BOOKS: EVOLUTION

Into Jurassic Air

Sharon Swartz

How did flying birds evolve from their earth-bound ancestors? Imagining the acquisition of this remarkable capacity—one that requires an exquisite, dynamically integrated coordination of bone, muscle, and nerve—challenges even the most creative of minds.

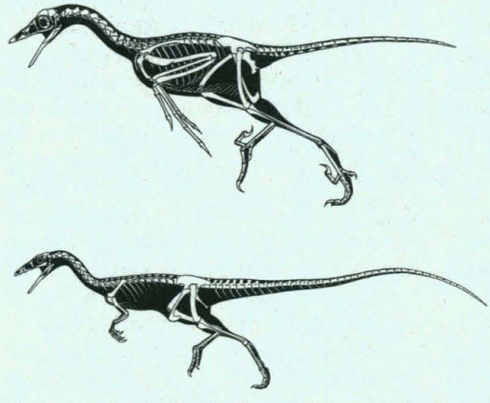
Plausible intermediates that might resemble steps along the evolution of forelimb into wing can be found in living taxa (for example, the gliding membranes of flying lemurs likely resemble an intermediate stage in the evolution of bat wings). But this comparative approach has, unfortunately, been unable to contribute much to understanding the evolution of bird wings. Even in the earliest era of evolutionary thought, Darwin noted: "When we see any structure highly perfected for any particular habit, as the wings of a bird for flight, we should bear in mind that animals displaying early transitional grades of structure will seldom continue to the present day..." (*1*).

In theory, the fossil record could provide the evidence lacking among living forms, but in 1859 Darwin could only hope that paleontology would illuminate the origins of bird flight. Remarkably, only 2 years after the publication of *Origin of Species*, an extraordinary specimen took the scientific community by storm. This creature, christened *Archaeopteryx lithographica*, possessed unambiguously reptilian jaws and tail in combination with indisputably feathered wings. Its discovery began one of the most contentious chapters in the history of vertebrate evolution; over 130 years later, many of the major debates concerning the origin and evolution of birds remain unresolved.

In *Taking Wing*: Archaeopteryx *and the Evolution of Bird Flight*, Pat Shipman tells the tale of the seven skeletons and one feather comprising the known record of *Archaeopteryx*. Through a presentation geared to the non-specialist, she recounts the story of the discoveries of these remarkable fossils. She discusses their roles in early discussions of evolution and in ongoing efforts to understand the origin of birds. Shipman follows the intense, often passionate disagreements concerning the interpretation of these specimens from their discovery to the present, and offers an outsider's perspective to contemporary controversies. In doing so, she sets herself many tasks: to narrate scientific history, to provide a synthesis and critique of the scientific studies of flight and the evolution of birds over the past 20 years, to participate in the analysis of these fossils, and to comment on the culture of modern science. This is an ambitious undertaking, and the book's somewhat uneven success is therefore not surprising.

Taking Wing: *Archaeopteryx* and the Evolution of Bird Flight
by Pat Shipman
Simon and Schuster, New York, 1998. 336 pp. illus. $25 or C$35. ISBN 0-684-81131-6.

Shipman is a wonderful raconteur and is at her best detailing the history of these intriguing fossils. We are transported to 1970, sitting at the shoulder of John Ostrom in The Netherlands' Teyler Museum as he begins to examine an interesting but unexceptional pterosaur fossil. We witness his amazement as he sees a fossil bird that has lain misidentified for over 100 years. Shipman shows us clearly how *Archaeopteryx* figured in the debates over evolutionary theory that occurred in the immediate aftermath of *Origin of Species*. Her skill at describing the histories of these fossils and those who have studied them makes this an informative and enjoyable introduction to the subject for scientists from other disciplines and the general public alike.



GREG PAUL/FROM *TAKING WING*

Controversial similarity. Two of the seven specimens of *Archaeopteryx* were initially misidentified as the small theropod dinosaur *Compsognathus*, although the fossil bird has proportionately longer arms and hands.

In the hope of weaving an integrative and synthetic view of the evolution of flight, Shipman has brought together information from diverse fields. She draws on recent experimental studies of how birds fly, details of fossil preservation and paleoecology, relationships among theropod dinosaurs (possible close relatives of *Archaeopteryx*) and early birds, anatomical evidence relevant to the acquistion of flight, and theories concerning flight origins. In particular, she clearly articulates the divergent views of those who believe that bird flight evolved from arboreal gliders (the "trees down" hypothesis) and those who see birds, and hence flight, evolving from a lineage of fast-running bipedal theropods (the "ground up" hypothesis).

Some important scientific issues do not fare as well. Interpretation of the evidence concerning the evolution of flight requires an explicitly phylogenetic perspective. This is often lacking, despite the author's periodic comments to the contrary. Even in the book's title, the evolution—and by implication, the origin—of bird flight is inextricably linked to *Archaeopteryx*. Much of the book's discussion is premised on the notion that if *Archaeopteryx* is the oldest known fossil bird, then knowing whether it was capable of powered flight will answer the key questions about flight origins. Nowhere in the book is the separation between two distinct and central topics clearly articulated: Given the details of its anatomy, what were the flight capabilities of *Archaeopteryx*? And, what are the genealogical relationships among *Archaeopteryx* and other taxa—particularly theropods and their close relatives, extinct birds, and modern birds?

To assess what *Archaeopteryx* studies can say about the evolution of flight, both of these questions must be answered. As Shipman reports, insights from functional, aerodynamic, and physiological analyses help determine the flight capacity of this extinct animal. But the meaning of such studies is obscured by her tendency to view *Archaeopteryx* as the direct ancestor of all later birds. *Archaeopteryx*'s capacity for powered flight surely informs our understanding of flight origins, but only indirectly. If *Archaeopteryx* could fly, then the origin of bird flight must have occurred before it lived, and without a dense fossil record we cannot know how much earlier. Nor should we expect that paleontology will ultimately uncover ancestral species very close to major evolutionary branching points; vagaries of preservation make the likelihood of this vanishingly small. The text, however, often reads as if

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Archaeopteryx is the "missing link," poised to reveal how birds evolved. As a result, Shipman misses an opportunity to present the view that researchers seek to uncover the transformation and diversification of lineages through a long interval of time during which many features of modern birds appeared sequentially.

For similar reasons, although Shipman devotes many pages to discussing the flora of *Archaeopteryx*'s environment, the presence or absence of trees at the fossil site cannot distinguish between the trees down and ground up theories of the evolution of bird flight. *Archaeopteryx* is itself a member of a lineage that has evolved since branching away from the common ancestor it shared with later birds. This is not to say that we learn little about early flight from analysis of *Archaeopteryx*, but Shipman would serve her general readers well by more clearly distinguishing what can and what cannot be learned from these fossils.

Moreover, Shipman's original scientific contributions seem somewhat out of place in this book, which primarily concerns the history and critical review of a complex and often contradictory literature. By entering the discussion as a scientific contributor, Shipman tries to simultaneously adopt the perspectives of impartial outsider and of active participant, a difficult position at best. Her analyses are quite limited in scope. She compares the positions of *Archaeopteryx*, shorebirds, passeriforms, and ducks on plots of wing shape versus body mass. She also compares the ratio of limb to body length in *Archaeopteryx* with that of insect models previously analyzed to assess the relative importance of thermoregulatory and aerodynamic functions. This latter effort is particularly problematic. Even large flying insects such as dragonflies are far smaller—often two to three orders of magnitude smaller—than a 200- to 250-gram *Archaeopteryx*, and this size difference has a profound effect on both thermoregulation and locomotion. As a consequence, results of analyses of insect wings cannot be applied to an animal the size of *Archaeopteryx* without appropriate scaling.

The challenges confronted by the kind of synthesis required in a book like *Taking Wing* have also been multiplied by circumstance: this book has come out in the midst of a truly remarkable time in the study of bird origins and evolution. New fossil taxa closely related to *Archaeopteryx* and its nearest relatives are being uncovered at an unprecedented rate, and the evidence for furculae and feathers in unquestionably dinosaurian taxa grows continually stronger (*2*). Hence, parts of this book are already outdated, as Shipman notes in the concluding chapter. On the other hand, general interest in these topics is certainly increasing as we learn more about *Archaeopteryx*'s extinct relatives. Shipman's discussion of these important and enigmatic fossils and their possible implications is, perhaps, all the more timely, and can serve as a starting point for readers unfamiliar with the territory.

In the end, this is a book about both the history of the *Archaeopteryx* fossils and complex and compelling issues in evolutionary biology. Although it has mixed success in analyzing the controversies over the origins of flight, it is a pleasure to read for its vivid chronicle of the inquiries of paleontologists and comparative biologists.

References

1. C. Darwin, *On the Origin of Species* (Murray, London, 1859), p. 182.
2. Q. Ji, P. J. Currie, M. A. Norell, S. A. Ji, *Nature* **393**, 753 (1998).

BOOKS: ECOLOGY

Mapping Natural Communities and Ecosystems

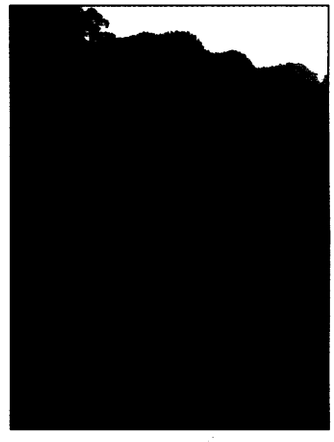
A Classification of North American Biotic Communities
by David E. Brown, Frank Reichenbacher, and Susan E. Franson

University of Utah Press, Salt Lake City, 1998. 152 pp. Paper, $19.95. ISBN 0-87480-562-7. With 1:10,000,000 map, $34.95. ISBN 0-8748-0-568-6.

Ecoregions
The Ecosystem Geography of the Oceans and Continents
by Robert G. Bailey

Springer, New York, 1998. 186 pp. $79.95. ISBN 0-387-98305-8. Paper, $39.95. ISBN 0-387-98311-2.

Madrean Evergreen Woodland (on the west slopes of the Sierra Madre Occidental of Durango) and Rocky Mountain Subalpine Grasslands (in the White Mountains of Arizona) are two of the regional plant formations exquisitely illustrated in 118 black and white plates in Brown *et al.*'s *Classification*. The authors have used previous analyses and modified the existing terminology of ecologists and biogeographers to construct a new hierarchical classification system for biotic communities from the Arctic to Central America. They offer their system as a step toward a universal standard for biotic inventory, habitat assessment, and the identification of natural areas. It incorporates the limiting effects of moisture and temperature minima on the structure and composition of vegetation, and its validity can be tested through statistical analysis of climate data and the distributions of plants and animals. In *Ecoregions*, Bailey takes a more generalized approach to mapping the world's ecosystems in which he stresses the importance of climate. He finds that latitude, relative continental or oceanic position, and altitude determine the type of regional ecosystem at a particular location, and that the patterns of sites within regions also recur predictably.



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–SHERMAN SUTER