Orig Life Evol Biosph (2013) 43:151–160
DOI 10.1007/s11084-013-9327-4

THEORETICAL MODELING

Biological Evolution of Replicator Systems: Towards a Quantitative Approach

Osmel Martin · J. E. Horvath

Received: 22 November 2012 / Accepted: 25 February 2013 /
Published online: 14 March 2013

Abstract The aim of this work is to study the features of a simple replicator chemical model of the relation between kinetic stability and entropy production under the action of external perturbations. We quantitatively explore the different paths leading to evolution in a toy model where two independent replicators compete for the same substrate. To do that, the same scenario described originally by Pross (J Phys Org Chem 17:312–316, 2004) is revised and new criteria to define the kinetic stability are proposed. Our results suggest that fast replicator populations are continually favored by the effects of strong stochastic environmental fluctuations capable to determine the global population, the former assumed to be the only acting evolution force. We demonstrate that the process is continually driven by strong perturbations only, and that population crashes may be useful proxies for these catastrophic environmental fluctuations. As expected, such behavior is particularly enhanced under very large scale perturbations, suggesting a likely dynamical footprint in the recovery patterns of new species after mass extinction events in the Earth's geological past. Furthermore, the hypothesis that natural selection always favors the faster processes may give theoretical support to different studies that claim the applicability of maximum principles like the Maximum Metabolic Flux (MMF) or Maximum Entropy Productions Principle (MEPP), seen as the main goal of biological evolution.

Keywords Replicators · Darwinian Selection Principle · Evolution · Non-equilibrium thermodynamics

Introduction

For centuries, the essence of life has remained rather elusive to human understanding. For this reason biology and the biological laws appear relatively isolated from the other well-

O. Martin
Departamento de Física, Universidad Central de Las Villas, Santa Clara, Cuba
e-mail: osmel@uclv.edu.cu

J. E. Horvath (✉)
Departamento de Astronomia, Instituto de Astronomia, Geofísica e Ciências Atmosféricas,
Universidade de São Paulo, São Paulo, SP, Brazil
e-mail: foton@astro.iag.usp.br