Thoughtplay

Games of Life. Explorations in Ecology, Evolution, and Behaviour. KARL SIGMUND. Oxford University Press, New York, 1993. viii, 244 pp., illus. $49.95 or £30; paper, $17.95 or £9.95.

There is a style of popular scientific writing that draws its narrative energy from the personalities of a few prominent scientists and the drama that flows from their obsessions. The best of this genre are well worth the attention of students and practitioners of science, but these readers are also well served by something a little meatier, in the manner of George Gamow or Erwin Schrödinger in their "popular" mode. Karl Sigmund's *Games of Life* is firmly in this latter tradition, though it does contain a few (quite entertaining) biographical asides.

The book is a semipopular account of theoretical evolutionary biology, with an emphasis on behavioral phenomena and on game-theoretical methods. The tone is genial and playful. Although the book is about mathematical ideas, Sigmund has opted to avoid explicit mathematics (equations). Presumably this is meant to make the book more palatable to a readership of biologists, but there are a few spots in the book where an equation or two would make the argument a lot more transparent.

Sigmund introduces his book with a spirited defense of the use of mathematical thinking in the context of biological problems. He reminds us, for example, that Mendel was a student far less of biology than of mathematics, and later in the book he goes so far as to suggest that Mendel's mathematical training accounts for the otherwise enigmatic circumstance that it was he and not his contemporary Darwin who laid the genetic foundation that was to support Darwin's own ideas. As one is carried along by Sigmund's persuasive account here, nothing seems more natural than to apply mathematical thinking in biology—one can almost imagine the day when a semipopular book on mathematical biology will contain a few equations.

For Sigmund, mathematics is the essential tool of the thought experiment, the exploration of the explanatory power of some *what if?* proposition. Of course, this is the stuff of deducing phenomena from hypotheses of mechanism and process—of theoretical science itself. But as Sigmund points out, this activity is very close in spirit to play, to games of *let's pretend*. The book has chapters on the mathematical theory of games, but it explores many other games as well, such as a penny-matching game between parasite and immune system as an explanation for sex and dice and card games to describe molecular evolution. Throughout the book, Sigmund plays with the word *play*, exploring the surprisingly many ways in which it is used.

The overall scheme of the book has some inspired touches. Sigmund begins with a chapter on artificial life, to my mind an appropriate acknowledgment of the fundamental role in evolutionary biology of this relatively new discipline. The object of research in artificial life is "to build models that are so life-like that they would cease to be models of life and become examples of life themselves," in the words of artificial life pioneer Chris Langton. The roots of such work lie in John von Neumann's concept of self-replicating automata. Sigmund's explication of this concept, one of many expository gems in the book, is the most lucid and forthright I have seen in print. His sketch of the proof by John Conway (with the help of numerous computer hackers) that even Conway's utterly simple game of "Life" provides enough material to build self-replicating automata is, at least to this reader, truly awe-inspiring. However, it seems hard to justify omitting to discuss in similar detail Thomas Ray's "Tierra" program, which is so startling in its spontaneous creation of recognizable biological phenomena and so relevant to Sigmund's overall theme that it actually is mentioned a couple of times later in the book.

In another inspired choice, Sigmund includes a chapter on probability theory, something that many scientists use in their work but take far too much for granted. The chapter is a very fine overview of the role played by randomness in evolutionary theory. It works out some of the implications for the structure of the genetic system itself of errors in replication and develops the rich body of thought that flows from the simple notion of neutral mutation. However, I was a little disappointed that Sigmund gives short shrift to relevant foundational issues in probability theory. For instance, he provides a marvelously bewildering list of probabilistic paradoxes, without any explanation beyond a reference to another book. I suppose he did not want to violate his pact with himself to avoid equations, but at this point Sigmund leaves his reader feeling a little frustrated.

In the following chapters, Sigmund discusses population genetics, the evolution of sex, game theory applied to conflict, and game theory applied to cooperation. The entire chapter on the evolution of cooperation (a subject on which Sigmund and some of his students have made significant contributions) is a masterly overview and could well serve as an update for those who enjoyed Robert Axelrod's book on the subject. The chapter culminates in news both good and bad. The good news is that all the further work, in the decade since Axelrod's book, on games with two players has confirmed the robustness of the evolution of cooperation. The bad news is that in games with more than two players, using different strategies, the more players there are the more difficult it is to achieve cooperation. There is no easy answer to the tragedy of the commons.

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