HOPE FOR MIND ON EARTH

Earth System Analysis for Sustainability. Hans Joachim Schellnhuber, Paul J. Crutzen, William C. Clark, Martin Claussen, and Hermann Held, eds. MIT Press, Cambridge, MA, 2004. 454 pp. $38.00 (ISBN 0262195135 cloth).

This is a hopeful work. Hope shines through despite the litany of worldwide environmental worries that the book documents. Hope chimes out despite the conclusions of many contributors that the biosphere is so highly nonlinear and supercomplex that we—the human enterprise—will have to make tough decisions about the future in the face of tremendous uncertainty and limits to our analytic and predictive powers.

The volume is the edited product of a Dahlem workshop held in Berlin in 2003. Dahlem workshops gather top scholars for week-long interdisciplinary retreats that avoid formal presentations so that the 40 lucky participants can jump into the depths of their collective knowledge, using previously circulated position papers as springboards. Published papers resulting from these workshops are put through a rigorous review process, as are the group reports, which in this case are outstanding.

Readers of *BioScience* will be familiar with the title concept of sustainability, which Clark, Crutzen, and Schellnhuber, in the introduction, call the "most recent big idea in the history of the Anthropocene." ("Anthropocene" proclaims a new geologic epoch in which humans are a planetary force.) But what about the other term in the book's title, "Earth system analysis"? This conceptual frame-

work treats the biosphere as a self-organized, interconnected whole that is simultaneously biological, chemical, and geological. What's new here, to my mind, is the full inclusion of humans (also called the "anthroposphere" in this book) within Earth system analysis. The result is a suite of papers that range from the origins of life and astrobiology to requirements for new forms of human institutions and, in a sense, even new forms of mind.

The four papers of the first section tackle such questions as these: Is life an inevitable planetary phenomenon? And what are the major transitions in evolution? The effects of life on the chemistry of the biosphere (or Gaia system) are seen primarily as by-products of local selection (Volk 2003). But as the evolution of new kinds of metabolisms affected the global chemical matrixes of air and water, these matrixes in turn affected the subsequent evolution of life. Uncertainties in dating make it problematic to discern causes and effects in the coordinated system of biological and geochemical events over Earth's history. Yet overall, the group report about this coordination, by British biogeochemist Tim Lenton and coauthors, is the best state-of-the-art statement I have read.

The second section focuses on the Earth system during the late Quaternary, a period that roughly covers the last of several glacial cycles of 100,000 years each. In the group report, led by oceanographer Andy Watson of the University of East Anglia, we are treated to a picture of the Quaternary Earth as a system as complex as any symphony, with harmonies played out by vegetation, carbon dioxide, methane, dust, ocean circulation, and other system properties that rise and fall (or fall and rise) along with the global ice sheets. But just as we stand in awe trying to imagine the process by which Beethoven or Mozart composed, so the experts stand in awe before the dynamic, cyclic Earth during the ice ages. Indeed, the group report concludes that a main lesson gained from scientific efforts to understand the Quaternary Earth as a system is that we are now "aware of our own ignorance."

Paul Falkowski and Dan Tchernov of Rutgers University take us headlong into the Anthropocene in the third group of papers, with their intriguing piece called "Human Footprints in the Ecological Landscape." It is perceptive of them to emphasize the awareness of death as a factor in the evolution of culture (Volk 2002), a factor still, of course, in play today. This, as well as several other factors they cite, such as the desire to accumulate wealth, may have created the high degree of human cooperation that has led to humanity's runaway success story. We now not only rival natural processes as a biogeochemical force, as detailed by other papers in this Anthropocene section. We also threaten the stability of those natural processes.

The book's fourth and final section moves into sustainability itself, and thus into issues such as the relationship of science to public policy, institutional reform, and crises caused by globalization's

impacts on ecological interdependence. For me, one of the most interesting papers in the volume is Wolfgang Lucht's "The Mental Component of the Earth System." Lucht, at the Potsdam Institute for Climate Impact Research, proposes a "tetrarchical loop" between four mental components, which he calls GeoScope, GeoGraphy, GeoMind, and GeoAction. The loop involves large-scale social properties, such as observation and theory, knowledge and social contexts, governance, and identity (Lucht dares to suggest that we—again, the human enterprise—need to ask who we are and what we want to be in the future). Thinking about ourselves and using metacognition to examine the process of cognition is what truly made us, in an evolutionary sense, human (Terrace and Metcalfe 2005). If the unconscious coupling of desire and cognitive powers is a large contributor to global environmental problems, then becoming more conscious of our cognition and its effects is indeed what we need.

Environmental problems require mental solutions. We need to internalize the planet, to bring the biosphere home (Thomashow 2001). Developing metacognition on a global scale is also emphasized in the final group report by Arizona State University urban ecologist Ann Kinzig and coauthors, who use terms such as "global self-awareness" and "global will." Sustainability will require a complete Earth system analysis that takes into account not only biology, chemistry, and geology, but psychology and sociology as well.

Who is this book for? Who will benefit? Direct your favorite students, graduates, and bright undergraduates to this book and let them feast on their areas of interest. A few papers are too technical for anyone but disciplinary experts. Most, however, are excellent for an overview of a field, especially if you want to catch up on some ideas related to but not exactly coincident with your own.

In this book, great minds have assembled ideas into a system that reflects the complexity of the biosphere itself. Many of the authors reveal a sense of awe, humility, and concern, to which they have been led by their understanding. The mixture of expertise and emotion is heartening. The human mind is here on the physical Earth, and we can all hope it is here to stay. This can best be ensured by directing our minds to Earth as a field of knowledge—and to ourselves, because we are now part of the biosphere system. So doing will foster hope. In the closing words to this volume, our "dreams tell us not merely to persist but to thrive."

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