



Principles of Paleontology, Third Edition, Michael Foote and Arnold Miller, 2007, W. H. Freeman and Company, New York, 354 p., hardcover, USD 93.95, ISBN: 978-0-7167-0613-7.

Early in my undergraduate career, I purchased a used copy of Raup and Stanley's first edition of *Principles of Paleontology* (1971). Despite the fact that this classic work was already nearly a quarter of a century old when I purchased it, it impressed upon me the point that fossils are not just objects to fill museums, but rather to address any number of exciting questions, that, if answered, might help us to better understand the history of life. Raup and Stanley's book was successful because of its clear descriptions and examples of both qualitative and quantitative methodologies and procedures used in paleontological research. The discipline of paleontology has, of course, evolved much since the similar second edition (1978) of Raup and Stanley's work, as has our understanding of ancient life. Consider, for instance, the point that a bolide impactor had not yet been proposed in 1978 as causative agent for the end-Cretaceous mass extinction event, as reflected by Raup and Stanley's (1978) antiquated account of possible causes for this event.

An update of *Principles of Paleontology* was, thus, long overdue. Foote and Miller have provided that update, though it comes largely—and by necessity—in the form of a completely new book, rather than a revision of the second edition. Foote and Miller state in their preface that the intended “purpose of this book is to provide a thorough *conceptual* coverage of paleontology appropriate for an undergraduate course” and “not a survey of the facts documented by paleontology but rather of the questions addressed by the field and the ways in which paleontologists go about their business” (p. xii); it is within this context that I evaluate the new, third edition of this text.

The third edition of *Principles of Paleontology* features ten chapters and a useful glossary of key terms. Each chapter stands well on its own, and connections between relevant sections of different chapters are made explicitly. Details of many methods are offset in boxes, which makes the text flow well. Most of the numerous figures (none of which are in color) have been reproduced from the primary literature, and many are classics. A significant portion of the text is built upon discussions of case studies from the primary literature, especially when those studies offered novel approaches for addressing paleontological questions. Each chapter concludes with a supplementary reading

list; these lists are not long enough, however, and should have highlighted various viewpoints where controversies exist.

The first chapter, The Nature of the Fossil Record, discusses the different ways in which fossils may be preserved and the methods that paleontologists use to sample the fossil record and assess its quality. Further, this first chapter discusses how our understanding of the fossil record has changed over time and provides a section covering some of the major bibliographic sources for paleontologists; missing are sources for plants, and two online databases that might have been included are the Bibliography of Paleobotany and the *Index Nominum Genericorum (Plantarum)*. Surprisingly, Google and Google Scholar are not listed either, despite their power as strong starting places for many taxonomic searches. Also missing from this chapter is a discussion of the importance of museum collections for both basic paleontological research and the generation of new data. Because many student projects begin with museum specimens, a section describing the benefits and potential limitations of museum collections for addressing various research questions should have been provided.

Chapter two, Growth and Form, discusses the basic methods that paleontologists use to describe and measure individual fossil specimens, as well as the means by which they assess ontogenetic growth within species. Much of the attention here is focused on commonly utilized morphometric methods and how these methods are used to quantify form. Additional discussion relates to the methods by which organisms grow and how paleontologists recognize different types and rates of growth.

The third chapter, Populations and Species, builds on the second by describing the methods and basic statistics that paleontologists use to characterize variation among populations and species and also does a nice job of summarizing the genetic and geological causes of the types of variation that paleontologists are likely to encounter. Perhaps expectedly, one section of chapter three focuses on the biological nature of species and species concepts in theory and practice. Such discussion is important—many undergraduates may be surprised to learn that species (extant or extinct) are not always easily distinguished—but additional focus on the subjectivities of the

human factor in species recognition might have been helpful here. In particular, the authors should have emphasized that in practice, morphological species are hypotheses to be tested against the information available.

It is not until chapter four that the reader is presented with the most fundamental and important paleontological activity: Systematics. The authors discuss the mechanics of how species are described and how their types are designated; three examples of new species descriptions from the literature are provided. Discussions about the proper presentation of taxonomic names and how taxonomic name changes operate are also provided. Following this overview of taxonomic practice, the authors address the subject of phylogenetic systematics. For the most part, the discussions of different aspects of cladistic practice and key terms and ideas are presented in a relatively straightforward though brief fashion, and special attention is paid to the temporal dimension that fossils may directly (e.g., stratocladistics) or indirectly provide to cladistic analyses. A noteworthy omission in this chapter, however, is any reference to the work of Willi Hennig, who should be rightly credited with developing cladistic theory in the mid-Twentieth century and thereby revolutionizing the activity of phylogeny reconstruction. Further, the extensive coverage given in Box 4.7 to the subject of phylogeny estimation using maximum-likelihood is surprising given how infrequently maximum-likelihood methods, which dominate molecular systematics, are used by paleontologists. Instead this space might have been better used to discuss some of the different ways in which data from extinct and extant taxa have been integrated in recent years by biologists and paleontologists. In the summary for the chapter, the authors discuss a “phylogenetic code for species nomenclature” (p. 119)—by which they presumably mean the rank-free PhyloCode nomenclatural system, which to date has not been able to successfully incorporate binomial species names as they now stand—and incorrectly relate it to the phylogenetic species concept of Nixon and Wheeler (1991).

Consideration is paid in chapter five, Evolutionary Morphology, to the explanation of morphological form. The subdisciplines of functional and theoretical morphology are each covered in significant detail, with plenty of classic (e.g., Raup’s [1966] computer simulations of shells, a highlight of the first edition of *Principles of Paleontology*) and new examples provided from the literature. Chapter six, Biostratigraphy, provides detailed accounts of biostratigraphic principles, methods of correlation, and how confidence intervals are calculated around biostratigraphic range data. Of all the chapters in the book, I expect that undergraduate students might find this one the most difficult to work through, in large part due to the complex nature of the subject. The seventh chapter, Evolutionary Rates and Trends, builds on the sixth by discussing the methods that paleontologists use to quantify evolutionary changes and rates within and among lineages, given their fossil records. Here the topic of punctuated equilibrium receives special attention, and criteria for recognizing punctuated patterns are outlined, as are possible explanations for morphological stasis within lineages. Chapter seven concludes with a discussion of evolutionary

trends and methods that can be used to test for morphological directionality in the fossil record.

Chapter eight, Global Diversification and Extinction, covers two of the most active areas of current research in paleontology. Alternative methodologies for calculating diversity curves (especially at the Phanerozoic scale) are described in the beginning of the chapter. Not unexpectedly, the taxonomic units of principle consideration here are higher taxa, despite the authors’ statement that a “diversity curve can be built at any taxonomic level” (p. 217). There are notable obstacles, of course, to calculating a species-level Phanerozoic diversity curve, but these reasons are not covered in the text and should have been discussed explicitly. The chapter goes on to discuss the methods that paleontologists use to quantitatively recognize and characterize mass extinction events, in addition to techniques that can be used to explore questions about the selectivity of extinction. Next, the chapter provides a discussion (with examples) of the importance of new computer databases for assessing large-scale patterns of diversification and extinction. The chapter concludes with a discussion of morphological disparity and how it is measured.

The ninth chapter, Paleocology and Paleobiogeography, discusses the first subject at great length, but the second receives only three pages. Topics covered in the paleocology section include the nature of paleoecological data (as compared to modern ecological data), the characterization and stability of paleocommunities across space and time, temporal patterns of ecospace utilization, paleoecological interactions between taxa (a subject perhaps given too little attention, considering the huge amount of research that has been published on the subject, especially in *PALAIOS*), onshore-offshore diversification patterns, and ecological interactions preceding and following mass extinction events. Additional attention is given to the use of isotopes and paleobotanical indicators to address paleoecological questions, particularly those related to ancient changes in temperature and precipitation. The short paleobiogeography section presents several case studies of biogeographical patterns that have been documented in Neogene fossils, but presents no examples of the novel tools being used by some researchers to explore the relationship between environmental change and organismal distributions in the fossil record, including Geographical Information Systems, niche modeling, and cladistic biogeographic techniques.

Finally, chapter ten, Multidisciplinary Case Studies in Paleontology, considers (as the title implies) active areas of collaborative research across the sciences that are addressing especially important problems in earth history, including the Cambrian radiation, the end-Permian mass extinction, the Paleocene-Eocene thermal maximum, and the extinction of the Pleistocene megafauna. Consideration is also given here to multidisciplinary research in conservation paleobiology (which may become one of the most active areas of paleontological research over the next decade) and astrobiology. This chapter should be of special interest to undergraduate students looking for potential research areas for graduate study.

Foote and Miller's clearly written and readily accessible third edition of *Principles of Paleontology* succeeds as an introduction to a highly analytical school of paleobiological research that has been developed largely, while not exclusively, by paleontologists who study the fossil record of marine invertebrates. While some will find this focus appealing, others may find the content of the text too unbalanced, either in terms of taxonomic coverage (there are few examples from paleobotany and vertebrate paleontology, which each have their own research traditions) or in terms of the ideas, research areas, or methodologies presented. Nevertheless, Foote and Miller's third edition of *Principles of Paleontology*

efficiently addresses many, but not all, of the major questions and avenues of research being explored by some paleontologists today, and so will likely be an influential contribution for students of those research programs.

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