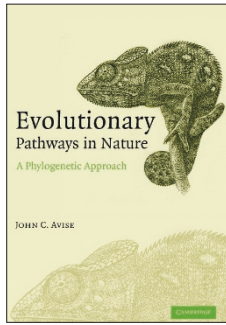


## Telling evolutionary tales

**Evolutionary Pathways in Nature: a Phylogenetic Approach**

By John C Avise

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Reviewed by Andrew J Roger

Phylogenetic analysis, once the exclusive domain of systematics, has now become an indispensable research tool for a variety of disciplines, ranging from evolutionary linguistics to comparative genomic analysis. As a result, there are now literally dozens of bioinformatics textbooks describing the various molecular phylogenetic algorithms and their implementation in software packages. Yet few books explain how to apply these methods to address basic evolutionary problems using real-world examples. A question recently posed to me by an advanced undergraduate bioinformatics student underscores the extent of this imbalance: “What exactly do biologists use phylogenetic trees for?”

John Avise’s book *Evolutionary Pathways in Nature: a Phylogenetic Approach* is a welcome corrective. It is a rich anthology of ‘evolutionary short stories’ detailing how our knowledge of natural history and biodiversity has been transformed by molecular phylogenetics. The breadth of examples covered is dizzying: multiple losses of limbs in reptiles, the evolution of web-weaving behavior in spiders, the origins of HIV, the multiple origins of endothermy in fish, the phylogeography of mammals, and the origin of humans, just to name a few. The book is aimed at a scientifically literate—but nonspecialist—reader, and despite the vast range of topics it covers, it is an amazingly easy read. It will not only appeal to the amateur naturalist but could also serve as a textbook for an undergraduate evolution course.

The book starts with a history of the development of phylogenetic methods and goes on to explain basic terms and concepts in phylogenetic analysis and character mapping that provide the analytical foundation for the following chapters. Avise then hits his storytelling stride, exploring examples in the evolutionary history of anatomical features; sexual and reproductive features; behavioral traits; cellular, physiological and genetic traits and biogeographical distributions. The stories are taken from the past few decades of molecular systematics research, and their underlying structures are often similar. However, through these different accounts, Avise introduces a variety of general principles of evolution and often provides evidence that they are not inviolable. For instance, Dollo’s law—that

complex traits are unlikely to evolve more than once—is introduced by counterexample in the context of the multiple origins of the apparently complex coiled shell morphology of some limpets. In another tale, Avise describes butterfly larvae that have evolved to trick ants into caring for and feeding them. In so doing, he showcases the concepts of social parasitism and coevolution between species. Fundamental concepts, such as polyphyly, are also challenged. Light-sensing organs in the various animal phyla have long been thought to be polyphyletic (in other words, they evolved multiple times), but recent findings have indicated that a conserved gene (*Pax6*) is involved in initiating the morphogenesis of eyes in diverse animal phyla. So are eyes truly polyphyletic? Avise advises that there is no clear-cut answer to this question. Even though some genes involved in eye morphogenesis may be conserved across animal diversity, probably hundreds of others have had distinct origins in the various lineages.

The book is not without shortcomings. The evolutionary stories are sometimes told with a pat historical narrative consisting of a peaceful progression from traditional evolutionary viewpoints to modern molecular reappraisals, glossing over huge debates that rage in the literature. For instance, the original mitochondrial DNA analyses of Cann *et al.* in 1987 that supposedly supported the “Out of Africa” hypothesis of human origins faced fierce criticism from traditionalists and molecular phylogeneticists alike, and aspects of these debates continue to this day. Scientific debate is not just dirty laundry; it is the engine of progress, and a flavor of this process should be conveyed in textbooks and the popular science literature.

A more serious problem concerns the treatment of microbes. The first 3 billion years of evolution on Earth was dominated by diversification of microbes. By any measure, these organisms now encompass the majority of the diversity of life on the planet. Yet Avise discusses only a handful of examples of microbial evolutionary pathways. To be fair, this problem is not unique to this book—the majority of systematists on the planet study multicellular eukaryotes such as animals, plants and fungi, and systematics journals are populated mostly with their evolutionary histories. Nevertheless, the microbial genomics revolution has led to some fundamentally new insights into the evolutionary process. The most surprising of these is the dominance of lateral gene transfer (LGT) as a mode of prokaryotic genome evolution. The impact of LGT on reconstructing microbial evolution is both corrosive and constructive. Dollo’s law is irrevocably broken, as entire suites of genes encoding complex traits such as nitrogen fixation or pathogenicity islands can be transferred between distantly related lineages. To understand the evolution of these features, we need not only to establish in which group they first appeared but also to glean the number and directions of subsequent gene transfer events.

In conclusion, Avise leaves us with the following:

“Despite current blemishes and potential pitfalls, comparative phylogenetics offers a powerful new mode of inquiry into the evolutionary nature of nature. If this sentiment has been conveyed, and a greater interest has thereby been stimulated in the marvelous workings of the natural world, then this book will have served its purpose.”

The abundance of fascinating evolutionary tales and the engaging clarity with which Avise tells them not only guarantee that this book will serve its purpose but also make it a ‘must-have’ for all enthusiasts of evolutionary biology.

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