Ricki Lewis

Animal Life

Life

Beginnings of Life
Animal Life
Plant Life
Evolution of Life
Behavior and Ecology of Life

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Kevin Kane
Senior Editor
Biology

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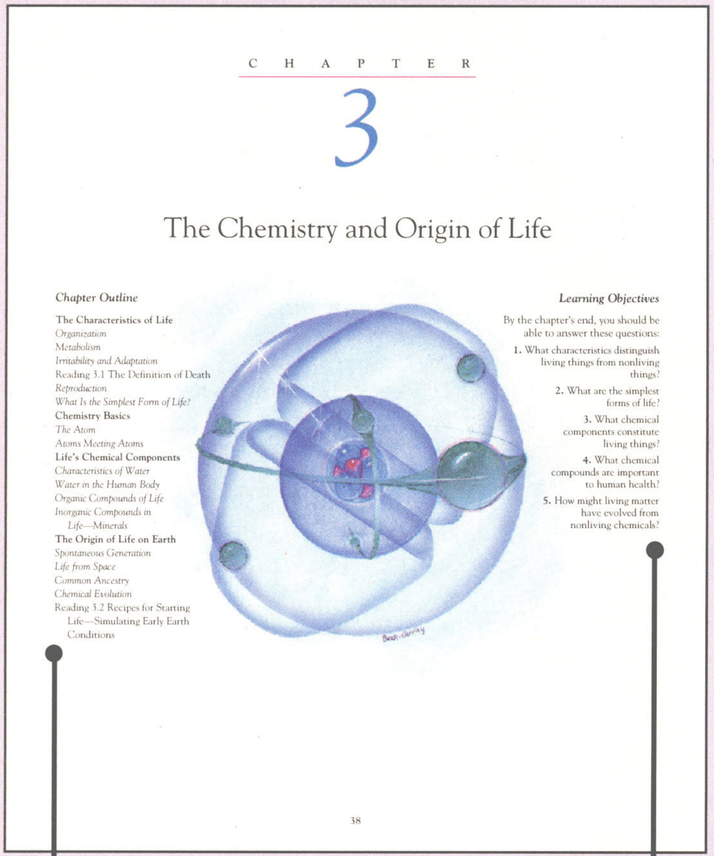
The *Life* Learning System



C H A P T E R

3

The Chemistry and Origin of Life

Chapter Outline

The Characteristics of Life
Organization
Metabolism
Irritability and Adaptation
Reading 3.1 The Definition of Death
Reproduction
What Is the Simplest Form of Life?
Chemistry Basics
The Atom
Atoms Meeting Atoms
Life's Chemical Components
Characteristics of Water
Water in the Human Body
Organic Compounds of Life
Inorganic Compounds in Life—Minerals
The Origin of Life on Earth
Spontaneous Generation
Life from Space
Common Ancestry
Chemical Evolution
Reading 3.2 Recipes for Starting Life—Simulating Early Earth Conditions

Learning Objectives

By the chapter's end, you should be able to answer these questions:

1. What characteristics distinguish living things from nonliving things?
2. What are the simplest forms of life?
3. What chemical components constitute living things?
4. What chemical compounds are important to human health?
5. How might living matter have evolved from nonliving chemicals?

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Chapter Outlines

Each chapter begins with an outline. These will allow students to tell at a glance how the chapter is organized and what major topics have been included in the chapter. The outlines include the first and second level heads for the chapter.

Learning Objectives

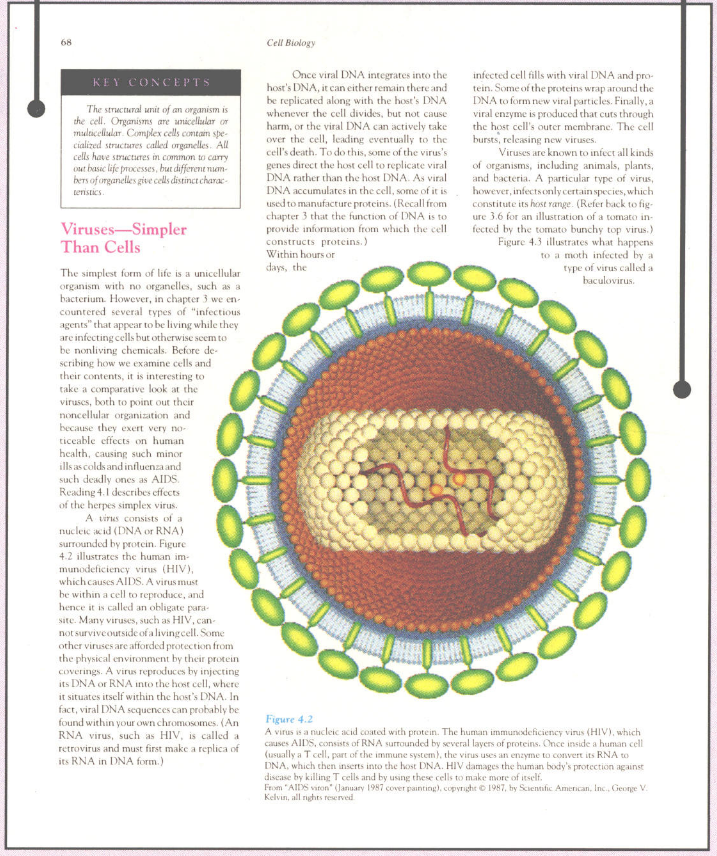
Each chapter begins with a list of concepts stressed in the chapter. This listing introduces the student to the chapter by organizing its content into a few meaningful sentences. The concepts provide a framework for the content of each chapter.

Key Concepts

At the ends of major sections within each chapter, summaries briefly highlight key concepts in the section, helping students focus their study efforts on the basics.

Dramatic Visuals Program

Colorful, informative photographs and illustrations enhance the learning program of the text as well as spark interest and discussion of important topics.



68 *Cell Biology*

KEY CONCEPTS

The structural unit of an organism is the cell. Organisms are unicellular or multicellular. Complex cells contain specialized structures called organelles. All cells have structures in common to carry out basic life processes, but different numbers of organelles give cells distinct characteristics.

Viruses—Simpler Than Cells

The simplest form of life is a unicellular organism with no organelles, such as a bacterium. However, in chapter 3 we encountered several types of "infectious agents" that appear to be living while they are infecting cells but otherwise seem to be nonliving chemicals. Before describing how we examine cells and their contents, it is interesting to take a comparative look at the viruses, both to point out their noncellular organization and because they exert very noticeable effects on human health, causing such minor ills as colds and influenza and such deadly ones as AIDS. Reading 4.1 describes effects of the herpes simplex virus.

A *virus* consists of a nucleic acid (DNA or RNA) surrounded by protein. Figure 4.2 illustrates the human immunodeficiency virus (HIV), which causes AIDS. A virus must be within a cell to reproduce, and hence it is called an obligate parasite. Many viruses, such as HIV, cannot survive outside of a living cell. Some other viruses are afforded protection from the physical environment by their protein coverings. A virus reproduces by injecting its DNA or RNA into the host cell, where it situates itself within the host's DNA. In fact, viral DNA sequences can probably be found within your own chromosomes. (An RNA virus, such as HIV, is called a retrovirus and must first make a replica of its RNA in DNA form.)

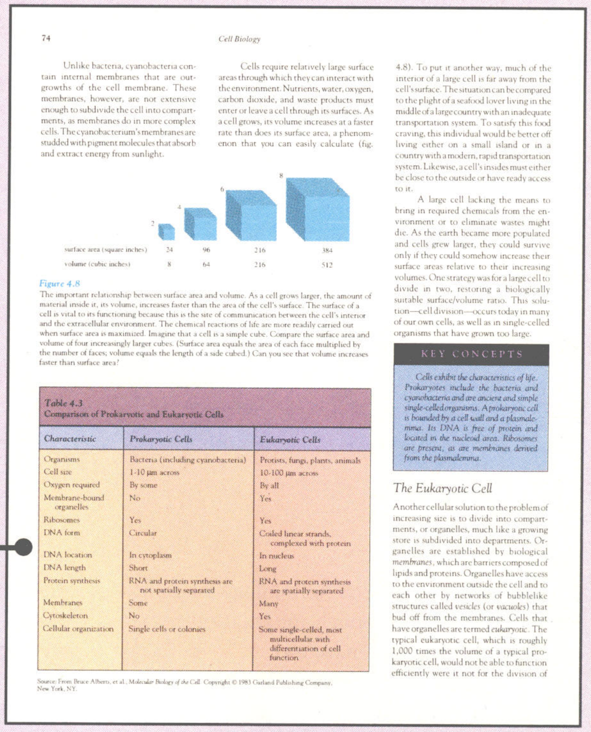
Once viral DNA integrates into the host's DNA, it can either remain there and be replicated along with the host's DNA whenever the cell divides, but not cause harm, or the viral DNA can actively take over the cell, leading eventually to the cell's death. To do this, some of the virus's genes direct the host cell to replicate viral DNA rather than the host DNA. As viral DNA accumulates in the cell, some of it is used to manufacture proteins. (Recall from chapter 3 that the function of DNA is to provide information from which the cell constructs proteins.) Within hours or days, the infected cell fills with viral DNA and protein. Some of the proteins wrap around the DNA to form new viral particles. Finally, a viral enzyme is produced that cuts through the host cell's outer membrane. The cell bursts, releasing new viruses.

Viruses are known to infect all kinds of organisms, including animals, plants, and bacteria. A particular type of virus, however, infects only certain species, which constitute its *host range*. (Refer back to figure 3.6 for an illustration of a tomato infected by the tomato bunchy top virus.) Figure 4.3 illustrates what happens to a moth infected by a type of virus called a baculovirus.

Figure 4.2
A virus is a nucleic acid coated with protein. The human immunodeficiency virus (HIV), which causes AIDS, consists of RNA surrounded by several layers of proteins. Once inside a human cell (usually a T cell, part of the immune system), the virus uses an enzyme to convert its RNA to DNA, which then inserts into the host DNA. HIV damages the human body's protection against disease by killing T cells and by using these cells to make more of itself.
From "AIDS viron" (January 1987 cover painting), copyright © 1987, by Scientific American, Inc., George V. Kelvin, all rights reserved.

Readings

Throughout *Life*, selected readings both elaborate and entertain. Some describe experiments, some provide health information, and others are closer looks at specific topics. All readings are written by the author.



Tables

Numerous strategically-placed tables list and summarize important information, making it readily accessible for efficient study.

Boldfaced Words

New terms appear in boldface print as they are introduced within the text and are immediately defined in context. If any of these terms are reintroduced in later chapters, they are italicized. Key terms are defined in the text glossary with appropriate page reference.

To Think About

Located at the end of each chapter, these questions are springboards for class discussions and term paper topics.

Chapter Summaries

At the end of each chapter is a summary. This should help students more easily indentify important concepts and better facilitate their learning of chapter concepts

Questions

The end-of-chapter questions often continue the storytelling style of the chapter, using anecdotes and experiments from the chapter to illustrate and apply concepts.

Suggested Readings

A list of readings at the end of each chapter suggests references that can be used for further study of topics covered in the chapter. The items listed in this section were carefully chosen for readability and accessibility.

Preface

Life was written with the nonbiology major in mind, but contains enough information to be suitable for a majors' course too.

Diversity in Action

While human examples and applications are emphasized, *Life*'s diversity is treated early in a separate chapter, later in an appendix on taxonomy, and is logically integrated into all chapters. The animal biology chapters, for example, explore a deep-sea shrimp's vision, an insect's exoskeleton, a cow's digestion, and much more. The behavior and ecology chapters are filled with glimpses into the lives of a variety of organisms, from aardwolves to fire ants to naked mole rats. The reader of *Life* will learn many new things, but also encounter familiar territory. The science of biology will not seem foreign—it will be fun and make sense.

Discovery and Evolution

Two conceptual threads weave their way through *Life*. The book opens with the first theme, discovery. The story of how the sweetener aspartame was discovered takes the student through the scientific method and experimental design, yet points out how the initial detection of the food additive was very much a surprise.

In chapter 2, "The Diversity of Life," taxonomy is alive and vibrant in the treetops of a Peruvian wildlife preserve, where biologists catalog the abundance of insect life; and in such an unlikely place as an urban fish market. A pair of children playing with spectacles led to the development of the compound microscope, as described in chapter 4. In chapter 6, "Biological Energy," the student can be the discoverer by using the reactions of photosynthesis to develop a photograph on a leaf. The inborn errors of metabolism, PKU (chapter 15, "Genetic Disease: Diagnosis and Treatment") was discovered thanks to a mother's alertness of her infant's odd-smelling diapers. And a simple treatment for newborn jaundice (chapter 24, "The Digestive System") was discovered by an observant English nurse changing "nappies" in the sunlight. Chapter 15 also tells the story of how a seemingly drunken sailor and his 5,000 living descendants helped provide the first genetic marker.

Not all discovery is accidental. The look at "Molecular Genetics" in chapter 13 is liberally sprinkled with descriptions of the most elegant experiments ever performed. The scientific method is reviewed in chapter 36, "The Behavior of Individuals," as students at the University of Miami track singing birds, and in chapter 38 "Populations," through ecologists conducting wildlife surveys. The creation of an artificial mini-biosphere, described in chapter 39 "Ecosystems," is an exciting view of scientific investigation—whether it works or not.

The second conceptual thread, evolution, accustoms the reader to continually wonder, "How did all of this happen?" How did a duo of protein and nucleic acid join forces long ago to form the first cell? How could random mutations in those early cells build the metabolic pathways of today? How did eukaryotic cells come by their highly successful "bags within a bag" organization? How do species arise, change, become extinct? How have our ideas about evolution themselves evolved?

Humor, History, and Human Values

An occasional foray into humor can help students learn. Consider the example of epistasis in chapter 11, borrowed from the soap opera "General Hospital," or the opening to chapter 34 "The Forces of Evolutionary Change," a love story between a moose and a dairy cow.

Historical references add interest and chronicle the evolution of ideas. The confusing multiple phenotypes of the blood disorder porphyria, for example, may have led the "mad king" George III to provoke the American Revolution. The study of genetics begins with early agricultural efforts nearly 10,000 years ago. How different were Edward Jenner's problems with how best to test his smallpox vaccine (chapter 28, "Plants Through History") from today's scientists' attempts to test AIDS vaccines? The state of the American temperate forest today reflects pioneer activity over the past centuries. Recent history brings the ecology chapters alive, from Mt. St. Helens to the Yellowstone fires to the nuclear explosion at Chernobyl.

Examining human values teaches the student to develop informed opinions and judgments about biologically relevant issues—a skill that will last long after the steps of glycolysis or the parts of the cell are forgotten. Should a pregnant woman who smokes or drinks alcohol be responsible for the health effects on her fetus? Should an employer be told the results of an employee's genetic marker test for Alzheimer's disease? Should we take extraordinary measures to save extremely premature babies if they will be handicapped after (or by) the treatment? Should we even attempt to clean animals drenched in oil from tanker spills? Should we limit reproduction? These disturbing queries are most often found in the "To Think About" sections at the chapters' ends, both so that they will not distract from learning major facts and concepts and so that the student is left thinking.

Integrating Technology

Technology has given new, exciting meaning to some difficult subjects. Discussing the development of extraembryonic structures segues into a peek at chorionic villus sampling. Liposomes are but an extension of cell membrane structure and function. Teaching DNA replication is no longer a hurdle, now that we have the polymerase chain reaction to demonstrate elegantly the power of the process. Filling in the details of food webs no longer requires being on the scene of a meal, thanks to stable isotope tracing (chapter 39, "Ecosystems").

The chapters on plant anatomy and physiology are bracketed by two unique applications chapters—chapter 28, "Plants Through History," chronicles our harvesting of the major crop plants, and chapter 32, "Plant Biotechnology," looks at how molecular and cellular techniques are likely to continue that harvest, via the genetic alteration of plant life.

Finally, Appendix A, "Microscopy", provides a closer look at the technology that really breathed life into biology, from the first crude lenses to today's powerful confocal microscopes. Yet the very technology that has taught us so much and made our lives so comfortable can get out of control, upsetting the delicate balance of life. Chapter 40 "Environmental Concerns," describes these problems, but emphasizes natural resiliency, leaving the reader, ultimately, with a sense of hope and purpose:

> *"This book has shown you the wonder that is life, from its constituent chemicals, to its cells, tissues, and organs, and all the way up to the biosphere. Do nothing to harm life—and do whatever you can to preserve its precious diversity. For in diversity lies resiliency, and the future of life on earth."*

Pedagogy

A great deal of creative energy has gone into the pedagogical aids, and some are quite different from those in the run-of-the-mill textbook. (For a visual walkthrough of these aids, examine the *Life* Learning System preview in this book's frontmatter.) The end-of-chapter "Questions" often continue the storytelling style of the chapter, using anecdotes and experiments from the literature to illustrate and apply concepts. The "To Think About" questions are springboards for class discussions and term paper topics. "Suggested Readings" go far beyond *Scientific American* and other textbooks, including sources such as *Science News, FDA Consumer* and the *New York Times*—sources that students are more likely to read, understand, and appreciate. "Learning Objectives," which open the chapters, "Key Concepts" following major sections, and end-of-chapter summaries reinforce main points.

"Readings" throughout the chapters both elaborate and entertain. Some describe experiments: "Enticing Cells to Divide in the Laboratory," "Recipes for Starting Life—Simulating Early Earth Conditions," "Tracking Development in Different Organisms;" some provide health information, "Cardiovascular Spare Parts," "Jon and Linda—The Plight of an Infertile Couple," "Our Overdrugged Elderly," "Steroids and Athletes—An Unhealthy Combination," "The War on Cancer;" others are closer looks, "A Closer Look at an Organelle—The Lysosome," "Tumor Necrosis Factor," "Odd Human Traits," or "The Herpes Simplex Virus." Some are practical, "Nutrition and the Athlete," "Food Inhalation and the Heimlich Maneuver" and many highlight diversity "Falling Felines," "Rumbles, Roars, Screeches, and Squeals—Animal Communication," or "Sexual Seasons."

Ancillaries

Instructor's Manual/Test Item File

Prepared by Heather McKean and James Hanegan of Eastern Washington University, the instructor's manual offers helpful suggestions for course outlines and developing daily lectures. Each chapter provides key concepts, key terms, chapter outlines, learning objectives, answers to the text's end-of-chapter questions, and suggested audiovisual materials. There are also 25 to 50 objective questions in a *Test Item File* in the back of the manual. (ISBN 0-697-10181-9)

Laboratory Manual

Written by Alice Jacklet, a colleague of mine at SUNY-Albany, the *Laboratory Manual* strongly emphasizes and guides students through *the process of scientific inquiry*. Beautifully illustrated in full-color, it features 20 self-contained exercises that can easily be reorganized to suit individual course needs. (ISBN 0-697-05637-6)

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Student Study Guide

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by Fred Drewes, Suffolk County Community College

This excellent new workbook offers students helpful suggestions for meeting the considerable challenges of a science course. It offers tips on how to take notes; how to get the most out of laboratories; as well as on how to overcome science anxiety. The book's unique design helps to stir critical thinking skills, while facilitating careful note-taking on the part of the student. (ISBN 0-697-14474-7)

The Life Science Lexicon
by William N. Marchuk, Red Deer College

This portable, inexpensive reference helps introductory-level students quickly master the vocabulary of the life sciences. Not a dictionary, it carefully explains the rules of word construction and derivation, while giving complete definitions of all important terms. (ISBN 0-697-12133-X)

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by Kent Van De Graaff, R. Ward Rhees, and Christopher H. Creek, Brigham Young University

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3. THE FIRST FORESTS
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   The ingenious adaptability of insects.
5. CONQUEST OF THE WATERS
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Brief Contents

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