THE DARWINIAN TRANSITION AND THE EMERGENCE OF THE FIRST SPECIES

Tommaso Biancalani[1] and Nigel Goldenfeld[1], [1]Carl R. Woese Institute for Genomic Biology, UIUC, Champaign-Urbana, IL, USA

Introduction: It has been proposed that, at its early stages, the evolution of life did not proceed through vertical descent, as it mostly does at present. Instead primitive cells collectively evolved by horizontally-exchanging fragments of genetic material, which accelerated the process of evolution and optimized the genetic code towards error minimization. In this phase of life, known as the progenote, it was the community that varied in descent, not individual organismal lineages. The earliest evidence for the progenote phase came from digital life simulations, but left open the question of how did life exit the progenote phase? In this talk, I will address this question by presenting the results of an "in silico" analysis of a simple stochastic model that exhibits the transition to vertically-dominated evolution --- referred to by Carl Woese as the "Darwinian Transition". Our model reproduces the Darwinian transition, and combines statistical mechanics methods and (appropriately extended) population genetic techniques. Key findings are that the progressive reduction in the frequency of effective HGT events is an emergent, rather than an ad hoc, property of the system's dynamics. We find that the inter-dependence of the fitness between different parts of the genome determines the order in which core functions are frozen out and evolve thereafter by vertical descent.

The interpretation of our results is that as cell designs increased in complexity and genomes became internally inter-dependent, a critical point is reached at which HGT becomes progressively less effective in improving the fitness of the fitter genomes, and vertical evolution became more important.

Our results are the first to provide a mechanism for the exit from the progenote phase that is emergent, ie. not introduced by hand. Further, our work implies that different parts of the genome became refractory to HGT at different times in a history of progressive "freezing out" of core functions, ideas which are experimentally testable.

This material is based upon work supported by the National Aeronautics and Space Administration through the NASA Astrobiology Institute under Cooperative Agreement No. NNA13AA91A issued through the Science Mission Directorate.