BIOLOGY

today and tomorrow

WITH PHYSIOLOGY

STARR EVERS STARR

SECOND EDITION

BIOLOGY

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A female crab flower spider (Misumena vatia) *raises its legs and shows its fangs in a defensive posture. Such spiders exploit the mutually beneficial relationship between flowers and their pollinators. A bee or fly that is lured into range by the flower's color and scent is snatched by the spider's elongated front legs and subdued by a venomous bite from the fangs.*

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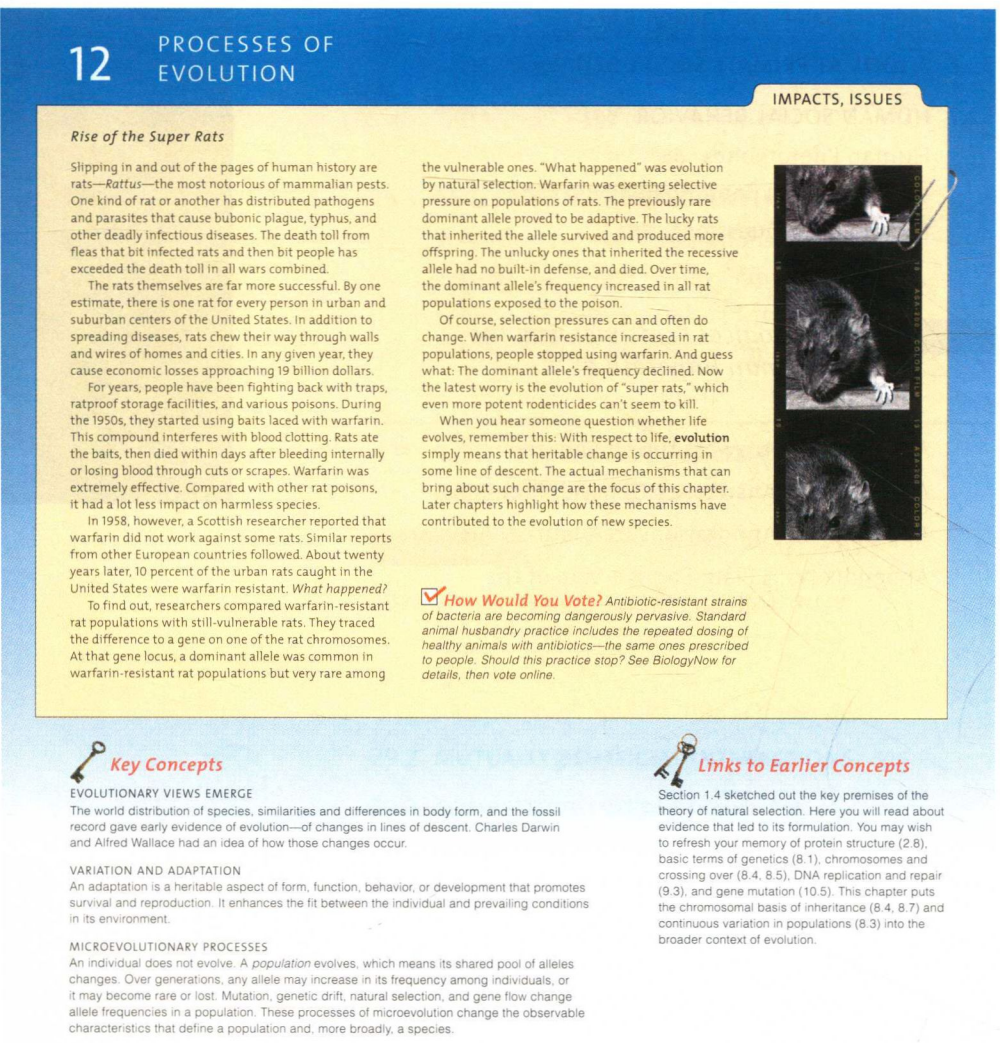
Preface

Biology opens a window on processes of nature that are so familiar that we might not even think about them. It reveals connections, sometimes subtle and sometimes not, between us and everything else on Earth. This is profound stuff that many nonmajors students are ill-prepared to grasp. Many enter college without adequate preparation in science, and often with the mistaken belief that they are not smart enough to learn biology. Should textbook writers reinforce their apprehension by squeezing all the juice out of a story, by producing a pedagogical husk? We think not. We find biology fascinating and eagerly devour news of recent discoveries. We believe that, with the proper guidance, students too can become lifelong learners who understand and are excited by the science of life.

This book is briefer than our other titles, but in it we strive to share our enthusiasm for biology with easy-to-follow writing on relevant topics. For this edition, we have shortened and streamlined many sections. We did not water down the science, but instead emphasize processes and relationships over detail.



12 PROCESSES OF EVOLUTION

IMPACTS, ISSUES

Rise of the Super Rats

Slipping in and out of the pages of human history are rats—*Rattus*—the most notorious of mammalian pests. One kind of rat or another has distributed pathogens and parasites that cause bubonic plague, typhus, and other deadly infectious diseases. The death toll from fleas that bit infected rats and then bit people has exceeded the death toll in all wars combined.

The rats themselves are far more successful. By one estimate, there is one rat for every person in urban and suburban centers of the United States. In addition to spreading diseases, rats chew their way through walls and wires of homes and cities. In any given year, they cause economic losses approaching 19 billion dollars.

For years, people have been fighting back with traps, ratproof storage facilities, and various poisons. During the 1950s, they started using baits laced with warfarin. This compound interferes with blood clotting. Rats ate the baits, then died within days after bleeding internally or losing blood through cuts or scrapes. Warfarin was extremely effective. Compared with other rat poisons, it had a lot less impact on harmless species.

In 1958, however, a Scottish researcher reported that warfarin did not work against some rats. Similar reports from other European countries followed. About twenty years later, 10 percent of the urban rats caught in the United States were warfarin resistant. *What happened?*

To find out, researchers compared warfarin-resistant rat populations with still-vulnerable rats. They traced the difference to a gene on one of the rat chromosomes. At that gene locus, a dominant allele was common in warfarin-resistant rat populations but very rare among the vulnerable ones. "What happened" was evolution by natural selection. Warfarin was exerting selective pressure on populations of rats. The previously rare dominant allele proved to be adaptive. The lucky rats that inherited the allele survived and produced more offspring. The unlucky ones that inherited the recessive allele had no built-in defense, and died. Over time, the dominant allele's frequency increased in all rat populations exposed to the poison.

Of course, selection pressures can and often do change. When warfarin resistance increased in rat populations, people stopped using warfarin. And guess what: The dominant allele's frequency declined. Now the latest worry is the evolution of "super rats," which even more potent rodenticides can't seem to kill.

When you hear someone question whether life evolves, remember this: With respect to life, **evolution** simply means that heritable change is occurring in some line of descent. The actual mechanisms that can bring about such change are the focus of this chapter. Later chapters highlight how these mechanisms have contributed to the evolution of new species.

How Would You Vote? *Antibiotic-resistant strains of bacteria are becoming dangerously pervasive. Standard animal husbandry practice includes the repeated dosing of healthy animals with antibiotics—the same ones prescribed to people. Should this practice stop? See BiologyNow for details, then vote online.*

Key Concepts

EVOLUTIONARY VIEWS EMERGE
The world distribution of species, similarities and differences in body form, and the fossil record gave early evidence of evolution—of changes in lines of descent. Charles Darwin and Alfred Wallace had an idea of how those changes occur.

VARIATION AND ADAPTATION
An adaptation is a heritable aspect of form, function, behavior, or development that promotes survival and reproduction. It enhances the fit between the individual and prevailing conditions in its environment.

MICROEVOLUTIONARY PROCESSES
An individual does not evolve. A *population* evolves, which means its shared pool of alleles changes. Over generations, any allele may increase in its frequency among individuals, or it may become rare or lost. Mutation, genetic drift, natural selection, and gene flow change allele frequencies in a population. These processes of microevolution change the observable characteristics that define a population and, more broadly, a species.

Links to Earlier Concepts

Section 1.4 sketched out the key premises of the theory of natural selection. Here you will read about evidence that led to its formulation. You may wish to refresh your memory of protein structure (2.8), basic terms of genetics (8.1), chromosomes and crossing over (8.4, 8.5), DNA replication and repair (9.3), and gene mutation (10.5). This chapter puts the chromosomal basis of inheritance (8.4, 8.7) and continuous variation in populations (8.3) into the broader context of evolution.

Promote Critical Thinking Like all textbooks at this level, we walk students through examples of problem solving and experiments throughout the book. Many historical and theoretical experiments have been integrated into the text. Each chapter ends with several *Critical Thinking* questions, some illustrated. Some are more challenging than others, but all invite students to think outside the memorization box. We return again and again in chapter introductions and in the text to examples of how science is carried out. Introductory students are not scientists, however, so we do not expect them to learn the language and processes of science by intuition alone; we help them build these skills in a paced way.

Make It Brief, With Clear Explanations To keep the book length manageable, we were selective about which topics to include but were not stingy with clear explanations. If something is worth reading, why reduce it to a factoid? Factoids invite mind-numbing memorization, which does not promote critical thinking about the world and our place in it.

For instance, you can safely bet that most nonmajors simply do not want to memorize each catalytic step of crassulacean acid metabolism. They *do* want to learn about the biological basis of sex, and many female students want to know what will be going on inside them if and when they get pregnant. Good explanations can help them make their own informed decisions on many biology-related issues, including STDs, fertility drugs, prenatal diagnoses of genetic disorders, gene therapies, and abortions.

Our choices for which topics to condense, expand, or delete were not arbitrary. They reflect three decades of feedback from teachers throughout the world.

Make It Relevant Most students taking this course will not become biologists, but biological research will affect their lives in direct and often controversial ways. *What they learn today will have impact on how they make decisions tomorrow*—in the voting booth as well as in their personal lives.

Each chapter starts with an IMPACTS/ISSUES essay on a topic of current interest related to its content. For instance, the microevolution chapter opens with how the use of warfarin has favored "super rats." Essays are expanded in custom videoclips and in sidebars on relevant pages within chapters, as shown on the facing page. We return to the essay topics in exercises on the student website and in the PowerLecture, an all-in-one PowerPoint tool for instructors. We also ask the students, HOW WOULD YOU VOTE? on an application related to the essay's topic. The exercise invites them to read a selection of articles, pro and con, before voting.

IMPACTS, ISSUES

Warfarin-resistant rats led to the development of anticoagulants that are more toxic and that persist longer in the environment. They are weakening and killing owls, hawks, coyotes, and other predators that have eaten poisoned rats. Between 1985 and 1999, for example, the number of barn owls with anticoagulants in their blood rose from 5 to 36 percent. And that was just one study in Great Britain.

Students throughout the country are already voting online, and they are accessing campuswide, statewide, and nationwide tallies. This interactive approach to issues reinforces the premise that an individual's actions can make a difference.

Make It Easy To Follow On each chapter's opening page is a preview of key concepts, each with a simple title. We repeat these titles at the bottom of appropriate pages as reminders of the chapter's conceptual organization.

New to this edition are **LINKS TO EARLIER CONCEPTS** that can help students follow the big connections within and between the chapters. The opening page lists the key sections in earlier chapters that students should be familiar with before they start the chapter. For instance, before reading about neural function, a student may wish to scan an earlier chapter's section on active transport. We repeat linking icons in the chapter's page margins as reminders of these and other relevant sections. This feature demonstrates how the concepts in the book are not separate topics, but are as closely interconnected as biology itself.

A conversational writing style eases students into the story. They can stay focused on that story without worrying about highlighting something they might be tested on. Why? We already highlight key points for them, in blue boxes at the end of each section. These **HIGHLIGHTED KEY POINTS** function as a *running in-text summary*. All chapters end with a *section-by-section summary* that reinforces what they have learned.

Students also can stay on track with **ANIMATED DIAGRAMS**. They can walk through the text's step-by-step art as a preview of major concepts, then check out the steps online. These visual learning devices are available in narrated, animated form, on *BiologyNow* and on the PowerLecture DVD. Exposing students to the material in a variety of modalities accommodates diverse learning styles and reinforces understanding.

Offer Easy-to-Use Media Tools Integrated into each end-of-chapter summary are associated media tools that will help students focus their study and understand the key concepts. With this new edition, taking advantage of these online assets is easier than ever. Students register their **1PASS ACCESS CODE** at *http://1pass.thomson.com*, then log in to access all resources outlined below. An access code is packaged in each new copy of the book.

BIOLOGYNOW™ tests which topics students have not yet mastered and creates customized learning plans to focus their study and review. Responses to the diagnostic pretest questions activate a personalized learning plan. Answer incorrectly, and the plan lists the relevant text sections, figures, chapter videos, and animations that the student may review.

A *Post-Test* can be used as a self-assessment tool or submitted to an instructor. Because BiologyNow is built into iLrn, Thomson Learning's course management system, the answers and results can be fed directly into an electronic gradebook. BiologyNow can be integrated with WebCT and Blackboard, so students may log in through these systems as well.

Interactive flashcards with audio pronunciation use the definitions from this edition's highly revised glossary. All the boldface terms within the text are presented in this resource.

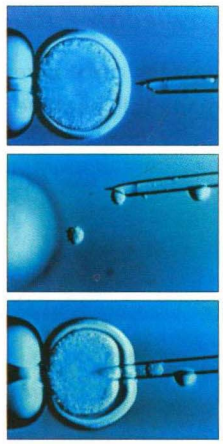
The *How Do I Prepare?* section of BiologyNow has tutorials in math, chemistry, and graphing, as well as a review of basic study skills.

1PASS grants access to **INFOTRAC COLLEGE EDITION™**, an exclusive online searchable database of more than 5,000 periodicals and close to 18 million articles. The articles are in full-text form and can be located easily and quickly with a key word search. For each chapter, the *How Would You Vote* exercise in BiologyNow references specific InfoTrac articles and websites. As students vote on each issue, the website provides a running tally by campus, state, and the country. Instructors can assign the exercises from iLrn, or students can access them through the website at *http://biology.brookscole.com/btt2*.

An online **ISSUES AND RESOURCES INTEGRATOR** correlates chapter sections with applications, videos, InfoTrac articles, and websites. This guide is updated each semester.

VMENTOR is an online tutorial service available from 6 AM to 12 PM Monday through Saturday. Students may interact with a live tutor in a virtual classroom by voice communication, whiteboard, and text messaging.

New college editions of the book can also include access to the **AUDIOBOOK**. Students can either listen to narration online or download MP3 files for use on a portable MP3 player.



1 Removal of the nucleus from a sheep egg during a cloning. At the center is an unfertilized sheep egg. A pipette has positioned the egg, which a microneedle is about to penetrate.

2 The microneedle has now emptied the sheep egg of its own nucleus, which holds the cell's DNA.

3 A nucleus from a donor cell is about to enter the enucleated egg. An electric spark will stimulate the egg to enter mitotic cell divisions. At an early stage, the ball of cells will be implanted in the womb of a surrogate mother sheep.

Figure 9.8 ***Animated!*** Nuclear transfer of sheep cells. In this series of photos, a microneedle replaces the nucleus of a sheep egg with a nucleus from an adult sheep cell. Newer methods involve direct transfer of nuclear DNA that has been treated with mitotic cell extracts to condense the chromosomes.

Acknowledgments

No short list can convey our thanks to the extended team that made this book not only possible, but also excellent. John Jackson and Walt Judd deserve special thanks for their detailed evaluations, perspective, and continued commitment to excellence. Dave Rintoul and his students helped us fine-tune some important last-minute details. Through focus-group participation, reviews, and class testing, he and the other instructors listed below helped us transform our first edition into the polished, cohesive textbook you see here, one that particularly addresses the needs of students who have been previously underserved.

With Jack Carey, Susan Badger, Sean Wakely, Kathie Head, Michelle Julet, and Michael Johnson, Thomson Learning proved why it is one of the world's foremost publishers; we doubt that any authors get finer support anywhere. Keli Amann managed production of all student and instructor media tools. Peggy Williams again brought her tenacity, intelligence, and humor to the developmental editing. Andy Marinkovich calmly kept us on track, and Grace Davidson made this book happen despite several hurricanes, both literal and figurative. Gary Head created great designs and graphics; Steve Bolinger did so for the media tools. Myrna Engler, Suzannah Alexander, Kristina Razmara, Karen Hunt, Stacy Best—the list goes on. Thank you to each one of you; this book would not exist without your help.

CECIE STARR, CHRIS EVERS, AND LISA STARR *November 2005*

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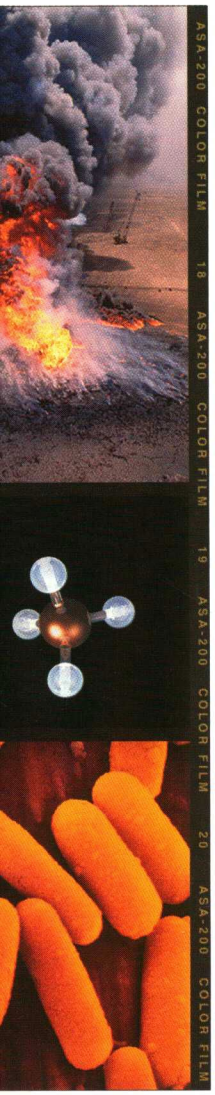
Current configurations of the Earth's oceans and land masses—the geologic stage upon which life's drama continues to unfold. This composite satellite image reveals global energy use at night by the human population. Just as biological science does, it invites you to think more deeply about the world of life—and about our impact upon it.

CONTENTS IN BRIEF



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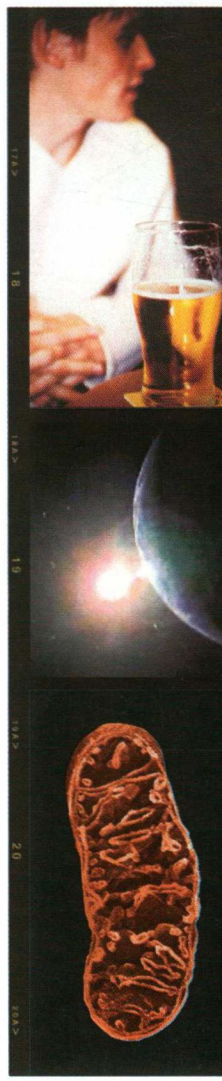

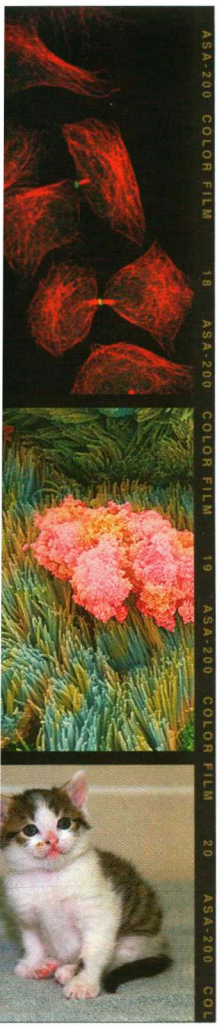

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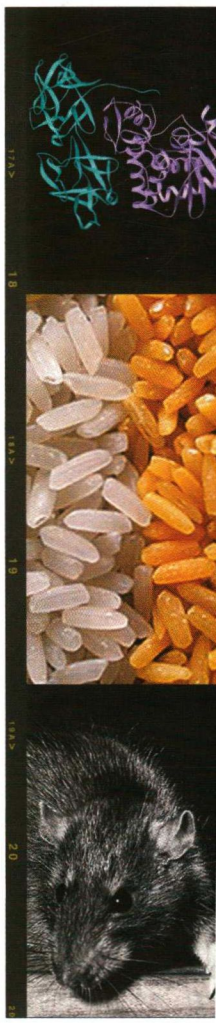

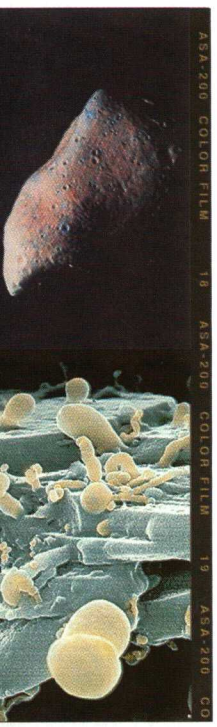

13 Evolutionary Patterns, Rates, and Trends

14 Early Life