

Foundations of Biology

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Front cover
American egret, Gainesville, Florida.
Photograph by Samuel Scheiner

Dedication

To Judy Scheiner, wife and mother.

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Preface

This book is a different kind of introductory biology textbook that is suitable for all classes, majors and non-majors alike. It takes a different approach to teaching biology by deliberately eschewing the typical bewildering array of detail and focusing on core concepts. The central conceit of this book is the slogan of the Bauhaus architectural movement: less is more. This book is emphatically NOT meant to be encyclopedic.

If you are a biology major, this book will equip you with a conceptual framework that you can use all of your other courses. If you are a non-major, you will gain a fundamental understanding of biology that you can relate to your own field of study. Towards these ends, the book is theory oriented. The theories prioritize the big ideas of biology, so that you will know where to focus, what you need to remember, and help you see the connections among the parts of biology. A theoretical allows you to see how knowledge comes about; it makes biological knowledge into something dynamic, and not received wisdom. To determine the list of fundamental concepts, we took as our guiding philosophy: "If I were teaching an upper-level course in topic X, what would I want my students to know about all of the other topics that I am not teaching."

The book avoids the very human-centric approach of nearly all introductory textbooks, an approach which greatly distorts your appreciation for the diversity of life. Our approach is to take a topic and discuss how it applies to all species. For example, we discuss the structure of cells of bacteria, animals and plants together. While we use human examples throughout the book in order to engage the student, we make it clear that humans are just one of many species. We emphasize that to properly understand human biology, you must appreciate biological science in its entirety. The book avoids, as much as possible, the specialized vocabulary of biology, instead presenting the concepts using plain English. We limit the use of specialized vocabulary to concepts that are used repeatedly in the book or are otherwise ones that a student is likely to need to understand topics in more than one advanced class.

Each chapter is presented within the framework of a unifying theory, focusing on the fundamental principles of those theories. The concepts are placed within a historical context which shows science as a dynamic process and the result of the activities of real people, rather than as a set of facts handed down from on high. To this end, each chapter features brief biographies of three important scientists. To relate the importance of the scientific process in gaining understanding, each chapter features a Critical Experiment.

Using the book

Throughout this book, we explore the broad properties that make up living systems, the characteristics of all or very many of those systems, rather than focusing on the numerous details and variation. There is certainly an important need to understand those details. However, you must first understand the overarching framework of life and the science of biology so that you have a context within which to place the details. In this chapter we will examine the fundamental characteristics of living systems. What separates life from non-life? How would we recognize life elsewhere in the universe if we came across it?

Those fundamental characteristics form the groundwork upon which are built theories that form our understanding of specific aspects of living systems. In the second chapter we look at the structure of theories and how different pieces fit together to create the science of biology. For now, we will just say that the fundamental characteristics are those that both are necessary for the specific theories, and are properties that arise

in each of those theories. They are also characteristics that supercede the details of the carbon-based life found on the Earth and, thus, can be used as a way of identifying non-terrestrial living systems.

Once we lay the groundwork for the characteristics of life and how we study it, the rest of the book looks at life from five points of view: genetics, evolution, cells, organisms, ecology. Each point of view examines an aspect of the structure of living systems and the processes responsible for that structure. Each point of view represents a discipline within the science of biology. We emphasize that science is ultimately unitary. All parts connect to all other parts. Thus, you will find themes that cut across all of the disciplines, some of the fundamental characteristics of life. Some of the most exciting new research happens at the boundaries of disciplines when ideas from different disciplines are given a chance to mingle. By focusing this book on the broad properties of living systems, we hope that you will be better able to see how those parts connect.

The chapters in this book can be approach in many different orders. The material in each chapter is largely independent of the others, with a few caveats. Chapter 2 (Science) can be read at any point. Chapter 1 (Life) should be read before chapters 3-7. Chapter 3 (Genetics) should be read before Chapter 4 (Evolution). Chapter 5 (Cells) should be read before Chapter 6 (Organisms).

You will note a lack of citations throughout the book. This absence is not meant to convey the impression that these concepts are simply given truths. Quite the contrary, they are the result of the work of very many people over decades. To give proper credit to all of the ideas and facts would require a thicket of citations that would obscure the text. Instead, we leave it to follow-up courses to provide those details, along with all of the others that we are leaving out.

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Many people commented on various drafts and versions of this book including: Michael Barfield, Judith Bronstein, Robin Bush, James Collins, Richard Kliman, Gordon Fox, George Gilchrist, Gabriel Herrick, Norman Johnson, Milton Muldrow, Adam Porter, Andrew Sinauer, Alan Tessier, Saran Twombly, Michael Willig, Grace Wyngaard, William Zamer, as well as several anonymous reviewers. All helped improve its content and for that we thank them.

To the reader:

This book is an ongoing project. Any help that you can give to improve the book would be appreciated. First, please let us know if you find an errors of fact, spelling errors, typos, or format problems. Second, we are aware that many of the figures are not ideal. We would appreciate it if you have, or can point us to, a better alternative; keep in mind that the alternative must be available under a Creative Commons license. Finally, any general feedback about the content of the book is welcome. If you are a teacher, we would greatly like to know how you are using it in your classes.