

GAIA A New Look at Life on Earth

Introduction

Most of us at some time or other have pondered the question, How is it that conditions on this planet happen to be just right for life? The answer I want to explore today is that conditions are right for life to exist because life exists. Life maintains the conditions for its own survival.

The title of this presentation is taken directly from this book, by James E. Lovelock, that presents the Gaia Hypothesis. Simply stated, the Gaia Hypothesis says that the entire planet behaves like a single self-correcting biological organism. That is to say there are feedback mechanisms at work on the planet that maintain conditions exactly right for life to not only survive but thrive. By implication then all the individual creatures on Earth, both plant and animal, are cells in this planetary organism.

If you're new to this concept of Gaia, I want you to think about this for a minute. The whole planet is a single living being. When I first encountered the Gaia Hypothesis about 15 years ago, I was just blown away. It was one of the most profound concepts I had ever encountered, and it still is. On the one hand it's mind-boggling and yet on the other hand, it's so obvious. That's what keeps the system going. It's self-regulating.

Background

In the early 1960's, Lovelock was a consultant to NASA's Jet Propulsion Laboratory while they were designing the experiments for the Mars Viking landers. At the time they were pondering the question, How will we know if we've found life on Mars? One group said that life on Mars would be chemically the same as life on Earth. So all we have to do is put an automated microbiology lab on the Viking lander and we'll know.

But Lovelock said, "wait a minute, how can we be sure that the chemistry of Martian life is the same as the chemistry of life on Earth?" It's entirely possible that life on another planet, with different environmental conditions, may have evolved around a different chemistry. To make a long story short, what Lovelock proposed was that the fundamental indicator of a life process is a *local reduction in entropy*. Anyone who has kids intuitively understands entropy. It's a tendency toward disorder, i.e. your kid's room.

Scientifically, the notion of entropy is that all the energy in the universe will dissipate until it's evenly distributed and no more work can be done. That is, the universe is running down.

As an aside, one of the arguments that the Creationists make is that evolution "violates the laws of thermodynamics". That is, thermodynamics says that the universe tends toward a state of uniformity and disorder, but evolution tends toward ever greater complexity. Therefore it must be wrong.

This argument troubled me for a long time. I knew there must be a plausible answer but I couldn't figure it out. Then I reread Lovelock's book. The answer is that a reversal of entropy is

the very definition of life! So whether you're an evolutionist or a creationist, life itself is defined by a local reversal of entropy. So that argument is really pointless.

Nuts and Bolts

The basis of the Gaia Hypothesis began with observations of atmospheric chemistry. In the absence of life there would be no free oxygen in the atmosphere. Not only is there free oxygen, but the proportion of oxygen, about 20%, just happens to be optimal for life. At less than 15% most life forms couldn't survive. At more than 25%, wildfires would be virtually unstoppable. Not only that, but the proportion of oxygen has remained remarkably stable for the past few million years.

It is not unreasonable to suggest that there is a feedback mechanism at work that actively maintains the oxygen level at around 20%. The obvious answer of course is that trees and other photosynthetic plants absorb carbon dioxide and, through photosynthesis, break it down into carbon and oxygen. In reality the feedback mechanism is much more subtle and complex than that, involving gases like methane and nitrous oxide and other less obvious sources (see diagram). The significance of Lovelock's insight is that this feedback mechanism is biological in origin. Without life it wouldn't exist.

Another self-regulating mechanism appears in the oceans. Why is the ocean salty? We all know the answer to that one. Minute amounts of salt are dissolved in river water as it flows towards the sea. Water evaporates off the ocean leaving the salt behind.

Like the atmosphere, the concentration of salt in the ocean, about 3.4%, just happens to be optimal for life. Most living cells can't survive at a salinity greater than 6%. Knowing the average salinity of the ocean, the total volume of the world's oceans and a reasonable estimate of the amount of salt washed in every year, we should be able to compute the age of the oceans. If you do the calculation, the answer you come up with is about 80 million years. Well, everything else we know suggests that the oceans are a lot older than that. So the question isn't why is the ocean salty? The real question is why isn't it saltier?

There must be a sink that removes salt from seawater at the rate at which it is being added. Indeed there is. There are several theories. I'll describe just one. It is known for example that the rate of evaporation is much higher in shallow bays, lagoons and isolated arms of the sea. This higher evaporation rate apparently causes the salts to precipitate out and it appears that the rate of precipitation is of the order of magnitude to solve the problem of maintaining constant salinity.

Is there a biological mechanism at work here? There may very well be. Many of these shallow areas are enclosed by coral reefs, structures miles high and thousands of miles long built over millions of years by the cooperative effort of fairly simple living organisms. Is it possible that these coral reefs are Gaia's mechanism to build evaporation lagoons? And even if it's not, it's an example of the kind of planetary engineering that life processes can carry out that is still well beyond our own capabilities..

Philosophy

So what about environmentalism and Gaia? Lovelock says: “It may be that the white hot rash of our technology will in the end prove destructive and painful for our own species, but the evidence for accepting that industrial activities either at their present level or in the immediate future may endanger the life of Gaia as a whole, is very weak indeed.”

I think what he’s saying here is that it is highly presumptuous of us humans to think that we have the power to destroy life on the planet. Environmentalism isn’t about saving the planet. If the Gaia Hypothesis is right, the planet can and will take care of itself, thank you very much. Environmentalism is about saving our asses. It’s about trying to maintain the biosphere at a state that can comfortably support human life.

As I said before, when I first encountered the Gaia Hypothesis it was the most profound idea I had ever encountered. I found it to be profoundly optimistic because it said to me no matter how badly we screw up, we can’t destroy life on the planet. Humans may very well become extinct, and we may very well deserve it, but life will go on. And maybe in a million years or so another intelligent species will evolve that figures out how to do it right.

At about the same time I encountered Gaia, the environmental movement was raising the first warnings about global warming. In response the oil industry flaks said, “not to worry, global warming is self-correcting”. Their argument was something to the effect that increased temperatures would increase ocean evaporation and lead to increased cloud cover. Clouds reflect sunlight and that in turn would reduce energy absorption. So we don’t need to worry about global warming. It will take care of itself.

From a Gaian perspective, of course global warming is self-correcting! How could it be otherwise? The question is, what is the nature of the correction? What’s creating the problem? Humans. What’s the simplest way to solve the problem? Get rid of the humans!

Role of Humans

So what is the role of humans in the Gaian scheme? Why are we here? From a Gaian perspective, it’s not at all obvious what role we play. One theory harks back to what Lovelock calls the greatest environmental disaster in the history of the planet when free oxygen first appeared in the atmosphere about 1 ½ billion years ago. This free oxygen was deadly to a large range of surface-dwelling micro-organisms called anaerobes, which can only live in the absence of oxygen.

The anaerobes were driven underground, to the muddy bottoms of lakes, rivers and sea beds. Today however, they’re back on the surface, comfortably ensconced in the digestive tracts of virtually all surface-dwelling animals, and in particular large mammals. Anaerobes serve a very important role in the oxygen regulation mechanism by generating methane. So it has been suggested that the primary Gaian role of the large mammals is to provide an environment for anaerobes. In other words, our Gaian role is to fart.

It has also been suggested that intelligent life was an evolutionary mistake. It just didn’t work out. And that mistake will eventually be corrected, perhaps with our help.

Another possibility. One of the objections to the Gaia hypothesis is that Gaia lacks a fundamental characteristic of every living creature, the ability to reproduce. How does a planetary organism reproduce?

Well, just maybe we are the agents of Gaia's reproduction. It has been suggested that with our ability to travel in space, our role is to propagate Gaia by colonizing other worlds. It's an intriguing idea.

So what of the future? If Gaia is real, how do we live in a Gaian world? I once had the opportunity to ask a biologist what he thought of the Gaia Hypothesis. He said whether or not it turns out to be literally true, it has been extremely useful in getting people to think about planet-wide feedback cycles. It has helped to identify feedback cycles that no one would have even considered before. So it's had a profound influence on our understanding of how the planet works.

Let me conclude by quoting Lovelock.

“What is remarkable about man is not the size of his brain, no greater than that of a dolphin, nor his loose, incomplete development as a social animal, nor even the faculty of speech or his ability to use tools. Man is remarkable because by the combination of all these things he has created an entirely new entity. When socially organized and equipped with a technology even as rudimentary as that of a Stone Age tribal group, man has the novel capacity to collect, store and process information, and then to use it to manipulate the environment in a purposeful and anticipatory fashion.

“If we scan backwards over the history of man as a collective species and direct our attention particularly to his relationships with the global environment, we discern a series of repetitions. There are periods of rapid technological development leading to what seems to be an environmental catastrophe. This is followed by a quite lengthy period of stability and coexistence with a new and modified ecosystem. Fire-drive hunting [by the first human occupants of North America] led to the destruction of forest ecosystems but was followed by the establishment of the great grassland ecosystems, the savannahs, and a new period of coexistence.

“From a Gaian viewpoint, all attempts to rationalize a subjugated biosphere with man in charge are as doomed to failure as the similar concept of benevolent colonialism. They all assume that man is the possessor of this planet; if not the owner, then the tenant. The allegory of Orwell's *Animal Farm* takes on a deeper significance when we realize that all human societies in one way or another regard the world as their farm. The Gaia hypothesis implies that the stable state of our planet includes man as a part of, or partner in, a very democratic entity.”