Utility and experimental testability of the Gaia hypothesis

Andrew Free, Amanda McNeil, Olivia Mozley and Rosalind Allen

University of Edinburgh
Andrew.Free@ed.ac.uk

Gaia theory describes the life-environment system of the Earth as stable and self-regulating. It has remained at the fringes of mainstream biological science owing to historical definition problems and its apparent incompatibility with individual-level natural selection. However, various bodies of ecological and evolutionary research suggest ways in which the biosphere might tend towards stability and self-regulation. Here we review this research, relate the results to a plausible and informative formulation of 'Gaia theory', and ask how the theory extends the perspectives offered by these disciplines.

We then address the question of how Gaia theory might be tested experimentally. Such tests require the (reasonable) assumptions that life, where it evolves, will exploit essentially all thermodynamically-feasible forms of metabolism, and that Gaian regulation should be possible with a purely microbial biosphere. The biosphere is a closed system driven by solar radiation, and we describe here a laboratory microcosm which is an appropriate analogue of such a system. We then describe our preliminary experimental results from characterisation of this system, and discuss how we will use advanced molecular techniques employed by modern microbial ecology, in conjunction with computer simulations of inter-species interactions, to study the system and answer questions of relevance to Gaia theory. We also describe how this combined experimental-simulation approach can be applied to many questions of evolutionary and ecological interest which lie within the research areas bounded by Gaia.