Bull. Math. Biol.

plausible models based on this idea. People often cite Winfree (1967) in this regard, but they are mistaken; that seminal paper deals only with populations of *circadian* oscillators.

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LITERATURE

Winfree, A. T. 1967. Biological rhythms and the behavior of populations of coupled oscillators. *J. theor. Biol.* **16**, 15–42.

Games of Life: Explorations in Ecology, Evolution, and Behavior, Karl Sigmund. Oxford University Press, New York, 1993. $45.00 hardback, ISBN 0-19-854665-3; $17.95 paperback, ISBN 0-19-854783-8, 250 pp.

The creator of *Games of Life* appears to have an inordinate fondness for puns and trivia, which abound at almost every leap of this wide-ranging frolic through the biomathematician's universe. But Karl Sigmund's word play is ingenious, and his trivia are both entertaining and educational (though a very few invite suspicion—for example, he attributes the invention of roulette to a French police officer, who must now join Pascal, the Chinese, a French monk and any other theories). Puns and trivia are John Casti trademarks, and one cannot ignore that Sigmund's book is from the same Vienna factory of applied mathematicians, but *Games of Life* is cast from a very different mould. Sigmund's style is earthier, more mischievous, more straightforward; whereas Casti is prone to genteel meanders, Sigmund darts nimbly off course to reappear just ahead. His sly humour enforces the mood: for games one should be playful, and this is a book about games and simulation.

It is also "a book on mathematics: more precisely, on the mathematics of evolutionary biology". It is not, however, a mathematics book; rather, it is a book about the essential insights that mathematicians have brought to biology with the use of abstract models, especially this century. Sigmund reveals those insights, and a few biographical details about the mathematicians, but he refers you to the library for the mathematics itself. This mathematics includes evolutionary games, nonlinear dynamics and stochastic processes (with an emphasis on discrete ones).

The book is divided into nine chapters. A short introduction reflects on the long and increasingly happy marriage between mathematics and biology,

comparing it with the more recent affair between mathematics and physics. Play begins in earnest in Chapter 2, with Sigmund's perspective on self-replicating automata and artificial life, and continues in Chapter 3 with a tour of population ecology and chaos. Much of this material is—like the iterated prisoner's dilemma in Chapter 8—already so widely known, through *Scientific American* columns and books by Douglas Hofstadter, James Gleick and others, that making it fresh is no mean feat. Sigmund manages very nicely (though I suspect that some readers—especially less literate, more pictorate, younger ones—will find the last two thirds of Chapter 3, where there are no figures, tougher going than it would have been with a few judiciously inserted phase-plane diagrams). By contrast, the raw material of the remaining chapters—on random drift and chain reactions (Chapter 4), population genetics (Chapter 5), evolution and sex (Chapter 6), evolutionary game theory (Chapter 7), and reciprocity and the evolution of cooperation (Chapter 8)—will probably be less familiar overall to the "potential or actual students" at which Sigmund primarily aims. By "shunning technicalities, formulae" and other ponderosi of limited appeal to such initiates, and by liberal use of reinforcing metaphors, Sigmund unfolds two thoroughly engaging panoramas on population genetics and evolutionary games.

As Sigmund acknowledges in his preface, he is not the first to deal with "questions of—literally—vital importance" in the spirit of a game. An earlier example of this approach is *Laws of the Game* by Manfred Eigen and Ruthild Winkler, which Knopf published in English in 1981. But although this book is very good, its scope is narrower than Sigmund's and it does not provide an entry to recent literature. Fully half of Sigmund's "voluminous" references are to works published no earlier than 1981, many during the last 5 years. The bibliography and endnotes are attractive features of the book, but I do have one minor quibble: I see no reason to use asterisks—frequently four or five to a page—for endnote references, with part of the text repeated for identification. This scheme leads to errors of omission—e.g. the last endnote of p. 86 or the first of p. 100—that would be far less likely if demure endnote numbers were used instead.

To conclude: *Games of Life* is splendid bait for luring the naïve into the practice of mathematical biology, and enjoyable reading for those who are hooked already. It is a compact, affordable, witty, informative, thought-provoking, nontechnical and up-to-date perspective on the art of modelling in ecology, evolution and behaviour. It is not a main course. But it is a masterful horsd'œuvre.

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