A TOY MODEL THE EVOLUTION OF DNA POLYMERASE POLARITY

by

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A DISSERTATION

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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 reactions. Taken individually, each of these reactions is governed by the laws of thermodynamics, and thus far there is no known upper limit to the scale to which thermodynamic principles may be applied.

In this work I present a model systems which is inspired by this hypothesis. In this 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 process of nucleic acid polymerization provides a clue as to what that advantage might have been. The toy model I have constructed demonstrates this, and the results provide an insight into the forces that might have driven early biological evolution.

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This thesis is dedicated to my loving and supportive wife.

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Chapter 1

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.

Chapter 2

Design of the Polymerase Evolution Model

In this chapter, I will provide a detailed description of the design of the model system used to investigate the question of the evolution of polymerase polarity. The goal of this model is to have organisms containing either $5' \rightarrow 3'$ or $3' \rightarrow 5'$ compete with each other in order to see which strategies are either evolutionarily dominant or evolutionarily stable.

Overview

Vita

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