

preface



I wrote this book for a general college audience, as an introduction to the principles and significance of Darwinian evolution. As the book unfolds, the student will meet intellectual challenges; visit the richness of evolutionary science today; explore evolution's insights in biodiversity, mass extinctions, and modern diseases; and examine his or her current and precarious place in nature. This textbook is intended to be the centerpiece of a course on evolution or an evolution-based course, around which instructors can build a course that suits their interests and that focuses on the students. To this end, this textbook departs in three fundamental ways from most other textbooks on evolution.

GENERAL COLLEGE AUDIENCE

First, this book is intended for a general college audience, especially for students early in their studies. Over the last two decades, I have taught such a course for biology and for nonbiology majors. It is surprising to me that even many biology majors, with a substantial number of life science courses behind them, are still inept at discussing or using basic evolutionary concepts. Their words are right, but they lack a true understanding of evolutionary principles. With some small effort, these students can spout dates, names, and jargon, and even some genetic laws they have memorized. But their basic grasp of scientific reasoning and ability to think critically lag substantially.

States are evaluating their K-12 school curricula, and times are changing. I hope for the better. But for the moment, students still largely learn about evolution from the pulpit and from pop culture. The misunderstandings they bring to the subject of evolution are the same fundamental misunderstandings they harbor about science in general. We can parade the facts before them, but we must also develop the intellectual equipment students use to think critically about a subject. For many students, the process of evolution is still mysterious, even threatening. Most students who enter college have heard at least of evolution's offense to religious beliefs, but not of its service in unifying all of the modern life sciences. This book is intended for just such an audience.

INTELLECTUAL SIGNIFICANCE

Second, this book departs from others in that it examines the intellectual significance of Darwinian evolution. Darwin's ideas on biological evolution touch every aspect of modern life, from genetic engineering to human medicine. This book explores the history of Darwin's thought; the evidence for his ideas, and the implications these have for the appearance and loss of life on Earth; and the significance to our own future as a species.

To begin, students need to be unburdened of the major misconceptions about evolution. At least in my course, they all want to be Lamarckians. Most students think that need drives change, progressively on to better and better organisms. Certainly, Lamarck's ideas initially seem sensible. Bolstered by our society's embrace of technology, many students enter a university under the influence of Western culture's boast of ever-evolving and improving innovations to meet our ever-escalating needs. Students expect biological evolution to be driven by the same engines of progress. Nothing, of course, could be farther from the truth. Biological evolution is not driven by needs. Therefore, a modern student arrives on the doorstep of such a course already harboring mistaken expectations that must be addressed head-on before any of this can be understood. Understanding what Darwin had to say requires much more than just examining the formal evidence for evolution. In a sense, each student must make an intellectual journey, and step outside the pervasive grip of the industrial and technological culture of our day.

ORGANISMS, SURVIVAL, FITNESS

Third, I have also chosen to depart from the standard treatment of evolution in other textbooks on evolution, wherein the arguments are reductionist, molecular, and overwhelmingly genetic in flavor. Certainly genetics plays a large and indispensable role in evolutionary thought, and genetics is covered here within these pages as well. But the much-deserved pride geneticists take in the success of their field has led to a hubris,

tempting some to believe that evolution is little more than a genetic shell game. As one such scientist rhapsodized, "it is only in genetics that there can be said to be a 'theoretical biology.'" Such claims, taken alone, are much too narrow to provide a full understanding of Darwinian evolution. This is especially true now that the successes of evolutionary morphologists and ecologists have taken the science from laboratories into the wild, and documented the workings of natural selection in nature. Organisms in populations are the center of the evolutionary action, so it is here, on organisms, that I center this book.

A BOOK TO BE READ

I have tried hard to write an inviting book that will be read—by students. The World Wide Web offers wonderful resources that can be accessed through powerful search engines. This is a comfortable medium for today's students, who have grown up mostly in a virtual world of information. But printed books remain important and even unique vehicles of information and ideas—they are convenient; they are reviewed and edited; they are organized; they can be thought provoking; they are coherent with a common voice. With a textbook in hand, the instructor of a course knows what information and what slant on the subject will be presented to students. The instructor can then build the course she or he wants, expanding or amending or even constructively disagreeing. But to serve this central and supportive role, the textbook must be read.

Many current textbooks are excellent encyclopedias of information. But too many are overbearing and stately—often mannered in presentation. They go unread by students. And that is a shame. I therefore experiment here with a writing style that I hope will engage students and encourage them to read, to pause and consider, then to read further.

ORGANIZATION AND RATIONALE

I do not pit evolution against fundamentalism, red in tooth and claw. Instead, the book is focused on the science of Darwinian evolution. I open by placing Darwin's ideas in historical context, but for the purpose of identifying particular scientific obstacles he faced—time and heredity. The remainder of the book brings evolution into a modern context, explores its biological implications, and concludes with a timely consideration

of the significance of evolution to human society today. Topics and chapters can be reordered to suit particular courses. Reasonably, everyone using this book will follow his or her own strategy, and the book supports this. Let me share my thinking on one approach.

CHAPTERS AND TOPICS

Chapter 1 (Evolution of Evolution)

Chapter 2 (Time)

Chapter 3 (Heredity)

Darwin's great achievement was not in proposing that organisms evolve. In fact, evolution was discussed by ancient Greek philosophers before the time of Christ, and thus was old news in Darwin's day. Most of the evidence was available to nineteenth-century contemporaries, but Darwin was the first to see around the distractions, misinformation, and scientific confusion and put it all together. His insight was profound, even disturbing, and is still the subject of serious debate, and is still being analyzed for its implications to ourselves, to our politics, and to our basic ethical systems. To understand this larger significance of evolutionary principles, most students must make the same intellectual journey as did Darwin. What did Darwin say? And what were the scientific objections of his contemporaries? With all the contentious religious objections receiving attention, then and now, we tend to forget that Darwin faced serious scientific challenges to his views. As a unit, these first three chapters set up the issues, and then show how each is resolved today.

Chapter 4 (Emergence of Life)

Chapter 5 (Diversity of Life)

What can be done about students' background in biology? At best, it is uneven. In some states, all students now have at least a brush with biology on their way through high school. And we should credit television with bringing nature programs to a general public. These chapters cannot, of course, substitute for a proper background course in biology. But I have tried to pack into these two chapters enough to refresh the memories of students with prior courses in biology. For those without such backgrounds, I have tried to be sure that all biological principles they meet elsewhere in the book are at least mentioned here, in these chapters, in a cohesive context. Chapter 4 notes the major, early transitions of life, and introduces

students to the prokaryotes; here the step to organic evolution occurs, heterotroph to autotroph, the appearance of a eukaryotic cell, and the basic coding structure of life itself is described—DNA, RNA. Chapter 5 places before us the further cast of characters in the evolutionary story, the eukaryotes—protists, plants, fungi, and animals.

Chapter 6 (Evidence of Evolution)

Now we are ready to critically examine the formal, scientific evidence favoring a natural explanation for evolutionary change, piece by piece. This chapter especially offers the chance to engage students in critical thinking. Formally, the chapter provides the student a chance to join in hypothesis testing, which is somewhat of the form “If . . . , then . . . , thus.” A hypothesis is stated, its implications or predictions are identified, and then these are tested. If the predictions are accurate, then the hypothesis is supported, and thus a tentative conclusion is drawn.

Chapter 7 (Selection)

Chapter 8 (Variation: Spice of Life)

Chapter 9 (Speciation)

Chapter 10 (Co-Evolution)

Chapter 11 (Life History Strategies)

Chapter 12 (Life in Groups)

If their curiosity is tweaked, students will want to know more about how the process of evolution works. Chapter 7 explores the workings of natural selection. Evolution runs on variation. The sources of this variation—genetic shuffling and mutations—receive attention in chapter 8. Chapter 9 examines how new species arise, and chapter 10 reflects on how species interact in co-evolutionary relationships. We are reminded in chapter 11 that life histories, not just adults, evolve. Levels of selection and life in groups raise a controversial issue in chapter 12—individual versus group benefits. Here we also meet issues of microevolution and macroevolution, because they can help us understand how evolution sometimes advances in macro steps to produce rapid changes.

Chapter 13 (Extinctions)

In chapter 13 we explore the other side of evolution—extinctions wherein old species become extinct in a boom (mass extinctions) or a whimper (background extinctions).

Chapter 14 (Human Evolution: The Early Years)

Chapter 15 (Human Evolution: Building Modern Humans)

By this point in the book, we have examined the workings of natural selection and the way in which complex associations arise. We are ready for our own evolution, discussed in these two chapters.

Chapter 16 (Evolutionary Biology: Today and Beyond)

Evolution happens. It happens today. It is an ongoing process that cannot be ignored, especially as humans take over much of the responsibilities for building a better genetic and social future. This sixteenth chapter considers evolution's implications in modern society, including its implications for molecular genetics with its possibilities and pitfalls, and how peoples and plagues continue the evolutionary race.

Chapter 17 (Afterword)

This short concluding chapter takes advantage of the collective case made throughout the book and brings it to bear on current issues facing students—the threat of epidemics and a critique of “intelligent design.”

NEW TO THIS EDITION

I have retained my approach to evolutionary biology described earlier, but incorporated welcome suggestions by reviewers and students.

- **Organization.** Major sections (e.g., hot- and cold-blooded dinosaurs) have been redeployed to chapters where they more logically fit and enhance the theme of that chapter.
- **Revisions.** Although all chapters were revised for currency, special effort was made to update chapters of central importance (e.g., Selection) or special interest (e.g., chapters on hominid evolution).
- **New Material.** A short section on population genetics has been added (chapter 3), as well as sections on “What Is life?” (chapter 4), “Darwin's” pigeons (chapter 7), ring species (chapter 9), and on cultural and social evolution in hominids (chapters 14 and 15).
- **Relevancy.** As epidemics or their possible arrival become an ever larger part of daily news, chapter 16 (Evolutionary Biology: Today and Beyond)

becomes an even more useful capstone to the study of evolution. To this I have added an Afterword (chapter 17) to also note the natural history of possible disease. In this last chapter, I also critique the subject of "intelligent design," which has a long ancestry without scientific utility, leaving it today as a vestigial, but much discussed, philosophy.

- **Illustrations.** Many figures have been replaced throughout, and many new ones added.

FEATURES

- **Study aids include:**

Key terms set in bold where they first appear, and defined in the glossary

End-of-chapter overviews. These highlight concepts to emerge from the chapter and discuss the chapter's most significant points. Students can use the overview to organize what they have just read.

End-of-chapter selected references

End-of-chapter Web links

"Missing Links" boxed essays that draw attention to the personal or scientific significance of one of the chapter's topics

Glossary

- **Appendixes:**

Primer on Cell Division

Techniques of Taxonomy

Molecular Clocks

- **Website:**

Color images, matched to each chapter, further enhance the book's contextual discussion

Interactive labs

Case studies

Guide to writing lab reports and scientific papers

Practice quizzing

Guide to electronic research

ACKNOWLEDGMENTS

From Charles Darwin to the present, evolutionary biology has grown into a major scientific discipline that unites all of the life sciences and holds a view of life that touches us all. Bringing this to a wider audience is a passion I shared with a team of publishing professionals

and special reviewers, without whom this edition would not have been possible. The professional team involved in producing this text has vested many hours in making it the best evolution text possible. I wish to express special thanks to McGraw-Hill for editorial support through Marge Kemp and Joan Weber; the marketing expertise of Tami Petsche; and the production team led by Lora Kalb, Brenda Rolwes, Lori Hancock, Sandy Ludovissy, Dan Wallace, and Judi David.

I am most grateful to the wonderful team of patient and thoughtful reviewers who offered considered comments on this text. Besides being scientists in their own right, they are exceptional instructors dedicated to improving science education in general, and the teaching of evolution in particular. In large and small ways, their insightful comments and helpful suggestions have been incorporated into this text. I hope that they find the finished product much improved, and I sincerely appreciate their efforts to bring a better book into the reader's hands. For their special help or suggestions I especially thank Lowell Carhart, L. Laszlo Meszoly, Michael Pollock, Michael Richardson, David Taylor, and Stanley A. Temple. Throughout, Tamara L. Smith was colleague, friend, and critical advisor, and for all of this I am always grateful.

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