A STUDY OF LIFE AS AN ENERGETIC PROCESS

by

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A DISSERTATION

Submitted to the Faculty of the Stevens Institute of Technology
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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2009

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ABSTRACT

It is my thesis that life can be modeled as a thermodynamic system. Specifically, it is my goal to use this approach to understanding life in order to investigate evolution as an energy minimization problem. In this sense, ecological niches represent local energy minima, selection criteria are nothing more than potential energy gradients, and extinction is the rate of change of the energy landscape exceeding the kinetics of adaptation. This idea is derived from the observation that life is, at its most fundamental level, nothing more than an elaborate collection of chemical reaction. Taken individually, each of these reactions is governed by the laws of thermodynamics.

In this work I present two model systems which are inspired by this hypothesis. In the first model, I will look at the directionality of nucleotide polymerases, all of which synthesize new nucleotide polymers in a 5' to 3' direction. This phenomenon could be the consequence of a very early founder effect. On the other hand, it could be that this directionality evolved due to an inherent advantage. I would propose that the energetics of nucleotide synthesis provide a clue as to what that advantage might have been. In the second model, I will look at *E. coli* RNA polymerase and its recognition of promoter sequences. In this process, RNA Polymerase must both bind tightly enough to recognize a specific sequence, but also release from the promoter in order to initiate transcription. If evolution is driven by thermodynamic constraints, it would be expected that RNA Polymerase has optimized the balance of these forces.

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Date: Sept. 18, 2009

Department: Chemistry, Chemical Biology, and Biomedical Engineering

Degree: Doctor of Philosophy

This thesis is dedicated to my wife.

Acknowledgements

I would like to acknowledge Marc Mansfield for the years of guidance, inspiration, and instruction that he so graciously provided during both my undergraduate and graduate education. I would also like to acknowledge Francis Jones for making this research possible, for the encouragement that he provided me as an undergraduate and the opportunity he made available to me as a graduate. I would also like to thank the members of my committee, A. K. Ganguly, Knut Stamnes, and Nicholas Murgolo, for their input and invaluable insight. Thanks also go out to the faculty and staff of the Department of Chemistry, Chemical Biology, and Biomedical Engineering for all the help they have provided through the years, and most especially to Mary Newell without whom I would not have made it past the first day of graduate school. Finally, I must humbly admit that the thesis presented here would not exist if it were not for the constant support and encouragement of my beautiful wife Ceren Örnek-Ballanco.

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Introduction

Evolution has been, since the time of Darwin, a science mostly concerned with explaining observations and predicting what new evidence from the past should eventually turn up, such as the existence of transitional forms. In this regard, evolution has been wildly successful. Where the study of Evolution has been lacking is in its ability to predict the future. That is, looking at collected fossil and current natural evidence, the Theory of Evolution gives us the ability to identify which selective pressures acted on past populations. What the Theory of Evolution cannot do, at present, is predict which environmental or other influences will act as selective pressures going forward. At best, we can make educated guesses based on past evidence, but we lack even the basic ability to assign a concrete measure of confidence in such predictions.

Vita

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