Earth and Life

Daisyworld: Gaia theory and the real world

James Lovelock

I see the apparent constancy of temperature on Earth throughout geological time, knowing that it is almost certain that the Sun has warmed up by something like 30% during that interval, which is a huge increase in output from the Sun, and enough to change the climate drastically. If it was freezing at the beginning, it should be well on the way to boiling now; if it was comfortable at the beginning, well beware, so yes it is one of the most solid pieces of evidence for a self-regulating system like Gaia, being present on the planet.

Voice Over

Lovelock now sees that the average temperature range that the planet self-regulates to is far more complex that he originally thought. For example, marine algae grow best in the laboratory at 20 Celsius but in the oceans they're limited to 8 Celsius or below. Water mixing ensures a supply of nutrients and the algae flourish. Huge algal blooms can occur as this satellite picture shows, even though the temperature of the water is 10 Celsius below the optimum growth temperature for the same algae in the laboratory.

James Lovelock

So this shows that it isn't just the needs of the organisms that determines the temperature of self-regulation, but the needs of the whole system; the geo-physics and the needs of the organisms can tightly couple together as a single system.

Voice Over

Another way of evaluating a theory, like the Gaia system theory, is to see how useful it is at making predictions.

James Lovelock

I suppose the first of them is a strange one because it happened before the, what was at that stage no more than the idea of Gaia existing, and here I refer to the prediction that Mars was probably lifeless. It was a prediction that was confirmed by the Viking landing which found there was no life on Mars, because if you go back to the evidence I've already talked about here, you will see it comes from the assumption that the Earth is a system which has an atmosphere which is self-regulating in the way that I described, and using that evidence Mars has an equilibrium atmosphere and therefore should not have life so that was perhaps the first one. The next one, and perhaps important one, is the prediction that chemical rock weathering would be modulated by the presence of living organisms at the Earth's surface so that their response to temperature change would, so to speak, control the rate at which weathering took place and therefore the level of carbon dioxide in the atmosphere, and thence climate; that was the second. Now the third is a double one; it was well-known that sulphur is in short supply on the land, and it is washed off by rain and taken down the rivers into the sea, and I thought there must be some biological process that would convey an element like sulphur back from the sea to the land. I know that the algae growing in the ocean produced dimethyl sulphide because in 1972 I sailed in a ship from Barry in Wales down to Antarctica and back, and measured the production as the strange gas all the way that the ship travelled, and everywhere in the ocean that it went, and Peter Liss at the University of East Anglia examined the data and calculated from it what will be the flux of dimethyl sulphide from the ocean to the air and, interestingly, it was just the quantity needed to balance the budget of the sulphur cycle. So, in a sense, this was the first experimental confirmation of a Gaian prediction that there would be element cycling in just the right quantity to sustain biological needs. Now this story didn't end there. In 1986 I spent a short while at the University of Washington at Seattle in the Department of Robert Charleston, the

meteorologist, and we got to discussing clouds and how they formed, and Robert told me about this business that clouds require condensation nuclei, otherwise they cannot form over the oceans. Of course instantly it occurred to me that the dimethyl sulphide could oxidise all too readily in the air and be the source of just these nuclei's that he sought. And we got together with Andy Andrei and another meteorologist, Steven Warren, and produced a paper which was published in 1987; this paper hit science like a storm and I would think there must have been at least hundreds, if not thousands, of papers that followed and investigations around the world subsequent to it, and I was very pleased that Robert Charleston at the Oxford meeting on Gaia in April 1994 fully acknowledged this fact, but for Gaia thinking we would never have developed this notion of the algae in the ocean being connected with the plants and the climate. So that is perhaps the third prediction to come from the theory. The best way to test a theory is to get it to make what I think that famous philosopher, Karl Popper, called risky predictions, and then go out into the world and see if these predictions can be falsified or justified. He prefers falsified because if it's falsifiable then you throw the theory out. It's never quite as simple as that. In practice we scientists modify our theories if we find them falsified, rather than throw them away. It's just as well we do. If we strictly adhered to Popper we wouldn't, Darwin would never have set sail on the Beagle, and where would we be then?