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BIOLOGY

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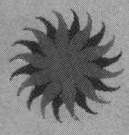

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Preface

The goal of BIOLOGY is to give the reader, the beginning biology student, an understanding and appreciation of the vast diversity of living things, their special adaptations to their environment, and their evolutionary and ecological relationships. We have emphasized the basic unity of life and the fundamental similarities of the problems that are faced by all living organisms. Along with this, we have been very conscious of our responsibility to impress upon students that we are not alone on earth. We share our home with many thousands of varieties of living things. Indeed we are dependent upon countless organisms for our very survival, and such is our position of ecological domination of the biosphere that they in turn depend on us. This interdependence is stressed throughout the text.

FOCUS. The principles of biology can be learned using as a model the frog, dogfish, daisy, and even the colon bacillus. We have chosen a comparative approach. A large number of students have a special interest in human biology—in the structure, function and development of the human body—generated perhaps by their plans for a career in medicine, dentistry, or one of the allied health sciences, or simply by an interest in how their body is put together and how it works. For this reason, we have, as have other textbook authors, made frequent use of the human being as a biological model, and we have given attention to the human aspects of biology. These very same students, however, are those who stand to benefit most from our comparative, principles-oriented approach; for as they continue their professional education, they may have little additional exposure to such subjects as plant biology, invertebrate biology, ecology, and evolution.

This book attempts neither to be encyclopedic nor cursory, but presents the concepts of biology and their relevance to human beings in interesting and understandable fashion. There is no general agreement among biologists as to the sequence in which the several major topics in a general biology course should be taught. This is understandable, for reasonable arguments can be advanced for each of the many possible combinations and permutations. The various aspects of biology are intimately related, and each could be grasped much more readily if all the other aspects had been learned previously. Since this cannot be done (except perhaps by a student repeating the course!), each instructor must choose the sequence that seems optimal to him or her. Because of this, we have taken special pains to write each chapter and each part so that they do not depend heavily upon preceding chapters and parts. The various parts and chapters can be taken up in any of a number of sequences with pedagogic success.

ORGANIZATION. An appreciation of science requires not only a grasp of the content of science but also an insight into the processes by which scientific knowledge is acquired. An introduction to the methods of science is given in Chapter 1 of Part I, and throughout the text examples of experimental work are presented to illustrate modern methods of biological research.

Part I continues with a discussion of the molecular basis of biology, and the architecture of cells and tissues. The chemistry chapters (Chapters 2 and 3) have been designed to be clear and biologically relevant. Too often a student turns to the first chapters of a biology book and develops the notion that he or she has actually enrolled in an introductory chemistry course. Chapters 4 and 5 (Cells and Cell Membranes) include the highest quality electron and light micrographs available; many of these are accompanied by detailed line drawings that clarify the fine points of cell organization. From Chapter 2 (Atoms and Molecules), through Chapter 3 (Macromolecules), on to Chapters 4 and 5 (Cells and Organelles), we have introduced the student to increasing large levels of organization in biological systems. In Chapter 6, we discuss multicellularity, tissues, and organ systems. However, since not all instructors will want to begin a discussion of these subjects early in the course, the chapter has been conveniently divided along the lines of plants and animals, so that the separate sections can be used immediately preceding the units on The Structures and Life Processes of Plants (Part V) and The Structures and Life Processes of Animals (Part VI).

Part II discusses the properties and constituents of enzyme systems, the flow of energy through the world of life, and the grand metabolic adaptations by which living systems obtain and utilize energy by photosynthesis and cellular respiration. Both in Part II and elsewhere in the book we have attempted to integrate the fundamental details of cellular energetics with the broad patterns of energy flow throughout the world of life.

Part III, Genetics, begins with a discussion of mitosis (first introduced in Chapter 4) and meiosis, and then presents the principles of classical Mendelian genetics. Chapter 12 emphasizes research and clinical applications in human genetics and genetic disease. The chapter includes information on population genetics that helps the student better understand how genetic variation is maintained through generations. This information, however, can be adapted easily to a curriculum that covers population genetics along with evolution (the fundamentals of the Hardy-Weinberg law are summarized at the beginning of Chapter 45).

Chapter 13 discusses in depth the genetic code and the transfer of biological information in DNA molecules from generation to generation. Chapter 14 is devoted to RNA and protein synthesis; Chapter 15 discusses gene control, with attention to possible regulatory mechanisms in eukaryotes. Chapter 16 emphasizes research in molecular

genetics and its possible applications. New advances in this rapidly expanding field are discussed throughout the genetics unit. Every chapter of BIOLOGY has been subjected to review by leading specialists; however, the chapters on molecular genetics (Chapters 13 to 16) are unique in the contributions made to the art and text by Drs. Roger McMacken and Jeffrey Corden of The Johns Hopkins University. Our knowledge in the subject of molecular genetics seems to be growing exponentially; the input of these two researchers has proven invaluable in making the chapters accurate, up to date, and exciting for students to read.

Part IV is devoted to the diversity of living organisms. It begins with a discussion of how and why living things are classified. Separate chapters are devoted to the viruses, monerans, protists, and fungi. The plant kingdom is given a comprehensive survey in two chapters: Chapter 22 presents the primitive land plants and discusses the evolution of mosses and ferns, and Chapter 23 describes the gymnosperms and angiosperms. The last three chapters of Part IV survey the invertebrate and vertebrate animals living today, their structural and functional adaptations, and their evolution. These are not, however, the only comparatively organized chapters in the book. The range of adaptations present in a variety of organisms is summarized in succeeding chapters in Parts V and VI on the systems and life processes of plants and animals.

Part V is devoted to a discussion of structure and life processes in plants. Separate chapters discuss in detail the physiological and morphological attributes of plants, plant growth and development, plant hormones, plant nutrition, and plant reproduction.

Part VI describes structure and life processes in animals. Each chapter begins with a comparative study of the particular adaptations of representatives of various animal phyla. Both structure and physiology are discussed in an evolutionary framework (that is, how different attributes might have evolved in response to stresses from the environment). Accompanying the discussions of human beings as biological models are a large number of high quality medical illustrations. These drawings are a unique learning aid in an introductory biology textbook.

The final section of this book, Part VII, explores the biology of populations. Evolution, animal behavior and ecology are the subjects of this unit. Chapters 45 and 46 discuss the general principles of evolution and the evidence for evolution. Chapter 47 introduces the student to the possible mechanisms of the origin of life itself on this planet. This chapter also summarizes some of the information in Part IV by giving a chronological history of the evolution of life on earth through an examination of the fossil record. Appropriately, since much of this knowledge is inexact, the chapter closes by presenting some of the important controversies in evolutionary theory today (such as the debate on punctuated equilibrium).

Behavior is discussed as a complex of adaptations in Chapters 48 and 49. Chapter 48 discusses behavior at the level of the individual organism, while Chapter 49 discusses the adaptive value of social behavior. Both these chapters are necessarily selective in their focus; their emphasis on adaptation, evolution, and the biological basis of behavior is designed to complement knowledge the student has acquired from other sections of the book.

Chapters 50 and 51 present principles of ecology from the standpoint of populations and communities and include discussion of adaptations, ecosystems, and the various types of biomes. Chapter 52, Human Ecology, emphasizes the impact of human beings upon the biosphere. Since, however, ecological themes are so much an integral part of the textbook, these chapters are, in part, a synthesis of the information the student has encountered elsewhere.

LEARNING AIDS. Many pedagogic aids have been included to help the student with the challenging task of mastering the principles of biology. Both **learning objectives** and a **chapter outline** are included at the beginning of each chapter. These help students as they begin to read a chapter and are useful later as a way to organize knowledge and study for an examination. Important new terms are set in **boldface** for emphasis throughout the text. Illustrations have been carefully designed to support and clarify concepts presented in the text, and tables are frequently employed to organize and summarize information.

Focus boxes present subjects in greater depth, introduce applications of material presented in the text, or integrate knowledge from the various subdisciplines of biology and related sciences. At the end of each chapter a **summary** in outline form is provided. There is also a **Post-test** (with answers at the back of the book) so that the student can evaluate his or her mastery of the factual material in the chapter. **Review questions** help the student to focus upon important concepts. At the end of each part there is a list of **supplementary readings**. These readings are selected specifically for the undergraduate biology major, and include numerous articles written at a level that the student can readily understand. A **glossary** giving the definitions of many important biological terms is integrated with the very comprehensive **index**. This feature is useful in enhancing student recall and allows the student to conveniently find references and examples in the text. Preceding the glossary/index is an **appendix summarizing the classification system** used in the text; this appendix also outlines minor phyla not covered in Part IV. Also included is an **appendix on common prefixes, suffixes, and word roots used in biology**.

SUPPLEMENTS. Many supporting materials have been provided to accompany this text. These include a comprehensive set of supplements for the use of both instructor and student: an **instructor's manual**, a **laboratory manual**, a **study guide** that includes additional review and self-tests, **overhead color transparencies** for classroom use, slides of **electron micrographs**, and a **test bank**.

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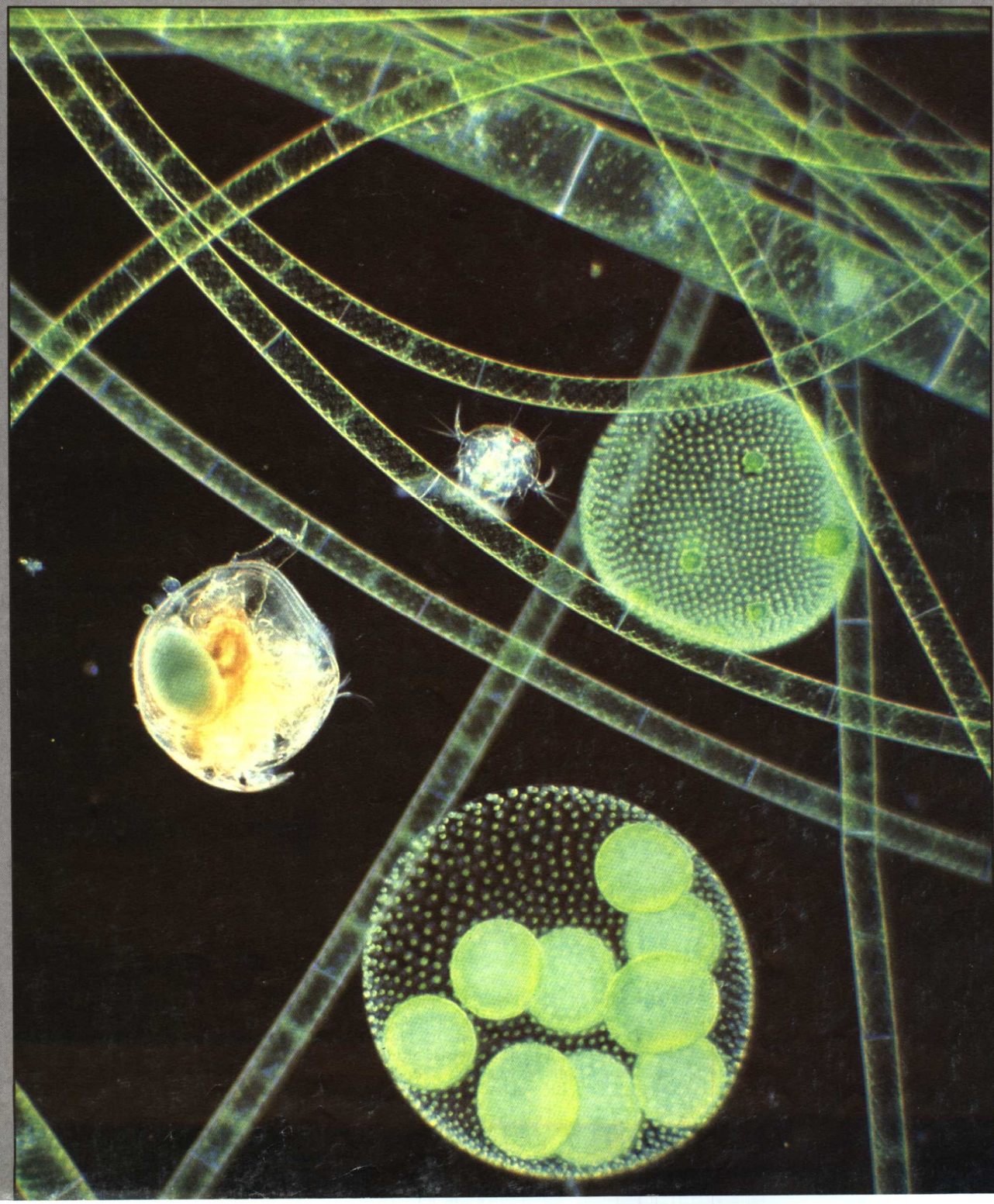
part I

THE ORGANIZATION OF LIFE



Microscopic jewels, several species of algae glitter in this photomicrograph by Tom Adams. The globular colonies are *Volvox*, one of which contains several daughter colonies about to be released to start independent life on their own. Filamentous algae, *Spirogyra*, curve in the foreground and background. Strands of such algae consist of numerous cylindrical cells joined end-to-end. Also seen are two small crustaceans, a copepod (left) and *Chydorus* (right). (Magnification ×60 and enlarged photographically.)

1
A View of Life

OUTLINE

LEARNING OBJECTIVES

After you have read this chapter you should be able to:

1. Distinguish between living and nonliving things, describing the features that characterize living things.
2. Define *metabolism* and *homeostasis,* and give examples of these processes.
3. Define *adaptation,* and describe its function in promoting perpetuation of a species.
4. List in sequence and briefly describe each of the levels of biological organization.
5. Describe the roles and interdependence of producers, consumers, and decomposers.
6. Identify the five kingdoms of living organisms, and give examples for each group.
7. Design an experiment to test a given hypothesis using the procedure and terminology of the scientific method.
8. Outline the ethical dimensions of the scientific method, and give examples of possible ethical problems that may arise in the course of scientific investigation.