

Finding Fitness: Adventures in Evolution

Introduction

- Explain why people might be interested in survival of the fittest, referencing its importance in pop culture.
- Provide a simple definition of the term survival.
- Offer a more complex definition of the term fitness, explaining why this part isn't so simple.

About Quasispecies

- Discuss the difficulty in quantifying fitness; it is a function of many variables.
- Mention the traditional belief that replication rate is a measure of fitness.
- Introduce the quasispecies model by Eigen that incorporates robustness.
- Define the concept of robustness as a statistical distribution (think bell curve) where a higher value means a wider curve and a lower value means a narrower curve.
- Note that this concept is well illustrated by Figure 2.

Relationship between mutations and robustness

- Provide a clear definition.

Method

- Delineate the differences between the two theories.
- Present a thought experiment that explains how an experiment probing this could be conducted.
- Explain the desire to use digital organisms.

Technical details of digital organism experiments

- Describe the Avida platform and experimental setup.

Discussion

- Discuss what the opposing theories would predict in this experiment.
- Explain how this experiment supports the quasispecies model over the traditional theory.
- Provide a detailed description of the results.

Conclusions

- State that this digital experiment worked out well.
- Suggest trying it on real organisms, such as *E. coli*.

Rewritten introduction

- Survival of the fittest. It has been the slogan for evolutionary advancement since Darwin founded the field. The term has been a problematic source of justification for the eugenics movement all the way to the concept behind lighthearted reality-based television shows, such as *The Bachelor*. However, the term is widely misunderstood. We must first define the key terms of survival and fitness.
- The term survival is fairly straightforward. In this context, survival denotes not just how long an organism lives, but whether it lives to reproduce. This leads to the crucial point that evolution applies only to those organisms that are able to reproduce. That means that no matter how well an organism carries out other life activities, it does not survive unless it produces offspring. For example, mules may be able to pull heavy loads better than other animals, but since they are sterile, they are non-survivors in the game of evolution.
- Unlike survival, fitness is a difficult term to define. We know that fitness describes an organism's ability to carry out life's activities, but a more precise definition seems elusive. Let's begin to investigate this complex notion by studying the simplest possible systems: populations of asexual organisms. In this realm, the notion of fitness may be reduced to "the ability of an organism to propagate its genetic material." In all Earthly biochemical life, genetic material comes in the form of DNA or RNA. This definition of fitness yields two subtle but critical implications. First of all, it implies that fitness cannot be measured instantaneously. That is, an organism's fitness cannot be determined just by plucking it out of a population and performing some measurements on it. In order to determine the ability to propagate genetic material, we must examine the long-term success of the lineage that is founded by the given organism. The success of the lineage can usually only be determined after many generations of reproduction, long after the original organism has died. The second implication is that fitness is dependent on the environment. All organisms adapt to certain environments, and for every organism, there exist environments in which it flourishes and environments in which it perishes. A splendid example of this is in the finches of the Galapagos, first described by Darwin himself (see Figure 4). Each species of finch is adapted to a very specific niche and environment. Although they survive well in their native habitats, they would probably be poorly equipped to deal with other environments. Thus, the idea of fitness only makes sense with respect to specific contexts.