Vignettes: Foundations of Economics

Taking a risk is not always the result of a calculation—far from it. Already in economic affairs, as Keynes pointed out, "If human nature felt no temptation to take a chance, no satisfaction (profit apart) in constructing a factory, railway, a mine or a farm, there might not be much investment merely as a result of cold calculation." A little further back he declared that "when enterprises were mainly owned by those who undertook them or by their friends and associates, investment depended on a sufficient supply of individuals of sanguine temperament and constructive impulses who embarked on business as a way of life, not really relying on a precise calculation of prospective profit."

—*Ivar Ekeland*, in *The Broken Dice and Other Mathematical Tales of Chance* (University of Chicago Press)

The moral and ethical content of economics instruction was . . . once much more explicit than now. It has not been absent in the mainstream economics of the past quarter century. Rather, it has been largely unacknowledged, as many modern economists contend that the prevailing paradigm in their field is or could be made to be value-free. . . . Economics, as practiced by an overwhelming majority of economists, is in fact fundamentally based on the value judgment that individual preferences should count in the allocation of society's scarce resources.

—*Malcolm Gillis*, in *Ecology, Economics, Ethics: The Broken Circle* (F. Herbert Bormann and Stephen R. Kellert, Eds.; Yale University Press)

that have been promulgated. One such, for example, is the so-called rational model. Here a particular technology is conceived of as emerging from a process in which the historical actors are aware of a choice of goals and in which the consequences of choosing a certain option can be judged accurately. Making a choice then leads to the technology that optimizes the trade-off between costs and benefits. But the papers in *Choosing Big Technologies* support a large body of other writings that suggest strongly that the rational model is hopelessly inadequate. In his introduction to the volume John Krige eschews general models and suggests instead that the choice of a technology or technological program is the "negotiated outcome of a sequence of mini-decisions taken against an ever changing background of scientific and technological knowledge and of social, political, and financial constraints." When, however, the intended outcome of the negotiations is ambiguous, as in the cases of ELDO and U.S. remote-sensing satellites, the results can be problematic at best.

A few papers in *Choosing Big Technologies* are overburdened by detail and are not lightened by the posing of general questions, the raising of comparative issues, or linkages to broader literatures. In a short introduction and longer afterword, Krige and Roger Williams respectively try gallantly to pull together the various strands, but in the end the collection, as such collections usually do, stands as something of a hodge-podge. *Choosing Big Technologies* nevertheless presents a rich series of case studies and lots of food for thought for engineers, scientists, and policy-makers, as well as those seeking to understand the ways some sorts of big technologies have helped to shape the history of the late 20th century.

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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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Molluscan Dwellings

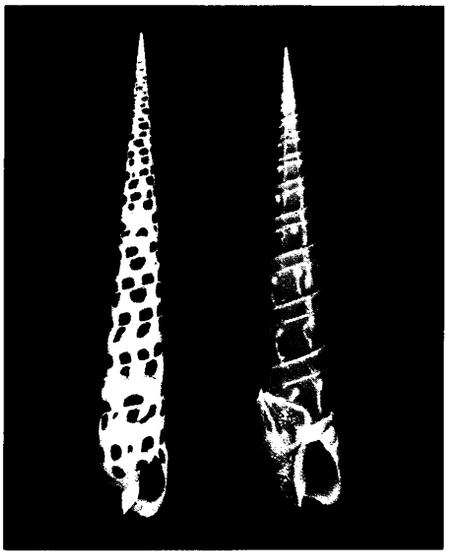
A Natural History of Shells. GEERAT J. VERMEIJ. Princeton University Press, Princeton, NJ, 1993. viii, 207 pp., illus., + plates. $29.95 or £22.50.

"I like shells." Vermeij's opening line is an understatement of his continuing love affair with shells. But his interest and affection have never focused just on aesthetics. There is always an undercurrent of appreciation for their beauty, but it is the interplay of function, design, and evolution that has been the hallmark of Vermeij's respected earlier works. This book approaches shells with a similar perspective and arranges the treatment in an interesting way: as though the author were evaluating house construction. From building materials, design, construction, maintenance, and defense to geography and economics, just about every aspect of molluscan shells is included here. It is a very readable, personal account, and references are kept to a minimum (this is in considerable contrast to Vermeij's earlier books, whose reference compilations I have always prized).

The first third of the book explores design, geometry, and construction, with obligatory coverage of torsion, coiling handedness, and geometry (curiously mentioning David Raup's elegant approaches to the analysis of shell form only by way of a reference). A cost-benefit analysis of shell materials skims overs the energetics of calcification, stressing such topics as the cost of including organic matrix in shell and the cost of thick shells or complex geometries. Similar examinations of the benefits of calcite (harder and less soluble) over aragonite as a building material and the protective value of a thick periostracum set a tone of "If there's a form there must be a function" that continues throughout the book. But Vermeij makes clear that mollusks just don't always do what they are supposed to—for example, many cold-water gastropods' shells are aragonite, and there are many warm-water calcite shells.

Shell mechanics, predation, and adaptation make up the central part of the treatment and are the subjects with which Vermeij is most at ease. His review of the form, function, and ecology of gastropods is heavily laced with specific examples. The review of morphological adaptations (in mostly shallow-water ecosystems) is not as complete as the coverage of predator strategies and the morphological responses of prey that have evolved.

The third major theme is the Tertiary historical biogeography of marine mollusks,



Apertural views of (left) *Terebra areolate* (Terebridae) from Luminau Reef, Guam, and (right) *T. guttata* from Majuro Atoll, Marshall Islands. "The orange shell of *T. guttata* is exceptionally high-spired. The high-spired spotted shell of *T. areolate* has a repair mark indicating an unsuccessful predation attempt by a calappid box crab." These specimens are slightly over 100 mm in length. [From *A Natural History of Shells*]

Gaping view of *Spondylus* sp., from near Koror, Palau. "Long spines extend beyond the valve margins, which are crenulated on their inner edges. All spondylids live attached to rocks. This specimen is 69 mm in height." [From *A Natural History of Shells*]

followed by essay-like treatments with catchy headings like "the evolution of enemies," "economics of specialization," and "the evolutionary history of the housing market," covering molluscan evolutionary responses to constraints imposed by their design, life-styles, and, of course, predators.

Can *Homo sapiens* learn anything from the history of shells? Vermeij thinks so (p.