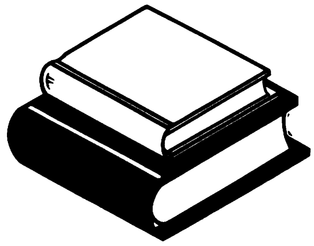
the proof by John Conway (with the help of numerous computer hackers) that even Conway's utterly simple game of "Life" provides enough material to build self-replicating automata is, at least to this reader, truly awe-inspiring. However, it seems hard to justify omitting to discuss in similar detail 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.

Peter Yodzis
Department of Zoology,
University of Guelph,
Guelph, Ontario N1G 2W1, Canada



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.

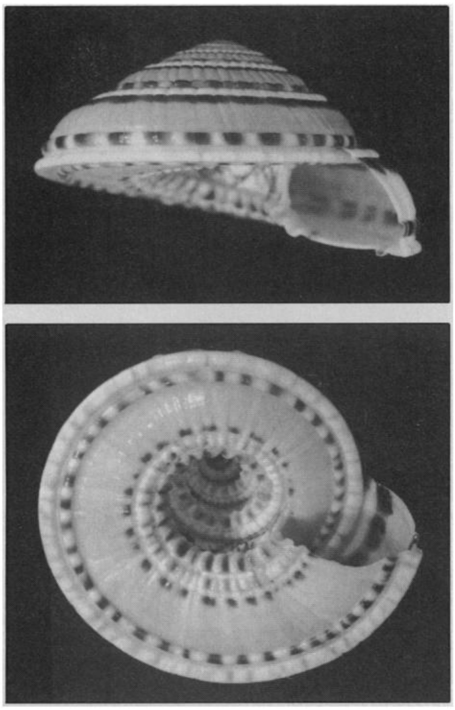
The third major theme is the Tertiary historical biogeography of marine mollusks,

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.



Architectonica perspectiva from Nosy-Be, Madagascar. "This snail lives in the sand, and is often found on poisonous zoanthids. Eggs are brooded in the broad umbilicus. Top, Lateral view of shell; bottom, ventral view showing umbilicus. This specimen is 34 mm in diameter." [From *A Natural History of Shells*]

197): "Molluscan shells offer a particularly rich chronicle of economic life and times of the past . . . day-to-day travails and successes of their builders . . . risks, costs, and benefits." In the history of mollusks, he points out, intervals of success and growth have been brief and rare, followed by long periods of stability and decline. High energy and resource dependence set up susceptibilities to physical crises; molluscan history reflects many such interruptions and provides a warning (p. 199) that "improvements in resource acquisition come at the expense of others in a society or an ecosystem subject to resource limitation."

No shell book can, I suppose, be published without pictures; this one provides excellent photographs, both in color and in black and white. Each specimen is carefully documented as to geographic source and size, but, alas, there is no mention of their ecological circumstances (for example, water depth or bottom type). The diagrams accompanying the text have little impact. Every shell book has a taxonomic burden, and common names are often included. Not here, and there is a rather strong presumption that the reader has a thorough knowledge of gastropod species, genera, and families.

All in all, this is a highly informative and readable review of themes that will be familiar to those who already know Vermeij's work. For those unfamiliar with his many contributions, it is a well-written, even philosophical introduction, overview, and synthesis.

W. Bruce Saunders
Department of Geology,
Bryn Mawr College,
Bryn Mawr, PA 19010, USA

Probing Biological Surfaces

STM and SFM in Biology. OTHMAR MARTI and MATTHIAS AMREIN, Eds. Academic Press, San Diego, CA, 1993. xii, 331 pp., illus. $69.95 or £54.

Twelve years have passed since the invention of the scanning tunneling microscope was reported by Binnig and Rohrer, and half that many years since Binnig, Quate, and Gerber introduced its cousin instrument, the scanning force microscope. In the intervening years, STM and SFM have had a large impact on many areas of physics, chemistry, and biology, and they are still developing at a vertiginous rate. More than a dozen different types of probe- or tip-based microscope exist today, and still more are likely to emerge. This proliferation of related methods best illustrates the unprecedented control of space first made possible by the original probe-piezo electric design.

In no area has the excitement about this new generation of microscopes been greater than in biology, for the operation of these instruments is not restricted to artificial or unnatural environments. This book attempts to put into perspective the biological applications of both STM and SFM. The task is not an easy one. The reason is twofold: First, it has been in biology that the applications of STM have been the most controversial. Second, the rapid growth of the applications of SFM in biology makes it very difficult to provide an account, in book format, of the current state of the field.

Each of the contributions to this book is largely self-contained. In the opening chapter, which constitutes about 40 percent of the book, Marti provides an in-depth description of the theoretical and technical principles underlying scanning probe microscopy, with special emphasis on STM, SFM, and scanning near-field optical microscopy (SNOM). It is an excellent synthesis and provides good access to the most relevant literature, but the presentation is formal, and the chapter is clearly directed to the professional interested in acquiring a general background in the physical foundations of these techniques. The chapters that follow discuss only those STM applications that have proved to be both reliable and reproducible. Among these are imaging of electrochemically deposited nucleic acids and proteins, high-resolution imaging of monolayers of liquid crystalline arrays of molecules, and imaging of proteins and membranes at high tip–sample bias voltages. A concise but rigorous account is given of the technical aspects and current limitations of each area. The final two chapters are dedicated to the biological applications of SFM, addressing the main issues encountered by the experimentalist using the microscope on biological samples. A clear effort has been made throughout the book to address methodological issues and maintain an analytic stance rather than simply giving an exhaustive but superficial review of the literature.

Although the individual chapters succeed at their tasks, the book as a whole projects a somewhat skewed perspective of the field in that most of the chapters are dedicated to STM even though it is becoming increasingly apparent that further developments in the applications of STM in biology may be difficult, owing primarily to the low conductivity of the samples. In fact, STM may never leave the specialist's laboratory to become a tool of general use in the broader biological community. It is SFM that is currently yielding the greatest number of biological applications and is likely to continue to do so in the future. Yet it is only during the last year and a half that reports have appeared on such important developments as reliable imaging of biomolecules under air and aqueous solutions, the implementation of the tapping mode of operation of the scanning force microscope, and new methods of deposition, specific labeling of macromolecules, and tip fabrication.

In sum, this book provides a good overview of both the physical foundations of scanning probe microscopy and the more technical issues involved in its applications in biology. It is a useful reference that nicely complements more circumscribed reviews that are better designed for hitting fast-moving targets.

Carlos Bustamante
Institute of Molecular Biology,
University of Oregon,
Eugene, OR 97403–1229, USA

Books Received

Ars Magna or the Rules of Algebra. Girolamo Cardano. T. Richard Witmer, Ed. Dover, New York, 1993. xxiv, 267 pp., illus. Paper, $8.95. Translated from the Latin edition (1545) by T. Richard Witmer. Reprint of *The Great Art or the Rules of Algebra* (1968).