

THIRD EDITION

# *The Nature of Life*

John H. Postlethwait and Janet L. Hopson

# The Nature of Life

T H I R D E D I T I O N

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# *The Nature of Life*

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This is dedicated to my enthusiastic teachers:

*Sam Postlethwait*

*Jack Otten*

*James Hawker*

*Al Chiscon*

*Joe Variable*

*Howard Schneiderman*

*Carroll Williams*

JHP

*For Jerry Dommer, my inspiration*

JLH

Cover photograph: Male panther chameleon (*Chamaeleo pardalis*). (Photo by James H. Carmichael, Jr./Image Bank.)

## INTERNATIONAL EDITION

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**JOHN H. POSTLETHWAIT** is Professor of Biology at the University of Oregon where he teaches General Biology for nonmajors and Genetics and Evolution, the introductory course for biology majors. He received his Ph.D. degree in Developmental Biology from Case Western Reserve University, and was a post-doctoral fellow at Harvard University. His research on the genetic mechanisms of embryonic development is supported by the National Institutes of Health and the American Heart Association. For three one-year periods, Dr. Postlethwait conducted research supported by Fulbright grants at the Institut für Molekular Biologie in Salzburg, Austria, the Laboratoire de Génétique Moléculaire des Eucaryotes in Strasbourg, France, and the Imperial Cancer Research Fund in Oxford, England. A recipient of the Ersted Distinguished Teaching Award, Dr. Postlethwait encourages active participation of undergraduates in research and includes them as coauthors on publications—see, for example, *Science* 264, 699–703 (1994) “A Genetic Map for the Zebrafish,” —on which nine undergraduates are coauthors. His love of teaching dates from 1963 when he was first an undergraduate teaching assistant. Currently Dr. Postlethwait is participating in the federally funded University of Oregon Workshop Biology program for innovative teaching of biology.

**JANET L. HOPSON** is an active freelance science writer and for many years has taught in the Science Communication Program, University of California at Santa Cruz. She has also taught writing courses at the University of California at Berkeley and Mills College. She holds B.A. and M.S. degrees from Southern Illinois University and the University of Missouri. Coauthor of three other biology textbooks for McGraw-Hill, *Biology* and *Essentials of Biology* with Norman K. Wessells, and *Biology! Bringing Science to Life* with John H. Postlethwait and Ruth C. Veres, she has also written a trade book on the human sense of smell. She won the Russell L. Cecil Award for magazine writing from the Arthritis Foundation and has published dozens of articles in national magazines and newspapers, including *Smithsonian*, *Psychology Today*, *Science News*, *Science Digest*, *Outside*, and others. Her biography is included in *Who's Who in Science and Engineering*.

Biology is an exciting but challenging subject, both for students to learn and for professors to convey. Successful students and teachers have both come to appreciate two key elements in learning biology: active participation in one's own learning, and the forging of links between new knowledge and a student's prior experience. The central focus of *The Nature of Life* is to provide the active student participation and the connections to prior knowledge necessary for meaningful mastery of biology. Since its first publication in 1989, *The Nature of Life* has focused on active learning and student involvement. This current edition, however, takes that charge to new levels and brings the reader to the science of life in innovative and we predict, unusually successful ways.

- We began by retaining our most successful features from the first two editions—approaches that were product-tested by thousands of students and professors in the United States and several foreign countries, and polished through countless rounds of reviewing, editing, and revising.

- To motivate and excite nonmajors, we generated 42 stories—one per chapter, and most of them new to this edition. These stories are vehicles for capturing and holding attention, as well as for posing central questions about the natural world and organizing basic biological concepts. Educational research shows that students show more interest in basic subjects presented this way and retain more of what they've learned.

- We created an art program full of orienting icons, unique process diagrams, and colorful photos, then closely coordinated them to the text so readers could verbalize and visualize biological structures and activities simultaneously.

- We updated the science where appropriate to reflect the exciting developments in this fast-moving field.

- We incorporated current social issues and topics of student relevance throughout the chapters and in the numerous boxed essays.

- We retained several end-of-chapter study tools, such as Connections and Highlights in Review, to help students integrate what they have learned and test their own comprehension.

- We continued to focus on evolution and the environment as major bookwide themes, and to emphasize the process of science—not just individual facts and ideas.

This current edition has a large number of new features, based on input from dozens of teachers and other colleagues, and designed to expand and improve student participation and learning dramatically.

- We have redesigned the book's graphic elements from front to back, making *The Nature of Life* not just more inviting to read and study but helping users find the book's major parts quickly and distinguish the hierarchical importance of chapter sections more easily.

- We have added hundreds of new photographs and enlarged most of the rest; our purpose was to help students remember details more easily, as well as to better enjoy the beauty and fascination of biological images.

- We have reconfigured many of the book's diagrams to maximize the student's ability to identify structures, comprehend where they occur, sort the more relevant details from the less relevant ones, and follow the steps of sequential processes more effectively.

- We now display a list of Messages on each chapter opener page to serve as a conceptual roadmap, a set of chapter objectives, and a framework for review.

- We include Concept Challenges at the end of each major section within every chapter. These questions require students to stop, reflect upon, and apply the concepts they have just covered to interesting real-world problems.

- We have added Active Learning Boxes that walk a student through the scientific investigation of biological problems. This helps students to see exactly how facts and concepts are applied via the scientific method to real issues and involves them in that process first-hand.

- We have developed several new Concept Integrators, that is, large hand-painted illustrations that visually link various concepts and facts from a chapter discussion.

- We have created Apply and Decide essays that pose societal issues, remind students of the relevant biological principles from preceding chapters, show how students can apply those principles to the issue, and ask them to make a personal decision on the issue.

- We have replaced each chapter's study questions from the second edition with a vastly improved set that necessitates far more critical thinking and application of facts and principles and far less recitation. Answering these questions requires real understanding. The questions will not only help the student to better prepare for evaluation, but will enhance retention of the material.

- Finally, we explain early in the book how students can construct Concept Maps, then present several Concept Mapping exercises to help students understand relationships between topics, construct knowledge in personally meaningful ways, and pinpoint weak areas in their grasp of facts or concepts.

While the enthusiastic, thoughtful teacher and the engaging textbook are the central tools for biology education, multimedia software can integrate moving images, sound, and text to show how organisms look and act and how sequential events take place in the microscopic domain of a living cell. This edition of *The Nature of Life* comes supported by a range of technological study aids that we think will be both effective and entertaining, and will promote active student participation.

*The Nature of Life* helps students learn biology not only by the pedagogical tools just listed, but by the logical approach to biology subject matter taken by most biology teachers.

## Our Approach to Biology

*The Nature of Life* takes a hierarchical approach to biology, beginning with the fundamental shared features of all life, moving to the specific features displayed by various groups of organisms, and then examining the interactions of groups of organisms with their environments. Chapter 1 introduces the main themes of the book, including evolution, the environment, energy, reproduction, and the process of science. Part I considers the fundamental principles that unify all life: Chapters 2 and 3 cover the molecular and cellular basis of life, and Chapters 4, 5, and 6 describe how organisms acquire and use energy.

Part II focuses on the many aspects of reproduction. Chapters 7 through 10 discuss how inherited traits are passed from parent to offspring. Chapters 11 and 12 explore the exciting world of biotechnology and the frontiers of human genetics. Chapters 13 and 14 probe the fascinating mechanisms by which genetic instructions and cellular mechanisms change an egg cell into a fish, fly, frog, or a human baby.

Once familiar with the cellular and genetic features that *unify life* from Parts I and II, the student is ready to investigate biology's grandest idea: the mechanisms of evolution, and how descent with modification can explain the *diversity of life*. Part III, new to the 3d edition, begins in Chapter 15 with an expanded investigation of the evidence for evolution in the natural world. This is followed in Chapter 16 by a grounding in the role genes play in evolution. Chapter 17 presents the fascinating theories for life's origins and history, and Chapter 18 places the world's current biodiversity crisis in an evolutionary context.

The book's evolutionary theme continues as we survey the evolution and lifestyles within the diverse kingdoms of organisms, from bacteria through protists, fungi,

plants, and animals in Chapters 19 through 22. This section ends with a new chapter, Chapter 23, that describes the evolutionary descent of our own species. The four new chapters in Part III plus the five retained from the second edition build on the evolutionary themes that permeated our earlier editions, and significantly increase the breadth and depth of coverage of this topic which is so central to all levels of biological thought.

Parts IV and V investigate how the bodies of animals and plants function in ways that allow them to survive in their particular environments. Chapter 24 introduces general concepts that recur throughout the study of animal anatomy and physiology. The next nine chapters analyze individual physiological systems in animals and show how organisms adapt to sometimes bizarre environments and how the reader's own physiological systems work in familiar and extreme situations. Of particular interest to students may be Chapter 26 on the immune system; Chapters 31 and 32 on nervous systems, the brain, and behavior; and Chapter 33 on exercise and the body's musculoskeletal support.

Part V, expanded in this edition, demonstrates the intriguing anatomy and physiology of plants and the interplay with their environments. Chapter 34 describes basic plant architecture, then Chapters 35 and 36 explore how plants obtain nutrients, how they reproduce and develop, and how plant biotechnologists are harnessing plants to improve human health and nutrition. Chapter 37 on plant growth regulators ends the section by returning to the bookwide theme of how organisms interact with and respond to their physical and biological surroundings.

The backgrounding in Parts I through V prepare the student to thoroughly absorb what is arguably the most important part of the book, Part VI: the interactions of organisms with their environments. Our hierarchical approach is again evident in this section, beginning with a discussion of population biology in Chapter 38, enlarging the scope to biological communities and ecosystems in Chapters 39 and 40, then expanding the focus still further in Chapter 41 to the biosphere, all living organisms and their environments on Earth. Chapter 41 emphasizes the global changes now being triggered by human activities, and encourages students to act personally and perhaps professionally to help maintain a cleaner world with sustainable resources. This ecological theme continues into Chapter 42, the book's final chapter, as it investigates animal behavior in natural environments, including human behavior and how it will inevitably shape the world of the future.

A skilled, enthusiastic teacher will always be the most important element in a student's introduction to biology. A textbook such as *The Nature of Life*, however, can be a crucial tool in the student's exploration by en-

gaging him or her, showing biology's relevance to daily campus life, and by conveying the excitement of discovery in life science. We believe this dramatically revised edition will enhance student participation and learning in demonstrable ways, and hope you will find that to be true.

## Supplementary Materials

A comprehensive and completely integrated package of supplementary materials accompanies *The Nature of Life*, Third Edition.

### THE SECRET OF LIFE

*The Secret of Life* is a multifaceted project that was developed in conjunction with WGBH, Boston to support and complement the third edition of *The Nature of Life*. *The Secret of Life* package includes the WGBH telecourse of the same name, and accompanying Faculty and Study Guides; an interactive videodisc with figures from the textbook and accompanying teacher's guide; and a videotape containing eight 15-minute modules, each dealing with a different concept in biology, and accompanying teacher's guide.

**Telecourse** The 13-unit college telecourse is intended as an introductory biology course for nonmajors with an emphasis on molecular biology. Each course unit builds understanding for those that follow, with early units addressing life at the cellular level and progressing to how animal systems function, how genes determine certain traits, and how life's species fit into the large picture of our planet. The telecourse materials include:

- ***The Nature of Life***, Third Edition  
John Postlethwait / Janet Hopson
- **Telecourse Programs\***  
WGBH, Boston and BBC-TV.\*

Eight one-hour television programs that reveal current trends in molecular biology, illustrate scientists at work, and convey challenges and opportunities in this growing field.

- **The Telecourse Study Guide and Faculty Guide**

Joan Jolly / Michelle Barg, The Cadmus Group, Inc. These guides provide the link for both professor and student between the telecourse and the textbook. Chapters

in the two guides follow that of the 13-unit telecourse. Among its features, the Study Guide provides students with an overview before viewing each unit, as well as followup exercises for after viewing the program. The Faculty Guide features information on additional readings; text references to *The Nature of Life*, Third Edition; expanded treatments of difficult concepts, and a number of questions for discussion, writing exercises, and exams.

### ***The Secret of Life Video Modules***

WGBH, Boston and BBC-TV

WGBH has produced eight 15-minute video modules that illuminate the biological universe with unique stories and animation. Based on "The Secret of Life" television series, these modules span topics from archaeobacteria and the basics of life to viruses, evolution, modern scientific technology and the biodiversity crisis. Each module concludes with a series of stimulating questions for class discussion.

- **Teacher's Guide to Accompany *The Secret of Life Video Modules*,**

Gail Patt, Boston University

### ***The Secret of Life Videodisc***

WGBH, Boston

A two-sided videodisc will be available as a companion to *The Nature of Life*, Third Edition. Side A of the videodisc will provide 30 minutes of film clips, animation, and still images, covering cells, genetics, interactions and ecology, and research techniques. Side B will also contain 300 stills from the third edition of *The Nature of Life*. Side B of the videodisc will contain 4 of the 8 video modules from *The Secret of Life* series. Topic coverage will include biotechnology, human reproduction, portraits of modern science and research, and human genetics. The videodisc provides menu access and editor software for users as well as a user's guide featuring bar codes for level-one use.

- **User's Guide to Accompany *The Secret of Life Videodisc***

WGBH, Boston

### FOR THE INSTRUCTOR:

#### **Instructor's Manual/Test Bank/Visiquizzes**

Dennis Todd, University of Oregon

For this edition, the instructor's manual has been combined with the text bank/visiquizzes to form a more unified teaching tool for the professor. The revised instructor's manual includes an updated multi-media reference list as well as the integration of eye-catching icons for quicker text and supplement cross-referencing.

The test bank has been revised and expanded to include 1000 new questions for a total of 3000. The visiquiz section will contain new black line illustrations from the third edition text for use in quizzes or exams.

\* Check your local PBS station for telecourse air dates.

\* Corporate funding for *The Secret of Life* is provided by the Upjohn Company.

**Computerized Test Bank** The printed test bank is available in a computerized format for IBM 5¼ inch, IBM 3½ inch, and MacIntosh computers.

**Overhead Transparencies** This package of 300 four-color acetate transparencies provide enlarged text illustrations and labels for use in lecture. These overhead transparencies will also be available electronically on *The Secret of Life* videodisc.

### **Instructor's Manual to Accompany Exploring The Living World: A Lab Manual for Biology**

Anton E. Lawson, Arizona State University

The instructor's manual that accompanies this unique approach to lab investigations is designed to provide supportive material for the professor using methods of scientific reasoning in his or her lab course. Instructors are provided with background information about each of the 40 investigative labs as well as teaching tips which include advanced preparations, explorations, term introductions, and concept applications.

### **Primis Apply and Decide Case Studies**

Janet L. Hopson

As a followup to this new text feature, the Apply and Decide case studies have been expanded to provide instructors with additional real-life studies that are tied into concepts presented in the text. By providing 25 original case studies on McGraw-Hill's electronic database system, Primis, professors will have the ability to incorporate additional case study topics over and above the six in the textbook. These can be used for class discussion, reading, or writing assignments.

## **FOR THE STUDENT:**

### **Critical Thinking Workbook**

Gail Patt, Boston University

In this revision the workbook has been updated to reflect the new organization of the main text. A new feature to the workbook is the addition of relevant popular press articles for each part opener to aid students in making the connection between biology and everyday life.

### **Exploring the Living World: A Laboratory Manual for Biology**

Anton Lawson, Arizona State University

This new lab manual features 40 investigative labs for introductory biology students. The author has taken an alternative approach to traditional lab manuals. With an emphasis on scientific reasoning, students using this manual are asked to come up with causal questions and proposed explanations before actually carrying out the laboratory experiment. They are also periodically asked to develop their own experiments using the materials provided.

### **Exploring the Living World: Primis Edition**

Anton Lawson, Arizona State University

This traditionally published lab manual will also be

available on the Primis electronic database for individual instructor organization and selection.

## **SECOND EDITION SUPPLEMENTS:**

### **For the Instructor:**

- Laboratory Prep Guide to Accompany Hands-on Biology
- *The Nature of Life* Videotape

### **For the Student:**

- Hands-on Biology
- Laboratory Manual to Accompany *The Nature of Life* revised edition
- Biopartner Tutorial Software
- Biology Write Now!

## *Acknowledgments*

Insightful critiques improve any product, and a textbook is no exception. We appreciate the many teachers, subject area specialists, and students whose comments helped us revise this edition and improve its utility in teaching biology. A complete list of those participants follows. Here, we would like, in particular, to thank those reviewers who read the entire manuscript for this third edition: Steve Muzos, Sandra Steingraber, and Rob Tyser. Their comments and suggestions have been enormously valuable.

We would also like to express special gratitude to those subject area specialists who helped us update and streamline subjects that are sometimes challenging for students. Katherine Milton contributed substantial material for the new Chapter 23 on human evolution; Mark Schlessman focused on the plant biology in Chapters 34 to 37. Tom Sharkey commented on our discussion of photosynthesis. And George Barlow helped orient Chapter 42 on animal behavior.

Our hearty thanks go to Gail Patt, who composed the end-of-chapter study aids, which go far beyond the simple recall of facts and definitions to higher-level learning of concepts, applications, and problem-solving.

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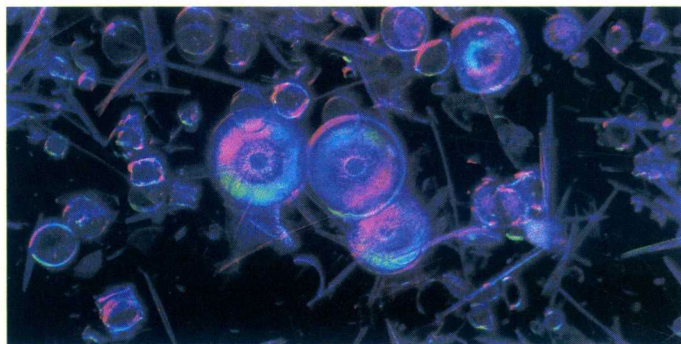
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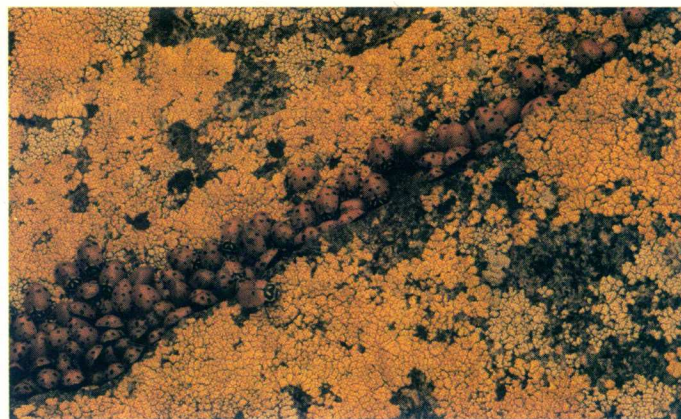


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