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Preface

Vertebrate morphology stands accused of failing to contribute meaningfully to the neo-Darwinian evolutionary synthesis. Although I strongly doubt this (see Chapter 1), I nonetheless take it as a challenge for the future. Our evolutionary theory is at a cusp—the power and efficacy of reductionism are undeniable, but equally so is its failure to deal effectively with intrinsic, organismal attributes. Despite leaps and bounds in our understanding of genetic- and population-level evolutionary phenomena, we remain almost embarrassingly ignorant about the fundaments of *phenotypic* evolution. Answers to the most basic questions are beyond our grasp: Why do some lineages evolve rapidly while others remain static? How do complex systems full of interacting characters evolve? And once evolved, how can they change? Our approaches to these questions are often simplistic and too facile. We point to "phylogenetic constraint," for example, as if it *explains* the failure of a lineage to evolve in some expected way when, in fact, it does little more than describe our ignorance. What is the *mechanistic basis* of phylogenetic constraint? Is it all just genetic background, or are there *phenotypic* processes that interfere with diversification and adaptive evolution or that facilitate it? Organisms are multihierarchical, complex systems, and as in other such systems, each level expresses emergent properties that are unpredictable, even unknowable, from the vantage point of other levels. If we want to understand the principles governing the evolution of phenotypes, it is logical, indeed, *necessary* to study the phenotype directly. Who better to do this than morphologists? The challenge to vertebrate morphology in the next century is therefore twofold: to develop the empirical database and conceptual tools needed to create a phenotype-based evolutionary theory, and to forge a new evolutionary synthesis by integrating this theory with the gene-based, neo-Darwinian paradigm.

This book addresses the first of these challenges. It examines in depth and breadth the myriad solutions to the essential problem of feeding in one clade of animals. It summarizes and synthesizes for the first time in 15 years our burgeoning knowledge of tetrapod feeding systems and how they have evolved. It explores the "variations on a theme" in this system and in so doing provides grist for evolutionary theorists. However, its proximate goals are more modest. The book is intended to instruct novice morphologists and others interested in animal form and function. It is both an introduction to the field and a presentation of the "state of the art." It is aimed at advanced undergraduate and gradutate students, as well as experts in the field who wish to delve outside their taxonomic bounds. It provides an accessible entrée into an exploding literature and showcases our impressive knowledge—but it highlights also our great ignorance. As Rubega points out in Chapter 12, there are many dissertations on tetrapod feeding left to be written. The greatest possible outcome I can imagine for this book is that it will stimulate and provoke the next generation of morphologists to fill in the gaps and shoot down the dogma.

In an effort to promote its utility to students, the book begins with two introductory chapters that establish the conceptual, historical, and factual contexts within which the empirical chapters can be interpreted. The empirical chapters provide a more-or-less phylogenetic survey of tetrapod vertebrate feeding systems. Although a phylogenetic approach is emphasized throughout, there are some cases in which I judged other criteria to be more useful in organizing current knowledge. Hence, some chapters are not limited to a monophyletic taxon, but are based on functional types (e.g., "marine mammals," Chapter 16), dietary types (e.g., "myrmecophagous mammals," Chapter 15), or the medium in which feeding occurs (e.g., "aquatic

feeding in salamanders," Chapter 3). Each chapter is authored by an expert or experts on the group, including both veteran and younger workers. I am very pleased to be able to include chapters on little-known groups, such as caecilian amphibians (Chapter 6), crocodilians (Chapter 10), paleognathous birds (Chapter 11), myrmecophagous mammals (Chapter 15), and marine mammals (Chapter 16). However, my goal of complete taxonomic coverage of all tetrapods was not quite achieved. Owing to many factors, a chapter on turtle feeding could not be completed. To mitigate this taxonomic breach, I have prepared a brief bibliography of turtle feeding to serve as an entrée into the literature (Chapter 7).

This book has a long and tortured history—even longer and more tortured than most edited works! It was inspired by a symposium on the ecology and evolution of feeding systems in lower vertebrates presented at the annual meeting of the American Society of Ichthyologists and Herpetologists in Austin, Texas, in 1993, to which I was a contributor. The symposium was organized by Drs. Peter Wainwright and Kiisa Nishikawa. Dr. Charles Crumly, a systematic herpetologist and editor at Academic Press, was in attendance. I had been toying with the idea of editing a book in the area of feeding, so when Chuck approached me with the idea I was thrilled to take it on. By the end of the meeting several authors were already lined up. That was the easy part! The project ebbed and flowed over the years as the author roster grew and shifted. Consequently, there is a large span of time over which chapters were completed and submitted. Although I have tried to update the literature where necessary, some chapters are inevitably not as current as others. Thus, authors who worked most dilligently to complete their manuscripts in time for early deadlines should not be held to blame for editorial shortcomings.

There are many people to thank for their contributions, direct and indirect, to this project. I must begin by expressing my deep gratitude for the inspiration of my teachers, Warren F. Walker, Jr., James R. Stewart, and Marvalee H. Wake, to whom this book is dedicated. Warren Walker first taught me vertebrate biology and comparative anatomy as a junior at Oberlin College and it was his deep knowledge and masterful teaching that led me to embark on a career in vertebrate morphology. I remain in awe of his knowledge of comparative anatomy; his course serves as the benchmark from which I measure my own feeble attempts. Warren had the poor taste to take a sabbatical leave my senior year at Oberlin, but this sad event (for me) had a positive side—James Stewart was hired to replace him that year. Jim came to Oberlin fresh out of Berkeley with a new set of experiences and ideas. I watched firsthand as he put together his own terrific course on comparative anatomy and I was given the opportunity to assist teaching in the lab. Jim supervised my senior thesis research (on lizard feeding!) and became a friend as well as a mentor. His calm, philosophical, and scholarly approach to both life and science deeply impressed me and continues to inspire me now. At Oberlin, Jim regaled me with stories of Berkeley, the Museum of Vertebrate Zoology, and the "Herp Lab," so after a short hiatus as a zookeeper at the Bronx Zoo, I was thrilled to be accepted into Marvalee Wake's lab at Berkeley for graduate study. Marvalee, to me, is the quintessential vertebrate morphologist—painstaking, detailed, thorough, and a scholar of the highest order. She was also the perfect advisor. She knew unerringly when to leave me on my own and when to push me. She supported my work *and* my psyche. Most important, she set a high standard in the lab and maintained it by example. The depth and breadth of her work on caecilian amphibians are a model of achievement and a personal source of inspiration. I have depended on Marvalee's wisdom for the last 20 years and still turn to her when I am in need of counsel. I am profoundly grateful to each of these people who have contributed so critically to my professional, intellectual, and personal development—often in ways they cannot imagine. Whatever strengths my work has shown since are owed to their mentorship.

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Kurt Schwenk
Storrs, Connecticut
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