PREFACE

> The thought we read is related to the thought which springs up in ourselves, as the fossil-impress of some prehistoric plant to a plant as it buds forth in springtime.
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> –ARTHUR SCHOPENHAUER, *Parerga und Paralipomena* (1851)

It is nearly two decades since the publication of *The Evolutionary Biology of Plants* and much has been learned in each of the scientific disciplines that contribute to our understanding of evolution and evolutionary theory. By necessity, therefore, *Plant Evolution: An Introduction to the History of Life* is a new book and not a second edition of my earlier work. To be sure, some of what is contained in the present volume draws heavily from my previous book. Although extensively rewritten, chapters 1 and 2 present the same general overview of the major evolutionary transformations that have shaped our planet's biosphere. On the other hand, the rest of this book is new and reflects recent advances. Chapters 3 and 4 review population genetics and developmental biology. Chapters 5 and 6 review the processes of speciation and macroevolution. Chapters 7 and 8 discuss the evolution of multicellularity, the plant body plans, and how evolution and

biophysics are interrelated. Finally, chapter 9 provides a perspective on evolutionary ecology.

Like all of my other books, this one is personal and eclectic. Every book, no matter how technical, is a reflection of the author's mind, and *Plant Evolution* is no exception, since it is a distillation of what I consider to be significant concepts, principles, and facts. This book was written with a single purpose in mind—to show why the study of evolution is important and why the study of plants is essential to understanding evolution. To paraphrase Theodosius Dobzhansky (1900–1975), if nothing in biology makes any sense except in the light of evolution, then nothing in evolutionary biology makes sense if not illuminated by studying plant biology. This claim rests on the fact that plants are very different from animals or fungi, yet much of the standard evolutionary literature is zoocentric. It is ironic to a botanist such as myself that biology textbooks sometimes begrudgingly treat plants as decorations on the tree of life rather than as the forms of life that allowed that tree to survive and grow. This is a blue planet, but it is a green world.

Plant Evolution does not provide a comprehensive overview of evolution. It is a collection of nine essays that attempt to cover the major lines of evidence that prove that evolution is fact—that is, evidence from the fossil record, molecular biology, comparative embryology, comparative anatomy, comparative physiology, the experimental manipulation of species, and biogeography. No author can survive the pretense of claiming to understand everything about evolution, and no single book can delve into every aspect of evolution, even superficially. Each book can only bring a particular perspective to illuminate some corner of the history of life. My goal was to cover the fundamental processes of evolution from the perspective of a botanist who has enjoyed studying plants and who has tried to comprehend the breathtaking discoveries made about them over the past two decades. By way of inclinations and biases, you should know that I was trained first as a mathematician and second as a paleobotanist. As a student

of numbers, I know that understanding evolution depends in part on understanding mathematics. I hold to the idea that if we cannot quantify something, we do not truly understand it. In addition, probability theory, the dynamics of changing gene frequencies, and many other aspects of evolutionary theory are mathematics in different guises.

But I am also a student of the dead. Knowing the fossil record is just as important as knowing about living organisms. If we neglect the past and study only the living, we would be totally ignorant of over ninety percent of all the species that ever lived and we would have no real insight into the causes and consequences of phenomena such as global climate change and mass extinctions. The study of the fossil record requires no apology—it is vital and important to every aspect of modern biology.

This book is intended to serve as the text for an upper-level undergraduate course, or as a text for an early postgraduate course. I freely admit that it is my intention to steer students toward studying plants professionally. For this reason, I have tried to keep the writing style of this book simple (albeit without sacrificing accuracy) and to use jargon sparingly. Jargon is unquestionably necessary at times. But technical words spoken glibly in the classroom or released on paper tend to sound like explanations rather than descriptions, and jargon in any form can easily mystify and alienate a student. Jargon has yet another negative aspect—it can build walls around disciplines and thereby hide a discipline's relevance to other fields of study. Unfortunately, biology has more than its fair share of terminology. Consider for example that the basal body is called a kinetosome by the protozoologist, who calls the cell biologist's undulipodium a flagellum, which is a very different structure from the flagellum studied by the bacteriologist. Likewise, what a phycologist calls siphonocladous, a bryologist calls symplastic, which is not to be confused with what the zoologist calls a syncytium. As these few but perhaps painful examples of terminology attest, the study of evolution, which employs the vocabulary of all of the scientific disciplines, involves learning the meaning of many tech-

nical terms. I have done my best to inflict as little pain as possible, and I have provided a glossary for some of the more troublesome technical terms (or those that I may have used idiosyncratically).

This book is intended as a textbook, or as a reading for a seminar; it was not written to cite the primary literature wherever a declarative sentence appears in the text. A few citations appear from time to time, but only when necessary to acknowledge the contributions of particular individuals. This tactic was predicated on the notion that libraries and Internet search engines are available to students. It was also based on the fact that the most recent literature is easily found on the Internet, whereas the older literature is more difficult to find electronically. A few key words, such as the name of a researcher, typed into the Internet's vast resource network can locate the required new literature easily. Whether the literature found in this manner provides reliable information is another matter. Each of us must exercise great judgment when reading anything, including this book. In lieu of references in the text, a suggested reading list is provided at the end of each chapter. An emphasis is placed on the older literature, which is often neglected or forgotten. Even though one of my goals was to integrate the new discoveries made about plants with the literature published one or more hundred years ago, re-reading this older literature gives credence to the proclamation *nihil sub sole novum*.

A few words are needed to explain the use of the word "we" throughout the text. As in my classroom when lecturing, I want you the reader and me the author to have a conversation as we take a journey through the corridors of time and space. I want us to engage in the joys of discovering new ideas or facts together. My copy editor will detest this practice, but I find the use of the word "we" singularly pleasing and appropriate.

Finally, I want to thank the wonderful people who have made this book possible. Everything that I am is a consequence of my parents' nurturing and genetics. Although they had little themselves, they valued an education, and they lived long enough to see me become a teacher, but not alas long enough to see this book, which is ded-

icated to their memory. My teachers and role models in school are also responsible for who I am. Lawrence J. Crockett showed me the wonders of plant life and how I could make mathematics literally come to life. Tom L. Phillips opened my eyes to the fossil record and served as the best model scientist and scholar. When speaking of my teachers, I must also thank all my students who, by asking seemingly simple questions, taught the teacher that he had much more to learn (and still does). I am also deeply grateful to Michael Christianson (University of California, Berkeley), Randy Wayne (Cornell University), and Bruce Tiffney (University of California, Santa Barbara), who offered many suggestions and comments while reading preliminary drafts of all the chapters. I also extend my deepest gratitude to my editor, Christie Henry, who provided unyielding encouragement throughout my pre- and post-publication anxieties; Mary Corrado, who provided brilliant re-edits of a very imperfect manuscript; Logan Smith, who attended to details too numerous to recount; and Julie Shawvan, who provided a beautifully detailed index. Finally, I acknowledge my 37-year-long collaboration with Edward Cobb, who took the majority of the photographs that adorn the text (the artwork with all its faults is mine) and who has given me more support than anyone truly deserves.