Fitness Landscape

This is the space of potential fitnesses a living organism can take.

Imagine a graph where there is a vertex for every possible genome of length n.
A genome is just a sequence of letters from among A,T,G,C.

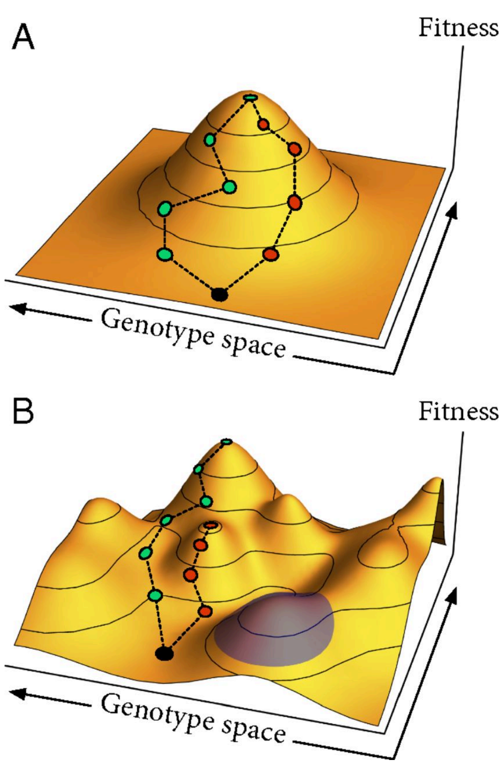
2 vertices are connected if the underlying sequence is different in only one place, i.e hamming distance = 1.

Each vertex has a fitness value which is the fitness of the organism with that genome.
(This fitness is sometimes represented on the y-axis of a 3-D graph)

The fitness value depends on the environment (This includes other organisms around).

Organisms generally inhabit this graph called the fitness landscape and move within it, generally taking 1 or 2 steps in any direction at a given moment in time.

The step they take is basically random, but the likelihood that the new organism survives and does well (fitness value is high) decides where the species as a whole ends up. Species 'evolve' within this landscape.



Chemostat

This is an environment for experimenting with evolution. It is an environment where only a fixed number of organisms exist in a stable state. For simplicity assume organisms reproduce in batches but this assumption can be removed in the simulations.

N organisms -> n organisms -> n organisms ….

We will start by modeling our simulations in a chemostat-like environment.

Assume all organisms have a unique identifier and a genome identifier, unique to all organisms of the same genome. To make up the next generation, we remove one organism at a time from the previous generation with replacement. I.e remove one, note it down and put it back. The new generation organisms inherit the properties of their parents + some randomness.

Can try to do this without replacement and see what differences it might make.

Genetic Drift

Lets say 10 unique organisms live in a chemostat of capacity 10 and all have the same fitness but different genomes. I.e one is not more likely than any other to survive but they are distinct and identifiable. Assume no mutation (i.e no random changes in genome during reproduction)

What happens to the number of unique organisms in the chemostat over generations? What happens as the number of generations approaches infinity?

Fitness + Chemostat

By default assume n organisms of fitness f. Every time we select an organism for the next generation, probability of getting selected = f/sum(f), f summed over all organisms in the denominator.

Start with n organisms of fitness 1 and let there be probability p that fitness changes. Change might be positive or negative with negative being x times more likely than positive. For the positive side, assume an exponential distribution with large improvements being significantly less likely than small improvements.

Traveling wave model

How does evolution work in this system? When an organism is created which is slightly better than the others, there continues to be a very high chance it dies right away. Even if it survives, the strain must gain enough numbers before we can confidently say that this fitter strain will take over the population.

Similarly, there is often some time before a new strain will appear in a system and come out of genetic drift and start to take over.

This gives 2 time periods, time from stable single strain to a new strain starting to take over and time from a new strain starting to take over to new strain completing takeover. In practice, time taken to complete takeover is much larger and this gives us the traveling wave model of fitness in a chemostat.