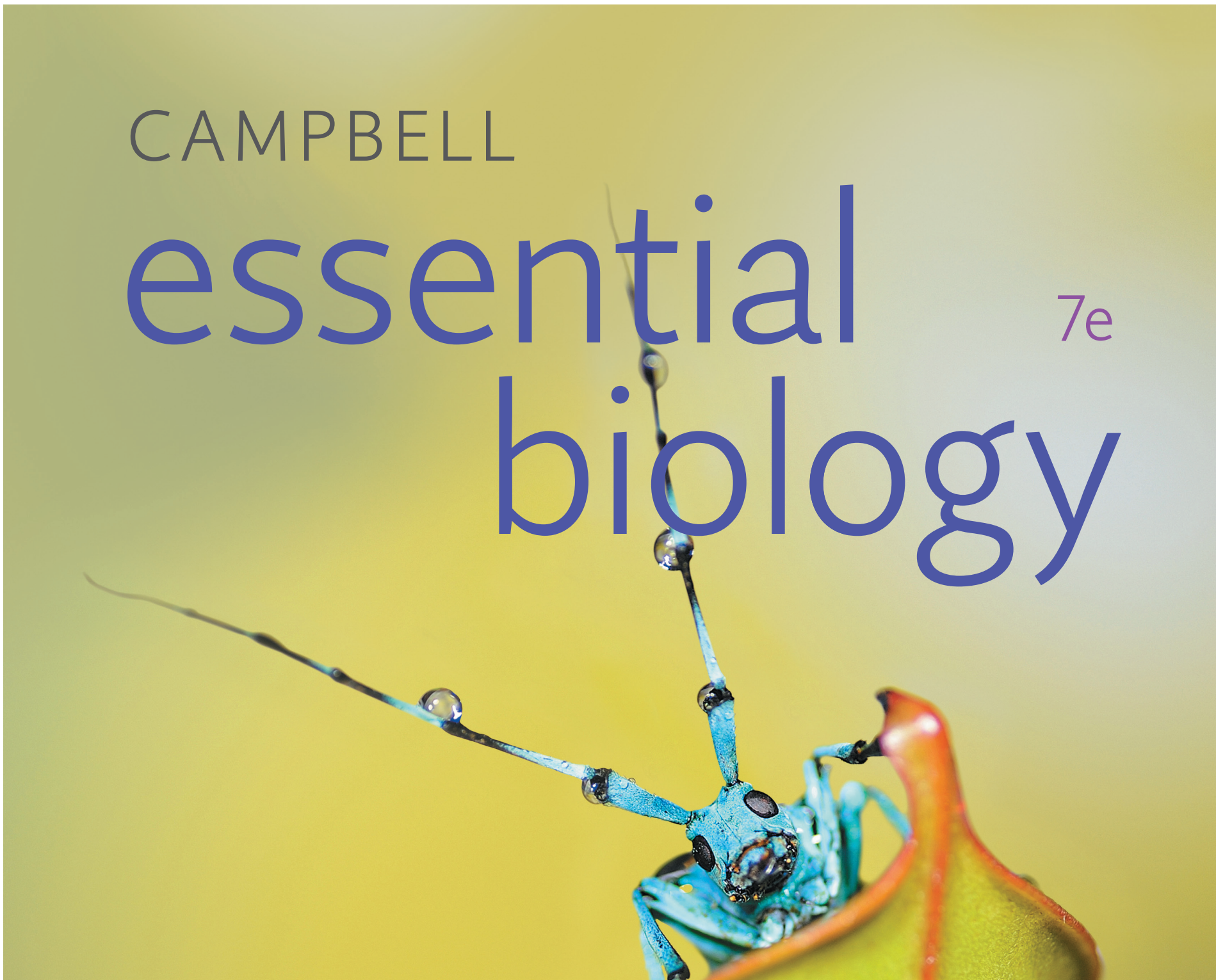


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# essential biology

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Eric J. Simon • Jean L. Dickey • Jane B. Reece

New England College

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from Harvard University. His research focuses on innovative ways to use technology to increase active learning in the science classroom, particularly for nonscience majors. Dr. Simon is also the author of the introductory biology textbook *Biology: The Core*, 2nd Edition, and a coauthor of *Campbell Biology: Concepts & Connections*, 9th Edition.

*To my lifelong friends BZ, SR, and SR, who have taught me the value of loyalty and trust during decades of unwavering friendship*



## JEAN L. DICKEY

is Professor Emerita of Biological Sciences at Clemson University (Clemson, South Carolina). After receiving her B.S. in biology from Kent State University, she went on to earn a Ph.D. in ecology and evolution from Purdue University. In 1984, Dr. Dickey joined the faculty at Clemson, where she devoted her career to teaching biology to nonscience majors in a variety of courses. In addition to creating content-based instructional

materials, she developed many activities to engage lecture and laboratory students in discussion, critical thinking, and writing, and implemented an investigative laboratory curriculum in general biology. Dr. Dickey is the author of *Laboratory Investigations for Biology*, 2nd Edition, and is a coauthor of *Campbell Biology: Concepts & Connections*, 9th Edition.

*To my mother, who taught me to love learning, and to my daughters, Katherine and Jessie, the twin delights of my life*



## JANE B. REECE

was Neil Campbell's longtime collaborator and a founding author of *Campbell Essential Biology* and *Campbell Essential Biology with Physiology*. Her education includes an A.B. in biology from Harvard University (where she was initially a philosophy major), an M.S. in microbiology from Rutgers University, and a Ph.D. in bacteriology from the University of California, Berkeley. At UC Berkeley, and later as a postdoctoral fellow

in genetics at Stanford University, her research focused on genetic recombination in bacteria. Dr. Reece taught biology at Middlesex County College (New Jersey) and Queensborough Community College (New York). Dr. Reece's publishing career began in 1978 when she joined the editorial staff of Benjamin Cummings, and since then, she played a major role in a number of successful textbooks. She was the lead author of *Campbell Biology* Editions 8–10 and a founding author of *Campbell Biology: Concepts & Connections*.

*To my wonderful coauthors, who have made working on our books a pleasure*



## NEIL A. CAMPBELL

(1946–2004) combined the inquiring nature of a research scientist with the soul of a caring teacher. Over his 30 years of teaching introductory biology to both science majors and nonscience majors, many thousands of students had the opportunity to learn from him and be stimulated by his enthusiasm for the study of life. He is greatly missed by his many friends in the biology community. His coauthors remain inspired by his

visionary dedication to education and are committed to searching for ever-better ways to engage students in the wonders of biology.

# Preface

Biology education has been transformed in the last decade. The non-majors introductory biology course was (in most cases) originally conceived as a slightly less deep and broad version of the general biology course. But a growing recognition of the importance of this course—one that is often the most widely enrolled within the department, and one that serves as the sole source of science education for many students—has prompted a reevaluation of priorities and a reformulation of pedagogy. Many instructors have narrowed the focus of the course from a detailed compendium of facts to an exploration of broader themes within the discipline—themes such as the central role of evolution and an understanding of the process of science. For many educators, the goals have shifted from communicating a great number of bits of information toward providing a deep understanding of fewer, but broader, principles. Luckily for anyone teaching or learning biology, opportunities to marvel at the natural world and the life within it abound. Furthermore, nearly everyone realizes that the subject of biology has a significant impact on his or her own life through its connections to medicine, biotechnology, agriculture, environmental issues, forensics, and many other areas. Our primary goal in writing *Campbell Essential Biology* is to help teachers motivate and educate the next generation of citizens by communicating the broad themes that course through our innate curiosity about life.

## Goals of the Book

Although our world is rich with “teachable moments” and learning opportunities, an explosion of knowledge threatens to bury a curious person under an avalanche of information. “So much biology, so little time” is the universal lament of biology educators. Neil Campbell conceived of *Campbell Essential Biology* as a tool to help teachers and students focus on the most important areas of biology. To that end, the book is organized into four core areas: cells, genes, evolution, and ecology. Dr. Campbell’s vision, which we carry on and extend in this edition, has enabled us to keep *Campbell Essential Biology* manageable in size and thoughtful in the development of the concepts that are most fundamental to understanding life. We’ve aligned this new edition with today’s “less is more” approach in biology education for nonscience majors—where the emphasis is on fewer topics but broader themes—while never allowing the important content to be diluted.

We formulated our approach after countless conversations with teachers and students in which we noticed some important trends in how biology is taught. In particular, many instructors identify three goals: (1) to engage students by relating biology content to their lives and the greater society; (2) to help students understand the process of science by teaching critical thinking skills that can be used in everyday life; and (3) to demonstrate how biology’s broader themes—such as evolution and the relationship of structure to function—serve to unify the entire subject. To help achieve these goals, every chapter of this book includes several important

features. First, a chapter-opening essay called *Biology and Society* highlights a connection between the chapter’s core content and students’ lives. Second, an essay called *The Process of Science* (in the body of the chapter) describes how the scientific process has illuminated the topic at hand, using a classic or modern experiment as an example. Third, a chapter-closing *Evolution Connection* essay relates the chapter to biology’s unifying theme of evolution. Fourth, the broad themes that unify all subjects within biology are explicitly called out (in blue) multiple times within each chapter. Finally, to maintain a cohesive narrative throughout each chapter, the content is tied together with a unifying chapter thread, a relevant high-interest topic that is touched on several times in the chapter and woven throughout the three feature essays. Thus, this unifying chapter thread ties together the pedagogical goals of the course, using a topic that is compelling and relevant to students.

## New to This Edition

This latest edition of *Campbell Essential Biology* goes even further than previous editions to help students relate the material to their lives, understand the process of science, and appreciate how broad themes unify all aspects of biology. To this end, we’ve added significant new features and content to this edition:

- **A new approach to teaching the process of science.** Conveying the process of science to nonscience-major undergraduate students is one of the most important goals of this course. Traditionally, we taught the scientific method as a predefined series of steps to be followed in an exact order (observation, hypothesis, experiment, and so forth). Many instructors have shifted away from such a specific flow chart to a more nuanced approach that involves multiple pathways, frequent restarts, and other features that more accurately reflect how science is actually undertaken. Accordingly, we have revised the way that the process of science is discussed within our text, both in Chapter 1 (where the process is discussed in detail) and in *The Process of Science* essay in every chapter of the textbook. Rather than using specific terms in a specific order to describe the process, we now divide it into three broad interrelated areas: background, method, and results. We believe that this new approach better conveys how science actually proceeds and demystifies the topic for non-scientists. Chapter 1 also contains important information that promotes critical thinking, such as discussion of control groups, pseudoscience, and recognizing reliable sources of information. We believe that providing students with such critical-thinking tools is one of the most important outcomes of the nonscience-major introductory course.
- **Major themes in biology incorporated throughout the book.** In 2009, the American Association for the Advancement of Science published a document that served as a call to action in undergraduate biology education. The principles of this document, which

is titled “Vision and Change,” are becoming widely accepted throughout the biology education community. “Vision and Change” presents five core concepts that serve as the foundation of undergraduate biology. In this edition of *Campbell Essential Biology*, we repeatedly and explicitly link book content to themes multiple times in each chapter, calling out such instances with boldfaced blue text. For example, in Chapter 4 (A Tour of the Cell), the interrelationships of cellular structures are used to illustrate the theme of interactions within biological systems. The plasma membrane is presented as an example of the relationship between structure and function. The cellular structures in the pathway from DNA to protein are used to illustrate the importance of information flow. The chloroplasts and mitochondria serve as an example of the transformations of energy and matter. The DNA within these structures is also used to illustrate biology’s overarching theme of evolution. Students will find three to five examples of themes called out in each chapter, which will help them see the connections between these major themes and the course content. To reinforce these connections, this edition of *Campbell Essential Biology* includes new end-of-chapter questions and Mastering Biology activities that promote critical thinking relating to these themes. Additionally, PowerPoint® lecture slides have been updated to incorporate chapter examples and offer guidance to faculty on how to include in these themes within classroom lectures.

- **Updated connections to students’ lives.** In every edition of *Campbell Essential Biology*, we seek to improve and extend the ways that we connect the course content to students’ lives. Accordingly, every chapter begins with an improved feature called Why It Matters showing the relevance of the chapter content from the very start. Additionally, with every edition, we introduce some new unifying chapter threads intended to improve student relevance. For example, this edition includes new threads that discuss evolution in a human-dominated world (Chapter 14) and the importance of biodiversity to human affairs (Chapter 20). As always, we include some updated Biology and Society chapter-opening essays (such as “A Solar Revolution” in Chapter 7), The Process of Science sections (such as a recent experiment investigating the efficacy of radiation therapy to treat prostate cancer, in Chapter 2), and Evolution Connection chapter-closing essays (such as an updated discussion of biodiversity hot spots in Chapter 20). As we always do, this edition includes many content updates that connect to students’ lives, such as information on

cutting-edge cancer therapies (Chapter 8) and recent examples of DNA profiling (Chapter 12).

- **Developing data literacy through infographics.** Many nonscience-major students express anxiety when faced with numerical data, yet the ability to interpret data can help with many important decisions we all face. Increasingly, the general public encounters information in the form of infographics, visual images used to represent data. Consistent with our goal of preparing students to approach important issues critically, this edition includes a series of new infographics, or Visualizing the Data figures. Examples include the elemental composition of the human body (Chapter 2), a comparison of calories burned through exercise versus calories consumed in common foods (Chapter 5), and ecological footprints (Chapter 19). In addition to the printed form, these infographics are available as an interactive feature in the eText and as assignable tutorial questions within Mastering Biology.
- **Helping students to understand key figures.** For this new edition, a key figure in each chapter is supplemented by a short video explaining the concept to the student. These Figure Walkthrough videos will be embedded in the eText and will be assignable in Mastering Biology. The animations are written and narrated by authors Eric Simon and Jean Dickey, as well as teacher and contributor Rebecca Burton.

Attitudes about science and scientists are often shaped by a single, required science class—*this* class. We hope to nurture an appreciation of nature into a genuine love of biology. In this spirit, we hope that this textbook and its supplements will encourage all readers to make biological perspectives a part of their personal worldviews. Please let us know how we are doing and how we can improve the next edition of *Campbell Essential Biology*.

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First and foremost, we must acknowledge our huge debt to Neil Campbell, the founding author of this book and a source of ongoing inspiration for each of us. Although this edition has been carefully and thoroughly revised—to update its science, its connections to students' lives, its pedagogy, and its currency—it remains infused with Neil's original vision and his commitment to share biology with introductory students.

This edition benefited significantly from the efforts of contributor Rebecca S. Burton from Alverno College. Using her years of teaching expertise, Becky made substantial improvements to two chapters, contributed to the development of new and revised Chapter Thread essays, and helped shape the emphasis on the unifying themes throughout the text and in Mastering Biology. We thank Becky for bringing her considerable talents to bear on this edition!

This book could not have been completed without the efforts of the *Campbell Essential Biology* team at Pearson Education. Leading the team is courseware portfolio management specialist Alison Rodal, who is tireless in her pursuit of educational excellence and who inspires all of us to constantly seek better ways to help teachers and students. Alison stands at the interface between the book development team and the educational community of professors and students. Her insights and contributions are invaluable. We also thank the Pearson Science executive team for their supportive leadership, in particular, senior vice president of portfolio management Adam Jaworski, director of portfolio management Beth Wilbur, and directors of courseware content development Barbara Yien and Ginnie Simone Jutson.

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Most instructors view the textbook as just one piece of the learning puzzle, with the book's supplements and media completing the picture. We are lucky to have a *Campbell Essential Biology* supplements team that is fully committed to the core goals of accuracy and readability. Content producer Lori Newman expertly coordinated the supplements, a difficult task given their number and variety. We also thank media project manager Ziki Dekel for his work on the excellent Instructor Resources and eText that accompanies the text. We owe particular gratitude to the supplements authors, especially the indefatigable and eagle-eyed Ed Zalisko of Blackburn College, who wrote the Instructor Guide and the PowerPoint® Lectures; the highly skilled and multit talented Doug Darnowski of Indiana University Southeast, who revised the Quiz Shows and Clicker Questions; and Jean DeSaix of the University of North Carolina at Chapel Hill, Justin Shaffer of the University of California, Irvine, Kristen Miller of the University of Georgia, and Suann Yang of SUNY Geneseo, our collaborative team of Test Bank authors for ensuring excellence in our assessment program. In addition, the authors thank Reading Quiz authors Amaya Garcia Costas of Montana State University and Cindy Klevickis of James Madison University; Reading Quiz accuracy reviewer Veronica Menendez; Practice Test author Chris Romero of Front Range Community College; and Practice Test accuracy reviewer Justin Walgaurnery of the University of Hawaii.

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Most of all, we thank our families, friends, and colleagues, who continue to tolerate our obsession with doing our best for science education. And finally, we all wish to welcome budding superstar Leo to our *Campbell Essential Biology* family.

ERIC SIMON, JEAN DICKEY, JANE REECE

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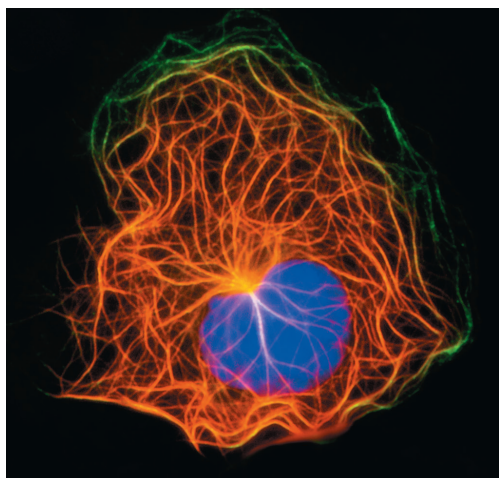
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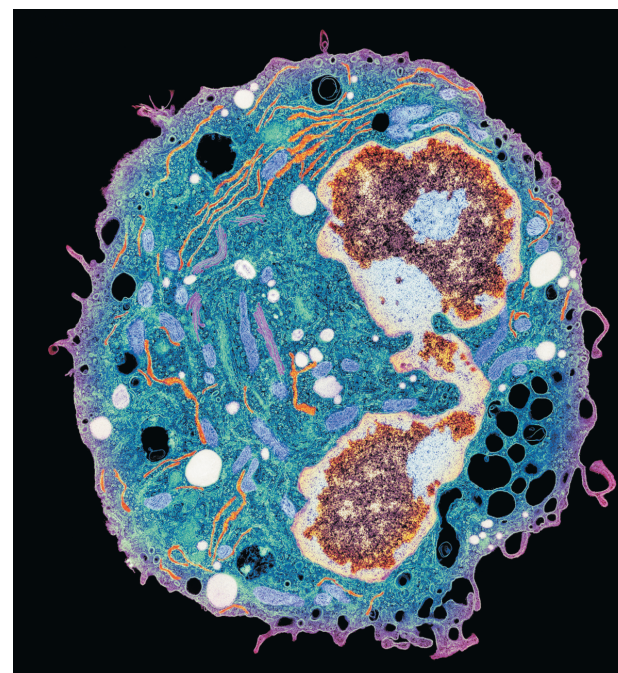
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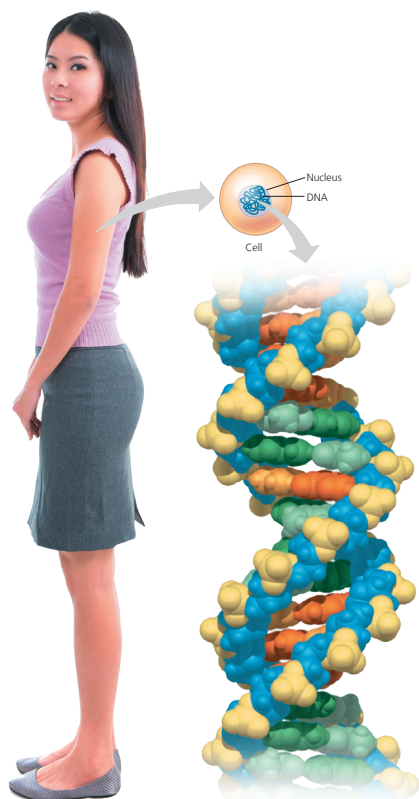
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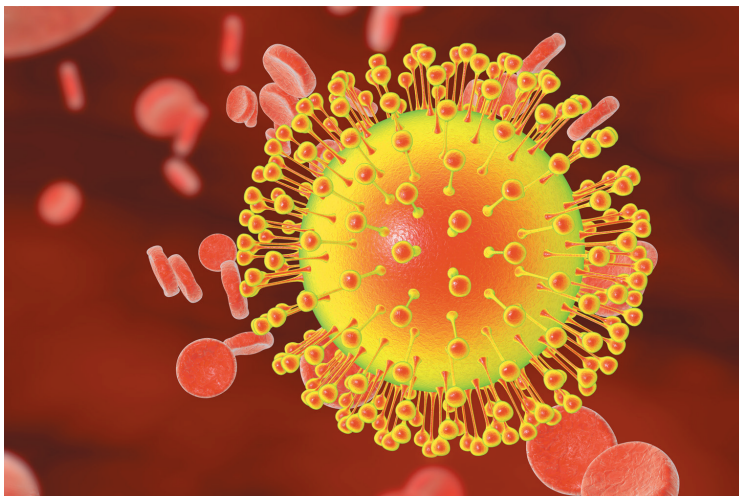
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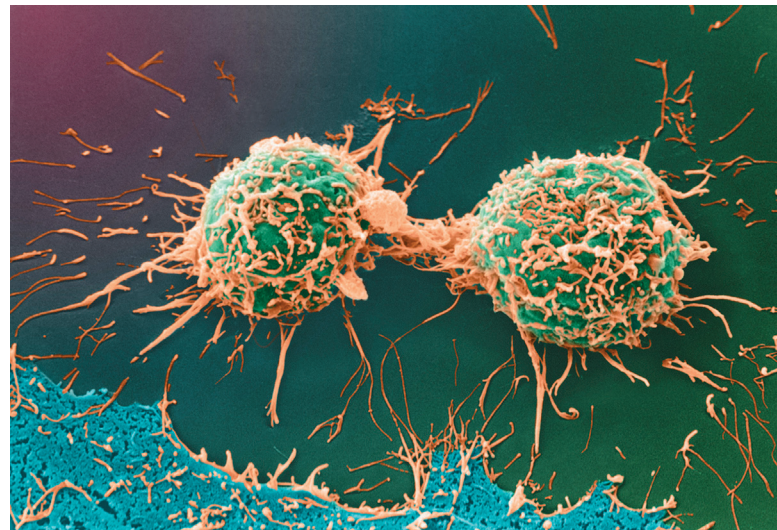




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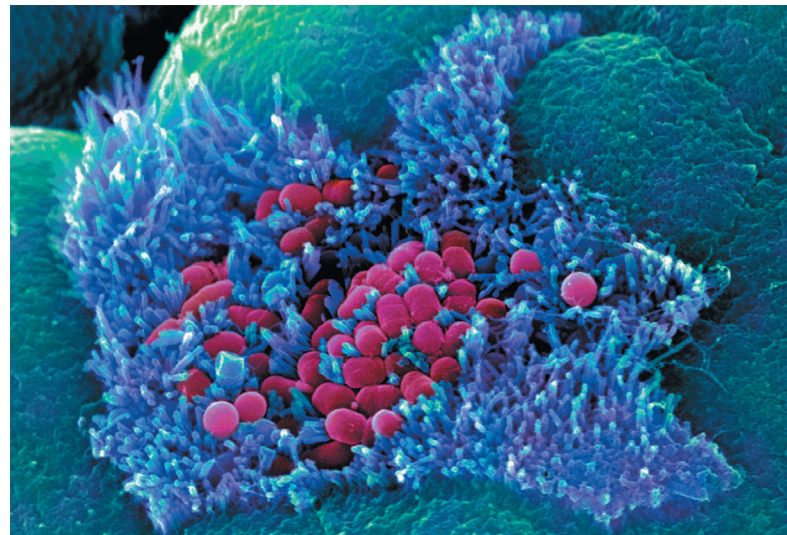
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