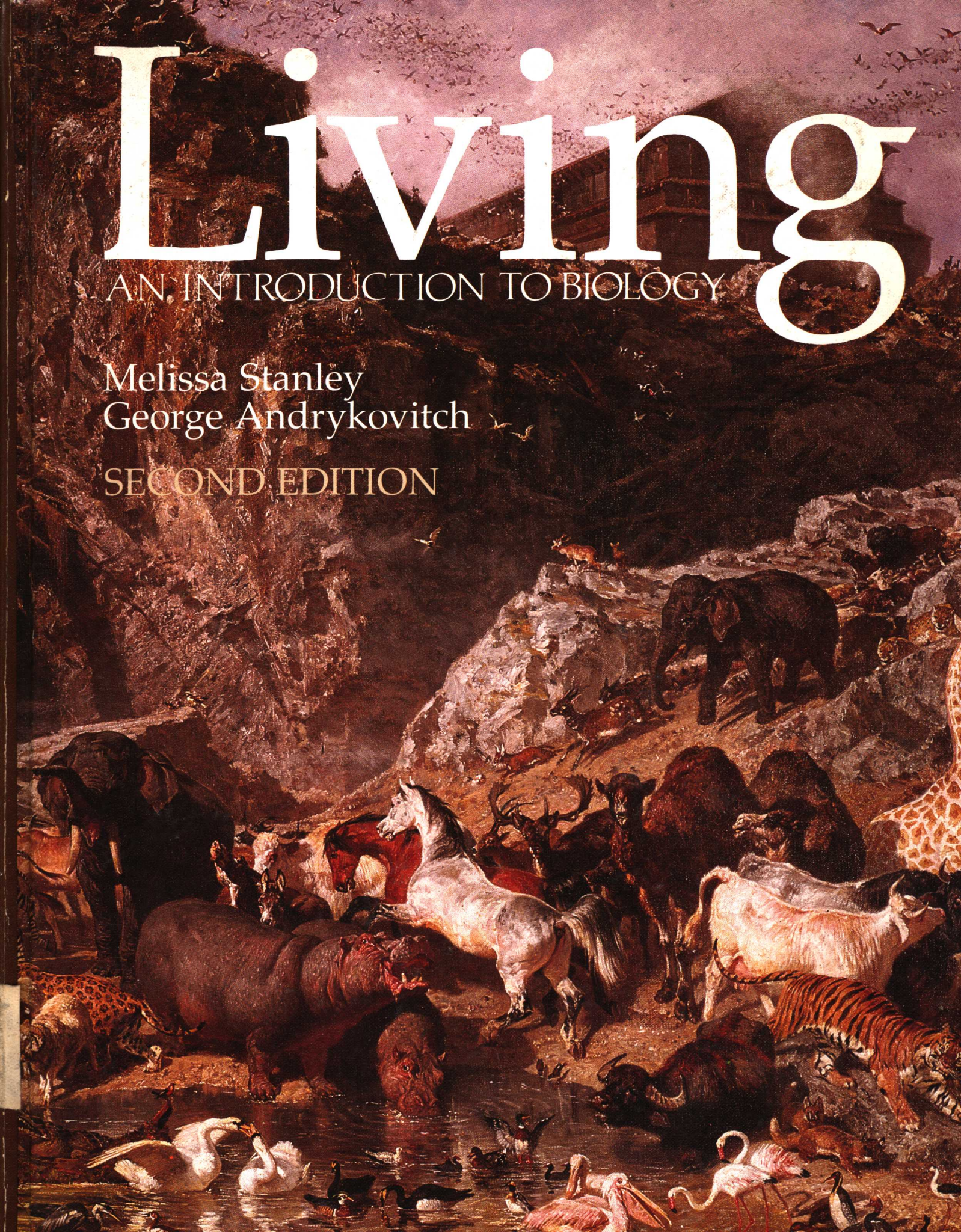


# Living

AN INTRODUCTION TO BIOLOGY

Melissa Stanley  
George Andrykovitch

SECOND EDITION



*To all biologists who strive to interpret the living world  
and  
to their students whose decisions may determine the fate of future generations*

---

This book is in the Addison-Wesley Series in the Life Sciences.

*Sponsoring Editor:* Nancy J. Kralowetz

*Production Manager:* Karen Guardino

*Production Editor:* Margaret Pinette

*Text Designer:* Catherine Dorin

*Illustrators:* Intergraphics; John M. and Judith A. Waller; and Sandra McMahon

*Copy Editor:* Carol Beckwith

*Art Development Editor:* Arthur Ciccone

*Art Coordinator:* Dick Morton

*Cover Designer:* Richard Hannus, Hannus Design Associates

*Cover Painting:* F. Palizzi, *After the Flood*. Editorial Photocolor Archives, Inc.

*Manufacturing Supervisor:* Ann DeLacey

#### **Library of Congress Cataloging in Publication Data**

Stanley, Melissa.

Living: an introduction to biology.

Includes bibliographies and index.

1. Biology. I. Andrykovitch, George. II. Title.  
QH308.2.S7 1984 574 83-15850  
ISBN 0-201-16460-4

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ABCDEFGHIJ-DO-89876543

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# Preface for Instructors

*CONCEPTS PRESENTED IN  
CONTEXT: THE INTERPRETIVE  
APPROACH*

This second edition of *Living* has been written for students in introductory biology courses, who want and deserve more than abstract theories and concepts. To meet their needs we have organized this text around the biologically important aspects of the world—from the inside of the human body to the organisms and organization that constitute the biosphere. Integrated within our discussion of human life and the biological world you will find the molecular and cellular biology, the genetics and evolution, and the botany and zoology you expect in a nonmajors text. In short, we have retained the interpretive approach while responding to your suggestions for making this book a more useful teaching tool.

*A NEW SECTION ON EVOLUTIONARY  
BIOLOGY*

New chapters on animal behavior and diversity are part of a section emphasizing both mechanisms of evolution and the history of life.

*MANY CHAPTERS REWRITTEN*

We reorganized several key chapters including those on chemistry and genetics to bring together topics from other sections. New material such as transposable genetic elements and speciation by punctuated equilibrium was added. But in selection of information we followed our original requirement that facts and concepts must contribute to the understanding of important biological processes.

*NEW PHOTOGRAPHS ADDED AND  
ILLUSTRATIONS REDRAWN*

Color photographs illustrate the new diversity chapter and the living ecosystems section. We carefully evaluated each illustration and replaced many to achieve a more uniform technical level. The script used to highlight processes in the first edition drawings has been replaced with easier-to-read type. Many drawings have been relabeled. Color was added to make the illustrations easier to understand. To take better advantage of space some illustrations have been enlarged and others reduced.

*LEGENDS SHORTENED*

Illustrations are closely tied to the text. The legends stress identification of the subject or process presented.

*KEY MATERIAL HIGHLIGHTED*

Sentences and phrases presenting important facts and ideas are underlined. We explain the significance of biological observations as you do in lecture and use underlining just as you might write key matter on the blackboard.

*CHAPTER-END QUESTIONS ADDED,  
FURTHER READINGS UPDATED*

Ten or more study questions have been added at the end of each chapter. Further readings appear at the end of sections and emphasize recent, relatively nontechnical articles.

*THOUGHT AND CONTROVERSY,  
CROSS-REFERENCES, AND CHAPTER  
SUMMARIES RETAINED*

We were pleased with the positive response to the opened thought and controversy sections. Cross-references to the location of related material on earlier pages have been well-received along with the chapter summaries.

*INDEX AND GLOSSARY*

Both the index and the glossary have been expanded to make them more effective study aids.

*SUPPLEMENTAL MATERIALS*

A full package of teaching and learning aids accompanies this textbook. Contact your Addison-Wesley representative for information on the instructor's manual, student study guide, test bank, 35 mm slides, and overhead transparencies.

Revisions, like first editions, depend on the help of many individuals, reviewers, editors, illustrators, and others to whom authors are indebted. We owe special thanks to the fine people at Addison-Wesley and our colleagues at George Mason University, who have worked so hard to help us make this a clear, forceful, and meaningful introduction to life sciences. Although we delight in finding new and better ways to express fundamental concepts, our insight alone is inadequate. We urge you to not only notify us of errors, but to forward suggestions for a third edition.

*Fairfax, Virginia  
November, 1983*

M.M.S.  
G.E.A.

---

# To the Student

PERHAPS THIS IS YOUR FIRST SCIENCE COURSE and you are wondering how to study biology. One strategy is to complete all the exercises in the study guide available specifically to accompany this textbook. Another, more general method is to pretend that *you* are teaching this course! Write yourself the kind of notes you would need if you were teaching. In preparing such notes, use the notes you take in lecture, this text, and at least one other text from the library. Follow your notes from lecture as a guide to overall organization and the material to be covered. Use the texts to check each piece of information. Most important of all, use your head to decide exactly what to write.

The process of deciding what to write is the crucial part. Active participation stimulates learning. As you write, don't merely copy; put everything into your own words. To do so, you must understand the matter at hand. Therefore you must read and think.

After you have written your notes, review them. Every time you sit down to write new notes, review those you have written previously. Consider each point and make sure you can explain it to someone else. Before an examination, it is worthwhile to write a condensed outline of your notes. The more time you devote to perfecting your notes, the better you will understand the material for the more you will have thought about it.

When practical, vocalize your notes. Perhaps you can form a study group with classmates and hold informal seminars. All kinds of students can help one another. Those who are well prepared will correct one another. Those who haven't devoted much time to study can provide questions that stimulate others to teach and thus to review the material over and over.

Both the study guide and the make-believe teaching experiences we suggest require that you study actively. When you examine facts and ideas, organize them, and question them, you will find that you learn readily. Learning may be work but active participation makes it fun, too.

We hope you enjoy studying this book as much as we have enjoyed writing it. Despite our best efforts it is imperfect, as you are sure to find. We urge you to write us with corrections and suggestions to make the book a more effective learning tool. Address your comments in care of Addison-Wesley Publishing Company, Reading, Massachusetts 01867.

*Fairfax, Virginia*  
*November, 1983*

M.M.S.  
G.E.A.

P.S. To sharpen your graph-reading skills, study Box 1B in Chapter 1.

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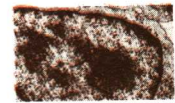
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SECOND EDITION

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# Living:

AN INTRODUCTION  
TO BIOLOGY

Melissa Stanley  
George Andrykovitch

George Mason University



ADDISON-WESLEY PUBLISHING COMPANY

Reading, Massachusetts

Menlo Park, California

London ◦ Amsterdam ◦ Don Mills, Ontario ◦ Sydney

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## PART ONE

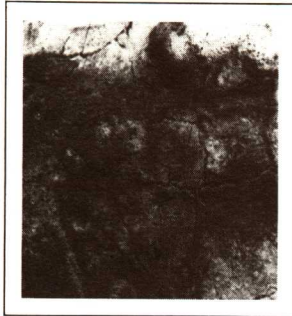
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# Perspectives on Living

We are living on the earth as parts of a dynamic complex of organisms and lifeless matter. Surely to continue living is our most fundamental goal. How long we succeed may be influenced by how well we understand ourselves and our environment.

This text provides an introduction to the requirements for human life and to the nature of the world in which we live. We believe it will help you to understand problems that people face today and to make decisions that will promote human life.

There are four major topics to be covered: the biology of humans, reproduction and inheritance, the living and nonliving components of our environment, and management of this environment. Each makes up a major section of the book. Your understanding of these topics will be enhanced by an introduction to biological principles and to the history of human life. Thus the first two chapters are intended to help you interrelate those that follow and to view the living world as a whole.



# 1

---

## Basic Biology: Principles and Practice

ANY ATTEMPT TO ANALYZE THE NATURE OF HUMANS and their relationships with other living things and with their physical environment is an ambitious project. Biological processes are often complicated, and their interactions are extensive and intricate. So let us begin by establishing a groundwork of biological information. Consider this chapter an overview of biology. Subsequent chapters will build and expand on the information given here, so you may want to consult this chapter frequently as we examine the living world together. If you return to these pages at the end of your studies, you will surely have a greater appreciation of the chapter's basic themes.

### THE UNITY OF LIFE

Is there anyone who does not marvel at the tremendous diversity of life on our planet? Most of us never lose that sense of wonder we experienced when we first visited a zoo or stopped in a beautiful garden or spent a summer at the seashore and found incredible living things among the rocks. On the surface, each kind of organism seems special and unique, but the extraordinary diversity of outward forms is deceptive.

Biologists have long recognized that there is a fundamental unity of life. Organisms share common patterns of chemical composition, structure, and activity. The unity of life is a basic philosophical principle underlying our belief that organisms can be studied systematically and that the knowl-

edge gained may be applicable in widely separated situations.

### A Common Chemistry

Some of the chemical constituents of organisms are found in both the living and nonliving worlds. However, certain chemicals are uniquely associated with life. The list includes **proteins, polysaccharides, nucleic acids, and lipids**. Each of these substances is important in its own way, but proteins and nucleic acids have special significance. Chromosomes, which carry the genes that determine the characteristics of an organism, are composed of **deoxyribonucleic acid (DNA)**. The genetic information in DNA includes directions for making proteins. And although some proteins, such as those of hair, are purely structural in their uses, many others are **enzymes**. Enzymes are substances responsible for initiating most of the chemical activities essential to life.

The chemical activities of organisms are collectively referred to as **metabolism**. Certain metabolic activities are common to all forms of life. Each organism must accumulate raw materials to make the constituents of living matter. At the same time, organisms must generate the energy needed to accomplish these activities along with others, such as movement.

All organisms coordinate and regulate their activities. In fact, life processes occur under conditions of relative **homeostasis**—that is, under con-



**FIGURE 1.1 Obvious Differences between Organisms Hide the Fundamental Unity of Life.** Here, the North American lizard, *Anolis carolinensis*, waits for its next meal amid the lush background of the sea ox-eye daisy.

ditions that remain nearly constant, despite changes in the outside environment. Most metabolic processes proceed in a step-wise fashion, with each step controlled by a particular enzyme. Many organisms exert a more generalized control by means of chemical messengers such as **hormones**. In people, hormones travel in the blood and sometimes act swiftly, far from the gland where they were secreted.

### Patterns of Organization

Organisms are not random stews of chemicals thrown casually together. Living material is intricately structured. The **cell** (Fig. 1.2) is the smallest unit of organization that exhibits the full range of interrelated activities that characterize life. Plant and animal cells are themselves composed of cytoplasm and organelles. Cell organelles include specialized structures such as the nucleus that contains the chromosomes.

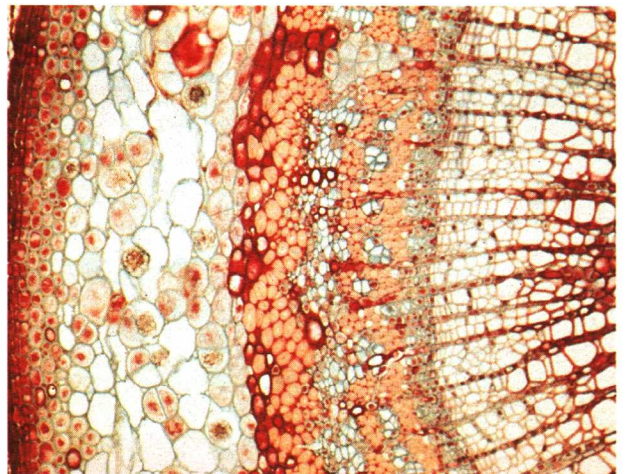
Although many small organisms consist of only one or a few cells, most familiar plants and animals contain billions of cells. In these complex organisms each cell is **differentiated** (specialized) for a particular function. Groups of cells of the same structure and function form a **tissue** (Fig. 1.3). Usually these cells are woven together to form distinct microscopic or visible structures, such as muscle, bone, or cartilage, but the cells of some tissues are free to move about. Blood is an example of such a tissue.

In animals, tissues are organized into distinct organs that perform more complex functions. The brain, stomach, liver, and heart are key human organs. The heart tissues include muscle, which makes up most of the mass; connective tissues, which bind the muscle together; and nerve fibers, which regulate the heartbeat. Many animals have **organ systems** composed of interacting organs. For example, the mouth, esophagus, stomach, intestine, liver, and pancreas are components of the





(a)



(b)



(c)



(d)

**FIGURE 1.2 Levels of Biological Organization in Plants.** (a) Chromosomes in root cells; (b) tissue layers of a stem; (c) reproductive organs of the red chokeberry; (d) two populations in a community.

human digestive system. Together these organs digest and absorb nutrients. Many plants have organs such as leaves, stems, and roots. Systems of organs aren't usually recognized in plants, although male and female parts (organs) of a flower might be considered a plant organ system.

Although in one sense individual organisms are independent, each is related by origin to other members of its kind, or **species**. Every organism is born into a **population** of its species. Members of a population share many potential interactions—reproduction, for example.

In any area, all the members of every species influence each other in one way or another, however slightly. These interactions take many forms, but the most obvious is the **food chain**. One species eats another and is usually eaten in turn, so that there are long chains of nutritional transfers involving many species. Many effects between species are more subtle, as when large plants provide smaller ones with shelter from sun, wind, or rain. Populations of organisms that live in a particular environment rely on one another so much that they are said to constitute a **community**. The use of the term "community" in this context compares the interactions of the members of a biological community to those in a human social community.