Review: Scientists Debate Gaia: The Next Century
Stephen H. Schneider, James R. Miller, Eileen Crist and Penelope J. Boston (Eds.)

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Stephen H. Schneider, James R. Miller, Eileen Crist, and Penelope J. Boston (editors) *Scientists Debate Gaia: The Next Century*. Cambridge, MA: The MIT Press, 2004, IX + 377 pp., ISBN 0-262-19498-8, (hardcover)

The Gaia theory proposes that the Earth's biological and geochemical systems work together to maintain the planet in a habitable state, a process of self-regulation that is the result of responses of its life forms to environmental disturbance and change over time. The first scientist to advance this concept of the biosphere was Vladimir Venadsky, a geochemist born in Kiev in 1863, whose scientific accomplishments have recently been re-evaluated. Jim Lovelock, an English atmospheric chemist, definitively introduced the Gaia hypothesis in the early 1970s, together with the American biologist Lynn Margulis.

After years of general scepticism, the idea that life substantially impacts the Earth's geochemical cycles in a way that favors living processes is now a flourishing theory, integrating views from many different branches of the sciences. A magnificent overview is this collection, *Scientists Debate Gaia*, which originated with the two "Chapman Conferences", held by the American Geophysical Union in San Diego (California) in 1988 and Valencia (Spain) in 2000.

The fundamentals of the Gaian assumption date back 3.5 to 4 billion years ago, when the first microorganisms were constrained in their evolution by the limits of an arid planet with a carbon dioxide-rich atmosphere. The original hypothesis involves biotic regulation of three main aspects of Earth's surface: temperature, acidity-alkalinity, and atmospheric composition. While it is clear that life affects the whole Earth's surface environment, greatly increasing the cycling of free energy, essential elements and water, the science of planetary ecology is still young and undeveloped. Nevertheless, good hypotheses generate good experimental and theoretical works, and this volume collects 31 lively contributions by researchers, environmental scientists, and science writers attempting to describe the evolution of living organisms and of their environment as a single, linked process.

After the introductory contributions by Lovelock and Margulis, the first chapter, "Principles and Processes"(p. 15-76), describes the mechanisms that regulate evolutionary processes and life's control on a global scale. The role of life in the development of Earth's biogeochemical cycles is a primary scientific question, thus the second chapter, "Earth History and Cycles" (p. 77-147), analyses the self-regulation routes that in earliest eras provided the biosphere with phosphorus and other resources. Chapter three, "Philosophy, History, and Human Dimensions of Gaia" (p. 151-227), discusses precursors of the Gaian theory in natural science, including Darwin's last publications. The fourth chapter, "Quantifying Gaia" (p. 229-305), examines the so-called Daisyworld model developed by Lovelock to demonstrate that the biosphere could theoretically regulate the climate system, in this case by modifying the lightness or darkness of the Earth's surface. Daisyworld has inspired scientists to study the feedback between biota and climate, showing that as the complexity of a system increases so does its ability to withstand disturbance. The fifth chapter, " Life Forms and Gaia: Microbes to Extraterrestrials" (307-364), deals with the co-evolutionary paths of life and environment, focusing on some specific examples like the Tinto River, the Amazon, and the NASA planetary biology internship program, in which the introduction of vegetation in a barren region is shown to create stabilizing climatic effects.

Life is complicated. T he concept of what is "habitable" has been broadened by discoveries of life in extreme environments on Earth, including organisms that require only liquid water and an energy source. However, more complex and recently evolved life forms have narrower habitability requirements, such as oxygen pressure higher than 0.002 atmospheres and temperatures lower than 50 °C. Several authors emphasize the enormous gaps in our knowledge about our planet and the life that transformed it, advising that we direct our attention toward better understanding.

As a whole the biosphere can be considered a "planetary-scale gradient reducer", but comprehending in detail how exactly this works is extremely challenging. While disagreement on facts lingers along with political disputes about the effects of human activities on climate and biodiversity, this volume—to be extensively recommended— represents a major step toward finding consensus on the concept of our planet as a living entity.

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