Commentary

SEEING DEEPER INTO GAIA THEORY

A Reply to Lovelock's Response

TYLER VOLK

Department of Biology, 1009 Main Building, Mailcode 5181, New York University, New York, NY 10003-6688, U.S.A.
E-mail: tyler.volk@nyu.edu

Lovelock's response to me (Lovelock, 2003) is not really a response to any technical issues. My points about the future of Gaia theory (to note just a few from Volk, 2002) involved the need for: a way to evaluate environment-enhancing examples of life against environment-degrading examples, a metric or metrics for biosphere-scale principles, the biosphere-scale principles themselves, quantitative analysis about the evolutionary costs and benefits to organisms that produce environmental changes (primarily as free side-effects, in a 'wasteworld'), and new models that look at chemical flows with and without life in a generalized manner. These are the issues we need to address via expert exchange to see deeper into Gaia theory.

Regarding the actual substance of Lovelock's response, while I agree with Lovelock that understanding the biosphere (Gaia) requires unprecedented integration across the sciences, I disagree with most of what he writes.

Lovelock begins by positing that the advances in quantum mechanics, evolutionary biology, and molecular biology came from reduction, whereas Gaia theory deals with emergence and the properties of whole systems. But his three examples of reduction were all instances of tremendous synthesis and thus holistic thinking. Quantum mechanics took isolated features of the micro world and created an overarching theory. Darwin synthesized species into a single global picture across time. Watson and Crick saw the whole DNA molecule from disparate clues in data. Lovelock has created a false binary (see Volk, 1995), which serves only as a rhetorical device that allows him to dismiss critics (such as Kirchner and myself) as belonging to the camp of reductionists, thus privileging his access to presumed truth.

Lovelock goes on to say that Gaia theory 'states that the Earth self regulates its climate and chemistry so as to keep itself habitable'. (I will refer to this as Lovelock's 'central tenet'.) This statement can be interpreted in a way that tempts us into thinking it is correct, but it is not. For nearly four billion years creatures have altered the planet's chemistry and climate. That's true. And because Earth is

Climatic Change **57:** 5–7, 2003.

habitable today it might be guessed that the Gaia system kept itself habitable. But today's world might be habitable only because current organisms evolved to deal with changes wrought by past geology and biology. Creatures are not necessarily alive today because there is some whole system property of Gaia that made this habitability inevitable. Whether the cloud-affecting gas dimethyl sulfide, for instance, improves or is detrimental to the global environment does not matter with regard to its continued creation as a substance from marine plankton (Volk, 1998).

Lovelock moves along to cite the enhancement of chemical weathering by plants, soil organisms, and soil structure as consistent with his central tenet. I have worked on this specific topic. As I overviewed (Volk, 1998, using the modeling formulation of Schwartzman and Volk, 1991; see also Schwartzman, 1999), the presence of this 'biotic enhancement of weathering' changed Earth's temperature substantially more than if Earth had had no such enhancement. Sure, as a result of the enhancement in the past, today's cool-loving creatures were subsequently able to evolve. But the earlier organisms were not part of some holistic order that specifically created environmental conditions of future habitability as a property of that order. Thus I see Lovelock's central tenet of Gaia theory as wrong, given what we understand about how evolution works in the local biological present and how life only inadvertently affects Earth's chemical properties. My more detailed technical criticisms of the central tenet (Volk, 2002), along with those from Kirchner (2002), were not addressed by Lovelock.

Lovelock calls for a marriage of geology and biology. I applaud that! But then he suggests that I set aside my 'Cartesian scruples' (whatever those are – I wasn't aware I had them). He also wants professional scientists in the Earth disciplines to 'take a vow to believe in the phenomena of emergence'. Surely going deeper in Gaia theory requires technical debate about the biosphere, not vows.

During the course of my career as a modeler, as someone who assembles components into mathematical systems, I have consistently sought emergent properties. If I could see the property of the whole system by knowing its parts as separate components then I would have no need to construct systems. So in reply to Lovelock, I would much rather seek truth in emergence that is actually observed in detailed, peer-reviewed studies, rather than taking vows that some specific example of it exists, say Lovelock's central tenet, even in the face of evidence to the contrary or, at minimum, significant controversy (Volk, 2002; Kirchner, 2002).

Lovelock states we should 'envisage Gaia without knowing the recondite details of its geochemistry', and also appeals to the human ability to recognize whole systems 'instinctively'. Gaia theory has no future if we are encouraged to accept truth through envisaging without geochemical knowledge. Vision and instinct might help us formulate ideas for what to explore and test (I have no qualms there), but we cannot accept visions and instincts as final truths about how the biosphere works, a situation especially crucial today in light of the environmental crisis.

I personally thank Jim Lovelock for many insights. He has been a leader in helping many of us appreciate that life and the abiotic environment are causally coupled. But to explicate the principles of this coupling and thus see deeper into Gaia theory will require more than anti-reductionist philosophical statements and vague allusions to emergence. We need to test a multitude of different, competing visions and intuitions via real data and carefully constructed simulations of the biosphere so that truth can be found by the procedure of science, the same hard-won cultural evolutionary process that gave us quantum mechanics and molecular and evolutionary biology.

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(Received 21 June 2002; in revised form 10 July 2002)