In the Light of Evolution: Essays from the Laboratory and Field

edited by Jonathan Losos

reviewed by Marvalee H Wake

In the Light of Evolution: Essays from the Laboratory and Field, edited by Jonathan Losos, is a wonderfully rich and diverse collection of essays that illustrate the way evolutionary biologists think and work—how they develop questions and hypotheses about evolution and how it occurs, how they test their hypotheses, why both lab and field work are important to resolution of many questions, and why the answers usually open new questions—and why that is useful for the progress of science. The authors of the essays present a wide range of exploration of several major areas of evolutionary biology, and of research on a great diversity of organisms. The essays are fast-paced and clearly written, accessible to any interested reader, no matter the level of either training in or skepticism about evolution. Virtually every author has framed his or her contribution with a background statement about Darwin’s approach to similar problems, and how their work is able to extend his approaches because of new tools and expanded knowledge—and they often point out Darwin’s prescience as he conjectured about pattern and process of evolution, especially natural and sexual selection. In fact, the book is part homage to Darwin, published two years after the bicentennial celebration of his birth, and part elucidation of Darwinian principles in today’s scientific vocabulary. Nearly all of the contributions treat the origin, maintenance, and increase in diversity of organisms, their parts, and their behaviors, ranging from the evolution of weapons (such as horns and poisons), immunity, selection of mates, and on and on … They emphasize that evolutionary biology is multidisciplinary in approach, and synthetic in analysis. The contributions illustrate current ideas and theory of evolution, using tools and technologies drawn from many subfields of biology, and chemistry, physics, computer science, social science, history, and philosophy. Each contribution includes a list of suggested readings, mostly the authors’ own papers, a Darwin or two, and a few additional references, all useful in giving additional information to the interested reader.

Losos selected a magnificent group of contributors—all experts in their own domains, hardworking scientists who report on their own work, which typically is integrative and synthetic, with emphasis on trying to understand diversity and unity, mechanisms, and history, illustrating that evolutionary biology is historical, observational, and experimental. “Being and becoming” is now testable in the lab and in the field. It had long been a premise that evolution is only historical, that it happened once, usually long ago, and that one must use clues to reconstruct pattern and process. Several of the contributions illustrate the new understanding and perspective that evolution is ongoing, and can be rapid, controlled,
or capricious in the response of selection to environmental (external and internal) change. Have we made progress in understanding the theory of evolution and how natural selection operates? This volume presents a resounding “yes” to that question. We can test how natural selection works, we can assess the genetics of change, the rate of evolution, and the effects of inter-individual through environmental interactions, how species arise, and what effects diversity and how it is maintained.

The interested reader should be able to find questions and/or organisms that stimulate thought—there is something for everyone, and mastering one essay is likely to lead to needing to read others! Organisms of study are mostly vertebrates (fishes, birds, amphibians, mammals including humans, lizards and snakes), but also beetles, ants, and butterflies. The volume opens with a foreword by David Quammen that puts current study of evolutionary biology in the context of Dobzhansky’s oft-quoted comment that “Nothing in biology makes sense except in the light of evolution”—the theme of the volume. The first contribution is an examination of Darwin as a “traveler, author, and naturalist”—that is, a working scientist—by the erudite historian and scholar of Darwiniana, Janet Browne. Essays follow by James Curtsinger, Carl Zimmer on Rich Lenski’s work on microbial evolution, Daniel Lieberman on bipedalism in humans, Jon Losos on the diversification of island anolis lizards, Butch Brodie III on the “arms race” between newts and snakes, Naomi Pierce and Andrew Berry on nitrogen scarcity and the evolution of mutualism between caterpillars and ants, Luke Harmon on Wallace and island biogeography, Doug Emlen on horn evolution as weapons of sexual selection in dung beetles, Marlene Zuk and Teri Orr on ornamentation, sexual selection, and female choice, Mike Ryan on sexual selection in frogs via calls (and their consequences), David Reznick on studying natural selection in guppies, David Queller on the evolution of altruism in honey bees, Axel Meyer on speciation in cichlid fishes, Hopi Hoekstra on the genetics of color adaptation in mice, Ted Daeschler and Neil Shubin on fossils and the origin of tetrapods, and Harry Greene on cows, deer, and the evolution of “wild”.

I will describe, briefly, two of the essays; I could have chosen any two to illustrate the scope, complexity, and clarity of the research areas described, but those by Dan Lieberman and by David Reznick provide excellent but very different examples—do read most or all of the essays, though, to get the depth of “flavor” of modern evolutionary biology, and the way it can and should inform so many of our current social constructs.

Both students and skeptics of evolution are interested in new research on the evolution of our own species. Lieberman introduces his discussion of human bipedalism with a thoughtful examination of Darwin’s perspective on human evolution. He points out that Darwin had far fewer facts at hand about human evolution than he had for many other species when he published *On the Origin of Species* in 1859, and his few comments were diffident. But by 1871, in order to prepare *The Descent of Man and Selection in Relation to Sex*, he had put together evidence for the relationships of humans to other mammals. He also speculated that humans evolved in Africa, and that they are most closely related to the great apes. Darwin reasoned that human bipedalism was a key innovation that set humans on a course that resulted in the evolution of speech, intelligence, and morality. The freer use of hands led to tool use, defense, prey attack, and so on. At the same time, Darwin apparently accepted that humans are “special”, and wondered how becoming special occurred as a consequence of their evolution. How did selection work on variation in humans? Darwin
realized that natural selection is a highly contingent process in which change is influenced by previous events—that is, the cumulative history of the entity. Lieberman then examines Darwin’s prescient ideas in the context of the current genetic evidence for the relationships of humans, and compares the hypotheses. He notes that there have been few hominoid fossils until quite recently, and he compares australopithecines with hominids regarding two issues—brain size and walking/running ability. Both aspects are major foci of his research program. Lieberman carefully and lucidly tests hypotheses regarding the evolution of brain size and the timing of the evolution of various capacities, such as tool use, and of the evolution of endurance running. He presents a fascinating scenario, based on two ideas supported by fossil evidence: at first, bipedalism was slow and awkward; large brains evolved well after hunting did. Given that, Lieberman postulates that the evolution of endurance running released a constraint on brain size, allowing persistence hunting, the evolution of language, aggressiveness, moral sense, concealed ovulation, and so on. Lieberman asserts that the meshing of these features that occurred based on chance events, contingency, and selection may indeed make the human species “special.” (I would argue that the species is unique, like all species, but different, again like all species …) The key is that humans are “us” and we do not always recognize our place in nature and the effect that we have on it. Lieberman’s ideas provide much food for thought!

David Reznick has developed a wide-ranging, intellectually challenging, diverse and synthetic research program that is devoted to understanding natural selection as a process, and the nature of adaptation. He tests experimentally many aspects of evolutionary theory. His essay showcases the course of his thinking about how to test evolution, and not in the lab, but in the field so that he could explore and manipulate variables in the actual lives and habitats of organisms. He notes that his early ideas came out of digesting the lab experiments on evolution in Drosophila, and his desire to test selection in the natural world. It was becoming clear that evolution is testable, that change doesn’t happen just once, back in distant time, but is ongoing and can be fast. Reznick is also interested in life history theory, including mate selection and aspects of fitness, such as numbers and sizes of offspring. His beautifully organized contribution presents the background for the thesis that natural selection is the cause of evolution. He next discusses how to develop ways of experimentally testing principles explicitly in nature, including choice of study organisms and sites. His rationale is that nature does experiments, as Darwin recognized. Consequently it should be possible to replicate the parameters of those experiments in the lab, and to manipulate them there and in the field. Life history theory predicts how the risk of death alters the way organisms allocate resources for life. Reznick reasoned that the numbers of predators at a locality establishes the level of risk. In situations with many predators, the prediction is that natural selection would result in early maturity, and high fecundity—lots of babies. Conversely, few predators would allow the population to delay maturity and devote resources to its own growth and maintenance. Reznick then thought about what species and what localities would allow him to test these predictions. He had visited Trinidad, and knew the species of guppies there. He also knew that there were different predators in kind and number and therefore different risks at the headwaters of streams in the mountains versus those at lower levels; therefore each stream constitutes a natural experiment. Guppies are viviparous, and have superfetation (clusters of embryos in the ovary that can be at different stages of development, resulting from different fertilization times and even different fathers), and high genetic diversity. A single female can start a
new population if she moves to a new site, because of the genetic diversity of her offspring. These factors, together with the presence or absence of predators in different streams, became Reznick’s natural laboratory. Reznick then set to work, manipulating guppy populations and predators and their numbers of species and individuals in Trinidadian streams. He found that the rate of evolution (trait change) in both field and lab was fast, but often at erratic rates. He found the imprint of predation on every trait that he tested—guppy locomotion, resource allocation, and so on—and thus determined the scope of adaptation by natural selection. His choice of species and sites made major theoretical discoveries possible. This description short-cuts years of thought and work, and doesn’t do it justice. For example, Reznick and his team started by doing mark and recapture studies for which each fish was marked, and photographed; he now removes two scales from each fish and genotypes the fish based on the DNA from the scales. They census the populations each month and they genotype new recruits and baby guppies, thus developing pedigrees of evolving populations, allowing new experiments in natural selection to be designed. Reznick concludes his essay with an inspiring discussion of the ways we can now test evolution as a process, and his view of what future research will be, for him and for the science. Biologists can now quantify fitness and assess the features of organisms, develop a quantitative theory of evolution that is predictive regarding species’ responses to their environments and changes in them, develop experimental designs that make natural selection observable and quantifiable (change over time), and work with contemporary, not just historical, data.

Each of the essays in this book is as thoughtful, informative, and perceptive as those of Lieberman and Reznick. They would be splendid points-of-departure for seminars on natural selection, biodiversity, evolution, or even research styles. An understanding of how scientists think and work is fundamental to our developing conception of the complexity of life and how it evolves. Losos and his fellow contributors reveal the histories, personalities, and futures of the scientists and the science in honest and engaging essays.

ABOUT THE AUTHOR

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