at the same time, the book gives a rigorous and essentially complete account of the field while touching on several relevant topics in molecular biology, physics, and biophysics.

The story begins in 1676 with Antony van Leeuwenhoek's fascination at what he saw swimming around under his microscope. It proceeds into the modern era with detailed measurements of the behavior of swimming bacteria, as populations and as individuals, and ends with an account of a marvel of biological nanotechnology: the bacterial flagellar motor, nature's most sophisticated rotary electrical motor. Along the way, Berg reveals the molecular signaling network that allows *E. coli* to sense its environment and to navigate, propelled by its flagellar motor, using a strategy that has been optimized over evolutionary eons.

E. coli in Motion is slim, and its short chapters are further divided into sections that are seldom more than a few pages long. Its style is concise and to the point. It brings simplicity and clarity in plain English to subject matter that might otherwise be complicated and difficult. The book is not short of colorful illustrations. For example, Berg writes that "the neocortex in humans is a multilayered sheet of cells, about 1 millimeter (mm) thick, almost large enough to cover your desk top." And although the book draws links to other fields where appropriate, it is never wordy and never strays far from the central theme. Most technical terms are explained for the layperson, and Berg describes basic biology and physics that might have been assumed knowledge in a purely academic text. The conflicting demands of thoroughness and brevity occasionally lead to bare statements of fact (but always accompanied by references) that might leave the layperson none the wiser. Berg makes little attempt to woo the reader, preferring to lay out the facts and let them speak for themselves. This may be a deliberate challenge, expressed in the last sentence of the book: "Curiosity is the driving force of basic science."

E. coli in Motion should appeal to a variety of readers. It is an excellently written and entertaining story of modern interdisciplinary science, full of information and without hype or wild speculation. For the specialist, it is a mine of information. But perhaps most of all, the book is a case study for anyone interested in the field of quantitative life science. I most heartily recommend it to any mathematician, physical scientist, engineer, or biologist who wants to learn more about what physics and biology can do for each other.

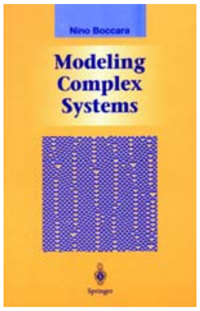
Richard M. Berry
University of Oxford
Oxford, United Kingdom

Modeling Complex Systems

Nino Boccara
Springer-Verlag, New York, 2004. $79.95 (397 pp.). ISBN 0-387-40462-7

Complex systems are ones with many strongly interdependent variables. This definition excludes systems with only a few effective variables, the kind found in elementary dynamics. It also excludes systems with many independent variables, the sort students learn to deal with in elementary statistical mechanics. Complexity appears where coupling is important—but doesn't freeze out most degrees of freedom.

Under the heading of complexity, physics journals now routinely publish papers on animal populations, botanical invasions, cardiac arrest, developmental biology, evolutionary games, finance, gene regulation,



historical linguistics, immunology, "junk" DNA, Kolmogorov complexity, learning machines, mass extinction, and so on—right up to Zipf's law. Yet there is no sound, introductory textbook on complexity, one from which students will absorb more valid insights than dubious metaphysics. Thankfully, Nino Boccara's *Modeling Complex Systems* is full of useful knowledge and free from odd notions about complexity.

Complex systems have been infiltrating physics for about two decades and have also crept into biology, computer science, and economics. They come from two sources that have led us to the recognition of computer simulation as an important tool to gain more knowledge about these systems. One source is dynamics, which involves studying the qualitative and effectively stochastic (that is, chaotic) properties of nonlinear systems; the other source is the statistical mechanics of critical phenomena. The study of criticality has taught us to derive large-scale order from local interactions and to expect that stylized models of those interactions would yield universally valid results. (Statistical mechanics of critical phenomena is underappreciated by nonphysicists because "fixed point of the renormalization group" sounds less intriguing than "strange attractor.")

The chapters in Boccara's book fall into three sections: the first contains two introductory chapters, the second contains three chapters on mean-field type models (part 1), and the third has three chapters on agent-based models (part 2). Every chapter contains a remarkable number of examples that mix classical and up-to-date models from many disciplines with physicists' contributions. Many of those contributions, such as the susceptible-infected-recovered model from epidemiology, recur throughout the book, revealing new aspects each time. The book's cornerstone is chapter 2, where Boccara gives a marvelous demonstration of how one models complex systems. He guides the reader through the construction of increasingly elaborate models of predator–prey oscillations in ecology, incorporating more and more sophisticated mechanisms of interaction and testing the results against stylized empirical facts. Much of the rest of the book elaborates the ideas presented in chapter 2.

The part on mean-field type models covers finite-dimensional global dynamics. Boccara, a physicist at the University of Illinois at Chicago, carefully states rigorous results of nonlinear dynamics, especially bifurcation theory, along with precise definitions of the concepts involved. He omits proofs and instead uses the theorems to analyze real models. The final part of the book, on agent-based models, delivers excellent, up-to-date chapters on cellular automata (Boccara's specialty), power-law distributions, and networks. Readers should know that Boccara defines "agent-based model" in a way that is different from, but ultimately equivalent to, the definition computer scientists or economists would give.

Chapter 8 on power laws deserves special mention: It gives cautionary examples showing how easy it is to mistake other things—for example, log normals—for power laws and offers a prophylactic introduction to statistical hypothesis testing. The book's cover promises deep thoughts on the nature of complexity, emergence, and so forth. Boccara wisely leaves these topics alone: Although interesting scientific work has been done on such issues, the science is quite advanced and is often obscured by a lot of fluff when discussed in other books. Instead, the author provides a guide to actual model building and covers an astonishing range of examples along the way.

Despite Boccara's broad scope, I was struck by three omissions. First, the author does not mention what one might call "traditional physics" complex systems: spin glasses, turbulence, polymers, and soft or far-from-equilibrium condensed matter. Second, Boccara's book has very little on the theory of information and computation— crucial components in meaningful complexity measures that are surprisingly underappreciated by physicists. Remo Badii and Antonio Politi's *Complexity: Hierarchical Structures and Scaling in Physics* (Cambridge U. Press, 1997) is a great but demanding guide to these subjects. Third, Boccara omits the subject of adaptation at the individual, population, or evolutionary level. Not even cases where physical methods have proved useful, such as understanding neural network learning, make it into the book. The best introduction I know to this subject is Gary W. Flake's *The Computational Beauty of Nature: Computer Explorations of Fractals, Chaos, Complex Systems, and Adaptation* (MIT Press, 1998), which is at a much lower mathematical level than Boccara's book. However, correcting these three omissions would have taken another 100 pages—at least.

The ideal audience for Boccarra's book is first- or second-year physics graduate students who have had a one-semester course in modern statistical mechanics and therefore would have some grasp of criticality, fluctuations, and correlation functions. Readers so prepared will find the book clear and well worth reading. *Modeling Complex Systems* should be the standard introductory textbook to the physics of complex systems for the foreseeable future.

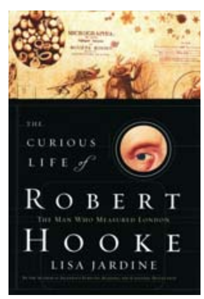
Cosma Shalizi
University of Michigan
Ann Arbor

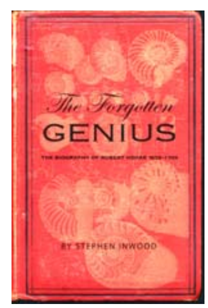
The Curious Life of Robert Hooke: The Man Who Measured London

Lisa Jardine
HarperCollins, New York, 2004. $27.95 (422 pp.).
ISBN 0-06-053897-X

The Forgotten Genius: The Biography of Robert Hooke 1635–1703

Stephen Inwood
MacAdam/Cage, San Francisco, 2003. $28.50 (482 pp.).
ISBN 1-931561-56-7





Robert Hooke has never really been forgotten. But he is usually remembered only as a peripheral figure of the scientific revolution, famous for his controversies with the great Isaac Newton or, especially in Great Britain, for being a minor colleague of Christopher Wren, the architect of St. Paul's Cathedral in London who also rebuilt the city after the great fire of 1666. *The Curious Life of Robert Hooke: The Man Who Measured London* by Lisa Jardine and *The Forgotten Genius: The Biography of Robert Hooke 1635–1703* by Stephen Inwood are both biographies by British authors, and Jardine's book