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Book review

Systematics: A Course of Lectures

Systematics: A Course of Lectures. By Wheeler, Ward C. Wiley-Blackwell, Oxford, 2012. 426 pp. ISBN 0-470-67169-6, ~$65.70. Paperback

I shall begin by saying that I have not taught a systematics class in the US yet, although I have taken many: several in Colombia and a couple of others in the US. I therefore read and judged the book from the student's perspective.

In an ideal world, systematics would be considered a fundamental discipline of biology, and as such it would be taught at the undergraduate level. However rare this is, Wheeler's book was conceived as a guide to be used in an advanced undergraduate or an introductory-level graduate systematics course. Each of the 17 chapters was designed to be covered during a single 90-min lecture, and hence the title of the book. The chapters are organized into five parts, which I proceed to describe here. Part I is entitled Fundamentals, and contains six chapters covered in 107 pages. The first chapter is called History. At least initially, the chapter does not seem intended to cover the history of systematics, but rather it aims to describe traces of "tree thinking" in the history of biology. As is customary, the three traditional methodological schools in systematics (evolutionary systematics, phenetics, cladistics) are described. The chapter ends with an interesting statement: that systematists today, wanting or not, are all cladists (*Okay*). Chapter 2 describes and discusses basic concepts, some of which are hard to understand outside the appropriate context (for example, the subjects of coding, polarity and rooting). The chapter also describes in mathematical terms what graphs, trees, and networks are, which I suspect is useful only for systematists interested in programing. Chapters 3 and 4 deal with the hairy subject of species concepts and the philosophical framework of systematics, respectively. These chapters are concise and do not extend beyond the critical points, which is important as judging by the amount of primary literature dedicated to them, each could occupy a book by itself (e.g. Rieppel, 1988; Wheeler and Meier, 2000). Chapters 5 and 6 are entitled Computational Concepts and Statistical and Mathematical Basics, respectively. The chapter on computational concepts has at first an historical flavour, but gets a little more intricate as it goes on. Both chapters have detailed descriptions of calculations and algorithms. However, it is difficult to understand the importance of these calculations before they are established in a practical framework of empirical phylogenetic inference.

Part II is exclusively restricted to discussing homology (35 pages). Chapter 7, "Homology," describes the historical transformation of this concept, types of homology and whether homology equates to synapomorphy—another of those hairy discussions in Cladistics. Chapter 8, "Sequence Alignment," discusses homology at the molecular level. I understand that this is perhaps Wheeler's favourite subject; nevertheless, the concepts and mathematical details in this chapter are described too minutely. The details of alignment calculations might be of interest for software developers but I fear they will turn off the average systematics student. As a user, I want to know why alignments are important, what happens to the data during an alignment, and which are the differences among the different methods currently available. Fortunately, these things are all there (Fig. 8.11 is particularly helpful), although the descriptions make the learning curve seem steeper than it is.

Part III is termed Optimality Criteria (139 pages). The first chapter is Chapter 9 and covers distances. Properties of distances and descriptions of the most common clustering methods are described. I particularly like the end of this chapter, which describes where the relevance of these methods lies right now, something about which students might not be aware. The discussion about neighbour-joining provides a good opportunity to examine some of the limitations of distances regarding, for example, its use in barcoding (not mentioned in the book). Chapters 10, 11 and 12 deal with parsimony, maximum-likelihood and Bayesian inference, respectively. Wheeler's treatment of the three methods is entirely operational and almost all aspects of each method are described in detail (calculations, treatment of data, etc.). This makes some of the descriptions heavy and tedious if you read all in one sitting. However, because the chapters contain lots of information about each method, this makes them a good source of reference material. Chapter 13 offers a comparison among optimality criteria based on epistemology, statistical behaviour and performance. This chapter is a really good read. Wheeler's extensive knowledge of systematics makes the whole book of value, but it was this chapter that did it for me.

Part IV is called Trees (72 pages). It begins with Chapter 14, which covers tree searches. All the strategies used during tree searches regardless of the optimality criteria are included here (Markov chain Monte Carlo methods are described in Chapter 12). The chapter is sufficiently exhaustive and straightforward. Chapter 15, entitled "Support," covers resampling measures and what Wheeler calls "optimality-based measures," which include Bremer support, the likelihood ratio test, and Bayesian posterior probability. Pros and cons of each measure are offered, as well as a comparison among them and how what each one measures relates to the others. Chapter 16 is about consensus, congruence, and supertrees. This chapter describes all types of consensus, and advice on when to use each is offered. The concepts of supertrees and supermatrices are described and nicely compared. My only objection to this chapter is that to begin with a description of the algorithm involved in the construction of an Adams consensus again seems over-complicated. If a student is going through the book without the assistance of a class, all he or she probably wants is to know what an Adams consensus is and when to use it. Perhaps there was an initial intention to include something about taxonomic congruence in this chapter but the subject of congruence is not explicitly addressed.

Part V, the last, is called Applications (nine pages). There is only one chapter here entitled Clocks and Rates. The chapter covers the now customary and quasi-obligatory tradition of producing dating estimates for nodes on a tree from calibrations that may or may not come from fossils. It discusses different tests of clocks, describes three of the main ways dates estimates are achieved, and reviews software implementations of these methods. The chapter finishes with a summary of criticisms to dating approaches, which all revolve one way or another about uncertainty. A couple of case studies are discussed in which dating procedures have been misused and their results incorrectly interpreted. Both examples effectively illustrate Wheeler's criticisms. Of course, phylogenies are applicable beyond the estimation of dates: an hypothesis about character evolution can be inferred from phylogenies, and the whole discipline of historical biogeography is based upon phylogenies; I wonder why these subjects were not discussed here.

As the most recently published textbook in systematics, *Systematics: A Course of Lectures* offers an improved framework to teach systematics, one that combines the right amount of history with discussion of ideas, methods, cases studies, and current software. However, regarding debatable subjects such as the concept of species or the discussion of homology, Wheeler is non-committal, which can be frustrating for students. The book is biased towards examples based on molecular data (Wheeler's field of expertise), and students interested in reading about the uses and treatments of morphological characters should beware (a nice textbook for those interested is by Wägele, 2005). On the practical side, there is a good balance in the amount of text and figures, and the type size and size of the book itself are good. But I do disagree with the inclusion of algorithms within the text (there are 31). Although these are clearly important, I think they could have been included as appendices, improving the flow of the text.

To finish, there are exercises at the end of each chapter although no answer key is provided. For the most part this does not seem too critical as the exercises are manageable; however, because computational biology and probabilistic statistics are often not part of a basic curriculum in biology, it could be hard for a student to evaluate their own learning process without having an idea of what the right answer is.

Throughout the book there are photographs of people who have made significant contributions to systematics: I counted (since modern times) 73 men and only three women (two of them not systematists). The field needs more women!

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