ever, we still know virtually nothing about the calls that are most analogous to human speech—close-range vocalizations used in social interactions. Psychologists working with chimpanzees in captivity often assume that their subjects' vocalizations are too simple to be relevant to studies of cognition. This is an assertion born of ignorance. After all, even monkeys (which are thought to be less intelligent than chimpanzees) use their vocalizations to designate features of their environment, to reconcile with opponents, and to facilitate social interactions. It would be very surprising if chimpanzees were not capable of at least this much. If language is crucial to culture, as most definitions would have it be, we will make no progress in understanding chimpanzee cultures until we have some understanding of their natural communication.

Finally, in what way are the cultural and cognitive capacities of chimpanzees different from those of other animals? Of the authors in this book, only Povinelli has attempted to test chimpanzees and monkeys on the same cognitive tasks. The results have suggested some perhaps fundamental differences between the minds of chimpanzees and monkeys. There is as yet little evidence, however, that under natural conditions the social behavior of chimpanzees is qualitatively more complex or variable than that of monkeys (or indeed of other social animals, like elephants). In captivity, species as diverse as parrots and sea lions have been found capable of solving extremely challenging cognitive problems. This book would have benefited from some discussion of these issues.

By letting the data speak for themselves, and by resisting the temptation to formulate any grand hypotheses that might be proved wrong by future research, the editors have compiled a volume rich in new and valuable data. In quite properly treating culture as just another source of diversity, they have also rendered a topic that could be exciting, provocative, and even poetic rather dull. But maybe this is not the editors' fault; maybe the chimpanzees themselves are to blame. Discussions of culture, after all, should focus not just on tools, technologies, and medicinal plants but also on art, song, ritual, and other functionally irrelevant behavior. And in the more than 100 years that have passed since Tylor's anthropocentric definition, none of these characteristics have been found in any animal species, chimpanzees included. Perhaps Tylor was right, and there is no poetry in this book because there is no poetry in chimpanzees. Chimpanzees may have cultural traditions, but, unlike us, they don't have useless ones. They construct rudimentary tools but they don't paint, they don't sing silly songs, and they don't worry about their jewelry. As Clairee Belcher, the doyenne in *Steel Magnolias*, put it so succinctly, the "thing that separates us from the animals is our ability to accessorize."

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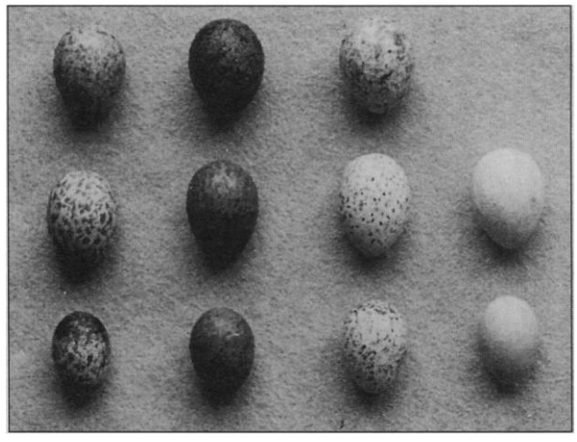
Coevolution Reconsidered

The Coevolutionary Process. JOHN N. THOMPSON. University of Chicago Press, Chicago, 1994. xii, 376 pp., illus. $49 or £39.25; paper, $19.95 or £15.95.

In 1986, after making revisions to a manuscript accepted by the journal *Evolution*, I was asked by the editor to make one additional change—to drop the term "arms race" from the title, since he felt that to label the interaction under study, between a herbivorous insect and its principal host-plant, as such was "premature." I obligingly made the change but was more than a little nonplussed, when the article came out, to see that it was followed in the same issue of the journal by one with a title that began, "Failure of the arms race analogy." But those were the '80s, a time of major disenchantment with the notion that interactions between species could effect evolutionary changes reciprocally, to create cycles of adaptation and counteradaptation epitomized by the arms race analogy. The disenchantment was to some degree well earned by flagrant abuses of the term "coevolution" in the preceding two decades, yet the swing toward conservatism with respect to the phenomenon in the last ten years has been extreme.

John Thompson's new book is a refreshing rejoinder to the naysayers and skeptics of the past decade and a delightfully well-reasoned call to restore the process of coevolution to a place of prominence in ecology. The book begins (part 1) with a historical review of the intellectual foundations of modern coevolutionary theory. Three chapters (part 2) then examine the genetics, phylogeny, and ontogeny of specialization across a broad range of taxa and the relationship of specialization to coevolution, particularly as manifested by phylogenetic diversification. Part 3 consists of five chapters that examine the action of natural selection in different trophic interactions and the ways in which selection imparts geographic structure to specialization. In the final series of five chapters (part 4), Thompson explicitly differentiates his "geographic mosaic" view from more standard views of interactions and provides specific hypotheses to guide future studies. A short epilogue places coevolutionary theory in the broader context of global biodiversity and argues for the preservation of interspecific interactions as well as specific species as goals for the conservationist.



"Mimetic eggs laid by cuckoos (*Cuculus canorus*). Cuckoo populations in Britain have evolved eggs that mimic three of their four major hosts. Top row: cuckoo eggs from red warbler mimics ('gentes'), meadow pipit mimics, and pied wagtail mimics. Middle row: model cuckoo eggs representing each of the three mimetic types plus a fourth representing a redstart egg (a suitable but currently rarely used host in Britain for which a mimetic type occurs in Finland). Bottom row: Eggs of the current favorite British hosts — reed warbler, meadow pipit, pied wagtail, dunnock." Differences in the readiness with which various host species reject the cuckoo eggs laid in their nests may reflect coevolutionary alternation, with time lags producing "a complex pattern of specialization in the parasite populations and a complex distribution of defenses among hosts." [Reprinted in *The Coevolutionary Process* from N. B. Davies and M. de L. Brooke, *J. Anim. Ecol.* **58**, 207 (1989)].

Thompson has integrated an amazingly diverse array of studies to illustrate his points. In a single chapter, sometimes even a single paragraph, he can ask his reader to evaluate phenomena as they relate to taxa as disparate as sea slugs, caterpillars, and bat flies, or aphids, parasitic wasps, and salamanders, or even rabbits, yucca moths, and endophytic fungi. These juxtapositions, though occasionally quite jarring, are always thought-provoking. The prose is fluid and highly readable; the summary of 19th-century efforts that laid the groundwork for today's enterprise borders on thrilling. Mercifully, jargon is kept to a minimum here (although I can't say I'm fond of the term "despecialization").

This book is not intended as a primer for beginners who wish to become familiar with the field; many technical terms, for example, are not explicitly defined. Nor is it textbook-like in its approach; coverage, though extensive, is uneven (for example, the discussion of fruit dispersal focuses exclusively on vertebrates with virtually no reference to dispersal by ants). It is, rather, Thompson's highly personal view of the history of the field and of the directions in which it should go. Just how personal is illustrated by the fact that Thompson cites close to 40 of his own papers, making him overwhelmingly the most frequently cited author in the volume. The main thesis of the book, a theme that underlies it in its entirety, is that "much of the coevolution occurring between species may occur through the geographic interplay of populations differing in defense, counterdefense, and specialization rather than through reciprocal change within local populations" (p. 166). Although Thompson labels this view the "geographic mosaic theory of coevolution," it is, in my opinion more of a perspective than a theory, one that has not been absent in the past as much as ignored or underemphasized. The hypotheses generated by emphasizing that geography determines the outcome of any given interaction are the sort to give headaches to anyone accustomed to constructing straightforward, easily falsifiable hypotheses; Thompson regrettably does not provide any guidelines to investigators who must now ponder how many populations constitute an adequate sample. The greatest contribution of this renewed emphasis on geographic variation, however, is that Thompson has elegantly (and compellingly) deconstructed received notions of "diffuse coevolution," generating in their stead alternative scenarios of interaction cycles that vary in time and space. In doing so, Thompson will undoubtedly inspire researchers to revisit interactions that were previously dismissed as unworthy of the term "coevolution" and to maintain a more thoughtful, open-minded attitude on the subject.

The polemical dimension of the book detracts only in places where Thompson, intent on promoting a generalization, ignores the specific details of the very literature he cites in support of the generalization. To cite just one example, Thompson claims that trenching or vein-cutting, feeding by insects in such a way as to sever conduits that allow the flow of defensive chemicals to particular plant parts, can lead to an expansion of host breadth and to a polyphagous diet—yet the papers he cites in support of this argument describe trenching behavior in at least as many insects with rather specialized diets. This case is by no means an isolated one; the tendency of the author to gloss over inconsistencies renders the book less suitable to novice readers who do not have sufficient familiarity with the literature to evaluate the arguments.

One other aspect of the book that is surprising is that, though there is considerable discussion of genes and their location, there is remarkably little discussion of gene products and their action. Though it is certainly of interest to localize a gene for oviposition preference on a particular chromosome, for example, basic understanding of the mechanisms underlying oviposition preference can only proceed from knowledge of the products and processes controlled by that gene. With the noticeable exception of a discussion of interactions between nitrogen-fixing nodulating bacteria and their host plants, there is virtually no detailed discussion of chemistry in the book. This absence is particularly conspicuous in the discussion of plant-insect interactions; after all, the landmark paper by Ehrlich and Raven (1964), which Thompson himself admits "spawned more work on coevolution than any other single article," focused not only on patterns of host-plant utilization by butterflies but also on patterns of secondary metabolism within and among host-plant families. Even for investigators whose main interest is in the chemical mediation of coevolution, though, this book is an invaluable resource by virtue of its 47-page bibliography alone. If it proves as influential as I think it might, arms races might make a comeback on title pages in quite a number of journals in the near future.

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Vignette: Prognostication

When T. S. Kuhn published *The Structure of Scientific Revolutions* in 1962, he truly knew not what he had wrought. "Paradigm shift" has become a war chant. . . . February 1995 will see an aggressive conference titled The First Annual Conference on Trauma, Loss, and Dissociation: The Foundations of Twenty-First Century Traumatology. . . . The preconference publicity quotes one of the speakers: "Advances in the field of traumatic stress research have led to exciting new paradigm shifts. The conference will break new ground for the 21st century. Perhaps I may be allowed a dour Canadian joke. In 1900 the prime minister of Canada announced, "The Twentieth Century Belongs to Canada."

—*Ian Hacking*, in *Rewriting the Soul: Multiple Personality and the Sciences of Memory* (Princeton University Press, forthcoming)

Protein Penetrants

Handbook of Membrane Channels. Molecular and Cellular Physiology. CAMILLO PERACCHIA, Ed. Academic Press, San Diego, CA, 1994. xx, 591 pp., illus. $150 or £92.

A long, long time ago, there were only three ion channels, Na^+, K^+, and acetylcholine-activated—arcane pieces of specialized molecular hardware dedicated to the task of producing regenerative electrical signals in nerve and muscle cells. Mainly thanks to patch-recording techniques, we now know that ion channel proteins populate a molecular zoo as teeming and elaborate as any functional class of macromolecules. These integral membrane proteins all work by forming aqueous pores right through the heart of the protein and thus across the membrane in which the channels reside, and they create these leaks for a huge variety of physiological purposes.

Like a dedicated Victorian naturalist, Peracchia has set out to collect in a single display as wide an assortment of species as the vessel can hold. The value of this book is that it illustrates the diversity of channel form and function in biological membranes; it utterly dispels the notion that ion channels are owned by the nervous system. To be sure, we initially are shown the customary lions and tigers—the voltage- and ligand-gated channels, whose molecular mechanisms are coming into increasingly sharp focus. But the book gives equal weight to beasts from more exotic physiological climes—epithelial Cl^- channels, gap junctions, aquaporins, cyclic nucleotide–activated channels, mitochondrial K^+ channels, exocytotic fusion-pores, channels in bacteria, yeast, and protozoa, and the Ca^{2+}-release channels of intracellular mem-