quently from Krishnan as from her nemeses.

But after the first 90 pages, apart from a mildly interesting sub-plot involving sperm stealing, the novel takes a more mundane turn and becomes a description of the biotechnology business plan to capitalize on Krishnan's discoveries. The interesting human aspects of the characters, the inner conflicts of scientists succumbing to competitive drives and the temptations of commercialization, become secondary to the not-so-suspenseful fate of their stock options.

Overall, the reader is most likely to be gripped by the well-researched biology of *NO* and the "jouissance" derived from reading about the science of sex, a term that, according to Djerassi, was fashionable among undergraduates at Wellesley College, Massachusetts, *circa* 1970. □

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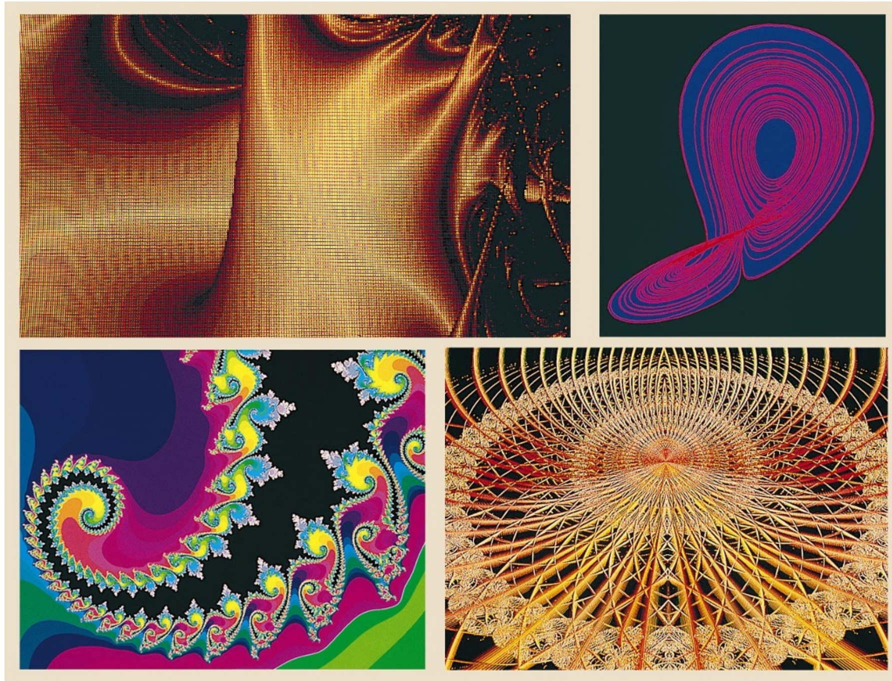

Out of the chaos: clockwise from top left are a Lyapunov space (used to study how enzymes break down carbohydrates), the Lorenz Attractor and fractal images entitled *Overseer* and *Scorpio's Tail.*

MEHAU KULYK, SCOTT CAMAZINE, , GREGORY SAMS,/SCIENCE PHOTO LIBRARY.

From chaos to complexity

Chaos Theory Tamed
by Garnett P. Williams
Taylor & Francis: 1997. Pp. 499. £19.95, $34.95

Dynamics of Complex Systems
by Yaneer Bar-Yam
Addison-Wesley: 1997. Pp. 848. $56

Michael F. Shlesinger

Chaos is no longer a new field. It has already been 35 years, and several generations of students, since Edward Lorenz discovered the strange attractor. Neither is chaos a fad or a dead end. It is based on the rock-solid foundation of physics, Newton's laws, and on tackling the nonlinear, non-integrable equations whose solution had to wait for an appreciation of unstable behaviour, new mathematical tools and the advent of computer visualization.

The thesis of Garnett Williams's *Chaos Theory Tamed* is that enough wisdom has accumulated to give an account of chaos theory mostly in words and pictures, without resorting to deep and sophisticated mathematics.

Williams is careful to focus on standard theoretical topics related to low-dimensional dissipative systems, and opts not to broach the rich, complex subject of Hamiltonian systems, thereby omitting topics such as the three-body problem and the strange kinetics associated with the fractal orbits-within-orbits of the standard and Zaslavsky maps.

Williams succeeds in his goal, with a carefully written, thoughtful exposition of standard topics (such as the logistic map, strange attractors, routes to chaos and Poincaré sections) and tools of the trade (including attractor reconstruction, Kolmogorov–Sinai entropy, fractal dimensions and Lyapunov exponents). Equations are included, but they are developed using careful discussion, rather than detailed mathematics. The first 158 pages of his book cover background information, including vectors, Fourier analysis, probability theory and time series. A good deal of discussion is given to the logistic map as a simple model to demonstrate many ideas of chaos. Those unfamiliar with the basic topics of nonlinear dynamics in dissipative systems would do well to study this friendly, self-contained book.

The success of nonlinear dynamics in handling chaos in systems with few degrees of freedom has led some to believe that these methods can be extended all the way to understanding complex social systems, such as economics, war strategy, psychology and city planning. But the ultimate success of the ideas of chaos in physics has been based on experimental verification of the existence of nonlinear instabilities and behaviours in well-controlled, repeatable experiments — in other words, the scientific method. Like the proverbial river into which one cannot step twice, one cannot repeat a social experiment, because the first experiment changes the conditions under which it was executed. But much can be learned, and a similar limitation has not deterred cosmologists.

Yaneer Bar-Yam's intriguing *Dynamics of Complex Systems* goes beyond chaos theory to the broader field of complex systems. He does not define complexity, but considers mainly systems with a large number of interacting parts, and seeks to discover pervading themes, such as memory, adaptation, evolution and self-organization, and then to model these phenomena.

The book begins with a 294-page introduction — a veritable book within a book — covering basic topics such as iterative maps, Monte Carlo techniques, random walks, phase transitions, activated processes and fractals. These topics form an extensive toolkit, providing the reader with the means to characterize, model and simulate aspects of complex systems.

In the body of the book, Bar-Yam begins with neural networks, then moves up the scale of complexity to protein folding, evolution, developmental biology and, finally, human civilization. The book does not try to have the last word on these vast fields, but introduces the reader to aspects that can be modelled and explored. Throughout, questions and their answers are folded into the text, and the many mathematical techniques and arguments are clearly presented. This book is an excellent place to start exploring the concepts and techniques of complex systems and provides an effective springboard to further studies. □

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