

Principles of Paleontology (Third Edition)

Reviewed by Michael J. Benton

Michael Foote and Arnold I. Miller
W. H. Freeman, New York, 2007
ISBN-13: 978-0-7167-0613-7 \$93.95; £29.99 hardback

Palaeontology has a good press and a bad press. Every week, stimulated by an article in *Nature* or *Science*, reports appear around the world of a new species of dinosaur, a remarkable fossil from China with hair or feathers (or both), or a new early human specimen that will 'revolutionise the way we think about our ancestry.' This news-led agenda does not represent the deeper advances in palaeontology that come from the application of rigorous analytical techniques to large datasets and illuminate our understanding of evolutionary trends, mass extinctions, phylogeny, and morphological change.

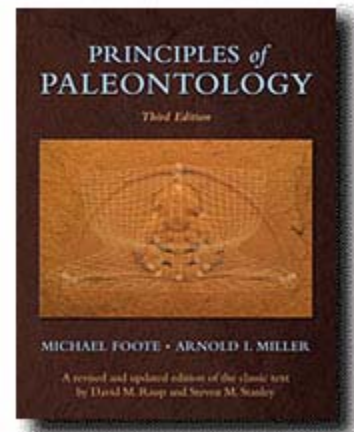
When David Raup and Steve Stanley published the first two editions of the *Principles of Paleontology* in 1970 and 1978, most palaeontologists were somewhat puzzled or amazed. Many ignored the books, while a few younger folk began to adopt the text in advanced palaeontology teaching. Times have changed, and palaeontologists in universities strive to impart a knowledge of statistics, cladistics, morphometrics, and other 'ics' to their students. Palaeontologists can choose this new edition, or Hammer and Harper's *Paleontological data analysis* (Blackwell, Oxford, 2005) as a means of introducing their students to quantitative palaeontological methods. As Foote and Miller stress in their introduction, their new book is not a comprehensive primer on palaeontology: students should have mastered the major fossil groups in earlier courses.

The first chapter provides a clear and well-illustrated account of preservation, taphonomy, and

completeness of the fossil record. A key feature of the treatment, when compared to many other palaeontological texts, is that quantitative aspects are introduced throughout, with basic descriptions of statistical approaches in the main text that

should not cause problems for any reasonably enthusiastic student, and fuller expositions on method in large boxed items. So, there are three such boxed case studies in this chapter that introduce the student to correlation in comparing living and dead specimen collections, rarefaction in comparing fossil collections at different taxic levels, and measures of palaeontological completeness.

Quantitative study of growth and form was a key element of earlier editions, and the topic is comprehensively introduced here (Chapter 2). Landmarks, harmonic analysis, ontogeny, growth rates, allometry, and heterochrony are well covered, although the exposition on the fundamentals of harmonic analysis spreads over four pages, and might overwhelm the neophyte student. The rest of the chapter, however, presents all the basic ideas and terminology, with a mix of well-chosen exam-



ples from among invertebrates, plants, and vertebrates.

Basic evolution is covered in Chapters 3 and 4, with an introduction to populations and species and systematics. Descriptive and multivariate statistics are introduced, and the systematics chapter is innovative in devoting seven pages to presenting actual examples of formal taxonomic descriptions and synonymy cases. There is a thorough presentation on cladistics, elucidating the fundamental meaning of homology, but also presenting methods and problems in detail. I'm not sure whether the inclusion of stratocladistics and an extensive discussion on whether paraphyletic taxa are a good or bad thing might not seem a little marginal to many students. These are obsessions of some, but by no means all, palaeontologists, and already seem dated. The chapter might have been strengthened by allusion to the tree of life, molecular phylogeny, the use of palaeontology in dating molecular trees, Bayesian techniques, and the like.

The chapter on 'Evolutionary morphology' brings together some disparate topics, from functional morphology (trilobites, dinosaurs, crinoids) to shape space and trade-offs in the achievement of optimum shape. This latter part of the chapter is pure Raup, and a strength of all three editions of the book.

We then move to Biostratigraphy in the next chapter, which covers the expected classic methods, as well as quantitative technique (graphic correlation, appearance event ordination, constrained optimization ranking and scaling, sequence stratigraphy, high resolution correlation, and confidence limits on stratigraphic ranges).

The remaining three chapters cover aspects of macroevolution, and build on the initial chapters. The coverage of evolutionary rates and trends is excellent, providing an update to George Simpson's *Tempo and Mode in Evolution* (1944). There is a thorough introduction to the measurement of rates, and the issues of scaling and missing data. The debate about punctuated equilibrium and species selection is touched on, and there is an excellent presentation of Alan Cheetham's work on bryozoan evolution in the past 20 million years of the Caribbean. The authors fully accept that much of evolution has been punctuated and that stasis is real, but are much less sure about the need for species selection. It might have been helpful if they had contrasted their case study on bryozoans with examples from asexual, clonal microfossils whose evolution is generally far from punctuational, and illustrates long-term species splitting often over mil-

lions of years. The coverage of evolutionary trends is careful and teaches the student to analyse the data before leaping to conclusions.

The eighth chapter on 'Global diversification and extinction' relies heavily on the work of Jack Sepkoski and Mike Foote, and presents a useful overview of diversity through time, diversifications, mass extinctions, regional transitions and replacements, and disparity. What the chapter lacks is a documentation of the key mass extinctions, differentiation of instantaneous mass extinctions from possible ecological turnovers, and an adequate treatment of events on land. Recent work by Shanan Peters, Mike Foote (!), Andrew Smith, Al McGowan, and myself exploring large-scale diversity patterns and how they relate to the rock record is not really covered at all.

The ninth chapter, on palaeoecology and palaeobiogeography, is an interesting mix of fundamental concepts and interpretive aspects. So, we move rapidly from a primer on communities, food webs, and the niche to Lower Palaeozoic marine communities, gradient analysis, and the classic onshore-offshore studies of the past thirty years. New themes include isotopes and palaeobotanical evidence for ancient climates. The treatment of palaeobiogeography is brief (three pages).

The tenth chapter is innovative, and its purpose is to show how all the skills introduced in earlier chapters may be integrated with other sciences to produce valuable results. Case study examples include the Cambrian Explosion (but with no reference to Geoffrey Wray or Kevin Peterson), the Late Permian extinction (rather weak, and without reference to anyone except the *Science* paper by Jin et al.), the PETM, Pleistocene megafaunal extinctions, conservation palaeobiology (role of humans on global systems as elucidated from palaeobiological studies), and astrobiology (extremophiles, origin of life, life on other planets).

This book is mostly a *tour de force*. The easy explanation of often complex numerical themes is exceptionally well done, and some chapters work extremely well. Mike Foote and Arnie Miller are superb authors, with a breadth and depth of experience across all themes in the book, so they write authoritatively, and give a 'Chicago view' of the palaeobiological research world. This is in line with the traditions of the book, and so we get themes that have been dominated by researchers from David Raup and Jack Sepkoski through to the present active community in and around the windy city. I regret the absence of a thorough investigation of mass extinctions and of the tree of life,

broad themes for example that dominate much current literature. As a vertebrate palaeontologist, I keenly wanted more on fossil plants, trace fossils, microfossils (almost no forams, radiolarians, acritarchs, and our other microscopic chums), mam-

mals, fishes, and so on (a few dinosaurs pop their heads in here and there). However, the book is a knock-out, and a bargain (at its British price at least).