troscopy sections, and although there is some potential for redundancy, it is kept to a minimum. The Special Topics section, on the other hand, comprises a potpourri of different topics and there is no clear theme tying all of them together. An important chapter in this section is one that discusses using component resolution for spectroscopic analysis. As any spectroscopic experiment that records data as a function of more than one linear variable requires multivariable analysis, this chapter presents an extremely important aspect of spectroscopy. A limitation of this chapter is that it focuses on analysis of fluorescence spectra. Although it is noted that similar analyses could be applied to other techniques, it is unfortunate that other examples are not explicitly given. Additionally, the section on selecting a model and evaluating the number of components required for the analysis could be more detailed; the reader is left with the feeling that empirical judgment is better than any mathematical or statistical tests.

The chapters are written by experts in the field and, in general, they vary in the depth and amount of theory presented. Many of the chapters contain detailed equations, which bring the reader from a more conceptual understanding of the technique to an analytical one. Other chapters, however, focus much more strongly on the application of the technique to demonstrate its potential utility. Of most use to the average reader is that in all of the chapters, the spectroscopic technique is critically evaluated by the authors. Typically, each chapter includes a straightforward discussion of the types of chemical or dynamic processes that can be observed, under what conditions the technique is best used, and the type of information that can be gained from each experiment. Rather than the theoretical approach, this straightforward evaluation of the technique will probably be most appreciated by the audience for whom this volume is primarily intended.

Although it is impossible for a volume of this magnitude to be completely comprehensive, a few new spectroscopic techniques that are already emerging as powerful tools in the study of biological molecules were not included in this volume. These techniques such as vibrational circular dichroism, femtosecond time-resolved infrared spectroscopy, and ultraviolet resonance Raman spectroscopy are alluded to in different chapters. This volume would have benefited from the inclusion of more of these new and emerging methodologies in separate chapters. Although some newer methodologies are covered in the Special Topics section at the end of the volume, a volume of this nature should review more of the new and potentially important techniques for biochemical spectroscopy. Perhaps, an additional section on newer techniques would have fulfilled this need.

Nevertheless, this volume is fairly comprehensive and covers many of the techniques that are commonly used for investigating biological molecules. The chapters are readable and accessible to graduate students and others interested in a particular discipline. It certainly provides an excellent introduction to a variety of topics in spectroscopy with many applications and examples to assist an experimentalist in deciding whether a technique is appropriate or not. Each chapter also includes enough references to make it a good starting point for a more in-depth study. I highly recommend it for all beginning graduate students who plan to use spectroscopy to study biological molecules. This volume is certainly not to be read in a single sitting, rather it will be of most use as a reference book and a valuable resource to be referred to time and again as an experimentalist encounters new and different problems that require solutions involving spectroscopy.

Chaotic Behaviour of Deterministic Dissipative Systems by Miloš Marek and Igor Schreiber

Cambridge University Press, Cambridge, 1995. 367 pages, $39.95

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For scientists and engineers who frequently delve into mathematical descriptions of complex systems, the term chaos has far deeper meaning than its ancient reference to the complete disorder of formless matter and infinite space predating the systematized universe. Careful scientific scrutiny of physical phenomena in more modern times has revealed that there are laws or rules of nature that govern the complicated motions of atoms and molecules and planets and suns. At the end of last century, the famous three-body problem of Poincaré demonstrated that even "simple" astronomical systems trace out trajectories that are unpredictable over time. But it was in the mathematical sciences that the concept of deterministic complexity arising out of structural simplicity matured. By 1975 it was time for a unifying rubric, and Li and Yorke came forth with the term *chaos*. Chaos in this new sense hypothesized that complex dynamical motions that appear random may actually be governed by few and simple deterministic rules.

One goal of Marek and Schreiber in their book (the 1995 paperback reprint of their 1991 edition) is to supply evidence that deterministic chaotic equations of motion provide adequate descriptions of complexities found in physical, chemical, and biological systems. Purported to be an introductory graduate text on nonlinear dynamics for students in physics, mathematics, engineering, and biology, the authors freely move back and forth between mathematical theory and experimental observation. Using 140 detailed text figures and references to over 757 primary sources, it is easy for the reader to start having serious doubts regarding randomness: 'What is really random, anyway?' This theme and the worthiness of chaotic modeling of real-world systems is emphasized in the first chapter, "Introduction."

Chapter two, "Differential Equations, Maps and Asymptotic Behaviour," details the theoretical time evolutions of systems ranging from stationary points and periodic oscillations to quasi periodicities and chaos (the new definition). The dual concepts of bifurcation behavior in time and geometrical attractors in space are discussed using the logistic equation that has been exploited in various biological contexts. An introduction to ergodic theory is also provided.

In chapter three, "Transition from Order to Chaos," Marek and Schreiber emphasize the importance of control parameters in steering dynamics through successive bifurcation points to the formulation of chaotic trajectories. Referring to many useful mathematical examples, several different flavors of bifurcations and various routes to chaos teach the dogma that deterministic complexity can arise out of unsuspecting simplicity.

"Numerical Methods for Studies of Parametric Dependences, Bifurcations and Chaos" is the title of the fourth chapter. Here the authors address problems such as solving ordinary differential equations, computing Lyapunov exponents and Poincaré sections for continuous orbits, reconstructing attractors from experimental time series, and estimating dimension and entropies of attractors. Presumptions and assumptions are made that the time series of interest exhibit stationarity over sufficient time to make the desired numerical measurements.

Turning from mathematical theory to experimental measurements, the authors embed the most references (303) in their longest chapter (77 pages), "Chaotic Dynamics in Experiments." Attention is given to nonlinear circuits (20 pages), mechanical and electromechanical systems (6 pages), solid-state systems (7 pages), nonlinear optical systems (4 pages), chemical systems (12 pages), biological systems (2 pages), and turbulent-flow systems (11 pages). Only about 3% of this chapter briefly touches upon biological chaos, and that without criticism.

Chapter six, "Forced and Coupled Chemical Oscillations - A Case Study of Chaos," constitutes a very theoretical and mathematical treatise (69 pages), the most complicated of any found in the book. One of the justifications for writing this chapter was the stated assumption that "forced chemical systems serve as simple experimental analogues of various dynamical systems arising at different levels of organization of living systems." This reviewer, who is a physiologist, is not so sure. The chapter is nonetheless useful if one wants to observe the integration of the authors' own experimental and numerical work.

In chapter seven, "Chaos in Distributed Systems, Perspectives," the authors attempt to review methods of studying deterministic chaos in spatially distributed systems. Interesting discussions of cellular automata and coupled map lattices are introduced for this purpose. The chapter ends with chaotic solutions to partial differential equations, and a perspective that the most significant applications of deterministic chaos may be in living systems. This latter statement is very strong, but not supported by the presentation of convincing biological examples.

The book ends with two appendices, "Appendix A: Normal Forms and Their Bifurcation Diagrams" and "Appendix B: CONT- A Program for Construction of Solution and Bifurcation Diagrams." The FORTRAN program is available through the Internet and is designed to help the interested user study bifurcation theory and chaotic dynamics.

Reflecting on the field of chaos in general and, more specifically, on the book by Marek and Schreiber, this reviewer cannot help but question, with Ruelle, the profitability of chaos. Over 60 years ago Einstein, Podolsky, and Rosen struggled with the concept of determinism in nature. The mistake that must be avoided is assuming that biological "determinism" is equivalent to mathematical determinism. Real life is not constrained to follow the rules of mathematics; some parallel lines do cross; some equations have multiple solutions; noise is not always uniformly distributed. In this context, for example, the gating of ion channels can be both deterministic (rule-based mechanisms of opening or closing) and stochastic (finite stochastic latchings in one state or another).

The book, *Chaotic Behaviour of Deterministic Dissipative Systems*, is an excellent compendium of numerous contributions to the field of chaos science, mostly from the 1980s. The tone and level of mathematical sophistication of the book are appropriate for the intended graduate audience, save the biologists. If the reader bears in mind Einstein's caution, "So far as the laws of mathematics refer to reality, they are not certain. And so far as they are certain, they do not refer to reality," the book reveals the continuing struggle to describe the physical universe in mathematical terms. Mathematical modeling is alive and well, but the mysteries of nature continue to surprise us at every turn.