Evolutionary Convergence and Divergence in a Model Fitness Landscape

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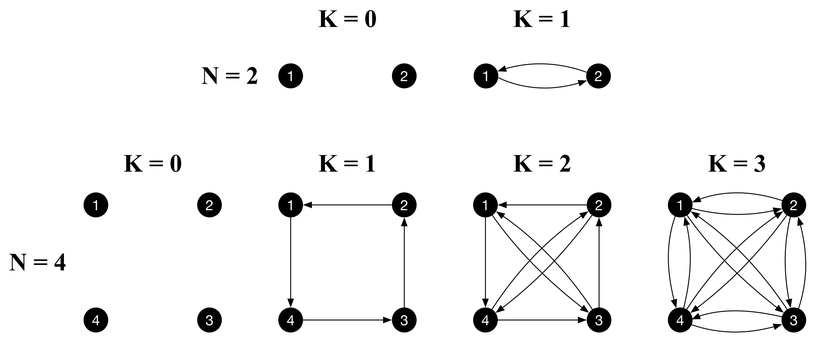
Background

Fitness landscapes are the invisible force responsible for directing the course of evolution. Further exploration of factors that influence the pattern of substitution of new mutations within these landscapes can provide insight to how evolution progresses. Epistasis is the interaction between two or more genes. As these interactions become more prevalent the fitness landscape becomes more rugged, making the course of evolution less predictable. Here, we look at the pattern of substitution of the first two mutations fixed in two diverging populations evolving on fitness landscapes with or without epistasis.

NK Model

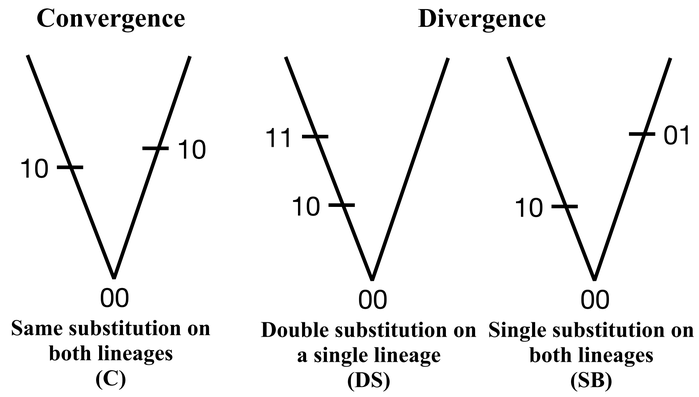


N = Number of Loci
K = Number of Loci Interacting with Each Loci (Connectivity)

K values can range from 0 to N – 1, with 0 meaning there is no epistasis, and N – 1 meaning all loci influence each other and the result of all interactions are random.

We assumed an adaptive fitness landscape fitness landscape with a large population size, so the probability of a deleterious or neutral mutation fixing is infinitesimal. Therefore, only beneficial mutations can fix within each lineage. At each time step in a simulation, a fitter neighbor was chosen at random and its probability of fixation was proportional to the normalized selection coefficient resulting from that mutation.

NK Model: N = 2

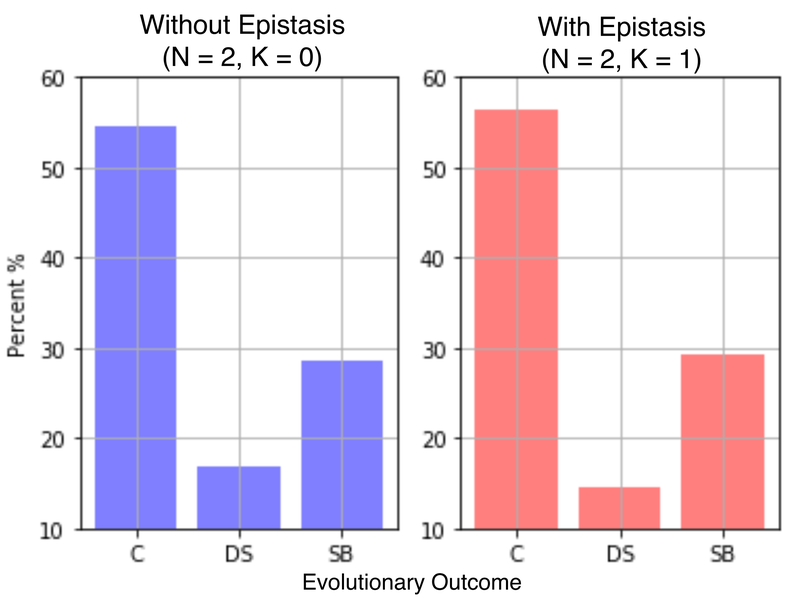


Total Genotypes: 4
Total Possible Landscapes: 4! = 24
Landscapes Where 2 Substitution Possible: 10
Possible Landscapes Under Each Sub Type:
1: 00 2: 01 3: 10 4: 11

	DS, C	**DS, SB, C**	**SB, C**
K = 0	None	1234 1324	None
K = 1	**DS, C** 2134 3124	**DS, SB, C** 1234 1324 1243 1342	**SB, C** 1423 1432 4123 4132

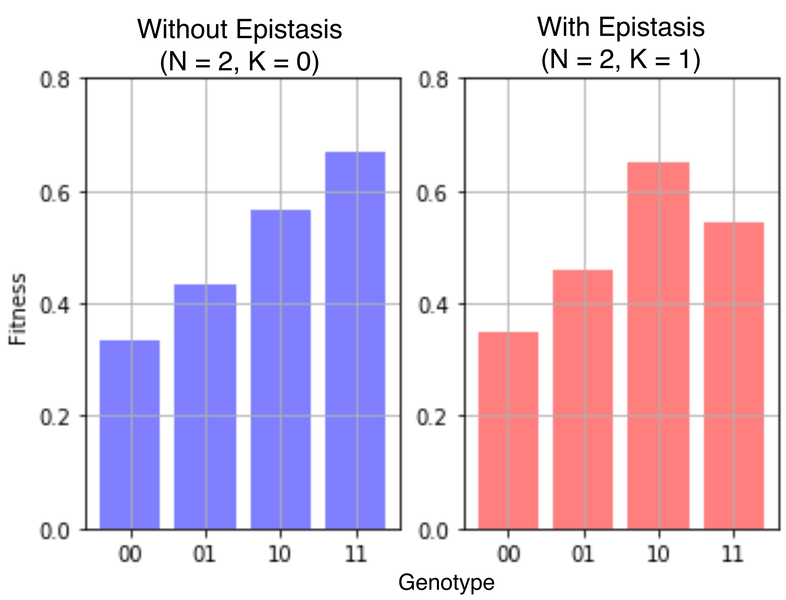
Results

SUBSTITUTION PATTERN:



C: Same Substitution on Both Lineages (Convergence)
DS: Double Substitution on a Single Lineage
SB: Single Substitution on Both Lineages

AVERAGE FITNESS LANDSCAPE:



Average Selection Coefficient of First Substituion:
Without Epistasis: 1.07
With Epistasis: 1.39

Conclusions

After looking at the effects of epistasis on convergence and divergence in a model fitness landscape, we conclude that in both cases of epistasis, convergence was more probable than both patterns of divergent substitution combined. However, despite having differing average fitness landscapes and average selection coefficients, under an adaptive NK model at N = 2, the level of epistasis does not largely influence the pattern of substitution of the first two evolutionary steps. Moving forward, we will aim to develop analytical theory on this subject. Investigating how the variation in average selection coefficients and the variation in the fitness landscape itself still give rise to similar, if not identical, substitution patterns, as well as moving to higher levels of N, can provide insight into these results.