

BOOKS

On the Emergence of Life, Terrestrial and Otherwise

Stepping Stones: The Making of Our Home World

▶ Stephen A. Drury
Oxford U. P., New York, 1999.
432 pp. \$35.00 hc
ISBN 0-19-850271-0

The Search for Life on Other Planets

▶ Bruce Jakosky
Cambridge U. P., New York, 1998.
336 pp. \$64.95 hc (\$20.95 pb)
ISBN 0-521-59165-1 hc
(0-521-59837-0 pb)

Planetary Dreams: The Quest to Discover Life beyond Earth

▶ Robert Shapiro
Wiley, New York, 1999. 306 pp.
\$27.95 hc ISBN 0-471-17936-1

Received by Andrew H. Knoll

In 1976 two Viking spacecraft landed on Mars. Sent to search for life, they revealed instead a forbidding landscape, unlikely to support biology. Interest in extraterrestrial life, brought to full boil by Viking's launch, was left to simmer on a decidedly back burner. It didn't cool completely, however, in part because of images supplied by Viking itself. Channeled landscapes and other geomorphological features indicate that four billion years ago—about the time that life emerged on Earth—Mars was not the bleak pile of rocks observed today but rather was a planet blessed with liquid water, active volcanoes, and, in consequence, widespread hydrothermal systems. Four billion years ago Mars may have been a habitable planet.

Biological interest in the solar system, sustained for two decades by a small but committed band of scientists, returned to prominence in 1996 with the publication of the extraordinary claim that ALH-84001, a grape-

fruit-sized meteorite from Mars, contained evidence of an ancient Martian biota. Astrobiology was reborn, and despite widespread skepticism about the meteorite story, space exploration is likely to continue to have a biological cast for years to come. Three recently published books mark this sea change.

Most Earth-bound of the three is Stephen Drury's *Stepping Stones*, a history of the Earth organized around the theme of biological evolution. Long ignored as an epiphenomenon by geochemists and geophysicists who were focused on planetary differentiation, biology is now viewed as a critical component of Earth's surface system. Drury's exegesis of this new worldview begins with serial introductions to fluid circulation, biochemistry, plate tectonics, and Milankovitch cycles.

His explanations are lucid, but would be demanding for a general readership. (Drury's target audience is not always clear). Armed with knowledge of interacting biological and physical processes, the reader is taken on a tour of Earth's history, from the emergence of life to the rise of technological humans (poisoned, in Drury's view, by capitalism). Drury is strongest when reconstructing geological events from field evidence. His accounts of biology and paleobiology are generally good, although not free of error. To cite one example, his digest of Cambrian animal diversification is inexplicably muddled, advancing, among other things, the demonstrably false notion that carbonate rocks were rare before the evolution of skeletons. Astrobiology *per se* gets little notice, except in cynical dismissal: "But even if Mars did once host life, so what?"

So what, indeed! If life is born of planetary processes, then it may arise wherever the right conditions obtain. And if biology can emerge through time as a set of globally important processes in its own right, we are encouraged to think that, where it is persistent, life will leave an interpretable signature. This logic is laid out clearly in Bruce Jakosky's contribution. Written as a textbook for undergraduate courses in astrobiology, *The Search for Life on Other Planets* provides a well-illustrated guide to

the biological universe. To skeptics, that universe consists of Earth and speculation; to Jakosky, it comprises Earth and exploration.

Like Drury, Jakosky begins with rudiments of Earth science and biology, but he quickly moves on to Mars, summarizing Viking results and the ALH-84001 debate. Future exploration of Mars is given brief but positive notice, as is the more debatable prospect of altering the surface of our planetary neighbor to make it more Earth-like. Venus, Titan, and, of course, Europa, round out the tour, garnished by musings on intelligence and philosophy. So much for the "so what?" of Drury.

Jakosky's book will serve courses well, but it is not a volume that I would expect to kindle excitement in my next-door neighbor about astrobiological exploration. For that, there is Robert Shapiro's *Planetary Dreams*. Shapiro is the best communicator of the three, and it shows in his lively discussions of two nearly incomprehensible things: time and space. An origin-of-life skeptic, Shapiro is more impressed by the lacunae in our understanding than by experimental insights. Despite this, he sees life as the expected outcome of planetary processes that are thought to occur widely in the universe. Those who view life as the rare product of improbable events are lampooned as "sour lemons."

Of course, given a sample population of one, it isn't clear whether it is logic or faith that separates the two camps. Shapiro advances astrobiological exploration as a means of settling the issue, but there is a problem: The biology most likely to be widespread in space is microbial, but we can search for microorganisms or their biogeochemical effects only in our immediate astronomic neighborhood. Astrobiological exploration of the broader universe is limited to a search for intelligent life, certainly a relatively—and possibly absolutely—rare phenomenon.

That multibillion dollar programs have political as well as scientific dimensions is acknowledged but not convincingly addressed by Shapiro. He ascribes post-Viking decay of planetary exploration to congressional budget cuts, although NASA was well

ANDREW H. KNOLL is a paleontologist interested in the early evolution of life on Earth. He is a professor of biology at Harvard University and a member of the NASA Astrobiological Institute.

supported during the period in question; it simply (and regrettably) chose to focus on the shuttle and international space station. Shapiro further sees no reason why funding human exploration of Mars should conflict with worthy social goals, despite a price tag conservatively estimated at 25 billion dollars. In the end, then, *Planetary Dreams* is a reverie on what might be: elsewhere—if some certain future comes to pass, if some certain worldview turns out to be correct, if some budgetary genies materialize from the ether, if... It would be churlish to condemn dreams, but the conversion of dream to discovery requires hard facts and concrete plans that are not much in evidence.

Quo vadis astrobiology? Drury, Jakosky, and Shapiro each provide thoughtful parts of an answer, but none succeeds fully in capturing the excitement, promise, and deep uncertainties of nascent astrobiology. For that we must await the next wave of explanations, already starting to appear on bookshelves.

Astronomy in Prehistoric Britain and Ireland

Clive Ruggles
 Yale U. P., New Haven, Conn.,
 1999. 285 pp. \$65.00 hc
 ISBN 0-300-07814-5

Behind Clive Ruggles's simple and geographically circumscribed title—*Astronomy in Prehistoric Britain and Ireland*—lies an exceptionally important, wide-ranging, and critical contribution to the field that has come to be called "archaeoastronomy." His professed aim is "to bring the wide range of people interested in prehistoric astronomy to a common starting point." His deceptively modest goal in fact hides a daunting project. This area of inquiry into the true significance of stone circles, "henges," isolated megaliths and other archaeological monuments that have been associated with prehistoric astronomy straddles archaeology, astronomy, and the often forgotten component of statistics, to mention only the main contenders. The very different prerequisites and approaches of these fields, as well as partial ignorance or selective use of them, have led to much miscommunication and many misunderstandings among the specialists whose paths intersect with prehistoric astronomy. A "common starting point" would indeed be first among

the desiderata for a field impaled, as Ruggles suggests, on C. P. Snow's "two (or three?) cultures."

Consistent with his aim, Ruggles's approach is at once foundationalist and pedagogical: What can we know with reasonable certainty about megaliths to which astronomical powers have been ascribed, if this knowledge is filtered through the best tools and insights that all three fields offer? And how can one demonstrate this common ground to the satisfaction of people from very different fields? Once trained in mathematics and astrophysics, Ruggles is now a senior lecturer in archaeology at the University of Leicester, UK, and therefore admirably suited to the cross-cultural task he envisions. Sprinkled throughout his chapters are not only many illustrations, maps, charts, and graphs, but also three categories of shaded one-to-two-page "boxes" that introduce the reader to the fundamental concepts of astronomy, archaeology, and statistics relevant to archaeoastronomy. Although these pedagogical capsules break up the chapters, they allow Ruggles to familiarize specialists in one area with the vocabulary, strengths, and limitations of the other two.

The tripartite structure surveys the entire field rather than any single archaeological monument or class of monuments. Part I ("Past Directions") combines a history of archaeoastronomy with a sharp critique of its pre-1980 conclusions and methodologies. This is passionate contemporary history, recounted by one of the most active participants in it. These early years, epitomized in Alexander Thom's concept of the monumental "observatories" distributed throughout the British Isles (*Megalithic Observatories*, Oxford, 1971) generated claims about astronomical alignments as precise as 1–2 arcmin. These amazing claims rested on the seemingly unimpeachable foundations of empirical fieldwork and statistics, the neglect of the archaeological context notwithstanding. As Ruggles demonstrates, however, such conclusions are derived unwittingly from selective alignment data that vitiated the non-randomness of Thom's statistics. A critical reexamination of this material (including massive new surveys of several hundred monuments) reintroduced much randomness into many alignments and effectively undermined Thom's claims for a high-precision astronomy, geometrical reasoning, a megalithic calendar, and a megalithic metric. Without under-

standing Thom's computations, many archaeologists already suspected as much, since such astonishing achievements clashed with the pre-literate culture inferred from the archaeological record.

For these colleagues in particular, Ruggles is at pains to argue that archaeoastronomy has changed. Part II ("Present Directions") draws on impressive empirical data from his own and others' fieldwork during the last fifteen years to show how. His context-sensitive examination of monuments in specific locales (notably three hundred West-Scottish recumbent stone circles, dozens of Irish axially oriented stone circles in Cork and Kerry, and dozens more Irish and Scottish stone rows) offers conclusions consistent with the methodological critique of Part I. The statistical analysis roughly correlates the overhead full moon with the orientation of the reclining stones found in the many Scottish circles, but shows no significant correlation in the axial stone circles.

Imprecise celestial alignments, therefore, guided the design of some monuments, but astronomy was arguably not the sole, or even the main, purpose of these monuments as a group. Indeed there are good reasons to doubt that alignments with the horizon were the dominant feature of these stone monuments. Against Thom's advocacy of a single megalithic astronomical culture, Ruggles uses his field data to reinstate the importance of local traditions and place-specific responses to the landscape, and, as always, to plead for attention to social and cultural context when drawing conclusions about the monuments.

In Part III (Future Directions"), Ruggles outlines a research agenda that avoids archaeological dismissals of archaeoastronomy (often based on pre-1980 work) and the older, archaeoastronomical fixation on decontextualized data. To the most diffident of his archaeologist colleagues, Ruggles presents a compelling case for the importance of questions about astronomical practices in ancient civilization. As he notes, the night sky was not only a crucial part of the natural environment of early civilizations, but virtually the only such element that we can reconstruct with great confidence. It would be rash indeed to turn one's back on such knowledge. Conversely, before the universalizing tendencies of his physical science colleagues, he pleads for sensitivity to the particular, the local, and the time-bound—and