

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 Boccarra’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 Boccarra’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 Boccarra 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 mod-

els covers finite-dimensional global dynamics. Boccarra, 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 (Boccarra’s specialty), power-law distributions, and networks. Readers should know that Boccarra 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. Boccarra 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 Boccarra’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, Boccarra’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, Boccarra 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 Boccarra’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.

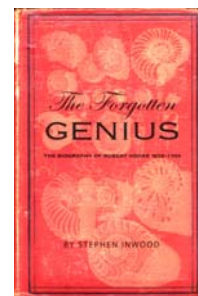
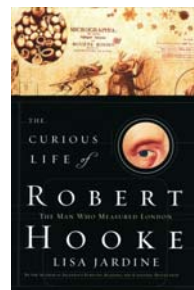
Cosma Shalizi
University of Michigan
Ann Arbor

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