FASTOVSKY • WEISHAMPEL

DINOSAURS

A Concise Natural History

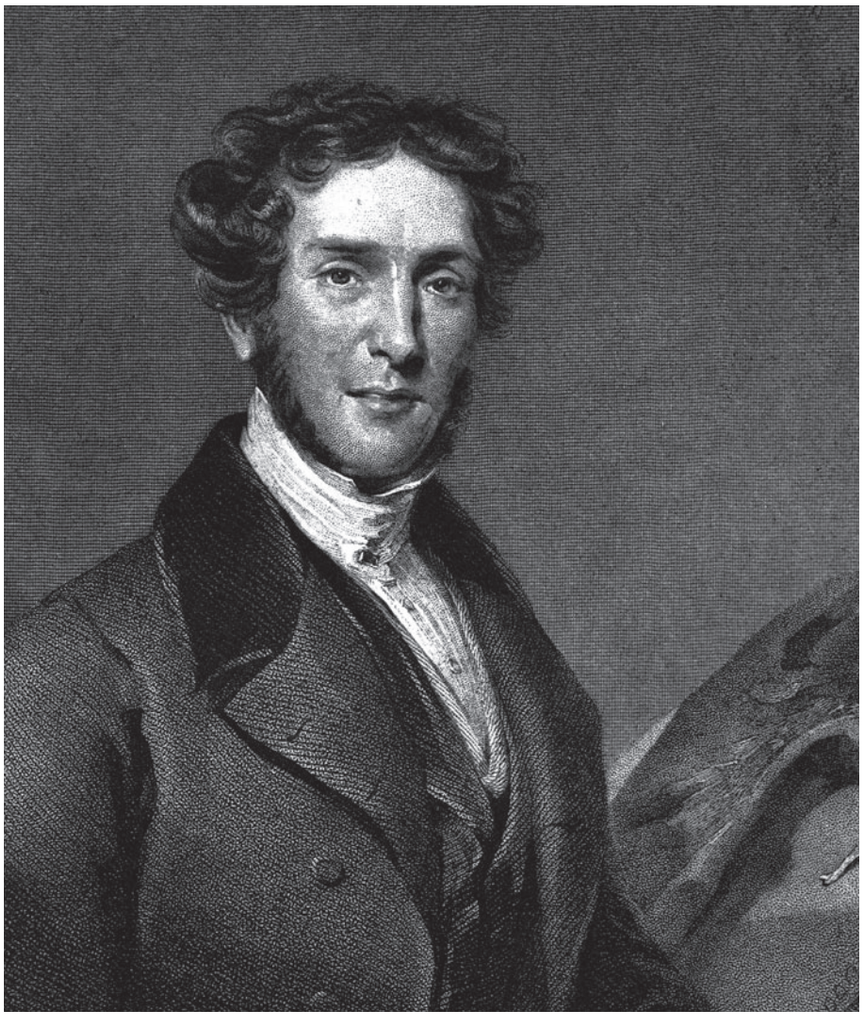
SECOND EDITION

Updated with the material that instructors want, *Dinosaurs* continues to make science exciting and understandable to non-science majors through its narrative of scientific concepts rather than endless facts. Now with an expanded section on the evolution of the dinosaurs, and new photographs to help students engage with geology, natural history, and evolution. The authors ground the text in the language of modern evolutionary biology, phylogenetic systematics, and teach students to examine the paleontology of dinosaurs exactly as the professionals in the field do using these methods to reconstruct dinosaur relationships. Beautifully illustrated, lively and engaging, this edition continues to encourage students to ask questions and assess data critically, enabling them to think like scientists.

DAVID FASTOVSKY is Professor of Geosciences at the University of Rhode Island. His interest in dinosaurs started as a child when he read about a 1920s paleontologist's adventures in the Gobi Desert. Dinosaurs won out years later when he had the tough decision of choosing between a career in music (he takes his viola on his many field trips) or paleontology, and he has carried out fieldwork in far-flung parts of the world. He's known as a dynamic teacher as well as a respected researcher with a focus on the environments in which dinosaurs roamed.

DAVID B. WEISHAMPEL is Professor in the Center for Functional Anatomy and Evolution at The Johns Hopkins University. His research focuses on dinosaur evolution and how dinosaurs function and he is particularly interested in herbivorous dinosaurs and the dinosaur record of Europe. Among his many publications he is senior editor of *The Dinosauria*, and has contributed to a number of popular publications including acting as consultant to Michael Crichton in the writing of *The Lost World*, the inspiration for Steven Spielberg's film *Jurassic Park*.

JOHN SIBBICK has been creating illustrations of extinct life-forms and their environments for over 20 years, producing numerous books on dinosaurs, as well as pterosaurs, and general books on prehistoric life. His work has appeared in scientific magazines such as the *National Geographic*, and in television documentaries and museums world-wide.



Frontispiece Gideon Mantell (1790–1852), the "father" of modern dinosaur paleontology.

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DAVID E. FASTOVSKY

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with illustrations by JOHN SIBBICK

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PREFACE TO SECOND EDITION

Why a second edition? After all, the goals of this edition are the same as those of the first: to give first- or second-year college students insights into the fantastic, long-extinct world of non-bird dinosaurs, while concomitantly using dinosaurs as an attractive vehicle to explore aspects of important themes that have clear relevance for our very-much extant world, themes such as natural history, evolutionary biology, Earth history, and the logic of scientific inference. Our point, then as now, is that knowing who dinosaurs are is really all about knowing who we are: but the latest inheritors of *c.* 3.8 billion years of uninterrupted life on Earth.

So why write a second edition? Our view is that second editions are needed when the field has changed sufficiently such that the first edition no longer properly treats the subject; second editions ought to be written when, having experience with the first edition, you identify places where the treatment can be refined and improved. These, then, are the twin motivations for this new edition.

In this new edition, we have attempted to retain the light tone of the original; dinosaurs are marvelous creatures and nobody should be crushed by the language that describes them. That said, we remain committed to presenting them in the way that professionals think about them: therefore, a rigorous phylogenetic context is retained.

In the time between the first and this edition, time and resources were devoted to learning users' responses to the first edition. The second edition, therefore, benefits from that effort: errors have been corrected and, in response to requests for a more detailed treatment of the origins of Dinosauria, an entirely new chapter (15) was written. The chapter is particularly timely, since in the years since the first edition, our understanding of transition from proto-dinosaurs to dinosaurs has greatly increased. Likewise, the chapter on dinosaur endothermy (12) has been much updated and completely rewritten. A brief section on plate tectonics has also been included in response to reviewers' suggestions; and the difference between diagnosis and definition in phylogenetic systematics is presented.

The new edition is completely updated. Since the last edition was published, important discoveries have been made about feathers: who has them (*T. rex*, for one!), what colors and patterns they show, and what they tell us about behavior and phylogeny. The power of CT scans and computer-generated reconstructions to elucidate dinosaur morphology is obvious now, and so we have included fully labeled CT scans, emphasizing soft anatomy such as brains and sinuses, to highlight the power of this important work. Likewise, new techniques in geochemistry – particularly stable isotopes – have become important tools for understanding dinosaur food preferences, and the new edition reflects these insights.

All the chapters on individual dinosaur groups have updates and/or added information. Thus along with feathers in theropods, we offer new details on, for example, the power of an ankylosaur club, nesting habits of *Protoceratops*, butting in pachycephalosaurs, breathing in sauropods, computerized muscle mass/weight estimates for dinosaurs generally, dinosaur diseases, and the evolution of large size in tyrannosaurids. Where appropriate, updated citations are also included. As was the case in the first edition, all of these changes are accompanied by illustrations – many from the professional literature and some specially commissioned for this book.

Fundamentally, the book is structured in the same way as the first edition. For this reason, we reprint the Preface to the First Edition in the pages that follow, since the suggestions for both students and faculty are still, we hope, useful. Finally, we remind our readers that, as in the first edition, any errors that appear in this work are entirely Dave's fault.

PREFACE TO FIRST EDITION: WHY A NATURAL HISTORY OF DINOSAURS?

Dinosaurs: A Concise Natural History has been written to introduce you to dinosaurs, amazing creatures that lived millions of years before there were humans. Along with acquainting you with these magnificent beasts, reading this book will give you insights into natural history, evolution, and the ways that scientists study Earth history.

What were dinosaurs like? Did they travel in herds? What were the horns for? Did the mothers take care of their babies? Was *T. rex* really the most fearsome carnivore of all time? Were they covered with feathers? How fast could brontosaurus run? Why did dinosaurs get so big? Along with getting answers to these and many other questions, you'll also meet legendary and charismatic dinosaur hunters (including the models for Indiana Jones and *Jurassic Park*'s Dr. Alan Grant) whose expeditions have helped to reveal the dinosaurs' stories from fossils and other fragmental clues left behind in the rocks. *Dinosaurs* will help you think like a scientist, while your knowledge of dinosaurs, natural history, and science grows with each chapter you read.

The book is written by authors who are active dinosaur researchers, with between them more than 50 years of experience teaching. It is illustrated by John Sibbick, one of the world's most famous dinosaur illustrators.

DAVID FASTOVSKY is Professor and Chair of Geosciences at the University of Rhode Island. His interest in dinosaurs started as a child when he read about Roy Chapman Andrews in the Gobi Desert (a story that, naturally enough, graces the pages of the book you are holding). Dinosaurs won out years later when he chose paleontology over a career in music. Fastovsky has carried out fieldwork in far-flung parts of the world, including Argentina, Mexico, the western USA and Canada, and Mongolia. He is known as a dynamic teacher as well as a respected researcher with a focus on the extinction of the dinosaurs, as well as the environments in which they roamed. He has made several television documentary appearances, and was a recipient of the Distinguished Service Award by the Geological Society of America in 2006.

DAVID B. WEISHAMPEL is Professor in the Center for Functional Anatomy and Evolution at The Johns Hopkins University. Recipient of three teaching awards, Weishampel teaches human anatomy, evolutionary biology, cladistics, and, of course, a course on dinosaurs. His research focuses on dinosaur evolution and how dinosaurs function, and he is particularly interested in herbivorous dinosaurs and the dinosaur record of eastern Europe and Mongolia. He is the senior editor of the immensely well-received *The Dinosauria*, and has written or co-written six books and very many scholarly articles. Weishampel has contributed to a number of popular publications as well, including acting as consultant to Michael Crichton in the writing of *The Lost World*, the inspiration for Steven Spielberg's film *Jurassic Park*. In 2011, a special symposium on duck-billed dinosaurs was convened by the Royal Ontario and Royal Tyrrell Museums, Canada, to honor Dr Weishampel's contributions in dinosaur paleontology.

JOHN SIBBICK has over 30 years of illustration experience working on subjects ranging from mythology to natural history and is probably best known for his depictions of prehistoric scenes and dinosaurs. In the first stage of any commission he takes the fossil evidence and consults with specialists in their field and works out a number of sketches to build up an overall picture of structure, surface detail, and behavior. From his base in England he has provided images for books, popular magazines such as the *National Geographic*, and television documentaries, as well as museum exhibits and one-man shows of original artwork. For this book he has provided 194 pieces of original art.

Dinosaurs: A Concise Natural History is a new textbook that uses a particularly attractive vehicle – dinosaurs – to introduce students in the early part of their college careers to the logic of scientific inquiry, and to concepts in natural history and evolutionary biology. The perspective and methods introduced through dinosaurs have a relevance that extends far beyond the dinosaurs, engendering in students scientific logic and critical thinking. The text is a fresh, completely rewritten version of our popular *The Evolution and Extinction of the Dinosaurs* (2005), with enhanced accessibility to students and added features to facilitate its utility for teaching.

A unique conceptual approach

Dino factoids – names, dates, places, and features – are available in zillions of books and websites. We depart from a "Who? What? Where?" approach to dinosaurs, instead building a broad understanding of the natural sciences through the power of competing scientific hypotheses.

Unique among dinosaur textbooks, *Dinosaurs* is rooted in phylogenetic systematics. This follows current practice in evolutionary biology, and allows students to understand dinosaurs as professional paleontologists do. The cladograms used in this book have been uniquely drawn in a way that highlights the hierarchical relationships they depict, ensuring that both the methods and conclusions of phylogenetic systematics remain accessible.

Long experience shows that students come to dinosaur courses with many preconceptions about the natural world; *Dinosaurs* asks them to think in new and revolutionary ways. For example, one of the great advances to come out of the past 20 years of dinosaur research is the recognition that *living birds are dinosaurs*. This somewhat startling conclusion leads to a couple of other counter-intuitive conclusions:

1 Birds are reptiles.
2 Dinosaurs didn't go extinct.

In this and in many other ways, our book will challenge students to reconsider their ideas about science and about their world.

Part I introduces the fundamental intellectual tools of the trade. Chapters 1 and 2 treat geology, the geological time scale, fossils, collecting, and what happens after the bones leave the field. The third chapter, a carefully crafted introduction to the logic of phylogenetic systematics, uses familiar and common examples to acquaint students with the method. Chapter 4 takes students from basal Vertebrata to the two great groups of dinosaurs Ornithischia and Saurischia.

Parts II and III cover, respectively, Ornithischia and Saurischia. The chapters within Parts II and III cover the major groups within Dinosauria, treating them in terms of phylogeny and evolution, behavior, and lifestyle. Ornithischia comes before Saurischia to reinforce the fundamental point that, on the cladogram, the ordering of Ornithsichia and Saurischia within a monophyletic Dinosauria makes no difference.

The phylogenetically most complex of dinosaur groups, Theropoda, is treated last in Part III, when students are best prepared to understand it. Three chapters cover the group: one for non-avian theropods, one on the evolution of birds from non-avian theropods, and one on the Mesozoic evolution of birds, since it was during the Mesozoic that birds acquired their modern form.

Part IV covers the aspects of the paleobiology of Dinosauria, from their metabolism, to the great rhythms that drove their evolution, to their extinction. A special chapter is devoted to the history of dinosaur paleontology. Although commonly introduced at the beginning of dinosaur books as a litany of names, dates, and discoveries, our history chapter – a history of *ideas* – is placed toward the end, so the thinking that currently drives the field can be understood in context. Yet we would cheat our readers if we left out accounts of the dinosaur hunters, whose colorful personalities and legendary exploits make up the lore of dinosaur paleontology; so we've included many of their stories as well.

Features

Dinosaurs is designed to help instructors to teach and to help students learn:

- The book is richly illustrated with many new, especially commissioned, art by John Sibbick, one of the world's foremost illustrators of dinosaurs. These images are exciting for the student to learn from and they effectively highlight and reinforce the concepts in the text. Many pages are also graced by research photographs, generously contributed by professional paleontologists.
- The chapters are arranged so that they present the material in order of increasing complexity and sophistication, building the confidence of the student early on, and extending the sophistication of their learning gradually through the book.
- The tone of the text is light, lively, and readable, engaging the student in the science, and dispelling the apprehension many students experience when they pick up a science textbook.
- "Objectives" at the beginning of each chapter help students to grasp chapter goals.
- Boxes scattered throughout the book present a range of ancillary topics, from dinosaur poetry, to extinction cartoons, to how bird lungs work, to colorful accounts of unconventional, outlandish, and extraordinary people, places, and stories.
- A comprehensive series of "Topic Questions," to be used as study guides, are located at the end of each chapter. The questions probe successively deeper levels of understanding, and students who can answer all of the "Topic Questions" will have a good grasp of the material. Variants of these questions can serve as excellent templates for examination questions.
- A Glossary ties definitions of key terms into the page numbers where the term is used.
- There are two indices: an Index of subjects and an Index of genera that includes English translations of all dinosaur names.

- Appendices are included in certain chapters to introduce material that students may need in order to understand chapter concepts, such as the chemistry necessary to understand radioactive decay, and the basic principles of evolution by natural selection.

Online resources to help you deliver your dinosaur course include:

- Electronic files of the figures and images within the book.
- Lecture slides in PowerPoint with text and figures to help you to structure your course.
- Solutions to the questions in the text for instructors.

To **Lesley**, **Naomi**, and **Marieke**,

my family.

To poor **Robert**, because...

To **Sarah** and **Amy**.

Thanks for continuing to remind your dad

that there are things other than dinosaurs!