enough to explain the massive increase in the amount of plant material. Perhaps the new growth comes from the water? Wrong again. Although the older and much larger tree holds more water in its many cells, the water provided to the plant does not account for the increase in the dry weight of the plant.

FIGURE 5-9 **When plants grow, where does the new tissue come from?** From the soil? From thin air?

Most of the new material actually comes from an element present in an invisible gas in the air. During photosynthesis, plants capture this element, present as carbon dioxide gas (CO_2) in the atmosphere, and use the energy from sunlight, along with water and small amounts of chemicals usually found in soil, to produce solid, visible (and often tasty) sugars and other organic molecules. These molecules are used to make plant structures such as leaves, roots, stems, flowers, fruits, and seeds. In the process, the plants give off oxygen (O_2), a by-product that happens to be necessary for much of the life on earth—including all animal life!

Plants are not the only organisms capable of photosynthesis. Some bacteria and many other unicellular organisms,

132 CHAPTER 5 • ENERGY

Vivid Photos Capture the Story of Biology

Striking images appear as unit openers and are combined with illustrations of biological processes, concepts, and experimental techniques to capture the imagination of the student.

BIOLOGY STUDENTS THE SUPPORT THEY NEED?

Cyanobacteria *Dinoflagellates* *Kelp*

FIGURE 5-10 **Plants aren't the only photosynthesizers.** Some bacteria and other unicellular organisms, along with kelp and other multicellular algae, are capable of photosynthesis.

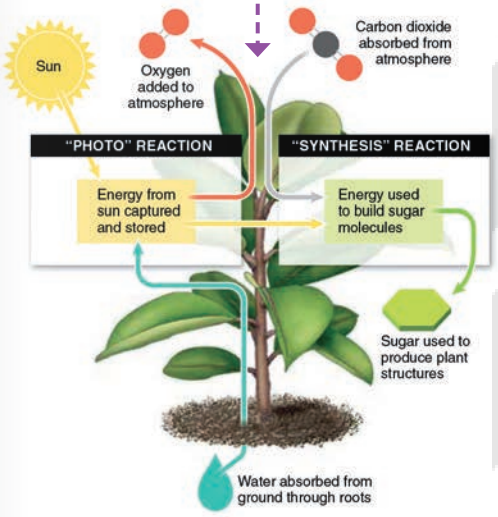

FIGURE 5-11 **Photosynthesis: the big picture.**

along with kelp and other multicellular algae, are also capable of using the energy in sunlight to produce organic materials (FIGURE 5-10).

There are three inputs to the process of photosynthesis (FIGURE 5-11): light energy (from the sun), carbon dioxide (from the atmosphere), and water (from the environment). From these three inputs, the plant produces sugar and oxygen. As we'll see, photosynthesis is best understood as two separate events: a "photo" segment, during which light is captured, and a "synthesis" segment, during which sugar is built. In the "photo" reactions, light energy is captured and temporarily saved in energy-storage molecules. During this process, water molecules split and produce oxygen. In the "synthesis" reactions, the energy in the energy-storage molecules is used to assemble sugar molecules from carbon dioxide from the atmosphere.

TAKE HOME MESSAGE 5.5

» **Through photosynthesis, plants use water, the energy of sunlight, and carbon dioxide gas from the atmosphere to produce sugars and other organic materials. In the process, photosynthesizing organisms also produce oxygen, which makes all animal life possible.**

THE NATURE OF ENERGY | PHOTOSYNTHESIS | CELLULAR RESPIRATION | ALTERNATIVE PATHWAYS

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Clear and Compelling Illustrations

Fresh and easy-to-understand figures bring the concepts to life. Collaboratively developed by the author and scientific illustrators, the text and illustrations are seamlessly integrated, effective learning tools.

Recurring Chapter Features Develop Students' Scientific Skills

The following chapter features are built around key learning goals from Vision & Change:

- **StreetBio** demonstrates how students encounter biology every day, helping students apply the scientific knowledge they learn to improve their own lives.
- **This Is How We Do It** helps students develop the ability to understand and apply the process of science by showing how scientists have approached an intriguing question.
- **Graphic Content** helps students learn to interpret visual displays of quantitative information and think critically about evidence.

Take Home Messages Reinforce Key Concepts

Each section ends with a Take Home Message that highlights the most important content.

Progress Bars Keep Students Focused on the Big Picture

Progress bars throughout the text keep students aware of where they're headed and where they've been in the chapter, helping them to understand how individual topics relate to the bigger picture.

LAUNCHPAD
LAUNCHPADWORKS.COM

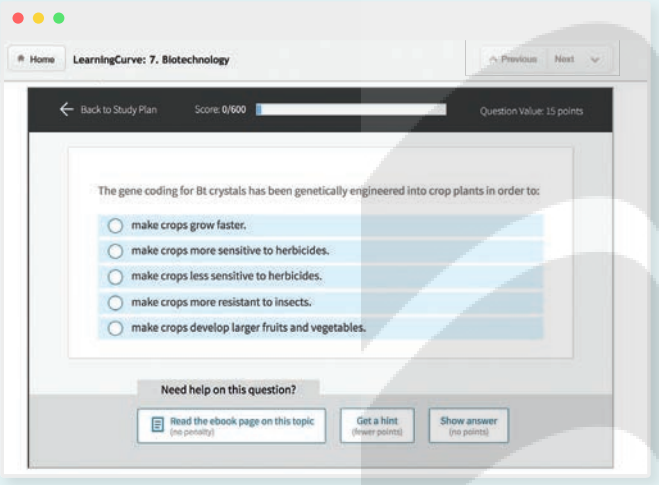
The full benefits of *What Is Life?* are realized through LaunchPad, Macmillan Learning's online companion platform.

WHAT IS LAUNCHPAD?

LaunchPad brings an interactive e-Book of *What Is Life?* together with book-specific media and assessments, including assignable versions of hallmark features of the text. Students can use self-study tools or complete instructor-created assignments that are automatically graded and tracked.

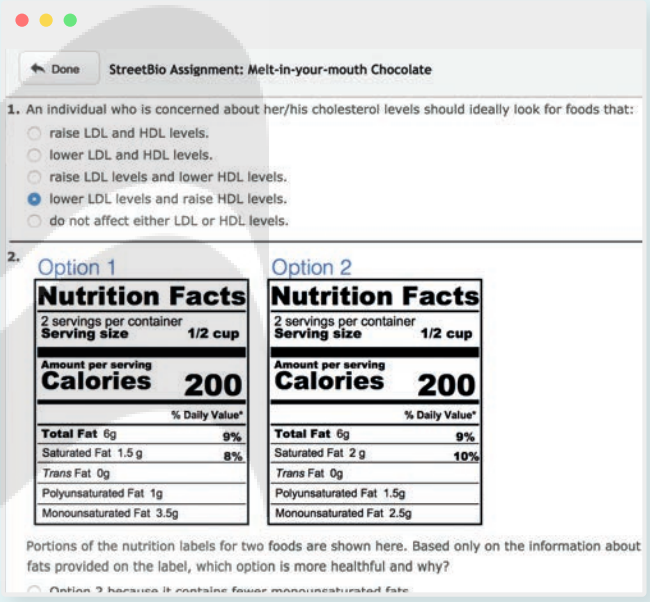
LearningCurve

Formative assessment in a game-like adaptive quizzing system, available for every chapter of the text.



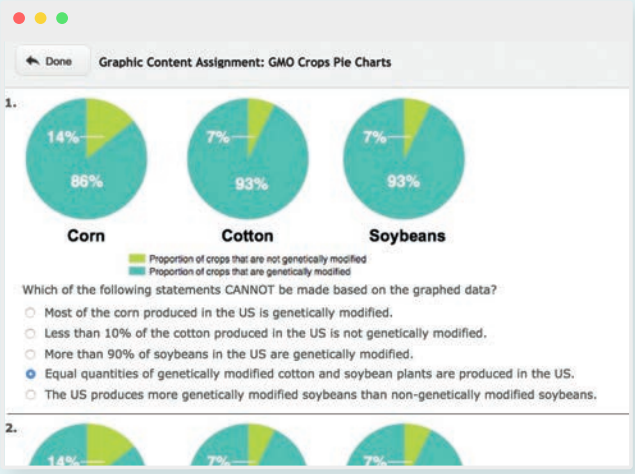
StreetBio Assignments

Short, curated assessments featuring multiple-choice questions focused on using scientific evidence to better understand everyday issues.



Graphic Content Assignments

Short, curated assessments featuring multiple-choice questions focused on interpreting visual displays of quantitative information.

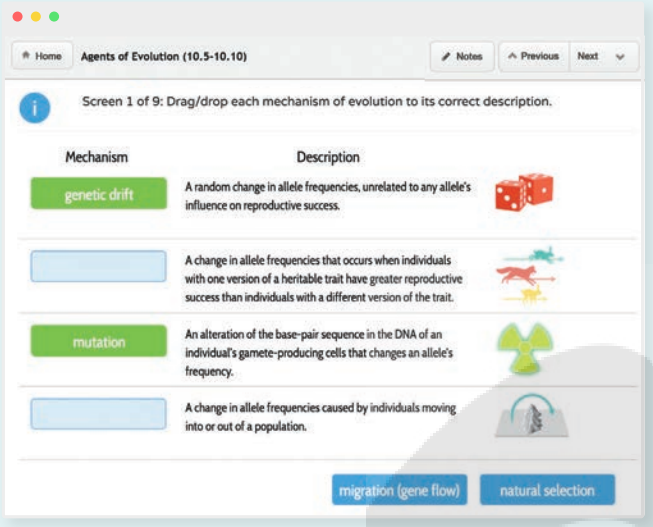


This Is How We Do It Assignments

Short, curated assessments featuring multiple-choice questions focused on understanding and applying the process of science.

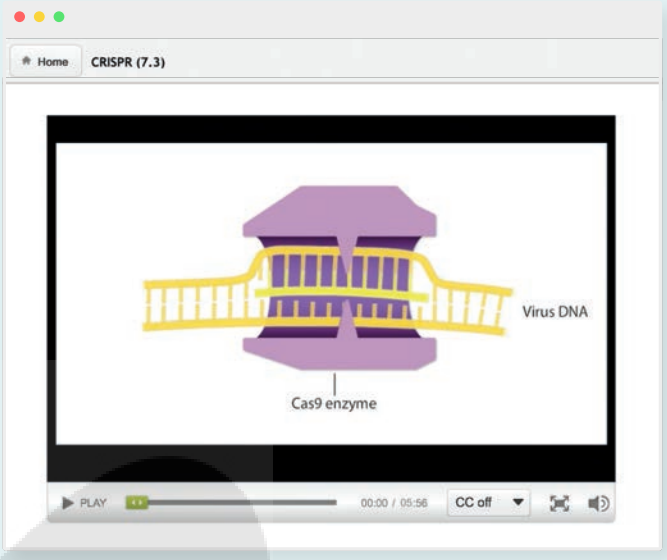
Tutorials

These brief activities, which feature drag/drop, click-to-match, and other interactive question types, are designed to help students review and learn core course concepts—particularly topics that are consistently difficult for students (ex: mitosis vs. meiosis, transcription vs. translation, and more).



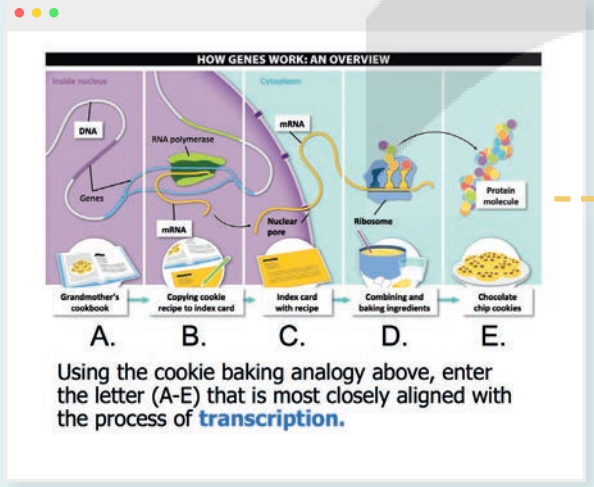
Animations

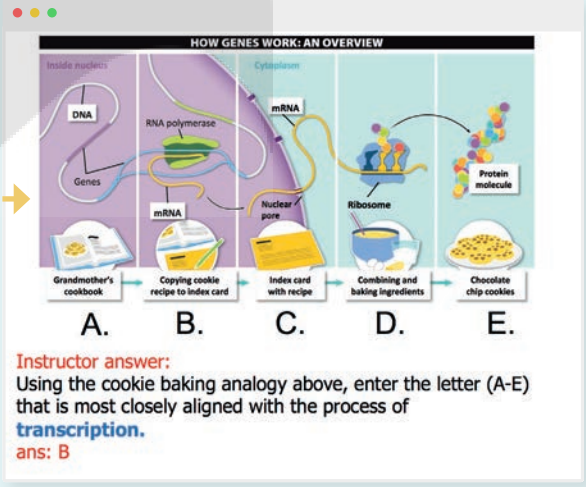
Available for select chapters, these animated videos bring to life key topics in non-majors biology (as identified by instructors) through a combination of chapter art and narration.



Active Learning: Visual Analysis Slides

Compatible with iClicker Cloud software, these clicker and discussion slides focus on checking understanding of important concepts through interpretation and analysis of select figures from the textbook.





NEW E-BOOK ALTERNATIVE

Vitalsource™

VitalSource eBook

For the first time, the VitalSource eBook is also available through an app that allows students to read offline and have the book read aloud to them. These features are in addition to the highlighting, note-taking, and keyword search that VitalSource has long offered.

WHAT IS LIFE?

A GUIDE TO BIOLOGY

FOURTH EDITION

BY JAY PHELAN

BRIEF TABLE OF CONTENTS

PART 1: THE FACTS OF LIFE

1 **SCIENTIFIC THINKING:** Your best pathway to understanding the world
2 **THE CHEMISTRY OF BIOLOGY:** Raw materials and fuel for our bodies
3 **MOLECULES OF LIFE:** Macromolecules can store energy and information and serve as building blocks
4 **CELLS:** The smallest part of you
5 **ENERGY:** From the sun to you in just two steps

PART 2: GENETICS, EVOLUTION AND BEHAVIOR

6 **DNA AND GENE EXPRESSION:** What is the genetic code and how does it work?
7 **BIOTECHNOLOGY:** Harnessing the genetic code for medicine, agriculture, and more
8 **CHROMOSOMES AND CELL DIVISION:** Continuity and variety
9 **GENES AND INHERITANCE:** Family resemblance: how traits are inherited
10 **EVOLUTION AND NATURAL SELECTION:** Darwin's dangerous idea
11 **EVOLUTION AND BEHAVIOR:** Communication, cooperation, and conflict in the animal world

PART 3: EVOLUTION AND THE DIVERSITY OF LIFE

12 **THE ORIGIN AND DIVERSIFICATION OF LIFE ON EARTH:** Understanding biodiversity
13 **ANIMAL DIVERSIFICATION:** Visibility in motion
14 **PLANT AND FUNGI DIVERSIFICATION:** Where did all the plants and fungi come from?
15 **EVOLUTION AND DIVERSITY AMONG THE MICROBES:** Bacteria, archaea, protists, and viruses: the unseen world

PART 4: ECOLOGY AND THE ENVIRONMENT

16 **POPULATION ECOLOGY:** Planet at capacity: patterns of population growth
17 **ECOSYSTEMS AND COMMUNITIES:** Organisms and their environments
18 **CONSERVATION BIOLOGY:** Human influences on the environment

Part 4 is where the core book ends.

Parts 5 & 6 are additional chapters available in the "with Physiology" version

PART 5: PLANT LIFE

19 **PLANT STRUCTURE AND NUTRIENT TRANSPORT:** How they function and why we need them
20 **GROWTH, REPRODUCTION, AND ENVIRONMENTAL RESPONSES IN PLANTS:** Problem-solving with flowers, wood, and hormones

PART 6: HEALTH AND PHYSIOLOGY

21 **INTRODUCTION TO ANIMAL PHYSIOLOGY:** Principles of animal organization and function
22 **CIRCULATION AND RESPIRATION:** Transporting fuel, food, and gases in, out, and around the body
23 **NUTRITION AND DIGESTION:** At rest and at play: optimizing human physiological functioning
24 **NERVOUS AND MOTOR SYSTEMS:** Actions, reactions, sensations, and addictions: meet your nervous system
25 **HORMONES: MOOD, EMOTIONS, GROWTH, AND MORE:** hormones as master regulators
26 **ANIMAL REPRODUCTION AND DEVELOPMENT:** From two parents to one baby to one adult
27 **IMMUNITY AND HEALTH:** How the body defends and maintains itself

SELECTED UPDATES TO THE FOURTH EDITION

1 SCIENTIFIC THINKING:
Your best pathway to understanding the world

- New discussion of the different types of questions in science.

2 THE CHEMISTRY OF BIOLOGY:
Raw materials and fuel for our bodies

- For improved flexibility, the chemistry coverage from the previous edition has been divided into two shorter chapters: Chapter 2 on "The Chemistry of Biology," and Chapter 3 on "Molecules of Life."
- New **StreetBio**: "The pros and cons of tap water vs. bottled water."
- New **Graphic Content**: "Interpreting modern data infographics."
- Two new Red **Q** questions.
- Additional focus on the relevance of chemistry to non-science students

3 MOLECULES OF LIFE:
Macromolecules can store energy and information and serve as building blocks

- New **This Is How We Do It**: "What is the impact of trans fatty acids on heart health?"
- Three new Red **Q** questions highlighting the difference between cellulose/fiber and starch, issues relating to trans fats.

6 DNA AND GENE EXPRESSION:
What is the code and how does it work?

- For improved flexibility, the DNA and biotechnology coverage from the previous edition has been divided into two shorter chapters: Chapter 6 on "DNA and Gene Expression," and Chapter 7 on "Biotechnology."
- New **StreetBio**: "Fast flushing: A faulty gene leads to unpleasant experiences from alcohol consumption, but may protect against alcoholism."
- New **Graphic Content**: "Comparing representations of proportions rather than absolute amounts."

7 BIOTECHNOLOGY:
Harnessing the genetic code for medicine, agriculture, and more

- New section: "What is biotechnology and what does it promise?"
- New section: "At the cutting edge of biotech, **CRISPR** is a tool with the potential to revolutionize medicine."
- New **This Is How We Do It**: "How do we determine whether GMOs are safe?"
- Three new Red **Q** questions.

18 CONSERVATION BIOLOGY:
Human influences on the environment

- New **StreetBio**: "Climate change: Clearing up misconceptions that cloud the issue."

19 PLANT STRUCTURE AND NUTRIENT TRANSPORT:
How they function and why we need them

AND

20 GROWTH, REPRODUCTION, AND ENVIRONMENTAL RESPONSES IN PLANTS:
Problem-solving with flowers, wood, and hormones

- In response to market feedback, plant physiology coverage from the previous edition has been condensed from three chapters into two chapters.

23 NUTRITION AND DIGESTION:
At rest and at play: optimizing human physiological functioning

- New **Graphic Content**: "Finding patterns by organizing data by a non-standard variable."