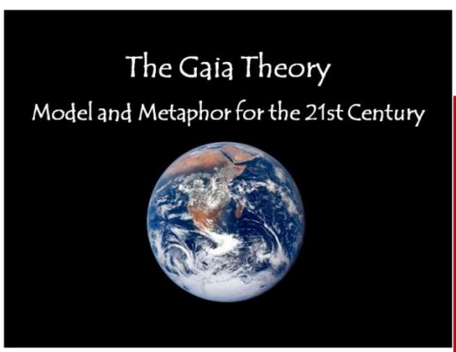
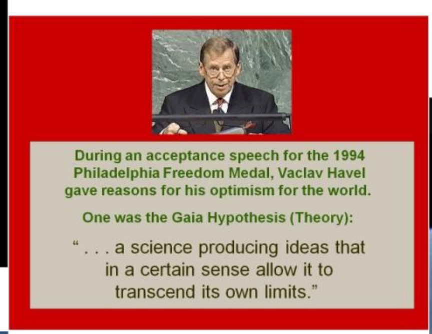
The Gaia Theory: Scientific Model and Metaphor for the 21st Century

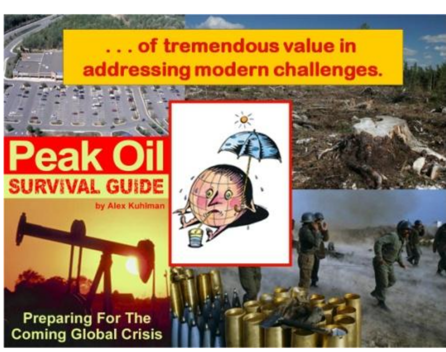
Martin Ogle
Potomac Overlook Regional Park, Northern Virginia Regional Park Authority,
Arlington, Virginia.
potomac@nvrpa.org

Abstract
This paper introduces the Gaia Theory, a compelling scientific context for understanding life on our planet. The theory asserts that the organic and inorganic components of Earth form a seamless continuum - a single, self-regulating, living system. British scientist, James Lovelock, who was commissioned by NASA to determine whether or not there was life on Mars, developed the Gaia Theory in the 1970's. Ironically, this theory has yielded some of the most "cutting edge" insights into life on Planet Earth. For example, Lovelock found ways in which the Gaian system regulates surface temperature, ocean salinity, and other conditions at levels necessary for life to survive. This paper also includes discussion about the value of the Gaia Theory for environmental educators
Keywords: James Lovelock, Gaia Theory, Planet Earth, Environmental Education

Resumen
Este documento presenta la Teoría de Gaia, un contexto científico de gran peso para entender la vida en nuestro planeta. La teoría afirma que los componentes orgánicos e inorgánicos de la Tierra forman una perfecta continuidad - un solo, auto-regulado, sistema viviente. El científico británico, James Lovelock, que fue encargado por la NASA para determinar si hay o no vida en Marte, desarrolló la Teoría de Gaia, en la década de 1970. Irónicamente, esta teoría ha dado fruto a algunas de las visiones más innovadoras sobre la vida del planeta Tierra. Lovelock encontró la forma en la cual el sistema Gaia regula la temperatura de la superficie, la salinidad del océano, y otras condiciones que son necesarias para que la vida pueda sobrevivir. Este papel también incluye una discusión sobre el valor de la Teoría de Gaia para los educadores ambientales.
Palabras claves: James Lovelock, Teoría Gaia, Planeta Tierra, Educación Ambiental

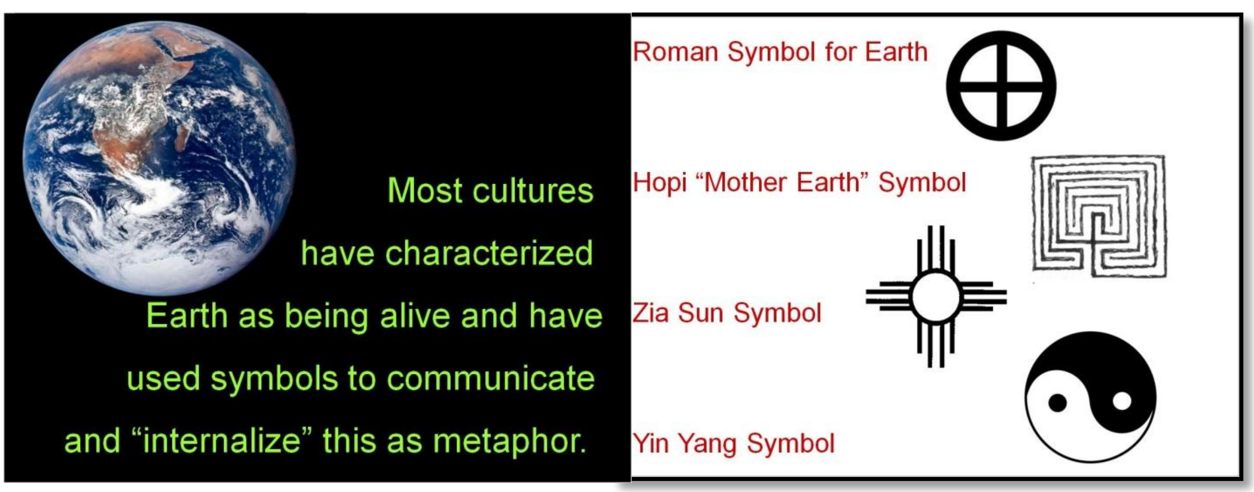






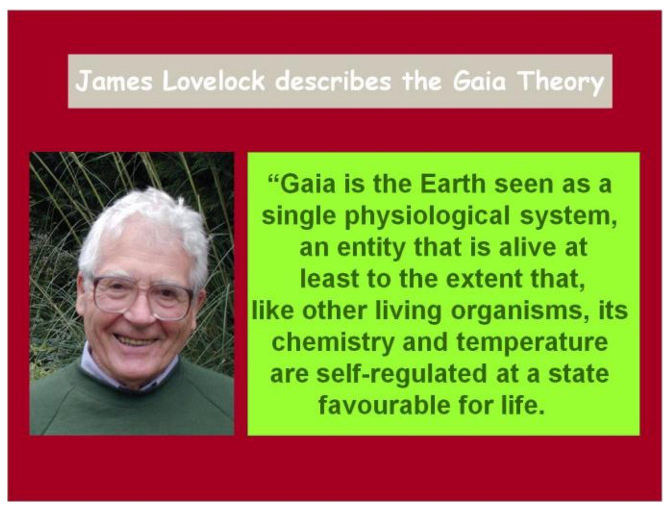
In 1969, James Lovelock, a British scientist, was taking a walk in the English countryside with his neighbor, William Golding (the author of *Lord of the Flies)*, telling him about his newly crystallizing views about life and evolution. It appeared to him that organic and inorganic (supposedly "inert") parts of Earth had evolved together as a tightly coupled living system that was self-generating and self-regulating. The entire planet, he told Golding, seemed to behave as if it were a single living entity. Hearing this, Golding made a suggestion with profound implications for science and society in general - Lovelock should name his theory the "Gaia Theory" after the ancient Greek Goddess of Earth. After all, Golding reasoned, ancient Greeks thought the Earth was alive, and science was now rediscovering this important worldview.

Like most new theories - especially grand, sweeping theories such as evolution and plate tectonics before it - the Gaia Theory was ignored or ridiculed for many years. Lovelock had taken an unusual step when he named the theory "Gaia" instead of a more technical appellation such as "geophysiology," or "Earth system science." To many scientists, "Gaia" connoted mysticism and they distanced themselves from the idea. Others took issue with Lovelock's claims that the superorganism of Earth could self-generate or self-regulate, citing the lack of demonstrated mechanisms by which Gaia could exist.

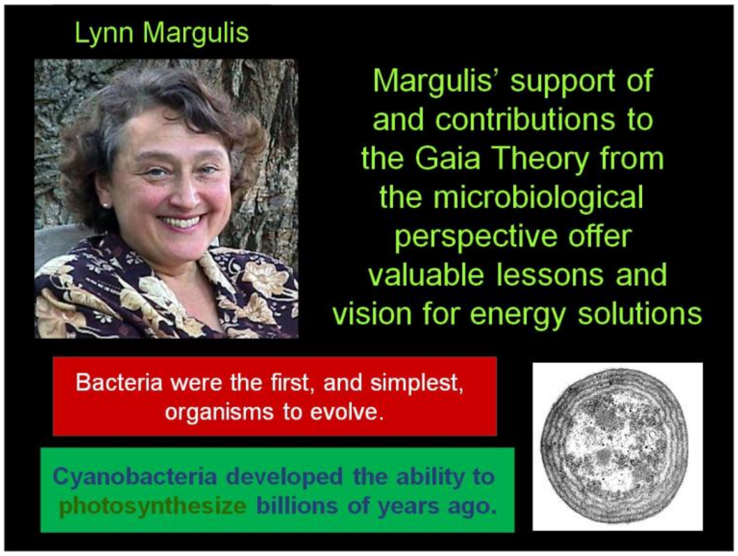


Relatively quickly, however, Lovelock’s research yielded compelling evidence to support his theory. He showed that the Gaian system regulates atmospheric gasses such as oxygen, methane, carbon dioxide, and hydrogen sulfide that react with living beings. The maintenance of oxygen near 20% in the atmosphere for at least 400 million years is an example. Likewise, ocean alkalinity, air temperature and other environmental factors were shown to be regulated by life. Lovelock and colleagues explored ways in which climate and the global sulfur cycle are moderated by oceanic microorganisms that release gasses that influence cloud formation. Even though the sun has increased its radiance (and thereby, its potential to heat the Earth) by almost a third during the time span of life on this planet, the Gaian system has maintained temperatures within a fairly narrow range suitable for its own existence. Myriad processes including feeding, excretion, breathing, reproduction, lightning, water condensation, and untold others dance together in the Gaian system that self-regulates conditions critical to life within narrow limits.

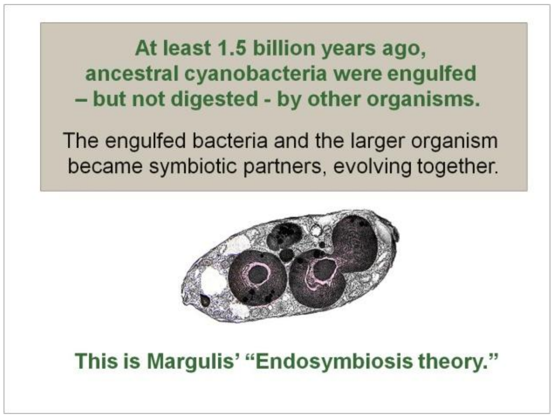
Lovelock describes Gaia in the following manner: “Gaia is the Earth seen as a single physiological system, an entity that is alive at least to the extent that, like other living organisms, its chemistry and temperature are self-regulated at a state favorable for life. Gaia became visible through the new knowledge about Earth gained from space and from extensive investigations of the Earth's surface. It is concerned with the working of the whole system not with the separated parts of a planet divided arbitrarily into the biosphere, the atmosphere, the lithosphere and the hydrosphere.”(Lovelock, 1991) In even more succinct fashion, he notes that “Its [the Gaia Theory’s] major difference from older evolutionary theories such as Darwinism is that it sees organisms not just adapting to the environment, but changing it as well.”



These realities of evolution were rediscovered in the 1970's by Lynn Margulis, now an evolutionist at the University of Massachusetts. Her own "endosymbios theory of cell evolution" was quickly accepted by scientists and showed that there was much more to evolution than Darwin could have known. The building blocks of all life – and evolution – are microorganisms that Darwin could not see. Physiologic behavior and community activities of microbes enmeshed the metabolism of different kinds of organisms billions of years ago, and *this became the foundation for all subsequent evolution.*



Lynn Margulis became an enthusiastic supporter of James Lovelock and the Gaia Theory. She collected information about microbes that underlies the understanding of how life controls Planet Earth's climate, ocean salinity and atmospheric content. One of the ways in which this happens is through carbon burial. Over eons, microbial life has incorporated carbon dioxide – the gaseous form that carbon takes in the atmosphere – into solid rock such as limestone (CaCO3). With large amounts of carbon sequestered in limestone (and carbonaceous "fossil fuels") – and thus prevented from reacting with oxygen – carbon dioxide levels decreased from about 95% of atmospheric gas when life began to the 0.03% it is today. Carbon dioxide is one of the most effective "greenhouse gasses" (gases that trap heat in the atmosphere). Despite the fact that the sun is about one third brighter now than it was when life began, our blanket of carbon dioxide has thinned at just the right rate to maintain temperatures suitable for life.

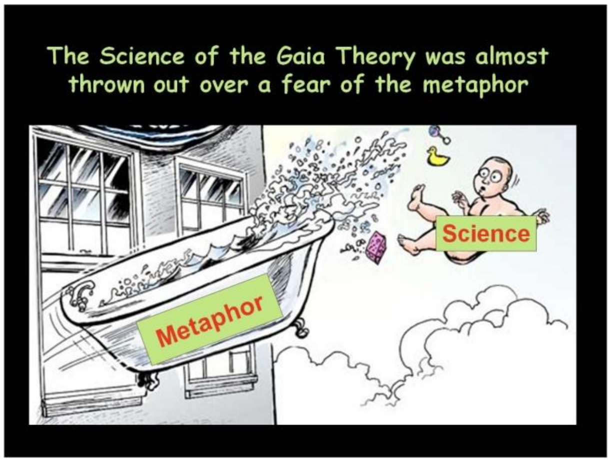


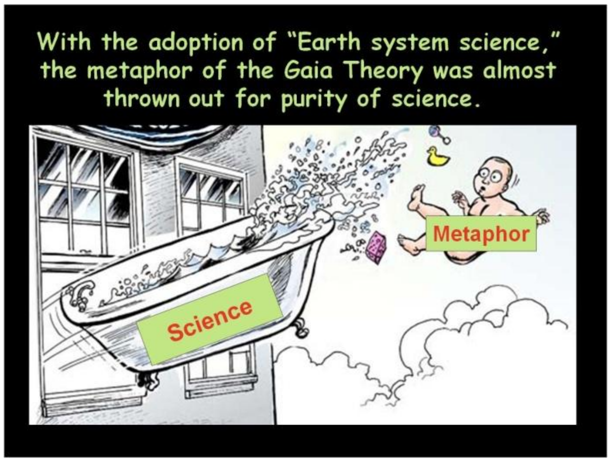
Lynn Margulis has long seen a profound intersection between her work in microbiology and Lovelock's Gaia Theory.

> "My primary work has always been in cell evolution, yet for a long time I've been associated with James Lovelock and his Gaia hypothesis. In the early seventies, I was trying to align bacteria by their metabolic pathways. I noticed that all kinds of bacteria produced gases. Oxygen, hydrogen sulfide, carbon dioxide, nitrogen, ammonia — more than thirty different gases are given off by the bacteria whose evolutionary history I was keen to reconstruct. Why did every scientist I asked believe that atmospheric oxygen was a biological product but the other atmospheric gases — nitrogen, methane, sulfur, and so on — were not? 'Go talk to Lovelock,' at least four different scientists suggested." (Brockman, 1995)

In 1948, Sir Frederick Hoyle, a British astronomer, wrote "once a photograph of the Earth, taken from the outside, is available . . . an idea as powerful as any other in history will be let loose." It seems as if that powerful idea is now taking shape in the form of the Gaia Theory.

The theory is at the brink of mainstream science and has arrived at this point faster than most theories of its magnitude.





The Gaia Theory as a Context for Science and Education

The Gaia Theory is, perhaps, the richest context for science and education in existence. The study and contemplation of this idea will yield questions and research that will help us address future needs. Many notable and influential personalities have begun a drumbeat of support for a new way of thinking underpinned by the basic concepts of the Gaia Theory.

In his July 4, 1994 address at Independence Hall, Philadelphia, on the occasion of his receiving the Philadephia Liberty Medal, Vaclav Havel said:

> The idea of human rights and freedoms must be an integral part of any meaningful world order. Yet, I think it must be anchored in a different place, and in a different way, than has been the case so far. [One example] is the 'Gaia hypothesis.' This theory brings together proof that the dense network of mutual interactions between the organic and inorganic portions of Earth's surface form a single system, a kind of mega-organism, a living planet, Gaia. (Havel, 1994)

Freeman Dyson, an eminent physicist, and formerly a tireless champion of space exploration, shifted his focus later in his life and came to essentially the same conclusion as Havel:

> One hopeful sign of sanity in modern society is the popularity of the idea of Gaia, invented by James Lovelock to personify our living planet. Respect for Gaia is the beginning of wisdom. . . . As humanity moves into the future and takes control of its evolution, our first priority must be to preserve our emotional bond to Gaia. (Dyson, 1988)

Consider the words of ecologist and inventor, John Todd:

> "Ecology as the basis for design is the framework of this new economic order. It needs to be combined with a view in which the Earth is seen as a sentient being, a Gaian worldview, and our obligations as humans are not just to ourselves, but to all of life. Earth stewardship then becomes the larger framework within which ecological design and technologies exist." (Todd, 1987)

Even Aldo Leopold, whose book "A Sand County Almanac" has been a staple for students of natural sciences for many decades, also foresaw the basic premise and importance of the Gaia Theory when he wrote: "The land is one organism. Its parts, like our own parts, compete with each other and co-operate with each other" (Leopold, 1949)

Of course, the words of famous personalities or scientists do not suffice. We must test these ideas against diverse sources of knowledge and truth before using them with confidence. Therefore, I urge scientists to study the Gaia Theory and see how it stacks up against modern scientific inquiry, ancient and traditional thought, common sense, empirical observations, and other ways of knowing.

Initially, the most powerful value of the Gaia Theory may simply be that of providing scientists a compelling and meaningful context. Recently, there has been much talk of "interdisciplinary education." But how can we conceptualize interdisciplinary education without a clear vision of what life is as a whole? Consider the black spots in figure 1.

Figure 1.

Figure 2.

It is difficult to see any pattern inherent in these spots until first looking at figure 2. The illustration of the dancers in figure 2 allows our brains to grasp the relationships between pieces that previously appeared to be random. The concept of a living Earth, Gaia, can provide us with just such a vision of how all of the pieces of life fit together. Huge schisms between disciplines even within the natural sciences might be bridged as we think at the Gaian scale. For instance, it is now known that the maintenance of ocean salinity (at 35 parts salt per thousand parts water) over at least hundreds of millions of years is a result of the interplay of climate, soil chemistry, coral reef formation, geologic processes, and many other factors. Scientists in these various disciplines are now beginning to communicate with one another and discovering that their fields are like different faces of the same system.

One of the most fascinating interdisciplinary links to be made is the true place of human society in the Gaian system. We begin to see human cultures and even religions as marvelous, biological adaptations of human beings that enmesh with the rest of life. With this viewpoint, we can rise to the challenge of adapting culturally to enable us to live in better balance with the rest of nature.

References

Brockman, John. (1995). *The Third Culture: Beyond the Scientific Revolution*. Simon & Schuster: New York.

Dyson, Freeman. (1988). *From Eros to Gaia*. New York: Pantheon Books.

Havel, Vaclav. (1994). *The Miracle of Being: Our Mysterious Interdependence.* Acceptance speech for the Liberty Medal presented at Independence Hall, Philadephia, Pennsylvania, on July 4, 1994.

Leopold, Aldo. (1949). *A Sand County Almanac*. Oxford University Press: New York.

Lovelock, James, (1991). *Healing Gaia: Practical Medicine for the Planet*. Harmony Books: New York.

Todd, John. (1987). An Ecological Economic Order In *Gaia: A Way of Knowing; Political Implications of the New Biology*. ed. William Irwin Thompson. Lindesfarne Press: Great Barrington, Massachusetts.

Transcript of an online chat, Friday September 29, 2000. http://www.ecolo.org/lovelock/lovelock-online_chat-00.htm

Citación de este artículo:

Ogle, M. (2009). The Gaia Theory: Scientific Model and Metaphor for the 21st Century. *Revista Umbral*, 1, 99-106. Disponible en http://ojs.uprrp.edu/index.php/umbral/article/download/32/20

Producción y Recursos en Internet:

Producción de Umbral, Facultad de Estudios Generales, Universidad de Puerto Rico, Río Piedras. Disponible en http://umbral.uprrp.edu/revista