Rereading the Fossil Record:
The Growth of Paleobiology as an Evolutionary Discipline

by David Sepkoski
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reviewed by Kevin Padian

This is the first book that examines the rise of paleobiology and the emergence of macroevolution as a separate subdiscipline within evolutionary biology. These advances began mainly in the late 1960s and 1970s, and they both shook the fields of biology, geology, and paleontology and established a framework of macroevolutionary questions that have been pursued ever since. The central focus of this work was a problem known since before Darwin: just how good is the fossil record, and how reliable is our reading of it? Before the period described in this book, the answer was generally that it was too fragmentary, episodic, and biased to be of much use. This uselessness was exacerbated during the hegemony of the Modern Synthesis (increasingly through the middle decades of the last century), when it was assumed that no useful theory could come from looking at fossils, and that all the action was at the level of population processes—which could be freely extrapolated to account for and even describe all the patterns of macroevolution.

In short, the fossil record was useless for ideas. It was perhaps amusing to see all the bizarre and giant forms that lived in the past, but really, what could possibly emerge from it that would provide insight about evolutionary processes?

John Maynard Smith was a formidable microevolutionary modeler and theoretician, and I knew him and respected him tremendously, both personally and professionally. When he first acquainted himself with the theory and supporting evidence of punctuated equilibria, he famously declared in *Nature* (1984), “The paleontologists have too long been missing from the high table [of evolution]. Welcome back.” Just as famously, he changed his mind several years later. But it hardly matters. Paleontology is at the high table of evolution, and it has always been. It is the only science that can document how evolution has worked in the long run—not at the (equally important) level of populations that turn over every few years or decades, but at the levels of millennia and millions and tens of millions of years. And we are not watching coat colors or numbers of leg bristles change. We are watching the emergence of wholly new clades, adaptations, physiologies, ecological invasions, and ecosystems. Science needs both macro- and microevolutionary patterns and processes in order to be able to test the general validity and importance of what we see at different levels. The movement in the 1960s and 1970s that David Sepkoski describes so well helped to redress the imbalance in the scientific approach to macroevolution. Now, with the ascendance of evolutionary developmental biology, we are finally able to see into some of the genetic processes that structure and permit the really critical changes in body plan to
David Sepkoski’s book is the one book that anyone interested in evolution should buy this year. And next year. And probably the year after. The reason is that, for the first time, the emergence of the modern science of macroevolution receives its due. This is as exciting as the history of the formation of the Modern Synthesis in the early decades of the last century, as gripping as the story of Salvador Luria's experiments with T2 and T4 bacteriophages, as thrilling as the race to sequence the human genome. Everyone who lived through those years remembers the anticipation and excitement that greeted each new issue of the fledgling journal *Paleobiology*, each session of the Paleontological Society at the Geological Society of America's annual meeting, each international conference on macroevolution and paleobiology. We were finally posing and testing hypotheses about what the information in the fossil record could really tell us. In short, evolution in the long run was giving up its secrets, and not just anecdotally.

What were the hypotheses, and what problems did they address? To understand this, you had to know the characters. And what a group they were! My favorite (*primus inter pares*) has always been David Raup, the wry, hard-bitten maverick who revolutionized the science of the past in two ways. First, he insisted on quantifying and testing hypotheses, not simply giving them the superficial eye. Second, he insisted that unless you could show statistically that an apparent pattern in the data deviated significantly from expectations, you had nothing to explain. In short, he pioneered the role of randomness (in the statistical sense), and held paleontologists to their data. This was a change from the more typical paleontological publication of the 1960s (and sometimes beyond, unfortunately) that spent ten pages describing a new fossil critter, then took a page to deliver unconstrained speculation about its life habits, the success or failure of its lineage, and the hope for the future.

In short, here are the major problems that the new science of macroevolution tackled, beginning in the early 1970s. First, diversity through time: how had it changed, how reliable is the fossil record, and how would we know? Two major insights came from this problem: first, that there is an endless range of statistical tests we can perform to help decide how accurate the preserved fossil record is; and second, that the answer to the main question depends on geographic scale (local, regional, or global). A second question was extinction: what are its dynamics? It was soon realized that there are two modes of extinction, background (the constant or “business as usual” extinction rate), and mass extinctions (of which there have been five major ones). It now turns out that at least two of the five resulted not from increased extinction rates but from depressed rates of speciation (origination rates). And that leads us to another very important consideration, which is the interaction of speciation and extinction rates in determining diversity in a lineage, a clade, an ecosystem, or a global flora or fauna.

Beyond these considerations, there were questions of the origins of major groups and adaptations, the mechanisms of adaptive change, and the tempo and mode of change at the level of populations—which is what was addressed by Niles Eldredge and Stephen Jay Gould in their famous theory of “punctuated equilibria.” Many scientists, some quite notable, have considered this theory and the evidence for it in completely different ways. Some ways are simply, flat-out wrong (for example, that “stabilizing selection” can explain it).
Others approach the theory from different scales, which is quite possible. Others see it as a question of the deployment of morphology through time, rather than a statement about speciation—which is not possible unless one can see a single lineage give rise to two.

David Sepkoski handles these questions and more, and it was not an easy task. Those principal players still alive sometimes remember their contributions differently than their printed (and sometimes private) words revealed at the time. Questions that loomed large for a year or two soon faded, but left their mark. And what exactly was the role of models such as MacArthur and Wilson’s of island biogeography on the nascent science? These are all debatable points, and wonderful in their complexity and historical context. The point is that in a very few years, probably from the late 1960s to the mid-1970s, the science of the past experienced a complete revolution, and the questions that were opened and tested are the same ones that are being tested today. No student of evolution should miss the chance to understand where those questions came from and why. David Sepkoski’s book is the first source to synthesize this information, and it is a superb synthesis. His father, one of the greatest paleobiologists ever, would have burst with pride. Waste no time, not merely in adding this to your bookshelf, but in reading it and marveling how so few people revolutionized our view of the past in such a very few years.

References


About the Author

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