



Earth and Life

Daisyworld: Gaia and Daisyworld

Voice Over

In the early 1960's Jim Lovelock worked for NASA which steadily grew obsessed with the search for life on Mars. Ten years before the Viking landings in 1976, Jim pointed out that life on Mars would have left its signature in the composition of the Martian atmosphere, and that evidence for such a signature was singularly lacking. The relationship between atmospheric composition and life on Earth led to the first detailed formulation of the Gaia hypothesis; it soon became controversial.

James Lovelock

The old Gaia hypothesis as it was first dated arose like this: what I'd found was that looking at the Earth in the Mars business and discovering this wonderful atmosphere, there were all of these gases out of equilibrium and yet somehow keeping constant, I knew there was something that was regulating it, and it was natural for me to think that it was life that was doing the regulating, and that it was doing it in such a way as to keep the Earth comfortable for itself. I think few would have come upon it differently when confronted with the evidence that I had then, and so the next few years I went chundering around looking for evidence that would support this notion that life was regulating the planet and keeping it comfortable for itself. And I was brought up short and sharp by Richard Dawkins and Ford Doolittle's comments that there was just no way that life could regulate anything beyond its vena type and this was all nonsense, and this led to the development of the Daisyworld model which showed how in fact it wasn't life, but the whole system of life tightly coupled with the physics and chemistry of the planet with its environment that did the regulating, with regulating being an emergent property of this tightly coupled system, not something that required purpose or foresight on the part of the organisms. And I think this definitively answered Richard Dawkins' criticism.

I think as another biologist put it even more forcefully than Richard Dawkins, if Gaia is to be real it would require a trades union of the species of organisms to meet annually on Mt. Ararat and negotiate next year's climate, which is clearly absurd. Now Daisyworld was a model that was made to show that the evolution by natural selection, using all of the selfish gene ideas that Richard Dawkins espouses, could quite naturally, if you coupled the evolution of the organisms tightly with the evolution of their material world, produce a system that was self-regulating; no purpose, no foresight, no planning, was needed. Now the details of Daisyworld are like this. I want you to imagine a model planet just like the Earth orbiting.

Voice Over

Daisyworld is a simple planet. Like the Earth it orbits a star, which like our sun is getting progressively hotter with age. Unlike Earth, Daisyworld has a very simple atmosphere with no greenhouse gases like carbon dioxide to warm it up. And it only has two sets of inhabitants: black daisies and white daisies. The black daisies absorb incoming solar radiation so they warm up, and as they warm up they radiate heat, warming up their surrounding area. The white daisies, on the other hand, reflect the sunlight and stay cool. For both colours of daisies 22.5 Celsius is the optimum temperature for growth. Now let's see what happens throughout the lifecycle of Daisyworld as things warm up. At first Daisyworld's young sun is cool and the planet is rather cold, and the heat-absorbing black daisies are at an advantage.

James Lovelock

And consequently by natural selection dark daisies will be favoured, and at the end of the lot, the first season, there will be many more dark daisy seeds left than light coloured ones. So at the start of the next season dark daisies will be off to a head start and soon will be spreading, warming not just themselves but their immediate locality, and then with explosive, positive

feedback dark daisies will spread right across the planet and warm it right up to temperatures close to those comfortable for the growth of daisies.

Voice Over

The black daisies proliferate and slowly spread out from the warmer equatorial regions until they cover most of Daisyworld, turning it black, so Daisyworld can absorb heat and warm up. As the temperature gets nearer the 22.5 Celsius optimum for all daisies life gets easier for the white daisies who then prosper. At first they grow best at the warm Equator, then they slowly move out finding a niche alongside the black daisies. But in areas of high solar radiation the white daisies do best as they cool their environment, whereas in areas of low solar radiation black daisies predominate by warming their environment. In all areas the numbers of black compared to white daisies depends on the proportion of heating or cooling necessary to maintain the optimum growth temperature.

James Lovelock

I have no doubt that by far the most important thing to come from Daisyworld was the mechanism that it offered to explain how the Earth regulates its temperature. You see, Gaia was not acceptable to most scientists, geochemists, biologists, or anybody else, without a mechanism that explained how it could work. It seemed to them just pure moonshine, nothing solid about it. It was rather like plate tectonics, the theory of vagueness theory. Until a mechanism was available nobody could believe there was anything in it, and the same was true for Gaia, and Daisyworld gave just that mechanism.

