

# THE GAIA HYPOTHESIS: FACT, THEORY, AND WISHFUL THINKING

JAMES W. KIRCHNER

*Department of Earth and Planetary Science, University of California, Berkeley,  
CA 94720-4767, U.S.A.  
E-mail: kirchner@seismo.berkeley.edu*

**Abstract.** Organisms can greatly affect their environments, and the feedback coupling between organisms and their environments can shape the evolution of both. Beyond these generally accepted facts, the Gaia hypothesis advances three central propositions: (1) that biologically mediated feedbacks contribute to environmental homeostasis, (2) that they make the environment more suitable for life, and (3) that such feedbacks should arise by Darwinian natural selection. These three propositions do not fare well under close scrutiny. (1) Biologically mediated feedbacks are not intrinsically homeostatic. Many of the biological mechanisms that affect global climate are destabilizing, and it is likely that the net effect of biological feedbacks will be to amplify, not dampen, global warming. (2) Nor do biologically mediated feedbacks necessarily enhance the environment, although it will often appear as if this were the case, simply because natural selection will favor organisms that do well in their environments – which means doing well under the conditions that they and their co-occurring species have created. (3) Finally, Gaian feedbacks can evolve by natural selection, but so can anti-Gaian feedbacks. Daisyworld models evolve Gaian feedback because they assume that any trait that improves the environment will also give a reproductive advantage to its carriers (over other organisms that share the same environment). In the real world, by contrast, natural selection favors any trait that gives its carriers a reproductive advantage over its non-carriers, whether it improves or degrades the environment (and thereby benefits or hinders its carriers and non-carriers alike). Thus Gaian and anti-Gaian feedbacks are both likely to evolve.

## 1. Introduction

Several years ago I overheard a radio interview with Douglas Adams, the author of *The Hitchhiker's Guide to the Galaxy*, in which he was asked to comment on the Gaia hypothesis. His answer, as best I can reconstruct it now, was roughly this:

Imagine a puddle, waking up in the morning, and examining its surroundings (a brief pause here, to let the audience grapple with this rather odd image). The puddle would say, 'Well, this depression in the ground here, it's really quite comfortable, isn't it? It's just as wide as I am, it's just as deep as I am, it's the same shape as I am ... in fact, it conforms exactly to me, in every detail. This depression in the ground, it must have been made just for me!'

Adams' fanciful image illustrates a central problem in some of the current incarnations of the Gaia hypothesis, and in all other theories that find, in Earth's obvious suitability for our particular form of life, evidence that the environment must be conforming to life's needs (e.g., Henderson, 1913; Redfield, 1958). The problem is



*Climatic Change* **52**: 391–408, 2002.

© 2002 Kluwer Academic Publishers. Printed in the Netherlands.

this: given that organisms must adapt to the constraints of their environment – or else they don't survive – the particular forms of life that we observe will always be those that are reasonably well matched to their environmental conditions. Those that are not well matched to their environment will not thrive and will not be noticed.

Thus the environment and its life forms will always appear well suited to each other, whether or not the environment is in any sense adjusted to life's requirements. It seems inevitable that sentient life should view its world as an Eden, because if there were any evolutionary lineages for which that world were a Hell, they would not persist long enough to develop intelligent life forms. To me, the Earth seems to be remarkably well suited to human needs. But I also understand that evolution has made it virtually inevitable that I should believe this, since any would-be ancestors of mine for whom the Earth were too hostile would have been removed from the gene pool long before their traits could have been passed on to me. Perhaps this helps to explain how the beneficence of nature has become a theme in human thought. As winners of the evolutionary lottery, it is not surprising that we would view ourselves and the life forms around us – with whom we share the winner's circle – as the beneficiaries of an environment that has been tailored to our needs.

What makes the Gaia hypothesis interesting is that it proposes that the beneficence of Nature is neither an accident nor the work of a benevolent deity, but instead is the inevitable result of interactions between organisms and their environment. Simply put, if organisms have a significant influence on their environment, then

... those species of organisms that retain or alter conditions optimizing their fitness (i.e., proportion of offspring left to the subsequent generation) leave more of the same. In this way conditions are retained or altered to their benefit (Lovelock and Margulis, 1974a).

Life and the environment evolve together as a single system so that not only does the species that leaves the most progeny tend to inherit the environment but also the environment that favors the most progeny is itself sustained (Lovelock, 1986).

Thus the Gaia hypothesis validates our sense of wonder and reverence for the natural world, by proposing a scientific basis for our sense that the Earth is indeed tailored to our needs, and those of the organisms that share the Earth with us.

Some have hailed Gaia as a profound discovery, while others have dismissed it as a 'just-so story' that is more entertaining than informative. Here I will argue that Gaia, in its different guises, is a mixture of fact, theory, metaphor, and wishful thinking. It will be necessary to untangle these from each other, and put each in its proper place, in order to get a clearer view of the Earth system as it is, in all its intriguing complexity. It has been a dozen years since my critique of the Gaia hypothesis appeared in print (Kirchner, 1989; Kirchner, 1991). My intent was to