ical functions. Some chapters on network properties and network science approaches could be further elucidated for analyzing additional network types such as gene regulatory networks and protein interaction networks. After a discussion of mathematics, Part III goes through the analysis to identify the biological phenotypes of reconstructed networks from the mathematical models. Although various models can be used, biological systems have their own uniqueness and constraints. One example is the dual causality in biology between genotypic and phenotypic spaces, highlighted in Chapter 15, which does not exist in physical systems. Readers will understand why and how biological constraints should be considered to model the reconstructed networks, especially for genome-scale models. Perhaps the book could devote additional context to other types of biological constraints such as how biological data size, processing, and management affect modeling.

The volume also reviews the experimental validations and applications of reconstructed networks in Part IV. The validated networks can further help design genome-scale experiments such as gene knockouts to systematically identify biological functions. It is appreciated that the author included Part V, which discusses teaching biological networks and models as well as designing the related curriculums. It could be even more useful if the volume included a list of widely used bioinformatics software for reconstructing and analyzing networks. That said, I recommend this textbook, and hope that it will educate a broad audience and move computational systems biology forward.

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UNDERSTANDING STATISTICAL ERROR: A PRIMER FOR BIOLOGISTS.

By Marek Gierliński. Hoboken (New Jersey): Wiley Blackwell. $59.95 (paper). viii + 213 p.; ill.; index. ISBN: 978-1-119-10691-3. 2016.

Establishing the validity of results is challenging—data are messy and filled with uncertainty. Error analysis tries to make sense of this, and although it specifically aims to distinguish, estimate, and present uncertainty in data and experimental outcomes, biologists get too little exposure to its many insights. Examples include using confidence intervals over *p*-values to improve inferences and assessments, discerning systematic and random error to promote better experimental design, and best practices for reporting and plotting results.

Gierliński's *Understanding Statistical Error: A Primer for Biologists* successfully introduces and exposes many of these practical insights. It also achieves this without delving too deeply into how many of the core principles of error analysis are mathematically accomplished. This makes the book very accessible to both students and researchers, and will certainly be useful to biologists interested in improving how they interpret and report uncertainty of results.

In nine brisk chapters, Gierliński covers a broad range of topics. The first outlines the author's rationale for why we need to understand error and how error bars are crucial to this effort. This sets the groundwork for the second chapter on how we typically model error using probability distributions. This chapter carefully brings together many topics that can be overwhelming (e.g., random variables, probability distribution functions, and various types of distributions such as normal and Poisson), and succeeds in acquainting readers with their underpinnings all while avoiding the mechanics of their mathematics.

The third chapter covers the various origins of errors (i.e., systematic, random, measurement, sampling error) and these provide the foundation for Chapters 4 and 5 on how errors are statistically estimated (e.g., standard deviation, standard error, bootstrapping) and why confidence intervals have emerged as the preferred way to present uncertainty in study outcomes. Chapter 5 also convincingly covers the negative effects of sampling error and the risky inferences that emerge from studies lacking replication.

Chapter 6 offers best practices on how to present errors visually in plots, as well as reporting standards for describing errors in text. For example, Gierliński makes a great case for why bar plots are limited and overused, and why box plots should become the de facto way to convey the shape of data. However, a point missing from this chapter that I feel obligated to supplement is the need to report sample sizes along with errors—which are more often absent than you would expect from publications. This is perhaps the quickest way to convey sensitivity to sampling error (as detailed in Chapter 5), and would also help improve poor reporting standards that plague research synthesis efforts—which require detailed readings of plots and text to extract the outcomes and uncertainty of published studies.

Chapter 7 on error propagation is the only section of the book that dives into the derivation of approaches, and the following chapter is notable due to its lucid introduction of error in regression. In particular, the description for why confidence intervals of regression lines are bowtie shaped is just one of the many practical insights found throughout the volume.

Finally, Chapter 9 aims to showcase all of the themes covered with fully worked examples. This is perhaps the most difficult chapter to follow, given that many examples are quickly and simultaneously covered. Further, since the examples are hypothetical, I found this chapter the least engaging. I also feel that this was a lost opportunity conclude the book with a strong case for the practically and strength of error analysis; this could be achieved with analyses of real data, rooted in a meaningful biological context, and have published sources that could be referenced and studied in more detail.

Perhaps the earliest and only exposure to error analysis for biologists was from an introductory physics laboratory on calculating the uncertainty of answers obtained from calculations (e.g., error propagation). Clearly error analysis has more to offer, and Gierliński's book successfully addresses this deficit, often with great humor. Finally, let me emphasize that good science requires transparent, repeatable, and robust results, and that conveying error is absolutely central to these endeavors. This volume highlights and promotes these high standards and practices, and should serve as an important starting point for biologists, data scientists, or anyone interested in effectively assessing and presenting uncertainty in data.

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PALEONTOLOGY

Dinosaurs: How They Lived and Evolved.

By Darren Naish and Paul Barrett. Washington (DC): Smithsonian Books. $29.95. 224 p.; ill.; index. ISBN: 978-1-58834-582-0. 2016.

Finally, a modern, intelligent, trade book on dinosaurs for thoughtful readers. *Dinosaurs: How They Lived and Evolved* is written by two authoritative specialists, and is beautifully produced with full-color illustrations. It is not a volume to sit down and read cover to cover; it is a little dense for that. Take it in small bits. The book is a startling testament to how far dinosaur paleontology has come.

The organization is conventional: a brief history (in Chapter 1), followed by dinosaur origins, after which phylogeny is introduced (Chapter 2). Then anatomy (Chapter 3), and dinosaur paleobiology (Chapter 4), the birdness of Dinosauria (and vice versa; Chapter 5), and extinction, including postextinction avian dinosaur evolution (Chapter 6). Boxes, in textbook style, fill potential lacunae in the background of readers.

The first two chapters were the least satisfying. The history of dinosaur discoveries, it seems to me, is much better appreciated when one knows something about dinosaurs. Chapter 2, The Dinosaur Family Tree, is a near-litany of familiar (or unfamiliar?) dinosaur groups, the relationships of which are superficially explained and somewhat difficult to piece together. Dinosaur anatomy (Chapter 3) is superb, emphasizing not only anatomy, but dinosaur reconstruction. Had it preceded the diversity chapter, the logic of the latter perhaps would have been more apparent.

From the outset, the authors affirm that birds are dinosaurs. They write, "some books . . . state up front that the term 'dinosaur' is being used as a synonym for 'non-bird dinosaur.' This might be convenient, but it's inaccurate—the fact that birds really are dinosaurs is so important that we should deliberately think of them . . . whenever we hear the word 'dinosaur.' . . . [o]ur use of the term 'dinosaur' is intended to be synonymous with the group name Dinosauria: that is, birds and all" (pp. 6–7). Later they write, "The group of animals that we today call dinosaurs was first recognized scientifically during the 1840s" (p. 14). It is a rhetorical problem for all volumes on dinosaurs.

The rest of the book moves forward wonderfully. Chapters 4 and 5 provide many unexpected insights: feathers immanent to (perhaps) Dinosauria (Ornithodira?); *Archaeopteryx* not flying like a bird and not looking that different from carnivorous ground-dwelling carnivores; large claws not for slicing open stomachs but rather for holding down still-thrashing prey; dinosaur day care; chewing as a means of personal expression; food selectivity; finite element modeling of skulls and slashing attacks; preserved guts and stomach contents; CT scans of bones; muscle reconstructions; parental care; and sexual selection . . . the list really is endless.

Chapter 6 closes with the "great extinction," a forgivably dino-centric perspective. The authors ascribe the extinction(s) to a combination of causes. This treatment does not exactly reflect the extinction conversation, but its general content is represented correctly. True to the promise that birds are dinosaurs, the next 66 postextinction million years of dinosaur evolution are only summarized; but in a book on nonavian dinosaurs, should it be otherwise?

In 1986, R. T. Bakker published a famous book, *The Dinosaur Heresies: New Theories Unlocking the Mystery of the Dinosaurs and Their Extinction* (New York: Morrow). His views then were perhaps "heretical," but the intervening 30 years, as summarized in *Dinosaurs: How They Lived and Evolved*, have shown dinosaurs to be more extraordinary, more unexpected and, yes, more heretical than anybody ever imagined.

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