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SMOOTHING THE ROCKY ROAD TO SEASHORE INSIGHT

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Molecular Evolution for the Masses

The Making of the Fittest: DNA and the Ultimate Forensic Record of Evolution. Sean B. Carroll. Norton, New York, 2006. 288 pp., illus. $25.95 (ISBN 0393061639 cloth).

In his new book, Sean Carroll summarizes the molecular evidence for evolution by natural selection for a nonspecialist audience. As stated in the introduction, *The Making of the Fittest: DNA and the Ultimate Forensic Record of Evolution* is intended to marshal the evidence from DNA sequence data to help contribute to the debates on evolution versus creationism/intelligent design. Although there are many books intended to educate the public about evolution (and we certainly seem to need them now), Carroll's book may be the first to focus specifically on the DNA evidence.

At least among biologists, Sean Carroll is an author who needs no introduction. He is one of the most prominent evolutionary developmental biologists alive today, and is a professor of genetics (and Howard Hughes Medical Institute investigator) at the University of Wisconsin, Madison. In addition to his credentials as a scientist, he is also no stranger to writing for general audiences. His first such book, *Endless Forms Most Beautiful: The New Science of Evo Devo and the Making of the Animal Kingdom* (New York: Norton, 2005), received numerous laudatory reviews from both scientists and the popular media (e.g., *USA Today*).

Carroll's new book describes adaptation through natural selection at the molecular level. Carroll starts out by explaining the "everyday math of evolution," how mutation and selection lead to changes in populations over time. He then introduces readers to the basic dogma of molecular genetics and the basic size and composition of genomes among taxa. With the basics of molecular biology and population genetics in hand, Carroll delves into the major themes of the book: the idea of "immortal" genes (genes with essential functions that have been preserved by natural selection for billions of years), "fossil" genes (functionless pseudogenes that accumulate many mutations), gene duplication and divergence as a means of developing new functions, the parallel acquisition of similar functions in different lineages, and the importance of "tool kit" genes for making complex structures. Many examples are derived from the evolution of the opsin genes and their relationship to the evolution (and loss) of color vision in primates and other vertebrates. There is also a chapter on molecular evolution and human diseases (e.g., sickle-cell anemia and malaria).

The last two chapters are somewhat out of step with the rest of the book, in that they have little to do with molecular evolution per se. One chapter focuses on why and how so many people resist evolutionary biology (using Lysenko's campaign against genetics as one example and the bizarre resistance of many chiropractors to immunizing patients against diseases as another). The final chapter discusses inadvertent selection by humans on natural populations of animals (e.g., body sizes in commercially exploited fish species).

Carroll takes considerable care to try and explain everything clearly and with everyday language. Rather than diving right into molecular evolution at the beginning of a chapter, he starts each one with a personal or historical anecdote. Furthermore, the book is extensively illustrated, with a black-and-white photograph or diagram appearing every few pages.

Overall, I enjoyed reading *The Making of the Fittest,* and I learned quite a lot from it. My research specialty is not molecular adaptation, and so many of the examples were new and exciting to me. But despite the fact that I found this book enjoyable and enlightening, I am uncertain as to how much it will contribute to the continuing battle between creationists and evolutionists. First, I question to what extent this book describes, as the subtitle proclaims, "the ultimate forensic record of evolution." The book primarily focuses on the molecular signatures of natural selection. But I think the main issue in the current "evolution wars" is not the causes of change in allele frequencies within populations. Instead, the main issue is whether the diverse species we see today have been independently created by supernatural forces or whether they originated from other species through evolution. When I think of "DNA and the ultimate forensic record of evolution," I think of phylogenies based on DNA sequence data, which show that all species are related to other species and are not independently created (or, if species were independently created, why should so many of their genes show concordant, nonrandom, hierarchical patterns of similarity and descent that link them to all other species alive today?). Phylogenies are certainly mentioned in Carroll's book, but not really as evidence for evolution versus special creation of species. In a similar vein, despite the extensive discussion of *The Origin of Species,* the book contains little or no mention of the origin of species. Of course, this is a failing in Darwin's book also, but one that Carroll need not replicate. To my recollection, speciation is barely mentioned in *The Making of the Fittest,* and is certainly never discussed.

Second, because the book is focused at the molecular level, some of the examples are not that easy to wrap one's mind around. For example, the book is full of wonderful examples of evolutionary patterns in opsin genes. But I would hesitate to use these examples in many cases, just because it would take so long to explain to students and nonscientists how opsins work and why the molecular variation matters. Similarly, for some of the traits discussed, natural selection seems to have been documented primarily at the molecular level. Thus the links between

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molecular variation, phenotype, and individual fitness in natural populations are sometimes assumed rather than thoroughly documented. Because of these issues, I think that many of the examples Carroll describes may have a difficult time competing in the classroom (and living room) with more obvious and intuitive examples, like the coloration of moths or the beaks of Galápagos finches.

In the end, Carroll's new book is a valuable addition to the popular literature on evolution, but it's no *Beak of the Finch.* On the other hand, being in the same ballpark as Jonathan Weiner's Pulitzer Prize–winning bestseller is really not too shabby.

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INSECTS FOR EVERYMAN

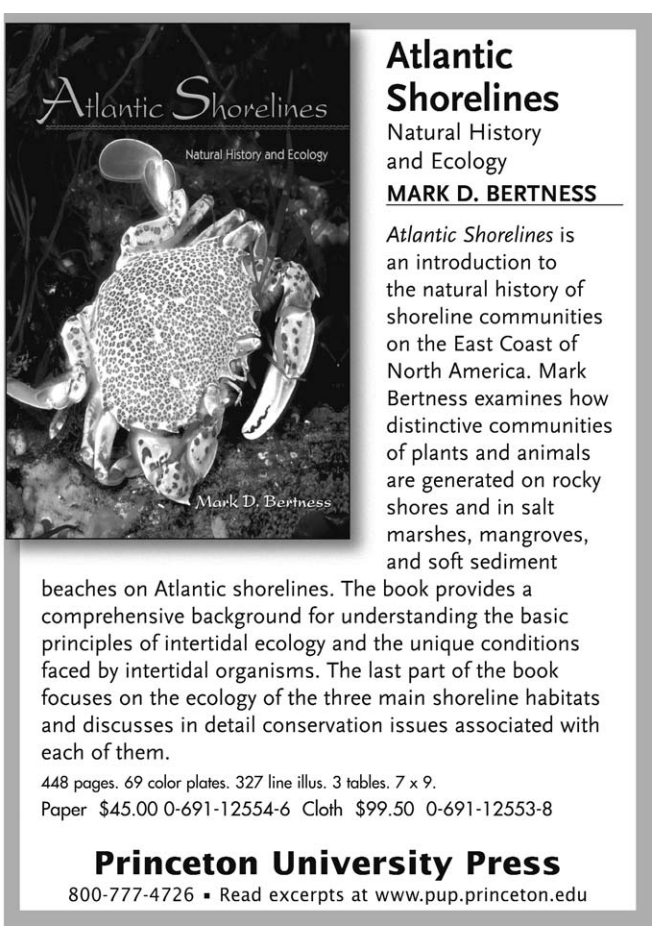
Insects: Their Natural History and Diversity. Stephen M. Marshall. Firefly Books, Richmond Hill, Canada, 2006. 718 pp., illus. $95.00 (ISBN 1552979008 cloth).

Book reviewers typically wait until the last paragraph to reveal their overall impression of the volume under review. Allow me to save you the trouble of skipping ahead: *Insects: Their Natural History and Diversity* is outstanding and should be on the bookshelf of every natural historian—insect lover or not—in eastern North America.

Compared with the literature currently available on the natural history of other North American animals, such as birds and mammals, there is little available on insects. Such neglect is surprising, not only because approximately 80 percent of all named species are insects and these often beautiful six-legged creatures are of tremendous economic and ecological importance but also because insects exhibit incredible behaviors that are easy to observe in the wild. Stephen Marshall, professor of entomology at the University of Guelph, has nicely filled this void by compiling a lifetime of natural history observation, in addition to 20 years of insect photography, into a beautiful and informative guide.

Marshall's book is ideally suited for anyone with an interest in insects, from the curious backyard observer to the experienced field naturalist or professional biologist. *Insects: Their Natural History and Diversity* offers a comprehensive, easy-to-use identification key and photographic guide for identifying specimens from pictures or collected material as well as a full index of species by both Latin binomial and common names. I put this book through its paces this past summer during collecting trips throughout Ontario, and found that every insect I encountered was represented by a beautiful photograph and informative description.

Make no mistake, this hefty tome—hardbound, with 718 glossy pages—is not meant to be an entomological field guide tucked into the naturalist's pocket during a walk in the woods. For that purpose, I recommend more traditional field guides, such as Donald J. Borror and Richard E. White's *Field Guide to the Insects of America North of Mexico* (Boston: Houghton Mifflin, 1970) or Lorus and Margery Milne's *Audubon Society Field Guide to North American Insects and Spiders* (New York: Knopf, 1980). However, I stress that these more portable guides involve a severe trade-off, as they offer only the most basic information on a limited number of species compared with Marshall's guide. Besides, the need for identification in the field may be less pressing nowadays, given the frequent use of digital photography among naturalists—this past summer I snapped digital pictures of specimens in nature and later, using Marshall's guide, identified them back at my car, campsite, and home.



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Nor is this guide meant to replace specialist taxonomic keys; if you require a more speciose list, consult the technical literature. *Insects: Their Natural History and Diversity* is, however, a happy compromise between these two requirements, covering approximately 95 percent of the insect fauna—both endemic species and introduced pests—that its readers are likely to encounter in eastern North America ("loosely interpreted as anything east of the Mississippi River and north of the state of Georgia").

Insects: Their Natural History and Diversity is loaded with 4000 stunning photographs made by the author, thus offering a level of uniformity between illustration and description often absent in many such books. Indeed, the photography is so spectacular that this volume could stand alone as a coffee table book of insects. That nearly all of these photos were taken in the field allowed Marshall to capture his subjects striking a natural pose in their natural environment. This certainly makes these photographs more helpful for specimen identification than the black-and-white line drawings so common in other guidebooks. An insect's size can often be judged through comparison with objects contained in Marshall's photos, but not always, and a scale bar would have been welcomed on some photos; however, this is a minor quibble.

Another strength of Marshall's book, and something rarely done in pocket field guides because of space restrictions, is the inclusion for some species of photos showing sex differences, color variations within species, and the stages of development. This latter feature is particularly helpful in identifying beetles and critical for identifying butterflies and moths. For readers inspired by Marshall's photography who wish to make their own photos, fear not; the author reveals his secrets and techniques in a chapter explaining how to observe, collect, and photograph insects in the wild.

In addition to its visual appeal, Marshall's book contains a wealth of biological facts and natural history trivia. For example, did you know that

- egg dispersal in some mayflies involves females exploding when they hit the water?
- crickets exhibit handedness?
- you can attract singing male katydids by mimicking the female response with a click of the fingernails?
- adult water treaders mutilate their own wings after dispersal?
- a millionth of a gram of female cecropia moth's pheromone can attract one billion males?

You get the idea. I'll let you discover these and other fascinating facts for yourself. Put simply, not only is this book a wonderful identification guide, it will serve as a fertile source of research ideas for students of entomology.

I was impressed with how current the book's information is, particularly with respect to higher-level systematics. This was probably in part because each taxon's chapter was reviewed and edited by experts on that group. Such care illustrates the lengths to which the author went to achieve such a high-quality publication.

I realize that a single book cannot cover everything on every reader's wish list. This volume is, after all, mainly an identification guide, not a treatise on insect biology. That said, however, I offer my own wish list: It includes maps showing species distributions, phylogenetic trees illustrating the relationships within and among orders to whatever resolution is currently available, and references to the primary literature for the more esoteric bits of information discussed in the text. Incorporating these items would double the book's current size, but one way around this dilemma would be to offer additional materials online at the publisher's Web site, something now done with increasing regularity in academic publishing. Online presentation of some material has the added advantage of facilitating frequent updating—for example, as species distributions change, phylogenetic relationships are refined, and more research is published.

It would not surprise me if, decades from now, professional biologists credit *Insects: Their Natural History and Diversity* with inspiring them to do what they do—it's that good.

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SMOOTHING THE ROCKY ROAD TO SEASHORE INSIGHT

Monitoring Rocky Shores. Steven N. Murray, Richard F. Ambrose, and Megan N. Dethier. University of California Press, Berkeley, 2006. 240 pp. $49.95 (ISBN 0520247280 cloth).

Monitoring Rocky Shores presents the cumulative how-to guidance arising from the three authors' many years of experience in reading about, contemplating, and especially doing quantitative sampling of plants and animals on rocky intertidal shores. Steven Murray is dean of the College of Natural Sciences and Mathematics and a professor of biology at California State University, Fullerton; Richard Ambrose is a professor of environmental health sciences and director of the Environmental Science and Engineering Program at the University of California, Los Angeles; and Megan Dethier is a research associate professor of zoology at the University of Washington in residence at Friday Harbor Laboratories. Together these authors have been involved in countless ecological investigations of rocky shores, which, along with their clear vision, qualifies them well to guide future monitors of shifting shores. The academic pedigrees of the authors include much contact with the two historic epicenters of training for North American seashore ecologists, Santa Barbara and Seattle.

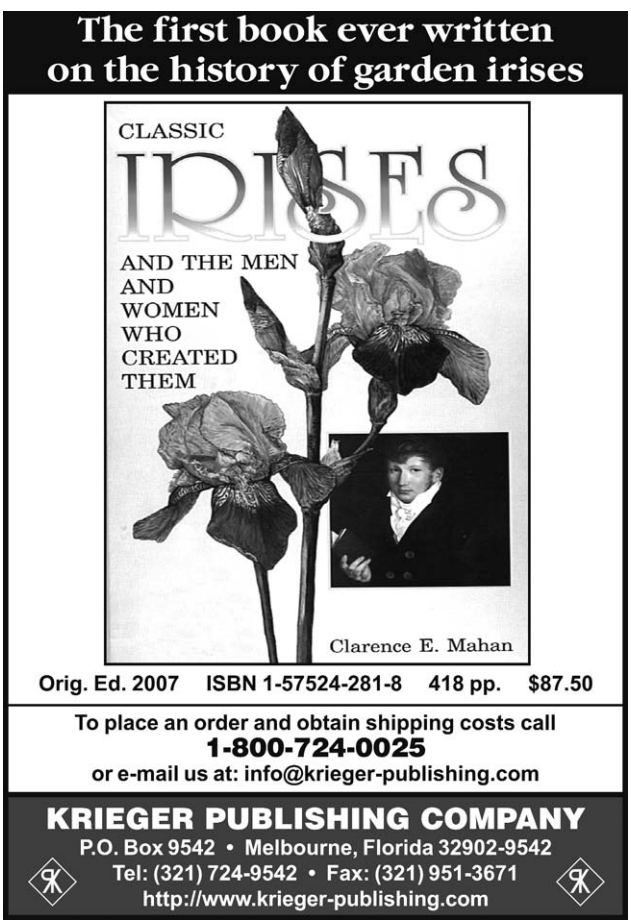
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That in itself does not guarantee that they learned their lessons well, but their book makes a compelling case for their present enlightenment.

The authors' intent in writing was not to provide a blueprint for all monitoring of the larger plants and invertebrate animals of rocky shores, but instead to offer organized insight into decision-making on each of the various components of a monitoring scheme. They place proper emphasis on first developing explicit monitoring goals to guide choices of what to measure as well as how to make the measurements. While logically unassailable, this advice is in practice all too frequently overlooked. The book takes on the challenge of partitioning design decisions into separate categories to render a complex task less overwhelming. Thus chapters are sequentially devoted to site classification and selection; the biological entities to sample (so-called biological units); sampling design; sampling units, from transects and quadrats to plotless techniques; alternative means of quantifying abundance, such as density, cover, and biomass; and possible assessments of individual parameters of size, age, growth, and reproduction. The guidance is sound and relatively complete, and helpful citations are provided to appropriate literature by other authors from North America, Australia, Europe, South Africa, and elsewhere for more specialized detail where a reader may desire it. Although the book may not contain many truly novel insights, combining the wisdom of previous experience in rocky shore sampling and monitoring into a single well-organized source volume gives this publication value. It should appeal to industry and agency scientists as well as to graduate and advanced undergraduate students and their faculty advisors, providing them a comprehensive single guide.

While the authors do address statistical analysis at some level, up to description of an asymmetrical BACI (before–after control–impact) design, this book does not attempt detailed guidance on statistical testing methods for data collected during monitoring. The absence of some of this statistical complexity could compromise proper choices of sampling design because the sampling design and statistical data analysis are so intimately interconnected. I do not view this omission as a serious flaw, but some users might wish to consult statistical sources that go beyond what is discussed or even cited in this book. For example, the dispute over the proper error variance to use when multiple control or treatment sites are included in a BACI design is not mentioned, and guidance to that specific literature is lacking. Similarly, uncited statistical literature exists on the use of paired designs to minimize unexplained error variance in establishing more powerful assessments of impact. Analysis of covariance may serve to reduce error variance and thus also deserves inclusion in guidance for rocky shore monitoring. Admittedly, such statistical testing issues go beyond the scope of the authors' intentions. What are included are sensible lessons and practical guidance from real-world experience, invaluable to those approaching the daunting task of field sampling on the intrinsically heterogeneous rocky seashore.

Some might question the need for a book devoted to monitoring in a single environment, the narrow zone of contact between the land and the sea. In relation to the surface area of the earth, the rocky intertidal zone approaches the trivial in size. However, its ecological importance is great and growing. This habitat has long served as perhaps the most effective testing ground for theory in community ecology, because of the existence of strong gradients in the physical environment and the ease with which component organisms can be manipulated without serious artifacts. Appreciation of how organisms on rocky shores reflect coastal oceanographic processes has grown to the point where integrating coastal oceanography and shoreline ecology brings new ecological insights into how connectivity must be included in our understanding of populations, communities, and ecosystems. Finally, as the globe warms and the sea level rises, rocky shore communities and populations become important sentinels of biotic change. To detect signals from the earth and use



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them to guide us scientifically, socially, and politically requires a solid scientific foundation of rigorous sampling. This book helps position scientists to resolve such messages of change in a sentinel habitat of ecological significance.

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