Review

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Gaia in Turmoil: Climate Change, Biodepletion, and Earth Ethics in an Age of Crisis, edited by Eileen Crist and H. Bruce Rinker, foreword by Bill McKibben, The MIT Press, 2010.

Is Gaia a Theory, Hypothesis, or a Vision?

Introduction

I have been intrigued by the Gaia hypothesis since reading Lovelock's original papers in the early 1970s. I read Lovelock's first Gaia book in 1980, and over the years my interest in Gaia has grown and deepened. I honor James Lovelock and Lynn Margulis for fertilizing a vast field of productive speculation, observation, and experiment – the Gaian research program. And I have always believed that the best way to show respect to the founders of a field is to take their proposals seriously while subjecting them to sustained critique. Here I will mainly focus on the ethical and environmental prescriptions that are coming from those influenced by the Gaian discourse and vision. But first I will give my brief take on the fundamental issue of whether there is a Gaia theory which addresses the current status of scientific Gaia.

Is Gaia a theory or hypothesis?

Is there a "Gaia theory"? The concept of theory is not, in my view, applicable to our present state of knowledge about the biosphere. In science, the term theory has a well-defined meaning, referring to a comprehensive and coherent system of concepts with proven explanatory and predictive power – as for example, evolutionary theory or Einsteinian physics. (Creationists thus misapprehend the scientific notion of theory when

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they claim that evolution is "just" a theory, by which they mean a problematic or speculative proposal.) Colloquial or non-rigorous uses of the concept of theory should be avoided in science. Lovelock's original strong version of Gaia – of life stabilizing and optimizing conditions for its continued existence – was a tentative hypothesis, albeit one that has been of great heuristic value in stimulating Gaian-related research.

Lovelock himself called Gaia a hypothesis, not a theory. This hypothesis has been constructively criticized in light of several catastrophes in the history of the biosphere, in particular the oxygen and cooling episodes that were catastrophic for anaerobes (organisms intolerant to oxygen) and thermophiles (heat-loving organisms), respectively. The early critique of homeostatic Gaia pointed to the occurrence of the oxygen catastrophe resulting from the rise of atmospheric oxygen about 2 billion years ago. Tyler Volk and I met at the historic Conference in 1988, sponsored by the American Geophysical Union, where this critique was mounted by James Kirchner and others (see Schneider and Boston, 1991).

Tyler Volk and I have offered an alternative Gaia hypothesis: the evolving biosphere is self-organizing and possesses emergent properties but not along a homeostatic trajectory; and the biota, rather than being the directing force in the Gaian system, is only one player among various abiotic factors (see Schwartzman, Shore, Volk and McMenamin 1994; Volk 1998; Schwartzman 1999, 2002; Schwartzman 2008). In my humble view, Gaian research is hopefully on the way to becoming a theory, but it is not there yet. Witness the continuing debates regarding the status of homeostasis on all levels of the biosphere, the potential role of group selection, and the long-term temperature history of the Earth's climate (perhaps now close to resolution, with mounting evidence for a hot Archean/early Proterozoic climate).

Even Lovelock's (2003) restatement of the Gaia hypothesis, a partial retreat from his strongest articulation, is considered problematic by some actively engaged in the Gaian research program, myself included. Lovelock maintains that "organisms and their material environment evolve as a single coupled system, from which emerges the sustained self-regulation of climate and chemistry at a habitable state for whatever is the current biota." If climatic temperatures for the early biota were thermophilic (ability to grow above about 50 deg C), however, then the subsequent drop in average surface

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temperature did not maintain habitable conditions in the global biosphere for thermophiles, but instead reduced the habitability of the very organisms that participated in the self-regulating system. Hence the thermophile catastrophe (and, analogously, the oxygen catastrophe for anaerobes) belies an airtight conception of self-regulation in service of "whatever is the current biota."

If life were not a player in the biosphere's self-regulation, would conditions still be habitable? Has the endurance of life since its origin been a consequence of homeostatic Gaia? Tyler Volk and I have argued that an abiotic Earth could now still be habitable for thermophiles though not for low-temperature life (Schwartzman and Volk 1989). To my knowledge, there is no robust evidence available supporting the view that the Earth's biota has kept the biosphere habitable within acceptable ranges, starting with the biogenesis event itself, constrained to have occurred between 3.8 and 4.4 billion years ago (the first evidence of liquid water inferred from oxygen isotopes in Hadean zircons).

In addition, I find tenuous the interesting hypothesis advanced by Harding and Margulis in this volume for the likely loss of the hydrosphere were it not for life's protection, an extension of the view that the Gaia has maintained habitability. Both the photochemistry of the Earth's early atmosphere and history of solar luminosity suggest that water would not have been lost on an abiotic Earth. Only when the effective solar radiation flux reaches the level of Venus 4 billion years ago (Venus receives twice the solar flux of Earth) will the Earth lose its water by photodissociation, i.e., molecular breakup driven by solar radiation, a few billion years in the future. If methane was mostly of biotic origin then life could have been blamed for the loss of water on early Earth, were it not for the probable abiotic mechanism of loss! So maybe the opposite hypothesis should be entertained in astrobiology, namely, that life could lead to early water loss and its self-destruction. This is one of the arguments advanced by Peter Ward (The Medea Hypothesis) as a direct challenge to the Gaia hypothesis. Only robust photochemistry and knowledge of biotic influence can answer the question of whether biotic activity helps retain water or threatens to lose it.

Is a "self-regulating" Gaia the probable outcome once life gets started on a planet? The evolution of biota on Earth suggests homeorrhesis, i.e., step wise shifts in steady-states, not homeostasis; hence self-regulation has its limits because of shifting

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abiotic constraints imposed on the biosphere (e.g., the role of rising solar luminosity in the consideration of the lifetime of the biosphere – see Lenton and von Bloh 2001). Lenton (2004) pointed out that environmental changes detrimental to life produced as byproducts of biotic activity tend to be self-limiting by boomeranging on the organisms involved. For example, the thermophile catastrophe arising through progressive cooling of the biosphere was indeed a boomerang on the very organisms that had a role (biotic enhancement of weathering) in the cooling process (Schwartzman 1999, 2002). When the climate cooled below thermophilic toleration, these organisms were left in refuges such as hot springs.

So I conclude that premature claims of Gaia theory are not helpful. Rather we should celebrate the diversity of views among Gaian-inspired scientific researchers.

Can Gaian thinking inform a vision, a program for a sustainable future?

A Gaian vision can clearly inform diametrically opposite prescriptions for confronting global climate change, as well as what constitutes a sustainable path for humanity. I plead for the end of the pretense that a Gaian vision by itself, in the absence of ideological and ethical predilections and technological wisdom regarding the political and physical economies, can provide clarity for a 21st-century agenda for planetary sustainability. Enormous crimes have been committed in the name of every religion and ideology, so let's refrain from claiming that a Gaian vision (or religion) is necessarily exempt from misuse. Should we look forward to a sustainable retreat for a privileged minority (as I interpret Lovelock's, 2006, advice) or rather an advance for all of humanity utilizing the bountiful solar flux with modern renewable energy technologies as persuasively argued for in this volume by Donald Aitken? Alternatively, Lovelock's argument for a sustainable retreat in this volume can be taken as the imperative need to drastically reduce our ecological footprint, by the rapid transition to renewable energy sources and agroecologies (Altieri, 1995), an interpretation that I would heartedly endorse. But Lovelock's technological prescription is to go the way of geoengineering and nuclear energy.

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Another related contentious issue is whether our planet is overpopulated with humans, making Malthus more relevant than ever in explaining our environmental crisis. James Lovelock has reiterated his long-standing neo-Malthusian views in *Revenge of Gaia* (2006). Here we find the following assertion: "The root of our problems with the environment comes from a lack of constraint on the growth of population . . . the number . . . has grown to over six billion, which is wholly unsustainable in the present state of Gaia, even if we had the will and the ability to cut back."

Lovelock elaborates on this theme in a recent interview (Revkin 2006):

> Q. You say in the book that sustainable development is a fantasy, essentially, and you have a different notion for what needs to happen, of "sustainable retreat."
> A. At six-going-on-eight-billion people, the idea of any further development is almost obscene. We've got to learn how to retreat from the world that we're in. Planning a good retreat is always a good measure of generalship.

An alternative view that I favor, equally consistent with a Gaian inspiration, is that our unsustainable fossil-fuel based industrial society magnifies the negative impacts of human population, while an alternative solar-based energy infrastructure could potentially stabilize population size and raise the quality of life for all. Scholars such as Joel Cohen and the Nobel Laureate Amartya Sen have critiqued the recent invocation of neo-Malthusianism (see Schwartzman and Schwartzman 2007).

I suggest the biggest obstacle to a solar transition rapid enough to prevent catastrophic climate change is the military-industrial complex itself, the generator of oil and resources wars. Barring some near future revolutionary breakthrough in the development of very cheap high efficiency thin film photovoltaics, the necessary funds for rapid conversion to a solar energy infrastructure will likely be on the order of several trillion dollars. Where is this funding and material resources coming from, especially in this time of global economic slowdown, if not by demilitarization? Jeffrey Sachs and many others have recently made this critical point, eloquently articulated in a different context by President Eisenhower some 60 years ago, warning us about the heavy weight of the military industrial complex. (I expanded on this issue at length in Schwartzman, 2009a, 2009b.)

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Gaian spiritualism, idealist or materialist?

I demand what the pragmatists and pessimists call the impossible – a future for my children and grandchildren and everyone else's on our planet that is free of war, hatred, and pollution, and with the maximum biodiversity possible. Facing the main obstacles to this future surely requires the broadest movement of people of Earth, acting in their common interests. People of all faiths and no faith must respect each other's religious orientation or philosophy, agree to disagree, and continue to dialogue – otherwise we will fail miserably. In much of the world, indeed in the United States, non-believers are a minority, mainly hidden in the closet, barely tolerated or even persecuted. Hence, claims that spiritual and ethical values must be grounded in religious belief should be challenged, in the name of universal human rights (we are now or should be celebrating the 60th anniversary of the Universal Declaration of Human Rights).

Therefore, I submit an argument for a spiritual vision grounded in scientific materialism, as an alternative to the religious orientation of some inspired by the Gaian vision. The potential for spiritual, religious, and aesthetic experience arose in the cultural matrix of prehistoric *Homo sapiens*, with the emergence of the self-conscious socially connected brains of our species. I highly recommend the illuminating discussions of this emergence by Mithen (1996) and Lewis-Williams and Pearce (2002, 2005).

I am convinced that whales and other species likely share this experience with us, but we are still not clever enough to reveal it. While their subjectivity certainly invites idealist interpretations, the scientific materialist argues these experiences do not support a non-material explanation, just as the properties of life itself do not require the addition of a non-material, i.e., by definition, an unknowable energizing force for its explanation. The history of science demonstrates the progressive retreat of idealist, vitalist, and other non-material hypotheses for what distinguishes life from non-life, and self-consciousness from other levels of brain and cell activity expressing the interaction of living organisms with their environment. While there are some scientists who still favor non-material explanations for consciousness, this privileging of residual idealism thankfully does not apparently inform the actual research program in cognitive science.

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So let us celebrate and enjoy the transcendent spiritual experience, especially of the incredible richness of the biosphere, without demanding the necessary legitimization of non-material explanation. And let us likewise welcome the recent appropriations of the Gaian vision to global challenges facing humanity, from the diversity of philosophical or religious inspiration.

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