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MODELING BIOLOGY

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A Natural History of Equations

Self-organization in Complex Ecosystems. Ricard C. Solé and Jordi Bascompte. Monographs in Population Biology 42. Princeton University Press, Princeton, NJ, 2006. 392 pp. $45.00 (ISBN 0691070407 paper).

I am going to be critical in this review, so in case it gets lost in what follows, let me say at the outset that *Self-organization in Complex Ecosystems* is an excellent book, and could well be the very best of its type. With clarity and persuasion, this book discusses the mathematics of emergent processes by importing from physics the tools of statistical mechanics.

It starts with an appealing overview of complexity in ecological systems. This whole school of complexity science makes much of nonlinearity, and that is where the authors go next, giving a good account of chaos theory. As a general issue in complexity and emergence, nonlinearity becomes worth recognizing as the scope of a discourse is expanded with a move up in scale to include what before was part of the context. Approximately linear relationships have room to show nonlinearity, which redefines the situation. That happens in nature as well as in equations, and causes the relative homogeneity seen inside entities to give way to heterogeneity between the inside and the outside of an emergent structure. Solé and Bascompte, however, are more interested in the mathematics of all this than in its appearance in nature. In fairness, the authors do not completely neglect the common sense and actual experience we have of material emergence.

This book has been much influenced by findings in landscape ecology, so spatial self-organization appears as an early chapter. The account of fractals is broad ranging and thorough. One of the book's strengths is that it raises important issues, such as habitat loss. But as a limitation, it is less about real-time loss than about the mathematics surrounding that issue, and then only a certain sort of mathematics. For a book with "self-organization" and "complex" in its title, there are some surprising holes in the literature cited, caused by the narrow view of what is relevant.

For example, the complexity and the emergence that happens as a space is filled with pixels were worked out by Gardner and his colleagues at Oak Ridge National Laboratory in the 1980s, but only more recent accounts are cited in this book. Oak Ridge did, after all, put down the foundations of this stuff, but the authors of this book belong to another invisible college. Solé and Bascompte appear to belong to the network theory, digraph school of ecology, so it is natural that their book should contain a large section on food web theory. Even after their good framing of all that, I persist in my misgivings that the problem of data collection and bounding food web networks has never been adequately addressed. I still ask if food web theory actually is about something material as opposed to something merely mathematical. But at least the mathematics here is laid out as well as it can be. The book ends with a very interesting section on complexity in macroevolution, where there are some new and substantial ideas.

Emergence has become the hallmark of complexity, and its underlying process of self-organization has become something of a buzzword. It goes back to what Schrödinger called "order from disorder" in his book *What Is Life?* (1944). There is a certain irony in Schrödinger's work being one of the critical foundations of this whole thrust toward emergence and self-organization. Schrödinger's position is now identified as safe and orthodox (order from order is genes, and order from disorder is the Prigoginian, far-from-equilibrium emergence discussed by Solé and Bascompte). But Schrödinger was radical in his day, and remains so. His bottom line in 1944 was that we had no physics adequate to address biology, and that shortcoming still applies today (Rosen 2000). In biology, one simply cannot get away with the assumption that the system is closed and close to equilibrium, a foundational assumption in physics so that the bookkeeping works. These authors want to import ideas from physics into ecology, but their chaotic strange attractors are equilibrium structures despite their nonlinearity and elaborate behavior. Schrödinger would probably have some misgivings about where his ideas on emergence have led Solé and Bascompte.

There is a tension in biology between the thermodynamics of life and the way in which it is coded. Self-organization applies when structure appears independent of any coded expectation. There is no plan for an emergent structure such as a whirlpool—it merely happens when a head of water sits above a hole. But in biological systems there is an interplay between thermodynamic emergence, which creates structure spontaneously, and coding, which stabilizes that emergence. Subatomic particles are divided from atoms over vast scale differences. In biology, coding stabilizes the small differences between biological levels, such as organelles and cells, allowing the dense hierarchies in biological structure to exist. Significance, with meaning and functionality, derives from coding. *Self-organization in Complex Ecosystems* never touches that coding, and so in a sense it misses exactly half the point of complexity. The book never gets further than the thermodynamics of the situation. Even when Solé and Bascompte do discuss evolution, it is in the context of flux leading to some elaborate expression of central tendency, not the development of meaningful function. That said, the book does go a lot further than most in exploring micro- and macroevolutionary fluxes, but it remains stuck in thermodynamic expressions of nature.

Where is C. S. Holling in the references? He is not even cited for type I, II, and III equations, although he is mentioned by name for them in the body of the text. How can one cover far-from-equilibrium systems without citing the classic 1994 article by Schneider and Kay, "Life as a Manifestation of the Second

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Law of Thermodynamics"? Where is the reference to Van Voris and colleagues' paper (1980), the only one I know that actually presented real-time experiments on material systems to show that complexity (as measured by intensity of periodicity of carbon dioxide), not diversity, was related to stability (both resilience and resistance)? There is also no reference to the extensive literature on hierarchy theory, which surely applies to self-organized emergence. Another missing body of literature is on stochastic modeling, and as my colleague Tony Ives says, stochasticity is really important if you are interested in real systems, since you are only going to be able to fit a *stochastic* model to data. But then again, all authors have to limit themselves as a matter of focus. These authors choose to give only a little room for nature, compared with their extensive treatment of their main topic, the equations of statistical mechanics in ecology.

The focus is narrow in *Self-organization in Complex Ecosystems.* Algebraic formulation is all. Good algebraists can prove whatever they are discussing. As a result they often feel obliged to prove it, and that slows them down and distracts from the significant biological issues at hand. I hasten to say that Solé and Bascompte do an excellent job of explaining these equations, to the point that the book will become a classic in those terms. But a compulsion that is overwhelming is evident in it. For instance, is it really necessary, when speaking of a binary transformation (all numbers below a threshold become zeros, while all other numbers become ones), to write a double-decker equation that says what I just said? For those who intuitively think in algebraic terms, I suppose the fit will be comfortable, but not for many other ecologists. Significantly, this book is a natural history of equations, rather than real-time complexity in biology.

In the end, I agree with Robert May, who on the dust jacket identifies *Self-organization in Complex Ecosystems* as being a powerful synopsis of the new ideas of recent decades. A lot of what appears in the book has been around for some time, but this is probably the clearest expression of it all. It is very nice to have it all in one place, and to see where it is going in this century. This book is narrow but is fairly characterized as adventurous. It will demystify a large literature. It is clear, thorough, and very well written. It will be a good book for a graduate seminar course, but only in ecology programs that have a solid quantitative basis. Be aware that it is firmly ensconced in a very particular way of addressing ecological systems, and has a certain myopia in that regard, but it should be on the bookshelf of any broad-minded ecologist.

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FROM DODO TO DARWIN

The Reluctant Mr. Darwin: An Intimate Portrait of Charles Darwin and the Making of His Theory of Evolution. David Quammen. W. W. Norton, New York, 2006. 304 pp. $22.95 (ISBN 9780393059816 cloth).

David Quammen is a traveler and science writer, perhaps best known for his account of the development of biogeography, *The Song of the Dodo* (Scribner, 1996). In his new book, *The Reluctant Mr. Darwin: An Intimate Portrait of Charles Darwin and the Making of His Theory of Evolution,* Quammen tells the story, at a popular level, of how Darwin conceived, substantiated, and eventually promoted his theory of evolution by natural selection. He certainly seems to have hit the nail on the head—the book has already received a rave review in *Science* from Janet Browne, author of the best modern scholarly biography of Darwin in the literature.

Quammen takes the unusual approach of beginning his story after Darwin's return from the voyage of the *Beagle.* He does this partly on the grounds that the voyage will already be familiar to many readers, but also because he wants to focus very closely on the theory of natural selection. He is very clear about the radical implications of the idea of undirected evolution, as opposed to more comforting visions of evolution driven by some kind of purposeful force. To chart Darwin's development of the theory, Quammen intersperses the story of Darwin's life with occasional flashbacks to fill in the previous history of the areas Darwin studied, including taxonomy and biogeography. There is a nice mix of the professional and the personal aspects of Darwin's life—the latter often of major significance, as with the death of his daughter Annie, which undermined the last of his religious faith. Quammen gives us a feel for the technical aspects of Darwin's work in areas such as barnacle taxonomy, and provides a balanced analysis of the controversial question of why he delayed publication of his theory. Was it the fear of persecution or the need to generate more scientific evidence? Probably a bit of both.

The Reluctant Mr. Darwin includes a clear outline of the argument of Darwin's *Origin of Species,* although here—perhaps inevitably—Quammen has to adopt a rather more didactic presentation to get the details across. His coverage of the role played by Alfred Russel Wallace is good, and he is aware of the possibility that the theory of natural selection presented in Wallace's 1858 paper was significantly different from Darwin's. He also gives a good account of the reception of the theory, although he says surprisingly little about the role played by Thomas Henry Huxley in defending Darwin against the early attacks.

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Here I have to declare an interest, because Quammen makes use (with generous acknowledgment) of my own work on the non-Darwinian theories of evolution that flourished in the late 19th century. In the end, Darwin persuaded almost everyone to take evolution seriously, but it would be another 50 years before the synthesis with genetics turned natural selection into the modern evolutionary paradigm. To simplify the last part of the story, Quammen ends with an interview he conducted with Douglas Futuyma, who explains how a modern geneticist understands the workings of natural selection.

Quammen is well aware of the disturbing nature of Darwin's theory, although he confesses that he can't really understand how present-day creationists can be so blind to the evidence supporting evolution. It's not, he claims, that we can *prove* evolution—but all the alternatives are useless as science. The ideas of directed, inherently progressive evolution that were floated in the 19th century in an attempt to head off the more disturbing implications of natural selection have also turned out to be unworkable.

We are left with a choice between Darwin and creation—and many Americans clearly prefer creation. Books such as *The Reluctant Mr. Darwin* may go some way toward helping to maintain an interest in Darwin and his theory, but whether they can stem the rising tide of opposition to Darwinism is another story. In the end, those who see supernatural creation as the default position—that is, the position one takes up without some good argument to the contrary—will never be persuaded, because the arguments for evolution will never be strong enough to move them. The problem for evolutionary biologists, and for writers like Quammen, is that for them the search for natural explanations is the default position, and this makes it hard for them to understand the thinking of those who feel quite comfortable invoking the supernatural.

What we need are not more accounts of Darwin and his discoveries, but more efforts to understand the underlying motives behind the debate. We also need a clearer presentation of the alternative positions that can be taken up by a serious Christian who wants to explore the possibility that the Creator might choose to achieve his ends through a complex and indirect process of natural development. I suspect, however, that in the run-up to the 200th anniversary of Darwin's birth and the 150th anniversary of the publication of the *Origin of Species,* we are going to get a lot more books like Quammen's. Few, however, will do a better job of presenting the story of how Darwin put together his momentous new idea.

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MATH FOR WISER DECISIONS

Introduction to Population Ecology. Larry L. Rockwood. Blackwell, Malden, MA, 2006. 339 pp., illus. $44.95 (ISBN 1405132639 paper).

The need for a concrete understanding of population ecology among all disciplines grows exponentially. This escalation is continually fed by changing land use, global climate change, more species invasions, and the myriad of other environmental problems that plague conservation efforts. Although often trained in traditional academic departments, students more and more embrace the once "alternative" pursuits of policy, management, or environmental consulting as mainstream careers. Accordingly, these professionals can readily put to use a solid understanding of how populations grow, decline, or interact. Such an understanding of population ecology should lead to wise decisions regarding management, especially of threatened and endangered species.

In his textbook, *Introduction to Population Ecology,* Larry L. Rockwood seeks to provide the background to integrate the basics of population ecology with applied challenges presented by conservation biology. Rockwood writes of his motivation to equip students with the mathematical understanding and critical thinking skills necessary to address questions that arise in the public arena. As an archetypal example, Rockwood suggests that both policymakers and federal employees need to be capable of competently discussing whether the introduction of wolves back into Yellowstone National Park has actually affected elk herds. Equally valuable, an emphasis on the nuances of population ecology facilitates the development of suitable research questions. Rockwood aptly acknowledges that ecologists frequently face challenges in developing proper methodology. An environmental consultant for a conservation project could use chapters of this book for brainstorming how to investigate extinction probabilities for small, isolated populations; for organisms that exhibit different life histories; or for species tied to other species through mutualistic or parasitic relationships.

With 30 years of experience teaching at the intersection of environmental science and policy at George Mason University, Rockwood correctly identifies the need for a textbook that achieves a balance between breadth of topics and depth of mathematics. As a new choice in population ecology textbooks, Rockwood's effort provides an up-to-date, comprehensive overview of population ecology that graduate students, and possibly select undergraduates, can readily understand. Rockwood takes the approach of most population ecology textbooks by first exploring single-species populations and then confronting more complex interspecific interactions. This textbook proves atypical, however, in that Rockwood briefly covers mutualistic interactions and expands typical coverage of host–parasite interactions. In contrast with most other texts, these novel chapters appear before Rockwood's exploration of predator–prey dynamics, which precedes a final chapter on plant–

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herbivore interactions. In that chapter, Rockwood relies primarily on terrestrial examples, although aquatic ecologists interested in herbivory could apply this information to freshwater systems.

The introductory sections of each chapter constituted my favorite feature of the text, as Rockwood did a superb job of succinctly summarizing ecological topics, clearly defining concepts (in boldface), providing a clear review for students, and laying the groundwork for incrementally developing the mathematical constructs. The book is well referenced, often providing the reader with several avenues to explore topics in more depth. Faculty employing Rockwood's text could test problem-solving ability more frequently by creating their own exercises that go beyond the limited in-text examples and questions in the appendix. Throughout the text, Rockwood highlights instruction on how to interpret trends in important variables within both simple and more complex models. This emphasis allows students to determine more easily whether a population might be increasing, fluctuating, or crashing. Establishing this mathematical background sets the stage for the applied purpose of the text.

Rockwood's text covers the major topics relevant to population ecology. However, the average undergraduate, especially in a program that does not offer a concentration in ecology or environmental science, may have difficulty in negotiating the dense reading that accompanies the otherwise logical and well-constructed stepwise explanations of the models and assumptions. In the digital age, proper use of color often facilitates understanding of complex graphics, and the average undergraduate may respond better to such illustrations. The brilliant cover picture of a reddish purple rainforest tree frog does not mirror the book's style, however, as no color appears in the text. The monochromatic presentation bucks the trend of most undergraduate ecology texts. The figures in *Introduction to Population Ecology* primarily provide illustrations of the theoretical relationships predicted by various permutations of assorted models. But, of course, a textbook should not stand alone but should exist in concert with lectures and exercises.

Several chapters end with discussions of laboratory and field examples. Professors could further complement this text by focusing their own graphical examples on published literature. Furthermore, the book could serve as a valuable resource for investigating specific topics in population ecology or providing broad topical coverage for graduate students.

In the preface, Rockwood points out that population ecology can be approached at a variety of levels, depending on the mathematical background of the students and professor. Although it relies on advanced algebra rather than calculus and differential equations, this book often provides more than a basic introduction to population ecology. Examples include an in-depth discussion of differences between deterministic and stochastic models, substantial exploration of flaws in the assumptions of the logistic equation, three modifications of a Leslie matrix, and repeated exposure to the complexity of age-structured dynamics. While a discussion of these topics holds value, it is unlikely that an instructor of a typical semester-long undergraduate course could adequately cover all the material Rockwood presents. This situation is not unusual, as all material in most other textbooks usually cannot be covered in a typical 14-week semester, no matter what the author's intent. Fortunately, *Introduction to Population Ecology* gives instructors ample material from which to choose their own emphasis.

The text of *Introduction to Population Ecology* achieves its goal of providing the mathematical background and basic ecological understanding that applied ecologists require to make wise management decisions. Nevertheless, management decisions do not exist in a vacuum of population ecology models, but must consider economic, political, and social consequences. To reach a professional audience faced with the everyday challenges of conservation biology, a perfect pairing to this text would be a supplement, or a course emphasis on case studies, that includes economic considerations, ethical dilemmas, or site-specific considerations. With this addition, the mathematical background Rockwood supplies, combined with knowledge of the multidisciplinary perspectives influencing conservation, could help enable us all to make wiser management decisions in the future.

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THE AGRICULTURAL BIOTECHNOLOGY DEBATE

Let Them Eat Precaution: How Politics Is Undermining the Genetic Revolution in Agriculture. Jon Entine, ed. AEI Press, Washington, DC, 2006. 203 pp. $25.00 (ISBN 0844742007 cloth).

Biotechnology has brought considerable promise and benefit to agriculture by introducing new insect-resistant and herbicide-tolerant crops. Such crops have resulted in higher yields, lower production costs, less pesticide use, and potentially more nutritious foods. However, consumer concerns, especially in the European Union, have resulted in considerable controversy, trade restrictions, labeling requirements, and a trade dispute before the World Trade Organization. In *Let Them Eat Precaution: How Politics Is Undermining the Genetic Revolution in Agriculture,* 10 well-recognized contributing authors from the United States and the United Kingdom provide insights into the benefits of agricultural biotechnology, offer an international perspective on why some groups are opposed to it, and suggest potential solutions to the controversy.

The various chapters in the book grew out of a recent conference, "Food Biotechnology, the Media, and Public Policy,"

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held at the American Enterprise Institute. Jon Entine, the editor, is an adjunct fellow at the institute and a scholar in residence at Miami University in Ohio.

The book is divided into three major sections. The first, entitled "Ideological Gridlock," contains three chapters. Results from attitude surveys of worldwide opinion leaders are presented by Thomas Jefferson Hoban in chapter 1. Biotechnology firms and farmers tend to favor the technology. Some consumers, regulatory agencies, government leaders (especially in the European Union), and food industry officials are less favorable in their perceptions of the health, economic, and environmental benefits of the genetically modified (GM) crops currently in the marketplace. While the transatlantic controversy rages, according to Robert L. Paarlberg in chapter 5, African and other developing countries struggle to gain access to, or benefits from, the promise of these technologies that might increase the productivity of their low-income farmers and provide more nutritious food for millions of undernourished children. Paarlberg further states that the European emphasis on the precautionary principle is creating a regulatory and trade gridlock. Although rich OECD (Organisation for Economic Co-operation and Development) nations may be able to opt against GM foods with minimal adverse economic impacts, the economic and human costs in developing countries can be huge. Hence, the intense political and ethical controversy has substantial international consequences.

The second section, entitled "Consequences," explores the implications of placing restrictions on the adoption and availability of GM foods from US, European, and developing country perspectives. The three chapters in "Solutions," the final section, examine possible ways to address the agricultural biotechnology controversy. Issues discussed include the organization and financing of antibiotechnology groups, the prospects for transgenic crops with enhanced nutritional or pharmaceutical attributes, and the role of the media in the debate.

This well-organized book offers insights into the sources and consequences of the still-unresolved debate on agricultural biotechnology that has been raging for over a decade. This is not intended to be a technical treatise on biotechnology, but rather a compilation of ideas on why a technology that has so much promise to enhance the well-being of agriculture, the environment, and consumers has not been adopted as rapidly as many initially anticipated.

All 10 authors are leading scholars on the topics addressed. The general tone of the book is favorable toward agricultural biotechnology, yet efforts are made to present different views and perspectives on the topic. For example, Hoban, the author of chapter 1, has conducted extensive domestic and international surveys on consumer attitudes toward agricultural biotechnology. C. S. Prakash (chapter 2) and Carol Tucker Foreman (chapter 6) both served on the US Department of Agriculture Advisory Committee on Agricultural Biotechnology during the Clinton administration. Patrick Moore (chapter 9), a founder of Greenpeace, has in recent years altered some of his views about the impact of the adoption of agricultural biotechnology, and now accepts it as potentially environmentally friendly.

All the authors suggest that effective communication focused on the current and potential benefits of agricultural biotechnology is essential if society is to benefit from these scientific advances. Sound science and regulatory review are only part of the process. Policymakers must also consider the political, social, ethical, and economic dimensions of the debate on agricultural biotechnology. Clearly, the degree of people's understanding of scientific discoveries is quite diverse: There are wide differences in their willingness to accept perceived risk, and their perspectives on the benefits depend, in part, on whether they represent a farmer, an agribusiness firm, a policymaker, or a consumer.

Resolution of this controversy has enormous consequences for the future of world agriculture as the global population continues to grow, and as we seek to offer a more nutritious food supply in an economically and environmentally sustainable fashion. The book provides thoughtful insights into the arguments about—and potential solutions to—the current agricultural biotechnology debate.

The book would be appropriate for a college-level course in science communication or in agricultural or science policy. Scientists involved in molecular biology and related research might find the book helps them better understand how something that they may think is a safe and exciting scientific discovery is not readily accepted by others in society.

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MODELING BIOLOGY

Dynamic Models in Biology. Stephen P. Ellner and John Guckenheimer. Princeton University Press, Princeton, NJ, 2006. 330 pp. $99.50 (ISBN 0691118434 paper).

Why should biologists be interested in mathematical modeling? Never at a loss for an anecdote, the late eminent biomathematician Lee Segel loved to quote Picasso: "Art is the lie that helps us see the truth," and, Lee quipped, "the same can be said for mathematical modelling." His assessment certainly proved true. Over the last 10 years we have witnessed dramatic changes in biological research in terms of its dependence on the quantitative sciences. In some university corridors, it is even possible to hear whispers of "the New Biology," which, according to one informed view, is made up of approximately one-third statistics, mathematics, and computer science; one-third physics, chemistry, and engineering; and one-third traditional biological sciences. The impact of the New Biology may be gauged by the recent estimate that 30

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percent of *all* high-performance computing worldwide is now dedicated to biological analyses. The new experimental setups, huge data sets, statistical analyses, and modeling approaches are having their effect. Many of the brightest young scientists are following the excitement and moving into the areas of biophysics, nanotechnology, bioinformatics, and biomathematics.

Unfortunately, these changes have hardly filtered into the undergraduate curriculum at most universities, yet there is an obvious need to train and prepare the next generation's young scientists. To help fill this growing gap, Stephen P. Ellner (Department of Ecology) and John Guckenheimer (Department of Mathematics), both highly respected mathematical biologists at Cornell University, have published their new book *Dynamic Models in Biology.*

The book is based on an interdisciplinary course given by the authors to a heterogeneous group of undergraduate students majoring in the biological and exact sciences, including medicine, computer sciences, mathematics, and engineering. Anyone wanting to bring together students from such wide-ranging backgrounds will find this no easy feat. It is in fact a major teaching challenge. The authors' strategy is to maintain a careful balance between the mathematics and biology presented, while following a "business school" model that gives an in-depth treatment of a selective set of case studies. Working through particular case studies allows students to come to grips with nitty-gritty aspects of biology that might push math students to their limits, while exposing biology students to areas of mathematics they may not otherwise have encountered, and possibly inspiring them to learn more in the process. The case studies chosen span major areas in biology, with chapter topics that include structured population models, membrane channels and action potentials, cellular dynamics and simple gene networks, infectious diseases, spatial patterns in biology, and agent-based models of digital evolution. In addition, there are several technical chapters conveying important background material on dynamical systems and the art of building biological models.

As part of their strategy, the authors pair up very different biological case studies that are amenable to analysis with similar mathematical frameworks. For example, chapter 2 introduces matrix models of structured populations, a good home base for ecologists or biologists who are likely to have encountered parts of this material previously. The chapter walks the reader through essential mathematical concepts that include projection matrices, eigenvalues, left and right eigenvectors, the Perron–Frobenius theorem, stable age distributions, and eigenvalue sensitivity (elasticity). These same concepts are heavily drawn on in the paired chapter 3, which moves on to the study of gating in membrane channels via Markov chain matrix models. Now, however, the probabilistic transition matrix replaces the projection matrix, and the right eigenvector and Perron–Frobenius theorem are used to calculate residence times rather than stable age population distributions. The pairing of chapters can be exploited by the course instructor to reinforce learning, or, alternatively, the instructor has the freedom to skip one of the pairs without loss of material required later in the book.

It becomes clear that the chapters are written by true specialists who have a deep knowledge of the subject matter and an extensive and up-to-date awareness of the literature. A good example is the chapter dealing with modeling infectious diseases, which gives a wonderful overview of the field. The first 17 pages deal with the basic textbook theory covering the classical SIR (susceptible, infectious, recovered) epidemic model (with and without the birth/death process), model scaling and dimensionless variables, the reproductive rate R_0, force of infection, and the model's natural oscillations, plus a little bit of history. These topics are dealt with in a linear and very readable fashion, and followed by a set of challenging computer exercises.

The remaining 15 pages move into some lesser-known terrain, where simple models lay bare (a) the role of core groups in sexually transmitted diseases (STDs) and methods for controlling disease spread; (b) the dynamics of drug resistance of infectious diseases such as tuberculosis and HIV; and (c) within-host dynamics of HIV and its T-cell targets. Each section is conveyed cleverly and compellingly. The section on STDs, for example, brings to light a paradox introduced by Hethcote and Yorke, namely, why does gonorrhea demonstrate long-term persistence when it shows all the signs of being on the brink of extinction? The reader learns that this can be resolved by introducing the concept of a core group, and it takes the authors a matter of seconds to set up a simple, elegant model that manages to illuminate exactly how this is done. The deep insights gained make the power of dynamic modeling directly evident.

The book's business school approach to modeling comes at a price, in that a large amount of course material accumulates as unrelated and weighty case studies are introduced and dealt with in succession. As a result, the material outlined in the book is more than can be covered in a one-semester course. The authors suggest guidelines for different course variants based on subsets of chapter combinations that should be realistic over a semester. Because of the amount of material covered in the book, the pace is sometimes uneven. Certain concepts are dwelt on at length, while others are necessarily covered too briefly and will need more careful preparation by any instructor planning to lecture on the material in class. However, overall, the book is well organized and well written, and the authors have a captivating style that keeps the reader interested and tuned in. This is facilitated by the witticisms scattered through the book, with the authors admonishing the reader with such warnings as "Thou Shalt Not Extrapolate Beyond the Range of Thy Data" or invoking fear of "the Curse of Dimensionality."

Speaking from my own experience of teaching a similar course, students will especially enjoy the hands-on computer laboratories and exercises that have been prepared for the book. The authors provide a well-documented laboratory manual that comes in two versions, for Matlab or for R (freeware). The manuals have been carefully thought out and make it

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possible to learn to program with these powerful software packages even if beginning from scratch. The manuals ensure that students will be able to build and test their own dynamic models in minimal time.

Dynamic Models in Biology stands apart from existing textbooks in mathematical biology largely because of its interdisciplinary approach and its hands-on, project-oriented case studies and computer laboratories. In an effort to explore biology in more detail, the authors bravely choose a style that differs from the classical biomath texts of, say, Murray and Edelstein-Keshet, whose focus is more on formal mathematics. The success of a course built around Ellner and Guckenheimer's textbook will depend on the instructor's skill in assessing the diversity of the students' backgrounds and catering to their different needs, but the task will be far easier and more enjoyable with this well-crafted book as a guide.

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STEERING BETWEEN EXTREMES

Infinite Nature. R. Bruce Hull. University of Chicago Press, Chicago, 2006. 258 pp. $17.00 (ISBN 0226359441 cloth).

Polarized views about the relations between humans and nature, development and preservation, and economy and the environment can paralyze sustainable development initiatives and conservation projects. If these alternatives are framed as an either-or, win-lose choice, then stakeholders and policymakers are forced to choose between nature and human well-being, and little can be done to integrate environmental concerns into private and public policy or economic and development decision-making. Bruce Hull, professor of forestry at Virginia Polytechnic Institute and State University, identifies this core problem and offers a radical solution by averring that "there is not one environmentalist position, or one environment" (p. 1). Hull's book dissolves dichotomous positions by portraying a plurality of views about nature and relations between human communities and their environments.

Infinite Nature takes the reader on a kaleidoscopic journey that provides a comprehensive and evocative description of the multiple perspectives from which we observe, understand, and value nature. The journey takes place in the course of 13 chapters that illustrate its anthropogenic, evolving, ecological, finite, economic, human-health, social-justice, spiritual, human–animal, ecological- and animal-rights, aesthetic, and moral dimensions. To address each of these multifaceted dimensions, Hull adopts an effective rhetoric. Each chapter begins with two subsections that present the extreme positions. These are followed by subsections that analyze and integrate these positions into a broader variety of perspectives, and a concluding section that offers Hull's synthesis. The clear structure of the book and the dialectic tension generated by presenting opposite perspectives keep the reader enthralled. What is more, the well-documented narrative is written in a style that makes it accessible to the general public.

The tensions between the dichotomous extreme positions characterize the entire book. For example, to develop the notion of an anthropogenic nature, Hull describes and criticizes the two most radical views about aboriginal peoples. These views present such peoples, on the one hand, as primitive "subhuman savages" (with associated arguments for subjugating them) and, on the other, as environmental "noble savages" (with arguments for respecting and admiring them). For example, the value of the Amerindian environmental culture is epitomized by the accomplishments of the Aztecs, who managed to construct and administer large cities like Tenochtitlán. Built around a lake, this city was environmentally sustainable and incorporated a grid of canals connecting islands that were made of rich soil dredged from the lake bottom. This Aztec design supported a highly productive agricultural system. The city also had an aqueduct, sanitation systems, markets, arts venues, and "a zoo that exceeded any known in Europe" (p. 12).

Hull emphatically affirms that Europeans discovered in North America a nature that was cultured, not pristine. But he also criticizes the romantic view that portrays Native Americans as universally in harmony with nature. Hull points out that the widely popularized "Chief Seattle's letter" was not written by Chief Seattle but was instead derived from the script of a long-forgotten film produced by the Southern Baptist Convention (see Callicott 1989). After some debunking, Hull assesses sustainable and unsustainable human behaviors by integrating ecological notions such as resilience with lessons learned from each of the cultural perspectives.

Throughout the book, the presentation of opposing views effectively helps to locate the nuances of complex environmental issues. For example, regarding the finiteness of our planet's resources, Hull opposes "techno-optimists" who believe that human creativity is infinite against "techno-pessimists" who argue that technological solutions inevitably create more problems than they solve. The former are confident that there will always be a technological substitute for depleted nonrenewable natural resources; the latter tend to advocate for the precautionary principle. After introducing the polarized views in this contested domain, Hull analyzes appropriate technologies, emphasizing that the "real world is not nearly so black-and-white; nature is not finite or infinite and technology is not good or bad" (p. 67).

In his approach to contrasting religious perspectives, Hull finds another lucid middle ground between extreme positions. The Judeo-Christian tradition offers both a dualistic view, which emphasizes sharp differences between humans and the rest of creation, and a unifying view, supported by the idea that

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humans are created from dust. Further, one finds in the Judeo-Christian tradition a transcendentalist strain, which affirms that "nature is God, and God is nature," encouraging humans to be stewards of the rest of creation. To overcome the paralysis that these confrontational positions might involve, Hull integrates the scholastic and natural-theology schools of thought by invoking sayings such as "God created two great books, the Bible and Nature." In addition, by quoting such documents as a papal decree by Pope John Paul, which in 1990 stated that "environmental degradation damages not just creation, but our human neighbors" (p. 129), Hull brings religious and scientific ecological perspectives into closer alignment.

Most chapters maintain an impartial, descriptive approach to presenting a wide variety of perspectives. However, in "Economic Nature," Hull openly criticizes capitalistic discourses that narrow our understanding of nature. Capitalism conceptually transforms "wildlife" into "livestock" (focusing on living capital rather than on living beings), "forests" into "woods" (reducing forest ecosystems to the materials produced by trees), and "nature" into "natural resources" (overlooking biodiversity by valuing only a few profitable species, and consequently promoting the conversion of diverse ecosystems into monocultures).

What prevail in *Infinite Nature,* however, are critical, balanced, and well-informed positions. Regarding animal rights and the vegetarian debate, for example, Hull judiciously points out that "vegetarian or organic diets are not clear-cut environmental winners. Eating locally grown, pasture-raised beef might be more ecologically benign than eating irrigated soybeans grown thousands of miles away on industrial farms" (p. 174). In addition, being pluralistic does not mean being paralyzed. Even in such chapters as "Human Nature," in which the author espouses a rather eclectic position regarding the similarities and differences between human and nonhuman animals, he emphatically concludes that "our [human] specialness creates a sense of responsibility to develop and implement a moral code that considers and respects other forms of life on Earth" (p. 156). This statement captures the book's concern not only with "infinite views" about nature but also with taking action to achieve sustainable and respectful relations with other living beings and ecosystems. *Infinite Nature* succeeds in pluralizing nature while providing a valuable textbook for discussion.

My main criticism of the book is that it should be made more explicit that the "infinite" views of nature refer almost exclusively to Anglo-American culture in the United States during the past two centuries. *Infinite Nature* does not pluralize environmental perspectives in general. This focus should be emphasized in order to avoid US centrism regarding environmental views, which might unintentionally hide other rich and diversified environmental traditions, such as those of Latin America and Europe (Jax and Rozzi 2004). At the international scale, ironically, such US centrism counteracts Hull's attempt to pluralize nature. At the same time, even at the North American scale, the rich diversity of perspectives that Hull explores—including gardening and recreation in nature, which are central elements of US identity as well as essential to material and spiritual human well-being—is such that the book holds out hope for finding viable solutions to achieve global sustainability. For example, Hull analyzes lawns around suburban houses, the cultivation of which emerged only some 60 years ago, spawned by a social-climbing middle class that wanted their surroundings to resemble golf courses after Woodrow Wilson popularized the game. Today, lawns are a ubiquitous and significant environmental problem in terms of water consumption and fertilizer use. Awareness of the origins and consequences of lawn cultivation in North America might liberate homeowners from this damaging practice.

Hull's journey through views about nature does not end with a recipe for what we should do. Instead, he leaves us better equipped to accept and understand diverse positions and to integrate the multiple dimensions of our "infinite nature." When combined with complementary readings, *Infinite Nature* should prove valuable also for high school and university teaching.

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ESSENTIAL ENVIRONMENTAL INFORMATION

The New Atlas of Planet Management. Norman Myers and Jennifer Kent, eds. University of California Press, Berkeley, 2005. 304 pp., illus. $39.95 (ISBN 0520238796 paper).

The authors of *The New Atlas of Planet Management,* Norman Myers and Jennifer Kent, are an honorary visiting fellow and an environmental researcher and analyst, respectively, at Green College, Oxford University. Each has an admirable résumé of writing about the global environment. Myers has been recognized for his efforts with membership in the US National Academy of Sciences, an ambassadorship for WWF–UK (the United Kingdom branch of the World Wide Fund for Nature), and numerous awards. Kent has coauthored four books with Myers on the interrelationships between the economy and the environment on a global scale. Together the two of them bring vast experience in the global environmental arena to this important text.

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My first thought when opening this massive volume was that it is simply loaded with information, a real tour de force. This elegantly illustrated book covers a huge breadth of environmental topics. It is also obvious that the editors have done much work to avoid a biased perspective (i.e., looking at these issues solely from the viewpoint of citizens of the developed world). The developing world perspective is well represented. The major topic divisions are introduced by the leading researchers in conservation and sustainability. Within each of these topics ("Land," "Ocean," "Elements," "Evolution," "Humankind," "Civilization," and "Management"), there are wide-ranging discussions with a great deal of cross-referencing.

This text would not make an effective textbook for a beginning environmental studies course, however. Given the breadth of discussion, no one topic is covered in the depth typically associated with a course. In addition, the format is extremely difficult to follow. Information is given in small sound bites, with side boxes, complex figures and figure legends, and the main text jumbled together on each page. The font differences between the different texts are minute, making it difficult to distinguish the main text from the very busy and diverse group of other types of texts. I thought that perhaps it was only as an old fuddy-duddy that I was unable to follow the information, and asked two of my undergraduate students to read a chapter and tell me what they thought. They too had difficulties following the message, but, after finishing the chapter, pronounced it fascinating. Both agreed that they learned a great deal, yet given the immense number of facts crammed onto each page, they learned the most after they had finished reading, as they sat and digested the material.

I am also concerned by what appears to be a bias on the part of the authors in terms of biomes. Grasslands are given short shrift, although they are one of the most endangered biomes on Earth. They are dealt with primarily in the section on food production. Only at one point in the text, a sentence on page 168, is the plight of grasslands discussed ("We shall plough up enormous areas of grassland"). This lack of understanding of grasslands and grassland processes is revealed also in a section concerning fire. The authors decry the abundance of fires that are destroying forests, particularly in the tropics, but ignore the fact that fire is a critical process in grasslands and that its absence actually threatens the preservation of this habitat type.

In the section on food production, the authors deal with desertification primarily as a function of the production of new areas with moving dunes, rather than treating deserts as systems with lower productivity and diversity than the system that was replaced. Not all deserts are composed of moving sand dunes, and desertification can result in systems with low diversity, low productivity, and no sand dunes. I was also concerned that the authors backed the currently fashionable thought that the best systems for terrestrial carbon sequestration are forests, again ignoring grasslands as critical carbon sinks. Indeed, much of the world's desertification occurs when arid grasslands are converted to desert and their potential to sequester carbon is diminished.

With these critical caveats, I cannot recommend this book as a beginning text for environmental studies, but its myriad figures and facts could be an important resource for the instructor of such a course, providing important data to help illustrate points for students. In addition, some of the figures can be used as templates for instructors seeking a way to illustrate key points in their lectures or course notes.

This volume's strongest points are the chapters at the end, which explain global political and economic systems in great detail. These issues are typically given short shrift in environmental science texts, because most of these texts are written by ecologists who have little training in either politics or economics. The chapters here give tremendous insights into how environmental issues are intimately tied to human politics and economic decisions, which is indeed the primary theme of this entire atlas. This is elegantly illustrated by a sentence in the "Managing Our Civilization" section: "Bottom line: ...we'll never attain the imperative of Sustainable Development without radical reform of the GNP concept." Many of us have heard about the importance of no-growth economies, but seldom do we learn about this from the perspectives of both the developed and the developing worlds.

Not only is *The New Atlas of Planet Management* a critical resource for those teaching environmental science or environmental studies courses, it is also critical for those in positions of power. Governmental decisionmakers, politicians, and leaders of nongovernmental organizations all would benefit by having this atlas on their desks—not their bookshelves.

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SPIDERS FOR AMATEURS AND PROFESSIONALS

Spiders of North America: An Identification Manual. Darrell Ubick, Pierre Paquin, Paula E. Cushing, and Vince Roth, eds.; Nadine Dupérré, illus. American Arachnological Society (*www.americanarachnology.org*), 2005. 377 pp., illus. $57.00 (ISBN 9780977143900 paper).

Very few of us harbor ambivalent feelings toward spiders. We admire their spinning work and thank them for killing the pesky fly, or find them repugnant and scary, sometimes to the extent of phobia. A decidedly nonarachnophobic organization, the American Arachnological Society (AAS), has published a remarkably thorough and useful manual that helps organize the incredible diversity of spider families and genera of the continental United States and Canada. *Spiders of North America: An Identifica-*

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tion Manual is the first edition of a guide that will serve the professional biologist as well as the motivated amateur; it will become an invaluable tool for those who want to answer the often not-so-simple question, "What spider is this?"

The manual is the outgrowth of a project initiated by the late Vincent Roth (1924–1997), who, with the help of many collaborators, published three editions of a guide to the spider genera of North America (Roth 1994). Roth's publications and various editions of Kaston's identification manuals (1978, 1981) were what researchers in North America used for decades as the initial starting point to identify an unknown specimen. These served us well, but arachnologists have made significant changes in the road map of spider taxonomy in the decade since Roth's latest edition, revising genera and many common families, and restructuring the way families are organized to reflect phylogenetic relationships.

In 2001 the AAS appointed a committee to revise Roth's third edition; the result was not a fourth, but a substantially changed and expanded version that clearly is a new publication. Over 30 taxonomists and three illustrators have created a guide to the spider genera of North America north of Mexico that will be an indispensable tool to the increasing number of ecologists, ethologists, and physiologists who are investigating spiders because of their ubiquity, their fascinating and diverse behaviors, and the simple fact that, in terms of species numbers and relative biomass, they are major players among invertebrate terrestrial predators. Those of us who have worked with schoolteachers and have fielded questions from the public realize that many nonbiologists also want to put a name on the spider that intrigues or frightens them. Professional biologists, amateur naturalists, teachers, and their students all may want different answers—some simply to the family level, others to the level of genus and species—but anyone interested in the spider diversity of North America (and most of northern Mexico) will find *Spiders of North America* an indispensable guide.

The first chapter, by Paula Cushing, presents an excellent introduction to spider anatomy and biology, techniques for collecting and rearing spiders, and how to maintain a collection. In chapter 2, Jonathan Coddington gives a comprehensive overview of spider phylogeny and classification after a valuable introduction to the theory and methods of constructing phylogenies. Chapter 3, by Darrell Ubick, is a key to 68 spider families that directs the investigator to the appropriate family chapter written by one or more of the authors. Each of these family chapters includes the common name; the number of genera and species in North America; a drawing of a representative specimen; a description of similar families with which the specimen might be confused; a summary of diagnostic features, followed by specific, quantitative descriptions of defining characters; a summary of the family's natural history; and the history of the family's taxonomy, including past revisions and currently unresolved taxonomic problems. This section also warns the reader if there is insufficient information to construct a complete and foolproof key to some genera in the family. A dichotomous key to the genera completes each family chapter. Along with the genus name at the end of the key appears valuable information on the genus's geographic distribution, the number of described and undescribed species, and, particularly important for the professional biologist, references to taxonomic publications describing the species in the genus.

The guide does not end with the keys. The chapter by H. D. Cameron is a 55-page, detailed summary of the derivation of the names of all the North American spider genera—an entertaining etymological spider dictionary complete with historical notes on the naming of the genus as well as a discussion of the derivations from Greek, Latin, and other tongues. This chapter is followed by a brief guide to pronunciation of the families and common genera. Students often stumble over taxonomic names, frequently asking their professors, whom they naively view as experts, questions such as, "How do you pronounce *Argiope?*" Now we have an updated guide that makes us all experts, and that also lists common alternative pronunciations, no doubt introduced by some of us ecologists ignorant of the "strictly correct" pronunciations first given by Comstock (1940).

Several features make *Spiders of North America* a powerful guide to spider diversity. The numerous detailed and beautifully executed illustrations by Nadine Dupérré are simply remarkable. They are not only useful scientific illustrations but also works of art. The detailed, illustrated glossary is an invaluable help, and includes general ecological and evolutionary terminology as well as descriptions and illustrations of anatomical features. A major strength of the book is the detailed bibliography, which allows the reader to access the original taxonomic literature in order to identify the specimen to species. A small but important feature: The book has a large spiral binding, which makes it easy to keep flat when working through the keys.

Can the manual be improved? Certainly there are some features that could be added. For example, among the numerous pages associated in the index with each family name, the page associated with the family chapter is given in bold; it would have been helpful if the page or pages in the key that refer to each genus were also highlighted—a simple oversight perhaps, and by no means a major one. In fact, the index is quite complete and includes references to individual species. Some researchers will grumble over the omission of a key to erigonine females (the Erigoninae is a subfamily of the species-rich Linyphiidae). However, the authors point out that currently there is no simple way to separate erigonine and nonerigonine females, and the manual does have a key to erigonine males. The manual points out problems such as these, and also explains when generic classifications differ from the *World Spider Catalog* (Platnick 2005).

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This outstanding guide to spider identification is a prodigious work of love by a large group of arachnologists. The manual will evolve with ongoing research on spider phylogeny and species descriptions, and in response to constructive comments from users, which the editors encourage (via e-mail to Ubick at dubick@calacademy.org). Thus what started over three decades ago as a group project inspired by Vincent Roth will continue as a group effort. In this spirit, my review has been aided immensely by input from members of my research group (Klaus Birkhofer, Mark Bostrom, Alberto Castro-Gil, and Erin Hladilek) who have used *Spiders of North America* to identify specimens.

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