BOOKS: EARTH SYSTEMS

A Goddess of Earth or the Imagination of a Man?

Stephen H. Schneider

The independent scientist and inventor James Lovelock is best known as the progenitor of the Gaia Hypothesis. So it is little surprise that the origins, development, and reception of that theory form the central strand of his fascinating autobiography.

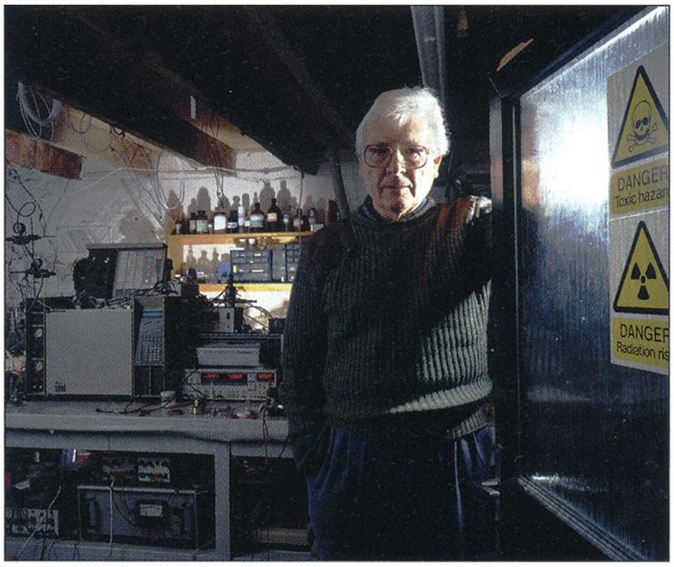
Homage to Gaia
The Life of an Independent Scientist
by James Lovelock
Oxford University Press, Oxford, 2000. 416 pp. £19.99. ISBN 0-19-286213-8.

Emerging from Lovelock's interaction with microbiologist Lynn Margulis (*1*), the Gaia hypothesis embraces the notion that Earth's living and nonliving components constitute a set of interactive feedback processes that reflect whole-system scale emergent properties—phenomena not likely to be revealed by disciplinary study of Earth's subsystems alone. Lovelock and Margulis suggested that through these interactions the biota made the physical environment more fit for life, a clear departure from earlier scientific ideas. The theory's name came from novelist William Golding, who told his neighbor Lovelock: "to propagate a large theory...you had better give it a proper name." And "Gaia" seemed better than, say, "the cybernetic theory of a homeostatic Earth."

Gaia is a "large theory," one further inflated by the claims of some of its advocates that it supplants Darwin's theory of natural selection. That assertion explains the often-hostile reactions from biologists, against which Lovelock repeatedly defends. He does accept some blame for the vehement reactions. "In the early days, we were somewhat outrageous in our statements. We had to be...like a neglected child who behaves badly...to attract attention. I used the metaphor of a living Earth provocatively to make some humorless biologists think I really thought the Earth was alive and reproduces. Of course, I did not." Eventually, Lovelock got more attention than he bargained for.

At the first American Geophysical Union Chapman Conference on Gaia (1988)—itself a controversial meeting because it addressed the topic as serious science (*2*)—geologist and philosopher James Kirchner quoted from various Lovelock and Margulis works over 15 years to demonstrate inconsistent implicit definitions of Gaia. Kirchner asserted that the weak versions (for example, "Influential Gaia") were already well known from research by T. H. Huxley, Vernadsky and others and the strong versions (such as "Teleological Gaia" and "Optimizing Gaia") were at best untestable (*3*). Lovelock confesses he was deeply angered by Kirchner's analysis, although he handled the situation with grace at the time. He has since let his feelings be known, and in *Homage* he calls Kirchner's arguments "sophistry."

Indeed, *Homage* is more a baring of the soul of the man than a physiological guide to the Earth muse [for the latter, see (*4*)].



At home in the lab. Lovelock carries out research from his village house on the edge of Dartmoor.

Despite some rambling, it is for the most part a beautifully written and deeply personal self-history. Lovelock traces his humble working-class upbringing, his early socialist-Quaker leanings, and his deprivations in war-torn England. He touches on his personal relationships and the medical struggles he and his family faced. He tells of his not-very-academic start as an inventor and chemist in a medical research establishment; his doctoral degree came later on, almost as an afterthought. Lovelock discusses his distrust of established science and its dogmas, and he describes the creation of amazingly clever inventions capable of precise micromeasurements. These accounts are juxtaposed against the evolution of Lovelock's mega-thoughts on emergent properties of Earth as a system. In spots, Lovelock's writing borders on the poetic.

But in *Homage*, the prose too often drifts into defensiveness, punctuated with bitter attacks on the "Greens" and "reductionist scientists" and their dogmatic social establishments. None of this is without some justification, which is backed by the experiences Lovelock relates in the text. And the narrow-mindedness of some academic disciplines or strident advocates is not unfamiliar to me either. Nonetheless, after several score I lost count of such (occasionally unbecoming) invectives against these targets.

This defensive stereotyping is particularly evident in the one-chapter history of the "Ozone War," in which Lovelock's celebrated invention, the electron capture detector, fueled the discovery of minute concentrations of trace industrial gases later hypothesized to be depleting ozone. The device rightfully earned many environmental prizes for its inventor. The sticky part is that Lovelock, whose independent scientific status included funding by chemical industries, was often looked at askance by those who noted the coincidence of this financial support and his (then) rather benign view of these emissions. I have previously described (*5*) conflicts with him over his early belief that Earth was resilient to human disturbances like ozone-depleting substances. I am gratified that Jim has transcended these early arguments on "resilience." In *Homage*, he recounts his courageous rejoinder to Mother Theresa's naïve assertion that we need "to take care of the poor, the sick and the hungry, and leave God to take care of the Earth." Jim replied, "If we as people do not respect and take care of the Earth, we can be sure that the Earth, in the role of Gaia, will take care of us, and if necessary, eliminate us."

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But the controversy that dominates *Homage* is between Lovelock and the group to which he turns to refute again and again: reductionist biologists. Lovelock's rejoinder to his Darwinist critics was the "Daisyworld" model he and his former student Andrew Watson constructed. His claims for this model, even within *Homage*, vary considerably. The caveat that it was "never intended ...to be more than a caricature" clashes with far-reaching assertions:

> Daisyworld is a synopsis of Gaia Theory. It shows how organisms evolving under the rules of natural selection are part of a system that is self-regulating....
> ...There is much at stake, for if Daisyworld is valid, then seventy-five years of neo-Darwinist science will need to be rewritten.

Daisyworld is a model planet having black and white daisies with separate fitness curves such that the black ones like it cooler and the white ones like it warmer. As the sun heats up over hundreds of millions of years, black daisies approach their optimum temperatures, become more fit, and thereby increase their numbers, causing the albedo (reflectivity) of the planet's surface to drop. This is a positive feedback, because while more sunlight is absorbed by the dark flowers the planet further warms. Black daisies increase until the temperature passes their fitness peak and moves into the fitness range for the white daisies. These then begin to multiply and replace the black daisies; this shift increases the planet's albedo, which serves as a negative feedback on further warming. The planet's overall temperature is stabilized for eons even though the sun inexorably increases its luminosity. But eventually, the white daisies are heated past their fitness range and can't resist further warming. The biota then collapses and temperatures rise rapidly to the level an inorganic rock would experience.

As a climate modeler, I am fully sympathetic with attempts to use simplified approaches to demonstrate basic principles. But relevance to Earth's history of principles suggested by virtual worlds requires empirical demonstrations that processes and parameters in the models have close parallels in the real world. Overall model behavior must be able to be matched against actual Earth behavior at comparable scales.

Lovelock and his supporters do not need Daisyworld and its nonempirical baggage to argue for emergent properties of complex biological-physical systems. Modern complexity theory is full of relevant examples, and the Gaians can proudly note their early recognition of emergence in Earth systems. But, as I argued at both Chapman Conferences, selection of surface albedo via daisies would, on the actual Earth, have little climatic influence because most of the surface is obscured by clouds and hazes. If we tweak a few parameters in Daisyworld to make it more like Earth, how much of the Gaian emergence would be suppressed? This criticism doesn't mean that some processes on Earth, once modeled credibly, won't have precisely the homeostatic characteristics Lovelock and Margulis predict. But the uncertainty is why we do the science; most answers are still out there, waiting for the next generation of Earth-as-a-system scientists to uncover.

In the meantime, we should credit Lovelock for such contributions as his early insight about Gaian emergence, the possibility of stabilizing feedbacks, and the stimulation of scientific debates that led to the uncovering of fascinating processes like algal emissions of dimethyl sulfide (which affect cloud albedo and may be a biotic feedback mechanism). These are accomplishments enough for any team, let alone an independent scientist.

Today, very few Earth scientists seriously doubt that there is emergence, as Lovelock and Margulis anticipated three decades ago. Moreover, the pair's persistent calls for serious scientific inquiry into bio-physical interactions at all scales in the environment, Lovelock's "geophysiology" (*6*), is a major spur to progress in understanding Earth as a system. It seems clear that the war to view Earth as a system is over. Now let's get on with the jobs of improving descriptions of natural systems and looking for emergent properties at all scales (being open to the likelihood that some will seem "Gaian" and some not). In the end, we will all know more about this fascinating life support system we have inherited. I warmly thank Jim Lovelock, Lynn Margulis, and the Gaia disciples for an important impetus in pushing us to look across all scales and processes for answers—even if, as is so often true in science, not all their original ideas will survive intact after a fair and dispassionate analysis.

References

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BOOKS: HISTORY OF SCIENCE

Culturing American Life

Audra J. Wolfe

In 1910, Charles Marlatt, acting chief of the United States Department of Agriculture's Bureau of Entomology, ordered the burning of two thousand cherry trees sent by the Japanese government as a gift to the city of Washington. Marlatt feared that the trees hosted a variety of parasitic organisms, which posed an immediate threat to American vegetation. The Imperial government had offered the trees in an act of cultural diplomacy—the Japanese would accept the so-called Gentlemen's Agreement to end Japanese immigration and the Americans would replace the elms in their nation's capital with oriental cherry trees. In authorizing the trees' destruction, Marlatt flexed newly acquired bureaucratic muscle and simultaneously expressed his philosophy of biological nativism. Two years later, when the Japanese government offered another shipment of trees duly inspected by the Imperial Quarantine Service, the Imperial Horticultural Station, and the Imperial University, the USDA accepted every one.

Biologists and the Promise of American Life From Meriwether Lewis to Alfred Kinsey
by Philip J. Pauly
Princeton University Press, Princeton, NJ, 2000. 329 pp. $29.95, £18.95. ISBN 0-691-04977-7.

Throughout *Biologists and the Promise of American Life*, historian Philip Pauly skillfully uses examples such as this one to recast the story of biology in the United States as cultural history. Authors of such histories of American biology usually turn to one of two familiar examples: eugenics or the teaching of evolution in schools. Although Pauly addresses these incidents as well, he expands the boundaries of the genre by examining a wide array of topics from national exploration and the culture of collection to sex education and scientific information syndicates. To do so, he confidently marshals lessons from international relations, environmental history, history of education, and even leisure studies. The result is a

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