

# Dinosaurs

## A Concise Natural History

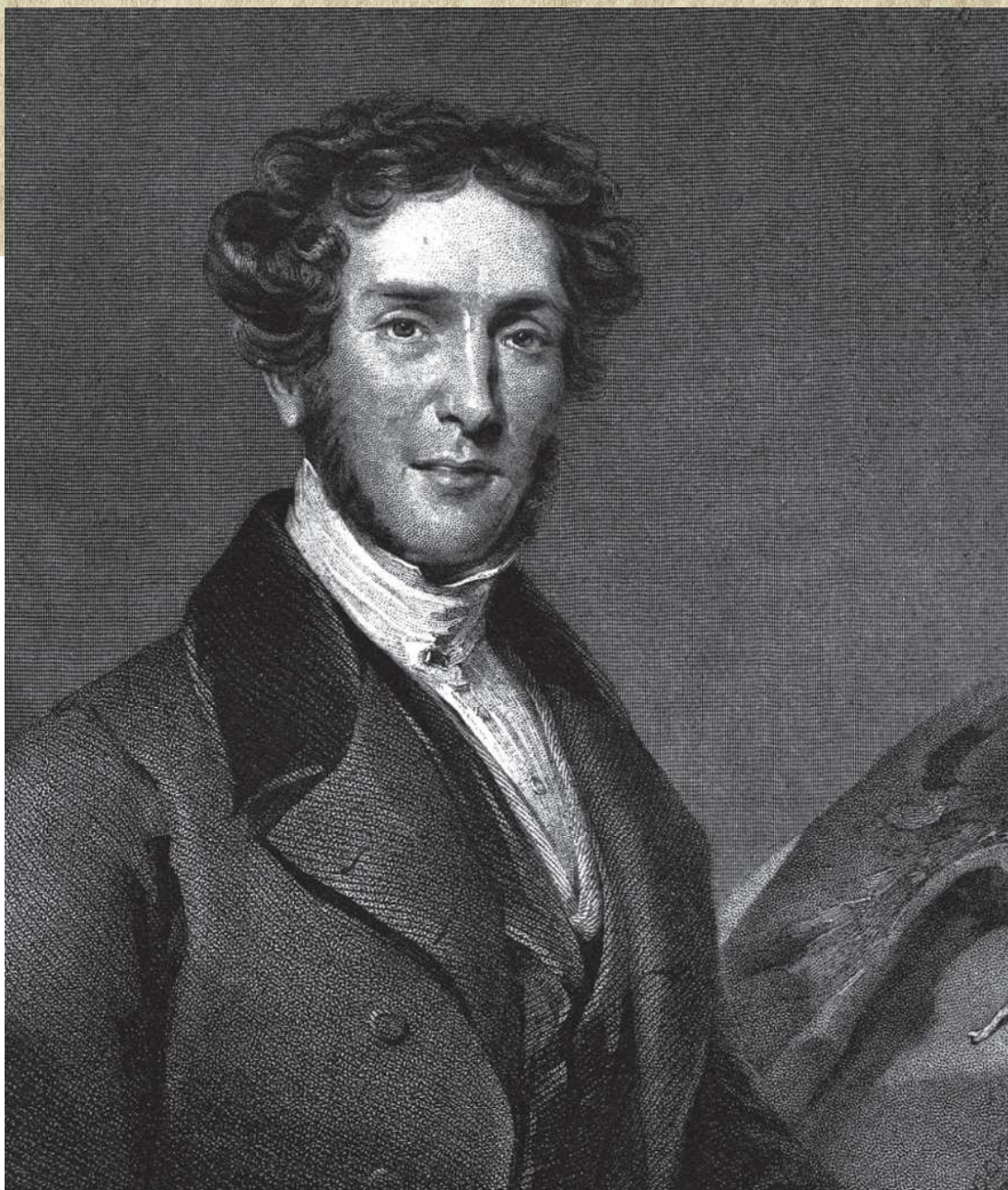
THIRD EDITION

The ideal textbook for non-science majors, this lively and engaging introduction encourages students to ask questions, assess data critically and think like a scientist. Building on the success of the previous editions, *Dinosaurs* has been reorganized and extensively rewritten in response to instructor and student feedback. It continues to make science accessible and relevant through its clear explanations and extensive illustrations. Updated to reflect recent fossil discoveries and to include new taxa, the text guides students through the dinosaur groups, emphasizing scientific concepts rather than presenting endless facts. It is grounded in the common language of modern evolutionary biology – phylogenetic systematics – so that students examine dinosaurs as professional paleontologists do. The key emerging theme of feathered dinosaurs, and the many implications of feathers, have been integrated throughout the book, highlighted by the inclusion of stunning new photographs in this beautifully illustrated text, now in full color throughout.

**DAVID FASTOVSKY** is Professor and Chair of the Department of Geosciences at the University of Rhode Island. His interest in dinosaurs started as a child when he read about a paleontologist's adventures in the Gobi Desert early in the twentieth century. 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 all over the world. He's known as a dynamic teacher as well as a respected researcher on the environments in which dinosaurs roamed, as well as their extinction.

**DAVID B. WEISHAMPEL** is Professor in the Center for Functional Anatomy and Evolution at The Johns Hopkins University School of Medicine. His research focuses on dinosaur evolution and how dinosaurs functioned, 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*. He was recently honored in an International Symposium on duck-billed dinosaurs, dedicated to him and his research.

**JOHN SIBBICK** has been creating illustrations of extinct life forms and their environments for well over 30 years, producing numerous books on dinosaurs, as well as pterosaurs and general books on prehistoric life. His work has appeared in scientific magazines, television documentaries, and museums, plus a set of stamps depicting dinosaurs and other prehistoric reptiles for the United Kingdom's Royal Mail.



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



# Dinosaurs

## A Concise Natural History

THIRD EDITION

**DAVID E. FASTOVSKY**

*University of Rhode Island*

**DAVID B. WEISHAMPEL**

*The Johns Hopkins University*

With illustrations by **JOHN SIBBICK**



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## PREFACE TO THE THIRD EDITION

Non-bird dinosaurs (“dinosaurs”) are very much in the news these days: dinosaurs had feathers; dinosaurs were warm-blooded; dinosaurs were snuffed out in mere seconds; we’ve just discovered the largest dinosaur ever; we’ve just discovered the smallest dinosaur ever; here is *Jurassic World*, there is *The Good Dinosaur*. . . it’s a media blizzard. And why not? Ideas about dinosaurs have moved conceptually far beyond the twentieth century: a few weirdo reptiles that lived on this planet, but were too stupid to survive. Today dinosaurs are recognized as centerpieces of vertebrate evolution; they’re just a whole lot more *interesting* than they used to be!

On the one hand, our book is written to help sort out who’s who and what’s what in this barrage of things dinosaurian; on the other hand, and more significantly, our book is written as an introduction to how scientists in general, and natural historians in particular, think about scientific problems.

So what has changed in this third edition? The answer is, a lot; most of it driven by the many exciting discoveries and ideas that have shaped an understanding of dinosaurs since the second edition was published. Even the very number of dinosaurs known has almost trebled just since we began our careers in paleontology, and with things moving forward so quickly, we must keep up.

### This new edition:

- contains the newest discoveries as well as new scientific hypotheses; these include feathers and feather *colors* in ornithodirans, new insights into the origin of dinosaurs, lots of new dinosaurian faces, many new (and updated) cladograms, and a gorgeous bestiary of feathered Chinese dinosaurs that has rewritten the origin of birds;
- has over 50 new illustrations, including many photographs shot especially for this book;
- includes newly modified versions of existing illustrations, for increased clarity;
- is for the first time printed in full color, to show the photographs and hand-drawn artwork to best advantage;
- is heavily rewritten, reorganized, and expanded to encompass improved treatments of dinosaur warm-bloodedness and the significance of feathers, a revised look at dinosaur–plant co-evolution, enlarged discussion of the insights gotten through geochemistry and CT-scanning, and an introduction to some stand-out members of the younger generation of paleontologists. In fact, every chapter has been thoroughly revised and, in some cases, completely rewritten; and
- is completely reorganized, reflecting the newest ideas about the origin and subsequent evolution of dinosaurs.

For all that, however, the book retains its essential qualities:

- it is unique among dinosaur textbooks designed for non-majors, because it introduces and exclusively uses the language and methods of professional paleontologists;

- multiple perspectives and hypotheses are presented; science, of course, doesn't consist of immutable answers;
- the beautiful J. Sibbick illustrations continue to grace its pages; and
- it still contains the same lively style, aimed at clear, understandable explanations of dinosaurs and their world.

To the student:

We've written DCNH to introduce you to dinosaurs, amazing creatures that last lived 66 million years ago! We'd also like to use these magnificent beasts to give you insights into natural history, evolution, and the ways that scientists study Earth history.

There are all kinds of questions you can ask about dinosaurs. Simple examples include: Were they really that stupid? Did they die all at once overnight? What were the horns for? Did the mothers take care of their babies? Was *T. rex* really nasty? Were all dinosaurs covered with feathers? What color were they? Could *Brontosaurus* run? How fast? Along with getting answers to these and many other questions, you'll also meet legendary and charismatic dinosaur hunters, younger and older (including the original models for *Raiders of the Lost Ark*'s Indiana Jones and *Jurassic Park*'s Alan Grant). DCNH will help you think like a scientist, while your knowledge of dinosaurs, natural history, and science grows with each chapter you read.

The authors, D. E. Fastovsky and D. B. Weishampel, are active dinosaur researchers, with a combined experience of almost 80 years of studying dinosaurs in the field and at universities. The book is enriched by the gorgeous original artwork of John Sibbick, one of the world's best and most famous dinosaur illustrators.

**DAVID E. FASTOVSKY** is Professor and Chair of Geosciences at the University of Rhode Island; he has also taught about dinosaurs and Earth history at the University of California (Berkeley), the National Autonomous University of Mexico and at the University of Vienna. His interest in dinosaurs started as a child when he read about Roy Chapman Andrews in the Gobi Desert (whose story you'll find in the pages of the book you are holding). Fastovsky has had many of his own adventures in far-flung parts of the world, including France, Argentina, Mexico, Venezuela, the western USA and Canada, and Mongolia. He is known as a dynamic teacher and 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 from, and is a Fellow of, the Geological Society of America.

**DAVID B. WEISHAMPEL** is Professor in the Center for Functional Anatomy and Evolution at The Johns Hopkins University. Recipient of two 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, not including the DCNH series, four books and a 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 to dinosaur paleontology.

**JOHN SIBBICK** has over 35 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 the United Kingdom, 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 around 250 pieces of original art.

### To the instructor:

*Dinosaurs: A Concise Natural History* is designed to introduce first- and second-year university students, many commonly seeking to fulfill general science requirements, to the logic of scientific inquiry and to concepts in natural history and evolutionary biology. The perspectives and methods introduced through dinosaurs have a relevance that extends far beyond the dinosaurs, engendering in students scientific logic and critical thinking. The approach has been successful, and new discoveries and interpretations now merit this third edition.

In its preparation, Cambridge University Press devoted considerable energy to obtaining extensive feedback from many instructors who had had experience teaching from previous editions. Their thoughtful, detailed, and, in many cases, comprehensive, answers were particularly useful in determining the ways in which this edition could be strengthened as a teaching tool; indeed, we responded, whenever possible, to all suggestions and recommendations. The care that this group of veteran instructors put into their answers has surely enriched our book.

### A unique conceptual approach:

Names, dates, places, and features are available everywhere these days. But litanies of names, dates, and places is not science; the *creative* synthesis of these data is far more important and, fortunately, far more interesting. The goal of this book is to help students achieve that synthesis.

Uniquely among dinosaur textbooks, phylogenetic systematics is immanent in DCNH. This approach, however, follows current practice in evolutionary biology, and allows students to understand dinosaurs as professional paleontologists do. To have had an entire class in dinosaurs, and yet be insensible to the underlying phylogenetic connections among these (and all) organisms strikes us as indefensible; it would be akin to studying biology without evolution. The cladograms used in this book are thus drawn in a way that highlights the evolutionary relationships they depict, ensuring that both the methods and conclusions of phylogenetic systematics remain accessible.

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, phylogenetically, from basal Vertebrata to Dinosauria.

Parts II and III cover, respectively, Saurischia and Ornithischia. The chapters within Parts II and III cover the major groups within Dinosauria, treating them in terms of phylogeny and evolution, behavior, and lifestyle. For the first time in the DCNH series, this edition puts Saurischia ahead of Ornithischia: this organization allows students to move smoothly from basal (non-dinosaur) dinosauromorphs to the earliest dinosaurs, whose affinities are clearly saurischian, although perhaps murky within that group (Chapter 5). Birds (Chapter 8) follow from the theropod chapters (6 and 7), because birds are living saurischians. In this edition, the normally prominent status accorded to the

venerable *Archaeopteryx* has been diminished, since the astounding Liaoning fossil discoveries in the past 20 years have diminished the uniqueness of *Archaeopteryx* as a transition to birds. In recognition of the close relationship between dromaeosaurs and avialans (including birds), we introduce the group Paraves for the first time in this new edition. Ornithischians are treated in Chapters 10–12, culminating in Ornithopoda, a group that, with the new millennium, has been phylogenetically somewhat fraught. By the time students reach this chapter, however, they will be in a position to understand, appreciate, and assimilate some of the uncertainty.

Part IV covers the aspects of the paleobiology of Dinosauria, from their metabolism (Chapter 13), to the great rhythms that drove their evolution (and co-evolution; Chapter 14), to a fully updated exposition on their extinction (Chapter 16). Chapter 15, the penultimate chapter, is devoted to the history of dinosaur paleontology. Although commonly introduced at the beginning of dinosaur books via a scaffolding of names, dates, and discoveries,<sup>1</sup> our history chapter – a history of *ideas* – is placed toward the end, so that the thinking that currently drives the field can be understood in context. We believe that the history of dinosaur paleontology is much more resonant when students already know something about the fossils being hunted and the ideas being developed. Finally, the book ends, like the dinosaurs themselves, with a discussion of the great Cretaceous–Paleogene mass extinction. Here we might say, as so many have, that Earth then entered the Age of Mammals, but, paradoxically, we’ll try to persuade readers that we’re still in the “Age of Dinosaurs”.

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 (Chapter 15). In the first and second editions of DCNH, we transparently introduced our own generation as “Young Turks,” forgetting that, like everybody else, we’ve aged too! The third edition, therefore, introduces its readers to a younger (thirties and forties) generation of paleontologists whose striking accomplishments bode well for their future achievements.

Finally, as in all previous editions, any errors that appear in this work are entirely Dave’s fault.

## Features:

DCNH is designed to help instructors to teach and to help students learn.

- The book is richly illustrated with new, especially commissioned, art by John Sibbick, one of the world’s foremost illustrators of dinosaurs. These images effectively highlight and reinforce the concepts in the text. Many pages are also graced by photographs, generously contributed by professional paleontologists or taken especially for this edition.
- 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

<sup>1</sup> Indeed, many of our respondents requested this.



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, plate tectonics, and the basic principles of evolution by natural selection (Darwinian evolution).

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; and
- solutions to the questions in the text for instructors.

All resources are available to instructors at [www.cambridge.org/dinosaurs3](http://www.cambridge.org/dinosaurs3).

# DEDICATION

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!