a polemic against current approaches to phylogeny reconstruction. In their excellent summary chapter, Forey, Gardiner, and Patterson summarize the conflicting views in the preceding contributions and examine them using numerical cladistic methodology. They favor a hypothesis that tetrapods are most closely related to a grouping comprising coelacanths and lungfishes plus the Early Devonian *Diabolepis*.

The second section of the book is concerned primarily with the origin of the three major groups of living amphibians, which are commonly and conveniently grouped together as Lissamphibia. The review by Bolt on the relationships of modern groups to certain Paleozoic taxa and the thorough phylogenetic analysis of living and fossil amphibians by Trueb and Cloutier both present a convincing case for the monophyly of lissamphibians and their sister-group relationship to the mostly late Paleozoic Dissorophoidea.

The third section discusses the origin and interrelationships of reptiles. The review of diapsid interrelationships by Carroll and Currie supports recent phylogenetic hypotheses and emphasizes persistent problems (such as the affinities of the various taxa of aquatic diapsids) that appear to be due to pervasive homoplasy.

The chapters devoted to *Archaeopteryx* and the origin of birds (section 4) offer little new information and insight, and several of the phylogenetic discussions display a lack of analytical rigor. Witmer provides a valuable historical review of the problem. Ostrom restates his (cladistically now well-supported) hypothesis that birds are most closely related to theropod dinosaurs. Martin criticizes many of Ostrom's arguments and instead postulates derivation of birds from a crocodile-like ancestor. Tarsitano's chapter presents a curious mixture of cladistics, evolutionary scenarios, and intuition. He rejects Ostrom's hypothesis and attempts to relate birds to forms similar to the poorly known Late Triassic *Megalancosaurus* (which is probably not an archosaur).

The final section deals with the Synapsida and the origin of mammals. Hopson's excellent, even-handed review of synapsid interrelationships reiterates the traditional view that parallel evolution is indeed a pervasive phenomenon during the evolutionary history of this group (and presumably other major taxa as well), rather than (as has frequently been alleged) the result of unparsimonious phylogenetic inferences.

Although it is encouraging that the majority of contributors at least use some form of cladistic analysis, their detailed methodological approaches vary considerably. Unfortunately, many chapters lack matrices for character distribution, which hinders evaluation of the arguments advanced by the various authors.

This volume contains many new data and insights and is an important reference work for any advanced student of vertebrate evolution. It will figure prominently in paleontological debates for years to come and succeeds well in highlighting areas of continuing controversy. The book also underscores the intriguing fact that, after almost two hundred years of intensive scientific study, there is still little consensus concerning the higher-level interrelationships among tetrapods and their aquatic sarcopterygian sister taxa.

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Themes in Ethology

The Tinbergen Legacy. M. S. DAWKINS, T. R. HALLIDAY, and R. DAWKINS, Eds. Chapman and Hall (Routledge, Chapman and Hall), New York, 1992. xii, 146 pp., illus. $57.50. From a conference, Oxford, U.K., March 1990.

Niko Tinbergen was the single most important individual in the development of modern ethology. He combined the separate strengths of the two ethologists who shared the Nobel Prize with him: Like Karl von Frisch, he had experimental finesse that set the standard for tricking animals into revealing their secrets through their behavioral responses; no one has ever surpassed Tinbergen's adroit use of models to dissect the innately recognized cues that trigger behavior. Like Konrad Lorenz, he insisted that animals be studied under natural or (when sufficiently understood) semi-natural conditions, setting another important standard for the field; his demonstration that evolutionary hypotheses could at least sometimes be tested added an essential empirical element to a discipline in which the formulation of just-so stories was (and remains) a debilitating temptation. Moreover, Tinbergen was the most effective communicator of the three; though Lorenz's *King Solomon's Ring* is in a class by itself, Tinbergen's *The Study of Instinct*, *The Animal in Its World*, *Curious Naturalists*, and *The Herring Gull's World* have had an enormous impact on young ethologists, particularly in the English-speaking world. In *The Tinbergen Legacy*, which consists of eight papers presented at a one-day conference in Oxford in 1990, the contributors attempt to capture the unique contributions of Niko Tinbergen.

Gerard Baerends, one of Tinbergen's early Dutch collaborators, offers a thumbnail biography, with special attention to the cultural milieu of the prewar Netherlands. I hope Baerends will expand this all too brief and telegraphic account into a book some day. Nicholas Davies focuses on the development of behavioral ecology from Tinbergen's early tests on the evolutionary purpose of behavior. Davies points out that Tinbergen's concentration on species-typical behavior led him largely to ignore individual differences and thus the various strategies that various individuals in a population adopt. In some species, animals measure the relevant variables and then opt for the preprogrammed alternative that has the most favorable cost-benefit ratio. Davies nicely balances his chapter by taking behavioral ecologists to task for ignoring the mechanistic bases of behavior, a factor that Tinbergen consistently emphasized.

Robert Hinde considers Tinbergen's special interest in human ethology. This was one of Tinbergen's less successful endeavors, and Hinde loyally attempts to gloss over the remarkable and uncharacteristic error Tinbergen made in assuming that autism is primarily a cultural phenomenon rather than mainly the consequence of genetic predispositions. Perhaps the best chapter is the one on motivation by Felicity Huntingford; it clearly and accurately summarizes Tinbergen's pioneering work and then looks honestly at the status of his ideas in modern ethological thought.

John Krebs's chapter on communication offers a brief view of Tinbergen's and (mostly) Lorenz's ideas on the evolution of communication and then presents at some length Krebs's by now familiar view that communication is inevitably dishonest and deceptive (excluding, one must suppose, book chapters). This is one of only two papers that cite their authors' work more often than Tinbergen's. Juan Delius chose as his topic the nature of culture, a subject on which Tinbergen had little to say. This is the only chapter that deals with learning, an important component of the Tinbergen legacy, and it doesn't really capture the essence of Tinbergen's contribution to the modern realization that much learning is species-specific and innately directed.

Michael Robinson's topic is the use of species comparisons in understanding behavior, a technique whose immense potential was clearly demonstrated in Tinbergen's work on gulls. Like Krebs's chapter, however, this one is more about the author's work than Tinbergen's or its legacy. The book ends with a curious chapter on Tinbergen's use of photography. The films that Tinbergen helped make (especially "Signals for Survival") are unsurpassed in communi-

cating the essence of field ethology to students, but this is a hard case to put in a book chapter. Just as only seeing one of his films can really illustrate this aspect of the Tinbergen legacy, the other contributors to this slim volume have to be judged against Tinbergen's own writings; all in all, I think most students will learn more from the seemingly timeless *Study of Instinct* than from this or any other retrospective.

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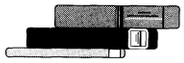

Faraday at Home and Abroad

Michael Faraday: Sandemanian and Scientist. A Study of Science and Religion in the Nineteenth Century. GEOFFREY CANTOR. St. Martin's, New York, 1991. xii, 359 pp., illus. $45.

Experimental Researches in Chemistry and Physics. MICHAEL FARADAY. Taylor and Francis, Philadelphia, 1991. xviii, 496 pp., illus., + plates. $55. Reprint, 1859 ed.

Michael Faraday and the Royal Institution. (The Genius of Man and Place) JOHN MEURIG THOMAS. Hilger, Philadelphia (distributor, American Institute of Physics, New York).

Curiosity Perfectly Satisfyed. Faraday's Travels in Europe, 1813–1815. BRIAN BOWERS and LENORE SYMONS, Eds. Published by Peregrinus in association with the Science Museum, London, 1992 (U.S. distributor, IEEE, Piscataway, NJ). xviii, 168 pp., illus. $33. IEE History of Technology Series, 16.

The Correspondence of Michael Faraday. Vol. 1, 1811–December 1831, Letters 1–524. FRANK A. J. L. JAMES, Ed. Institution of Electrical Engineers, London, 1991 (U.S. distributor, IEEE, Piscataway, NJ). I, 673 pp., illus. $95.

Michael Faraday is surely one of the best-known scientists of the 19th century. His discovery of electromagnetic induction in 1831, his early steps toward field theory, his great talents as an experimenter, and the romantic story of his rise from humble beginnings to the pinnacle of fame have made him one of the great heroes of science. In recognition of his status—not so much as father but as patron saint of the electrical age—the British Post Office issued a stamp last year to honor the 200th anniversary of his birth in 1791, and his portrait now graces the Bank of England's new £20 note. Scholars have honored Faraday's bicentenary in their own way with a whole series of conferences and publications, and the five works under review represent just part of the recent production of the Faraday industry.

Despite their diversity, these five works have a common thread: all bring out relatively unfamiliar aspects of Faraday's personality and achievements. He appears here not just in his usual guise as the brilliant electrical experimenter who could seemingly sniff out the truth or as the eloquent lecturer who enthralled fashionable audiences at the Royal Institution. We instead see Faraday as a young man making an extraordinary scientific tour of the Continent at the height of the Napoleonic Wars; as a chemist, doing both original research on new compounds and workaday analyses of water and ore samples; and as a deeply committed Christian, a member, as he told Ada, Countess of Lovelace, of "a very small and despised sect of Christians, known, if known at all, as Sandemanians."

Geoffrey Cantor's *Michael Faraday: Scientist and Sandemanian* is the first full-length study of Faraday to focus primarily on his religion and its role in his life and thought. Indeed, Cantor's opening chapters are in effect a history of the small Sandemanian sect (it never numbered more than about a thousand members) from its beginnings in Scotland in the 1730s to its gradual dissolution in this century. Although they professed a simple Biblical faith and demanded strict adherence to the literal word of Scripture, the Sandemanians were perhaps not quite as dour as they have sometimes been depicted as being; indeed, their practice of serving Scotch broth at their weekly Love Feasts won their church the popular sobriquet of the "Kail Kirk."

Michael Faraday. Portrait by H. W. Pickersgill, engraved by Samuel Cousins. [From *The Correspondence of Michael Faraday*, vol. 1]

A striking feature of the Sandemanian sect, emphasized by Cantor, was its members' strong sense of being set apart from "the world" and of forming a community unto themselves. This was reinforced by close family ties, for Sandemanians—including Faraday and his siblings—tended to marry fellow Sandemanians. As Cantor makes clear, though Faraday had many friends, particularly fellow scientists, who were outside the Sandemanian circle, his most intimate relationships, and the center of his own identity, lay firmly within his church. It formed, both literally and figuratively, his extended family.

Cantor's compelling portrait of Faraday's personality is intended, he says, not as "a reductive exercise but . . . rather as an attempt to show why he was so strongly attracted both to a peculiar religious sect and to science, or, more precisely, an idiosyncratic conception of science" (p. 10). Regrettably, Cantor gives a sustained picture of Faraday's personality only in his final chapter; this might best be read first, to provide a connecting thread as the successive aspects of Faraday's life and thought are examined. Cantor's Faraday emerges as a man with a deep fear of "confusion" of any kind and a strong need to order his environment, themes that pervaded both his science and his religion. Cantor also makes a persuasive case that Faraday's religion affected his science more directly as well, notably in his conviction that nature was orderly and "economical" and that divinely ordained natural powers were indestructible, and in his caution about the speculative interpretation of experimental facts—a caution that paralleled the Sandemanians' adherence to the literal word of the Bible, without interpretation. Indeed, Sandemanian "exhortations" consisted of (carefully chosen) Biblical passages strung together with a minimum of connecting material, just as Faraday's scientific papers ideally consisted of (carefully chosen) descriptions of experimental facts strung together with a minimum of speculative interpretation.

When Cantor discusses Faraday's scientific work, he focuses on his electromagnetic researches—an understandable choice, given the undoubted importance of Faraday's contributions to electrical physics. But one of the striking points about the other works under review is the extent to which Faraday appears, especial-