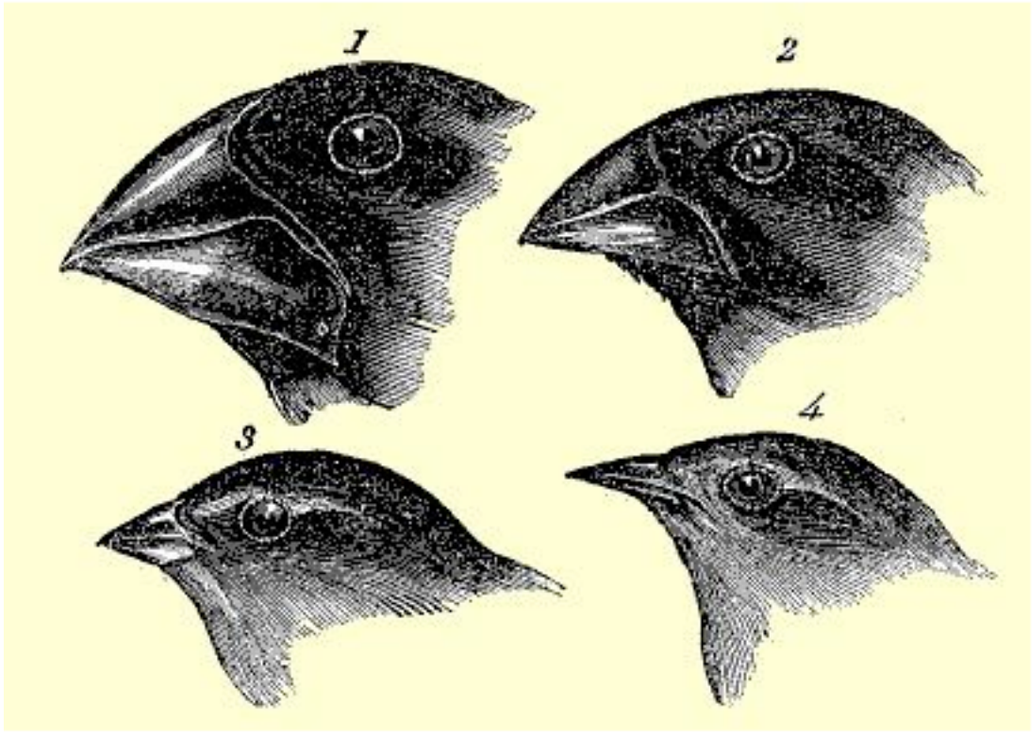
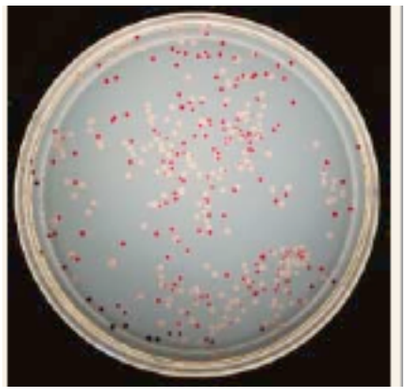
Darwin’s finches



Charles Darwin, On the Origin of Species by Means of Natural Selection or The Preservation of Favoured Races in the Struggle for Life, 24 November 1859, London

How is evolution studied now

Fitness Experiments



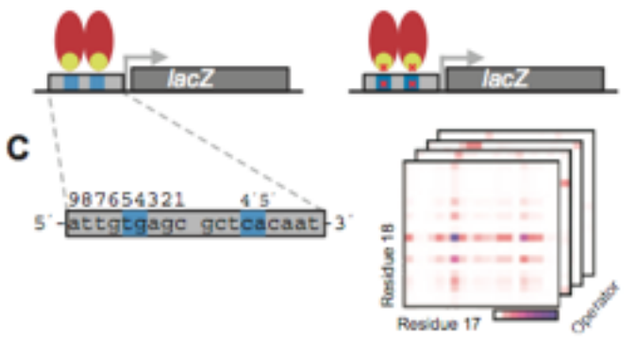
Theoretical Population Genetics

$$\partial_t q(x_0;x,t) = v(x_0)\frac{\partial q(x_0;x,t)}{\partial x_0} + \frac{D(x_0)}{2}\frac{\partial^2 q(x_0;x,t)}{\partial x_0^2}$$

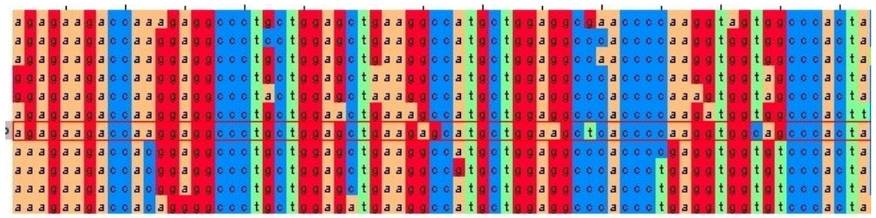
$$v(x_0) = 2Nsx_0(1-x_0)$$

$$D(x_0) = x_0(1-x_0)$$

Experimental evolution of networks, function



Inference from Sequence Data (Metagenomics, Phylogeny)



Evolutionary forces

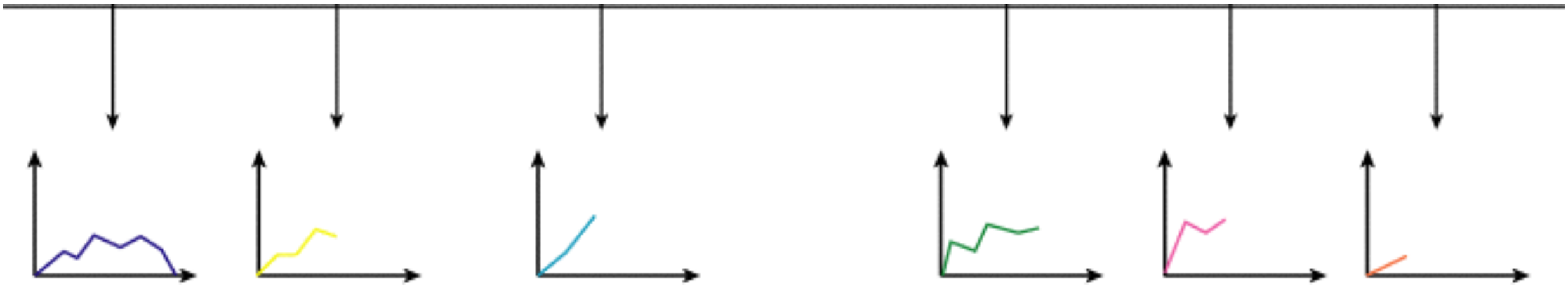
Mutations:
beneficial
deleterious
neutral

Genetic Drift
Well understood
But what do deviations mean?

Natural Selection
Reduces diversity

Demography
Bottlenecks, expansions reduce diversity

Geography
Environmental structure increases diversity

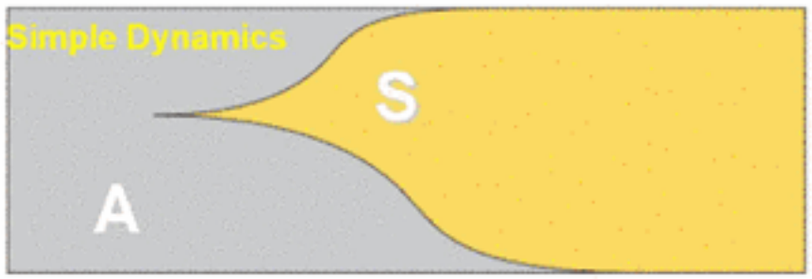


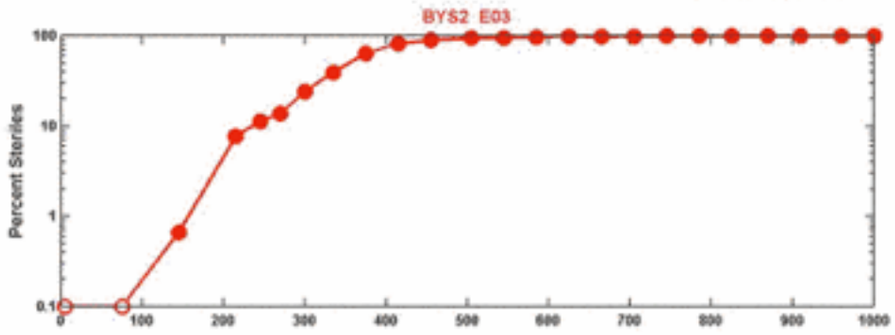
Calculate the fate of each mutant forward in time.

Fate of each mutation is not in steady state

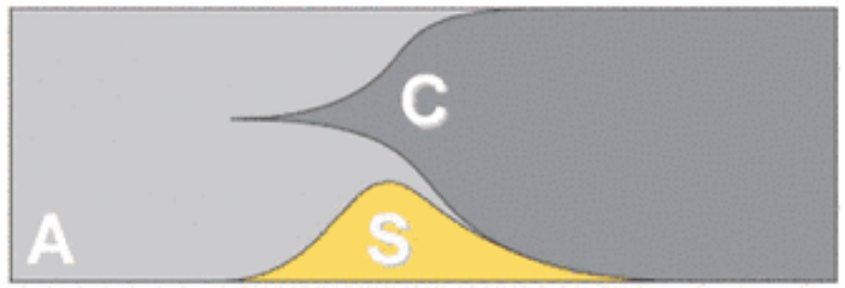
But there is a steady state distribution of the distribution of mutant frequencies

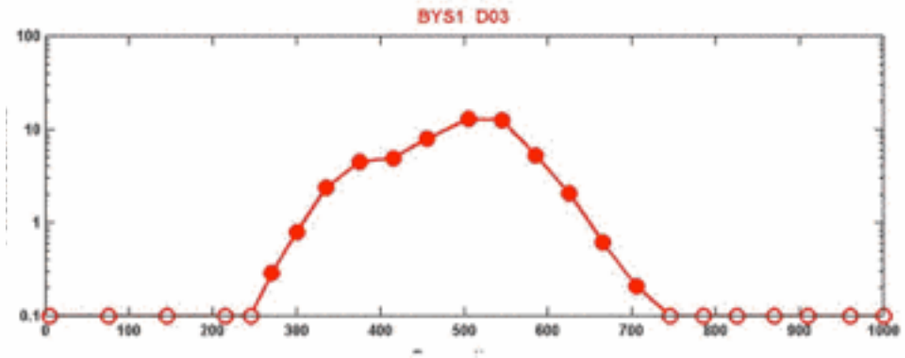
Simple Selective Sweeps



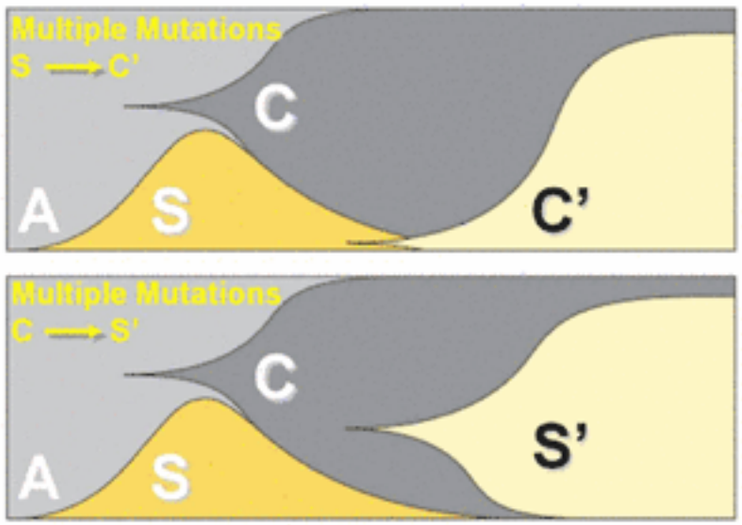


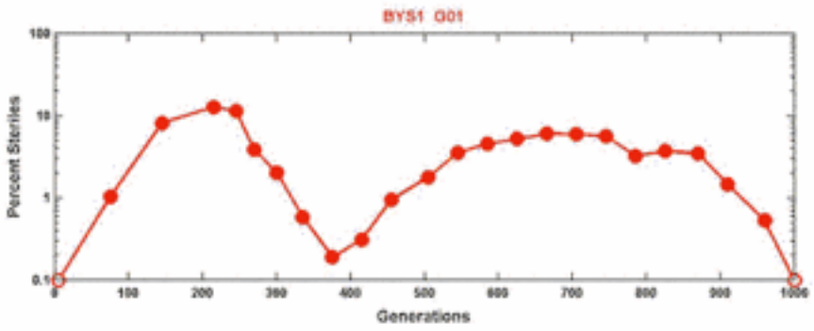
Clonal Interference



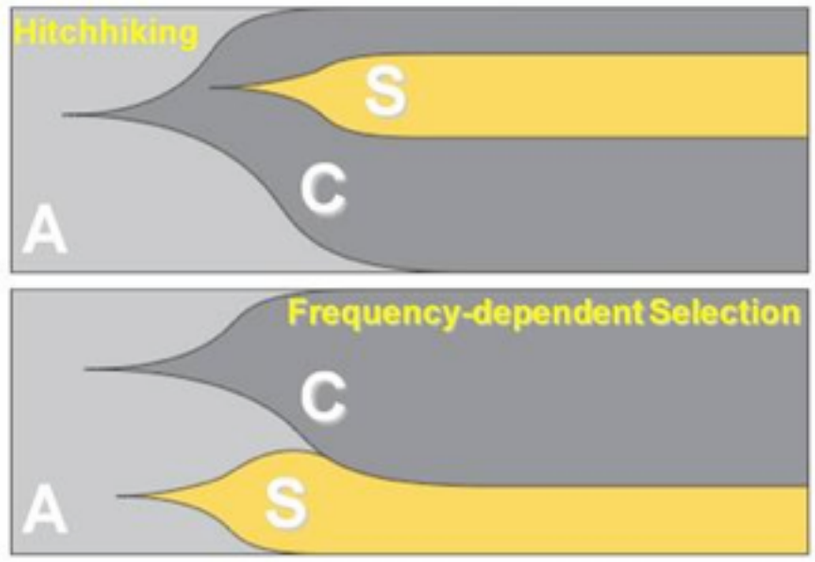


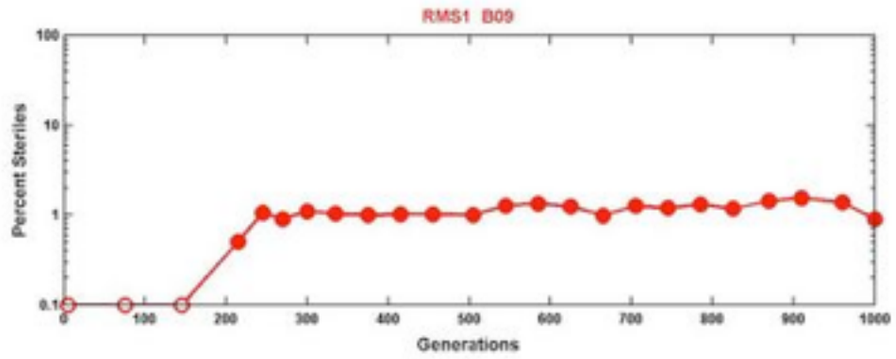
More Complex Dynamics



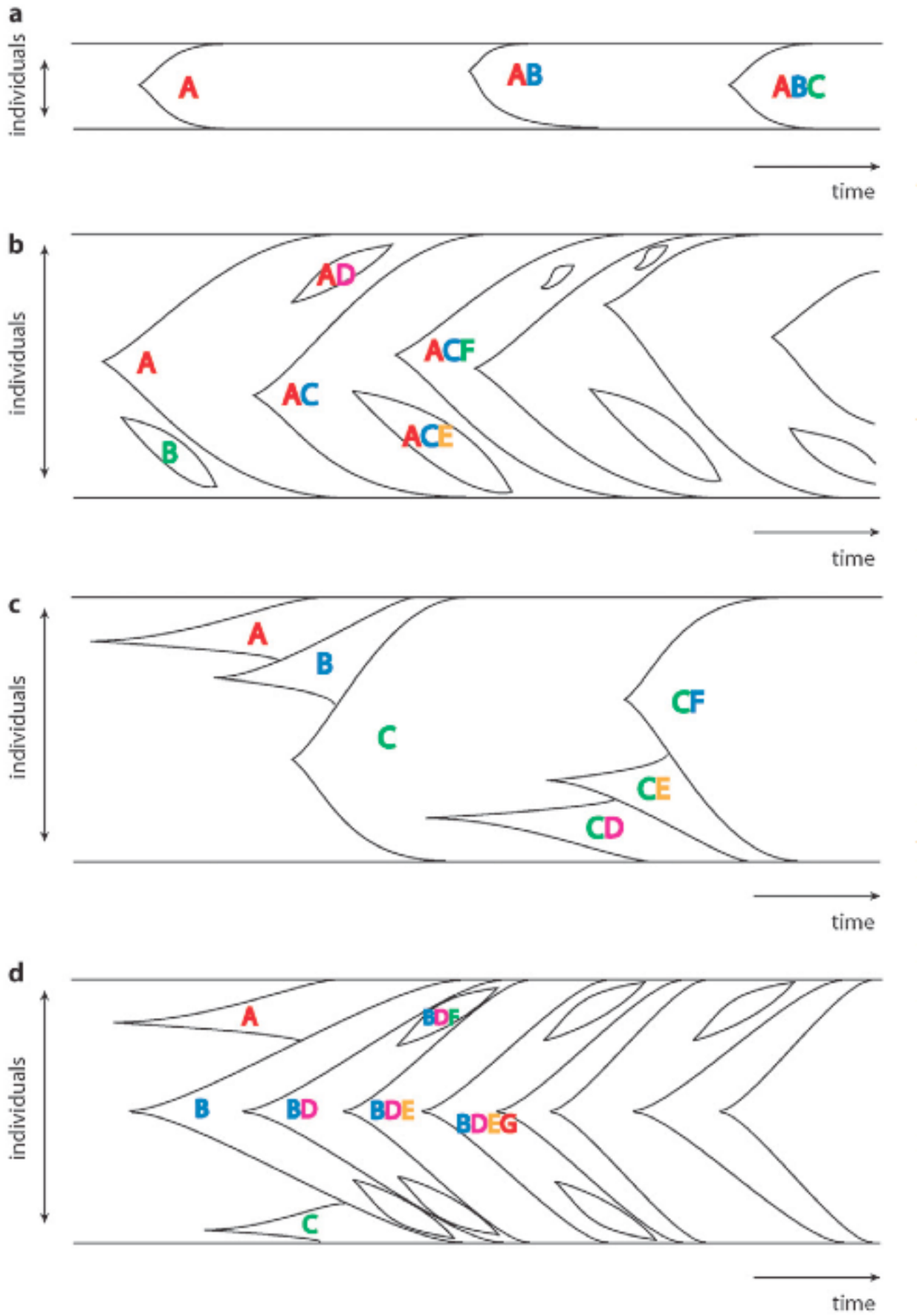


Steady Sterile Frequencies



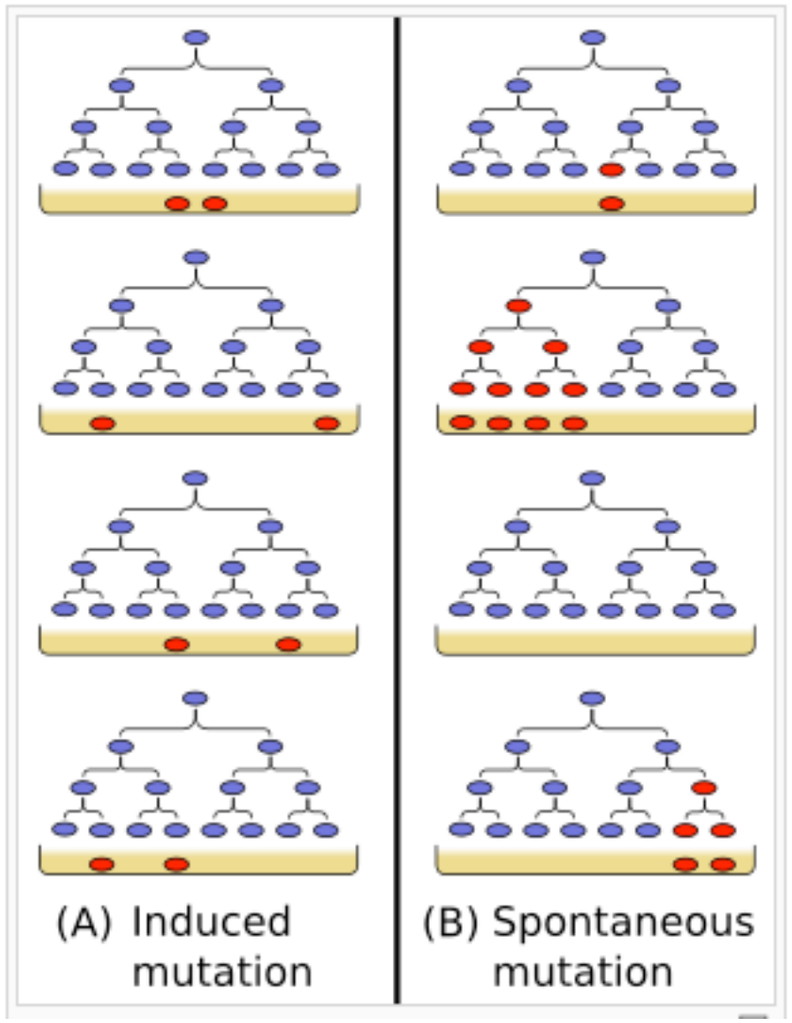


from S. Kryazhimskiy and M. M. Desai



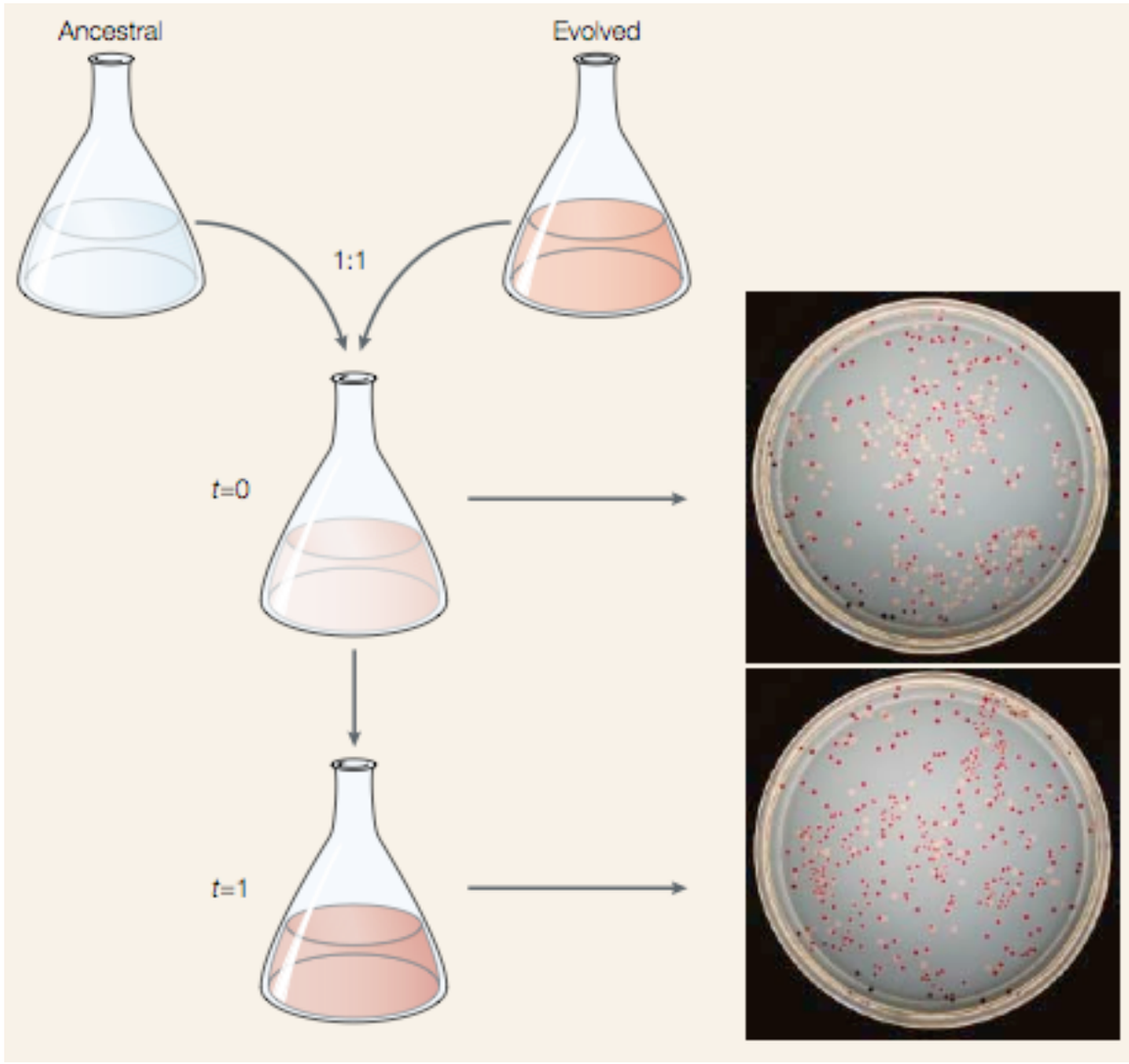
M. M. Desai and D. S. Fisher (2007), "Beneficial Mutation-Selection Balance and the Effect of Linkage on Positive Selection." Genetics 176:1759-98 (2007)

The Luria-Delbruck experiment



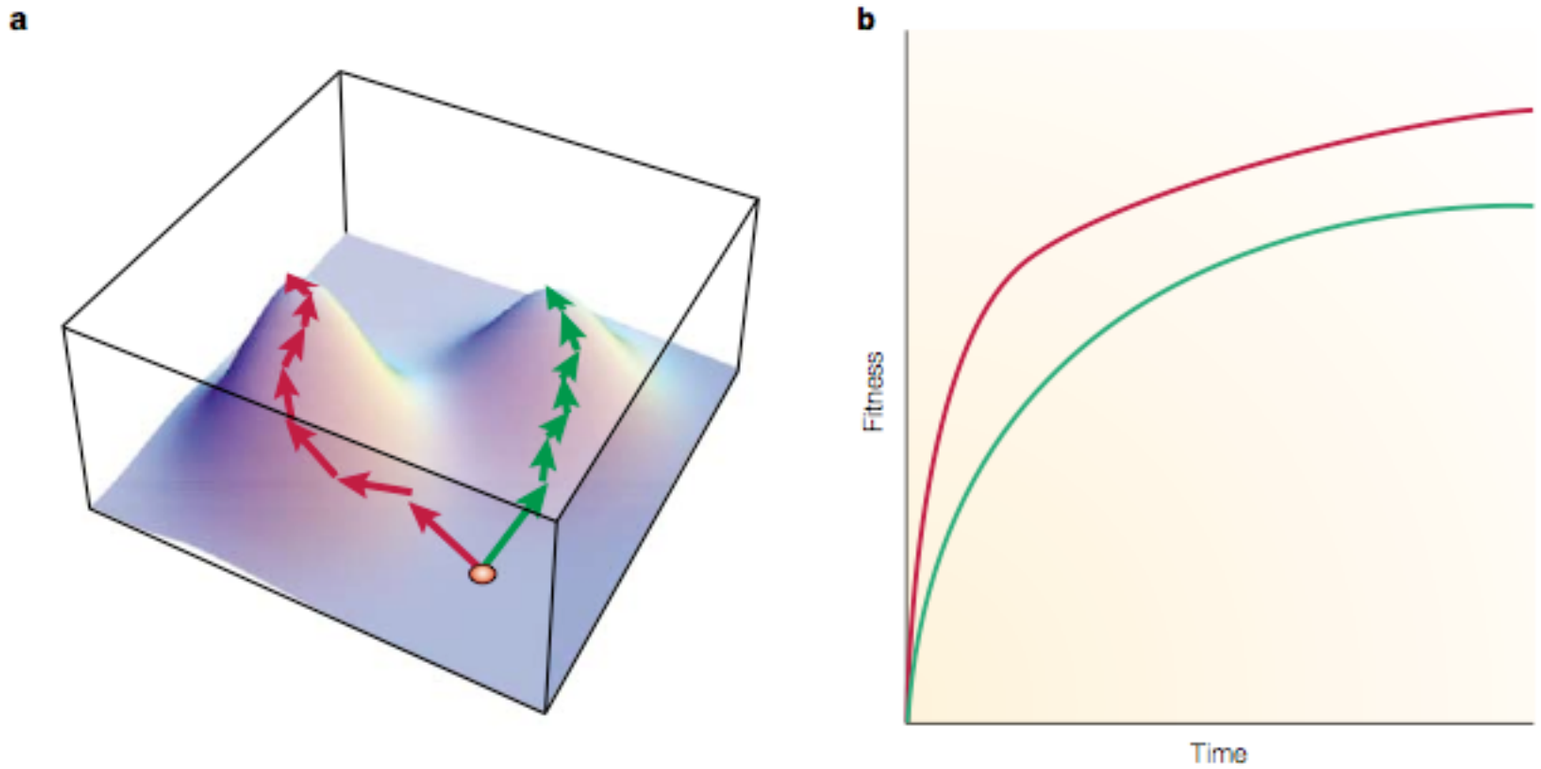
SE Luria and M Delbrück, (1943). "Mutations of Bacteria from Virus Sensitivity to Virus Resistance". Genetics 28 (6): 491–511

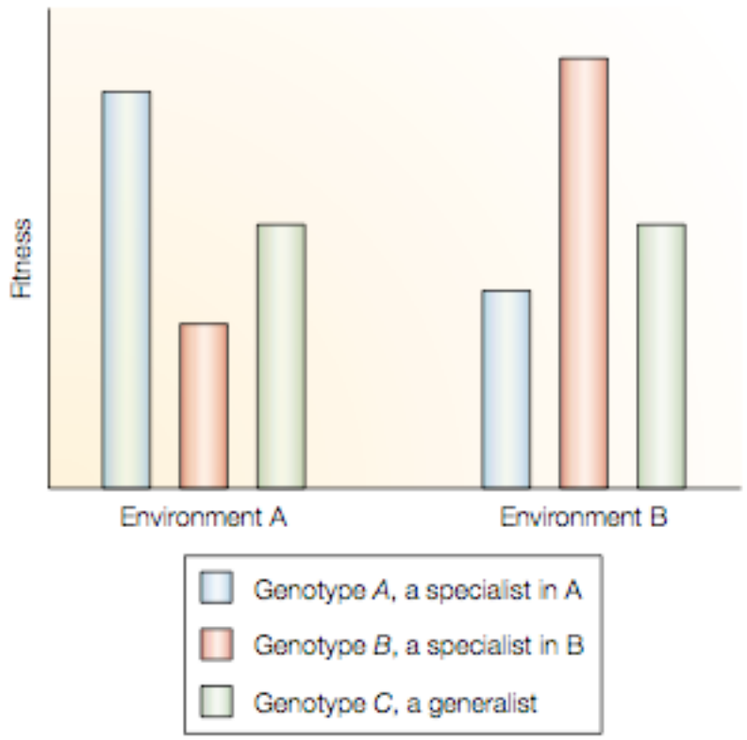
The Lenski experiment



SF Elena and R. E. Lenski. 2003. Evolution experiments with microorganisms: the dynamics and genetic bases of adaptation. Nature Reviews Genetics 4:457-469.

The Lenski experiment





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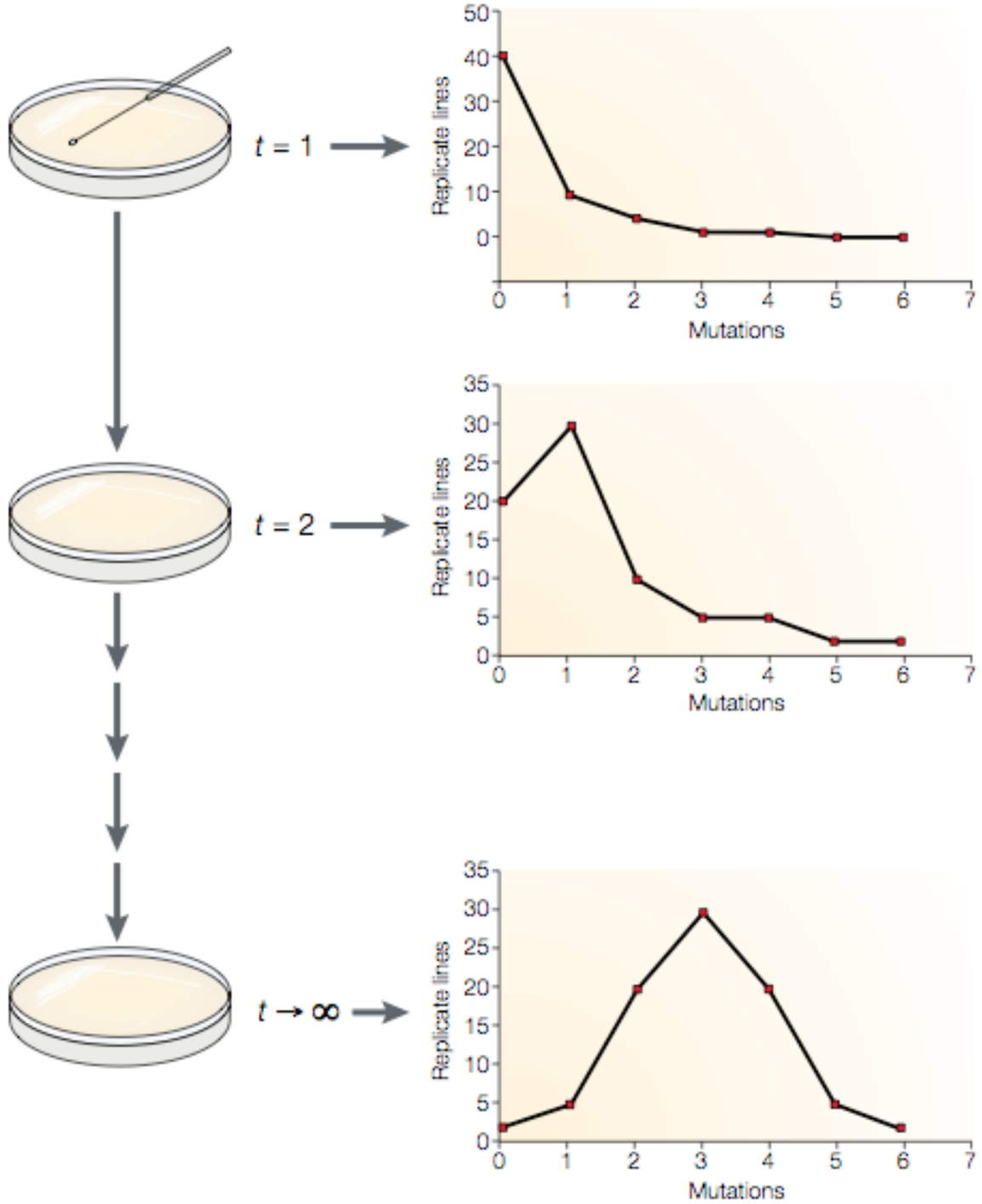
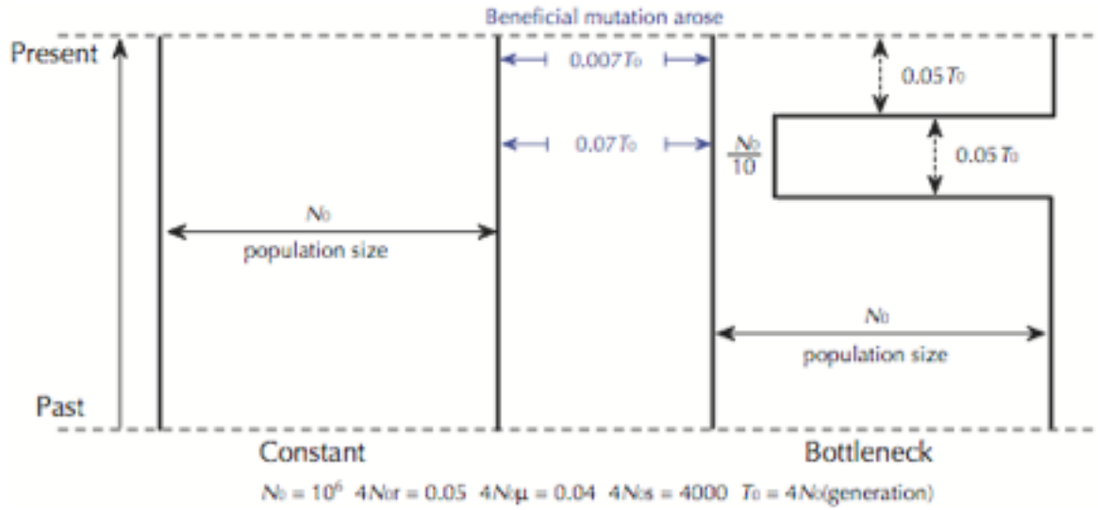
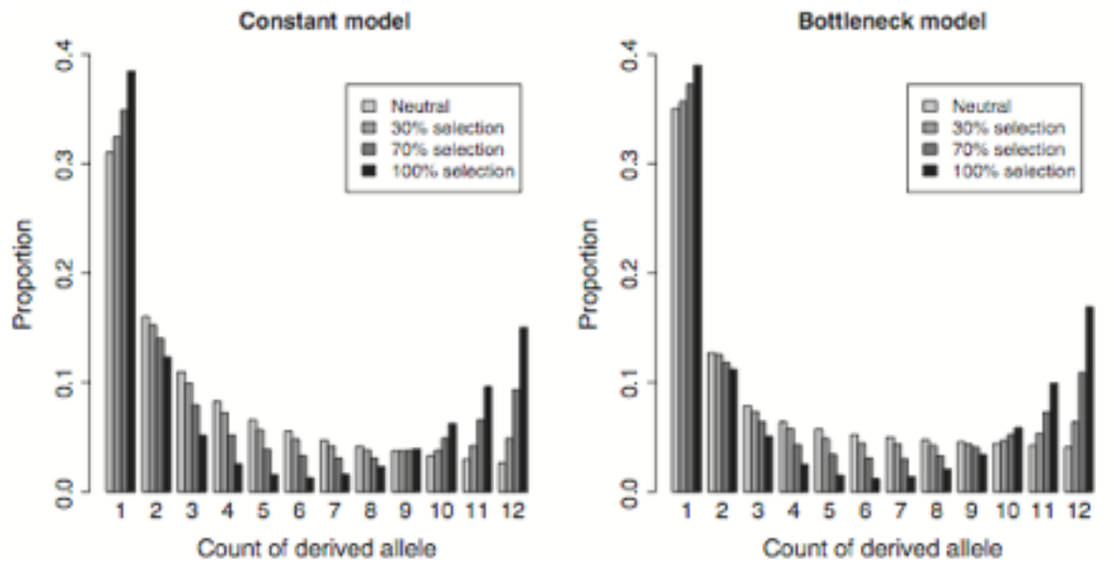
The Lenski experiment

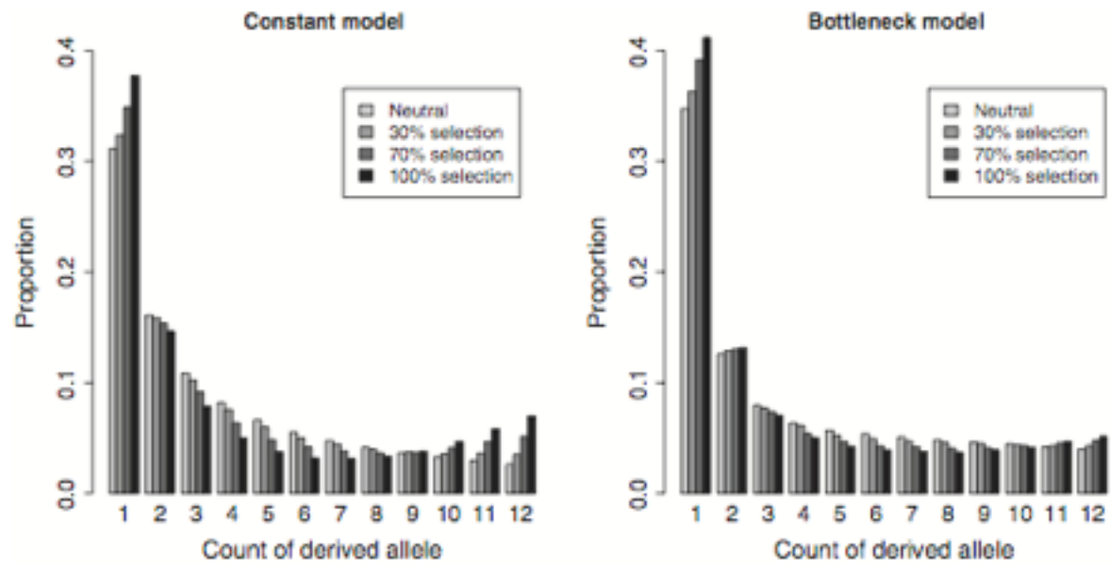


SF Elena and R. E. Lenski. 2003. Evolution experiments with microorganisms: the dynamics and genetic bases of adaptation. Nature Reviews Genetics 4:457-469.

Demography vs Selection





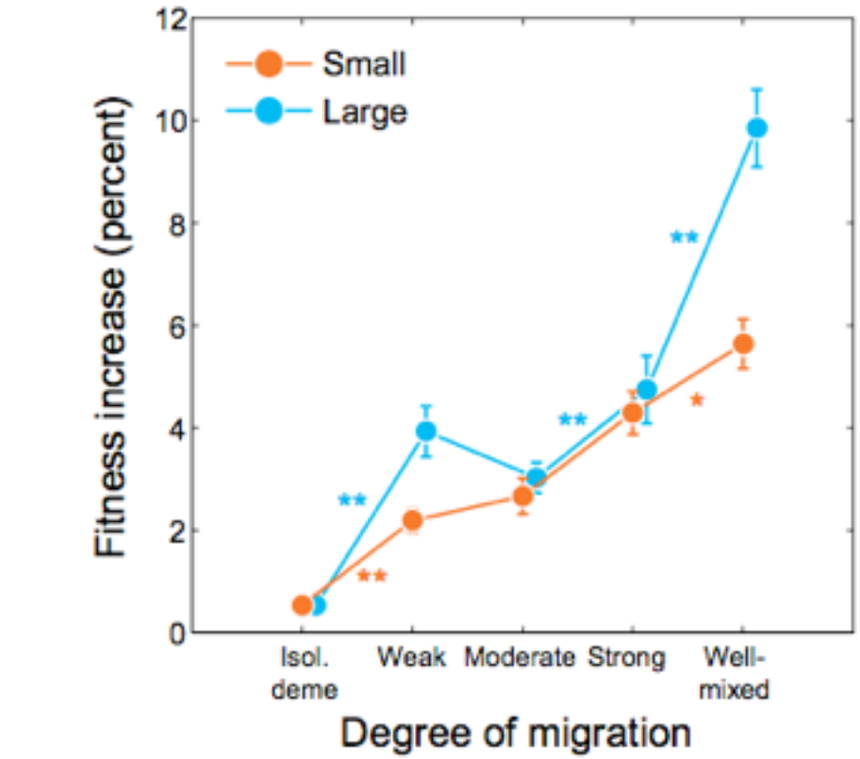


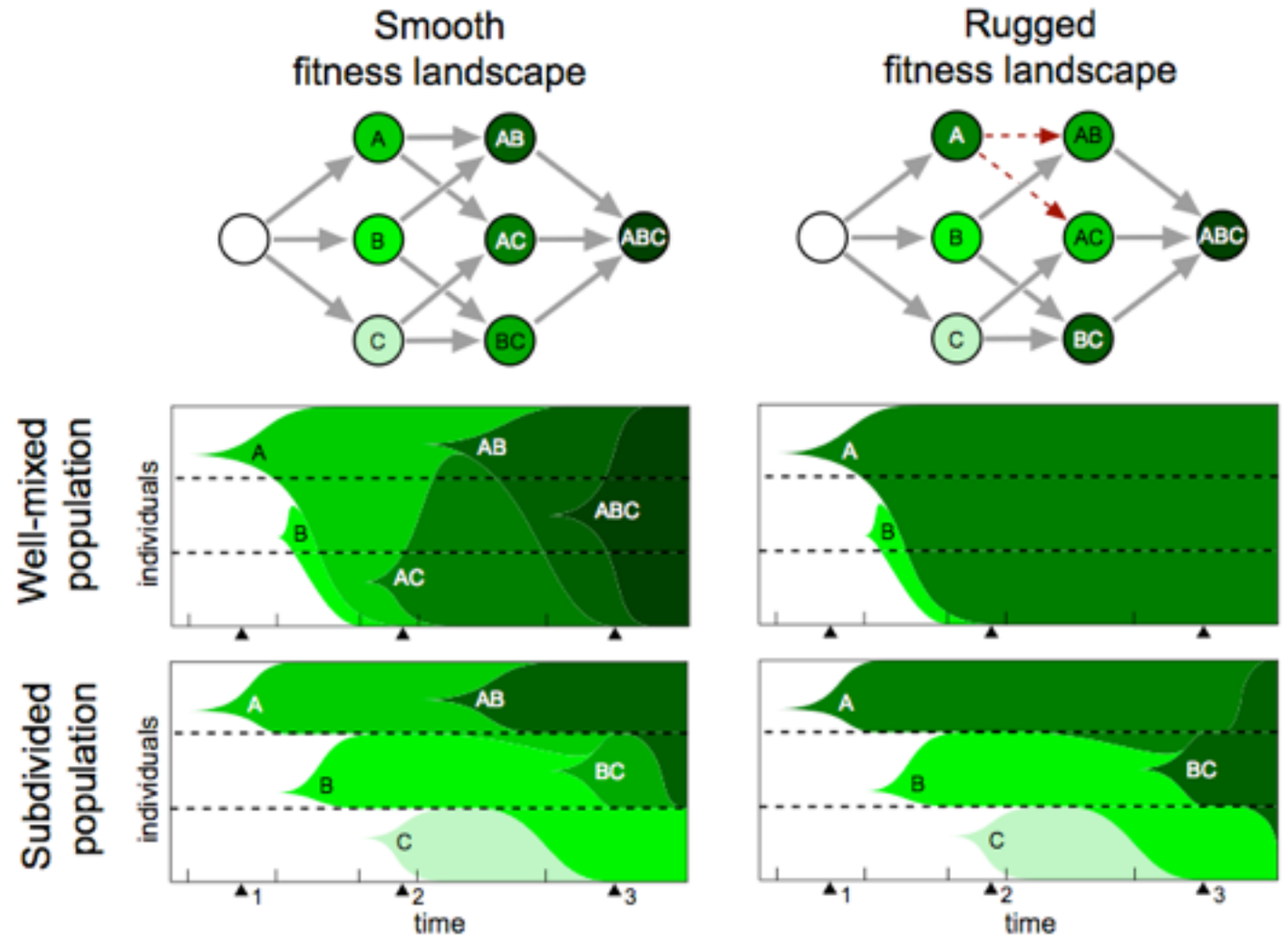
J LI, H LI, M JAKOBSSON, S LI, P SJODIN and M LASCOUX

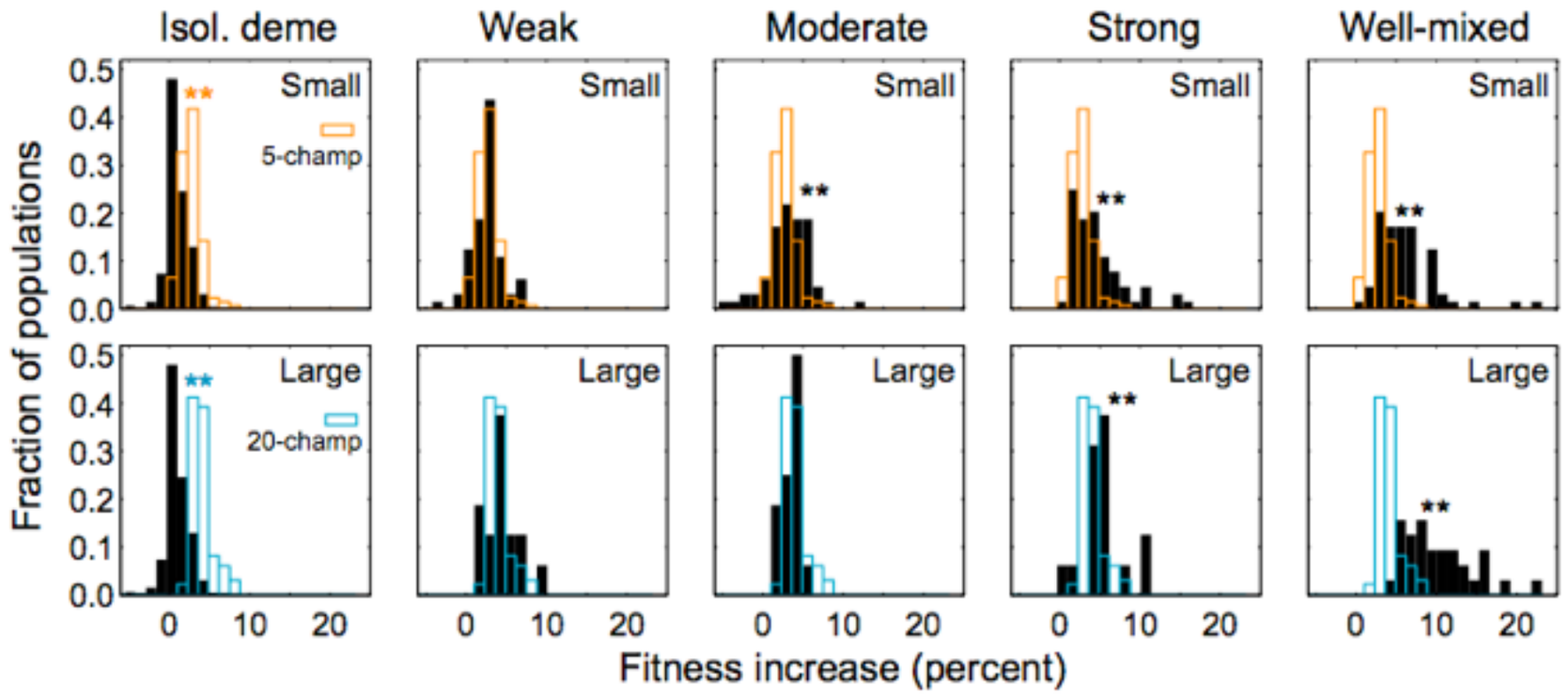
Joint analysis of demography and selection in population genetics: where do we stand and where could we go?

Molecular Ecology (2011)

Niches (mixing) and selection





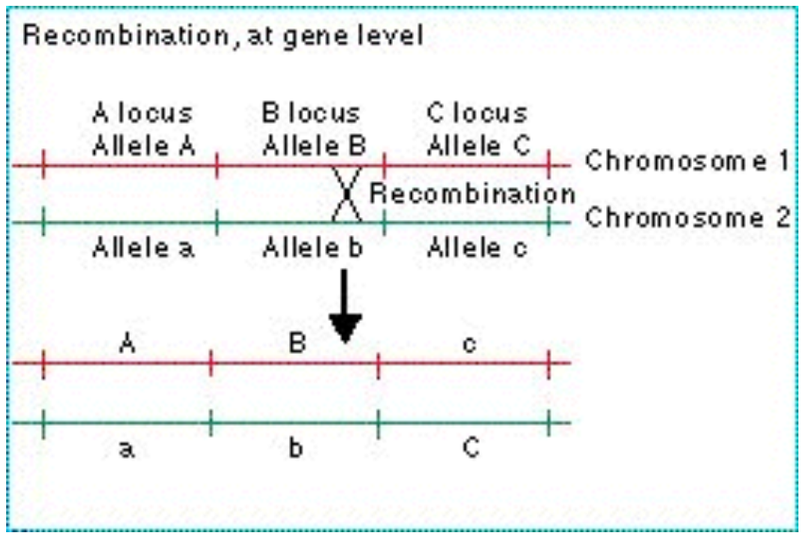


S Kryazhimskiy, DP Rice, MM Desai

Population Subdivision and Adaptation in Asexual Populations of Saccharomyces cerevisiae

Evolution (2012)

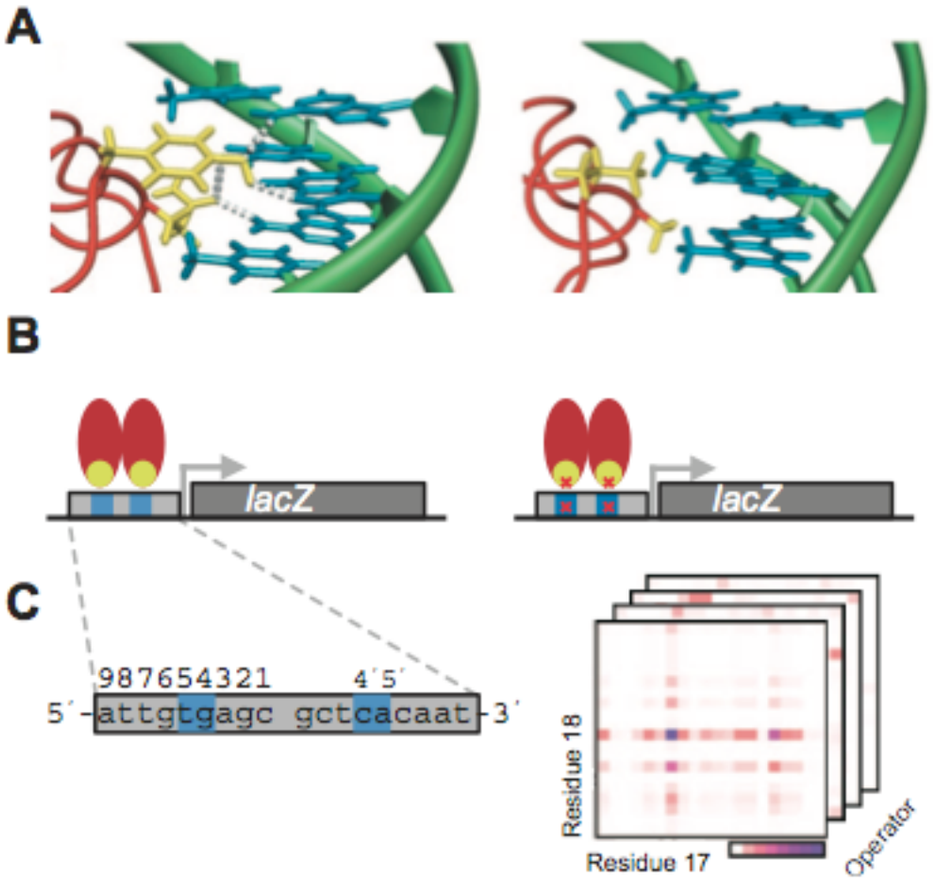
Sexual reproduction - recombination



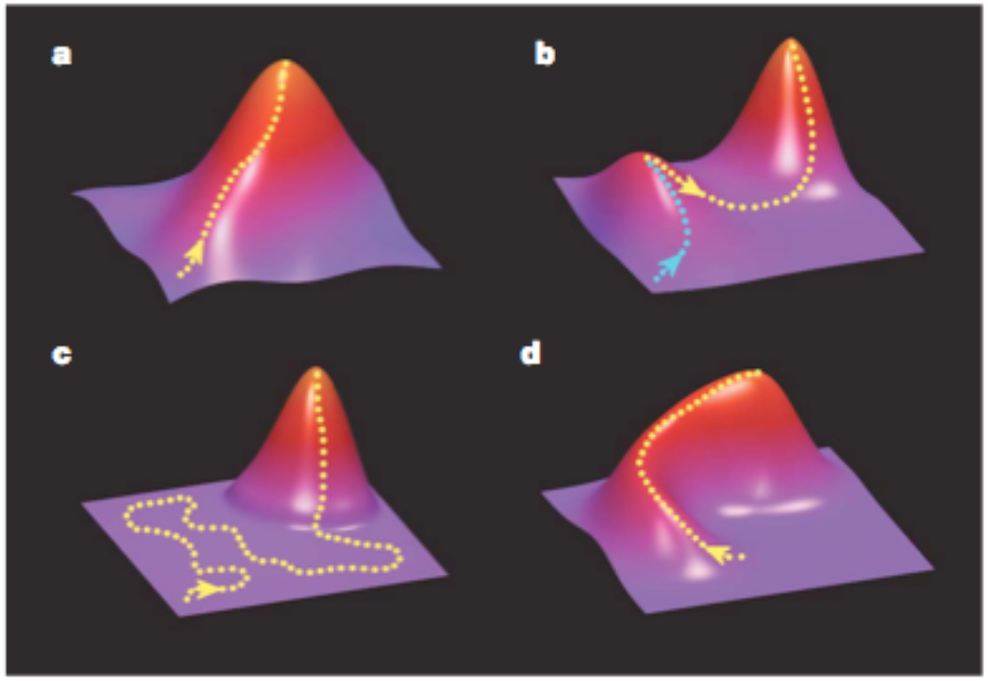
effects of recombination of mutations, effects of selection on recombination ....

how do we distinguish recombination from geographic effects ...

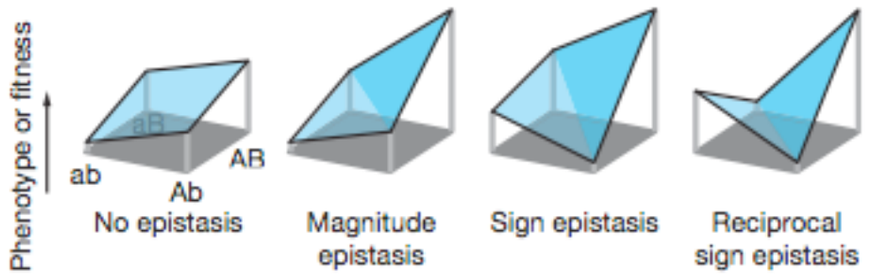
Molecular evolution



lac repressor

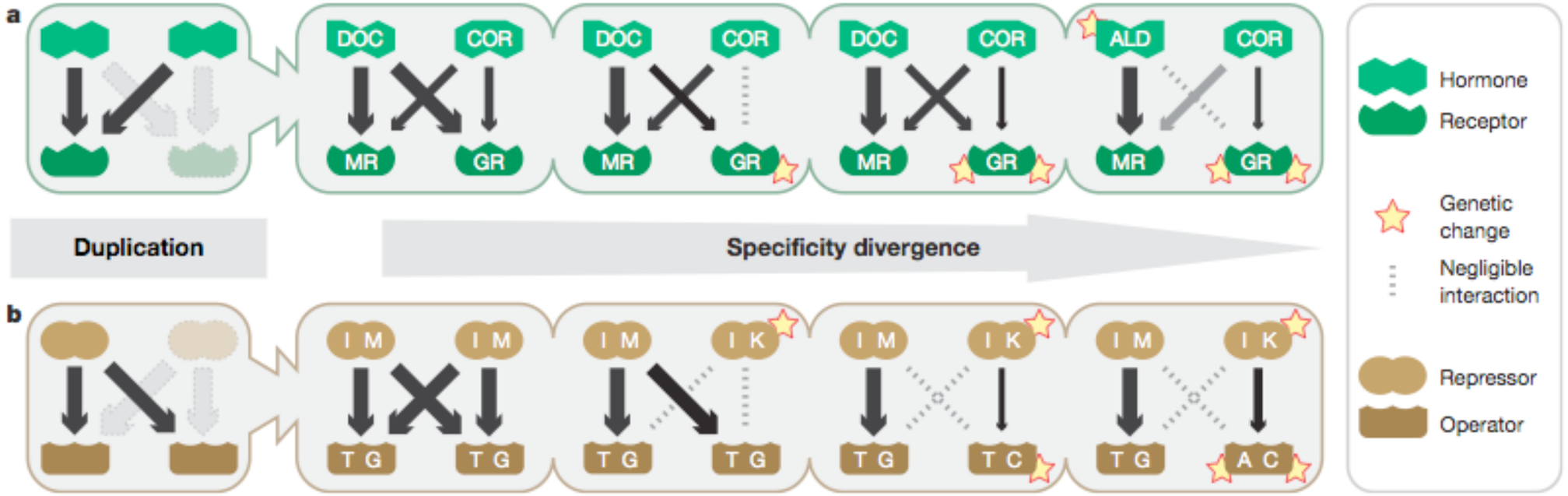


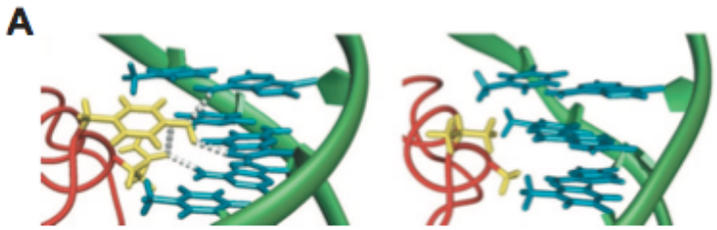
bacterial beta-lactamase to the antibiotic cefotaxime

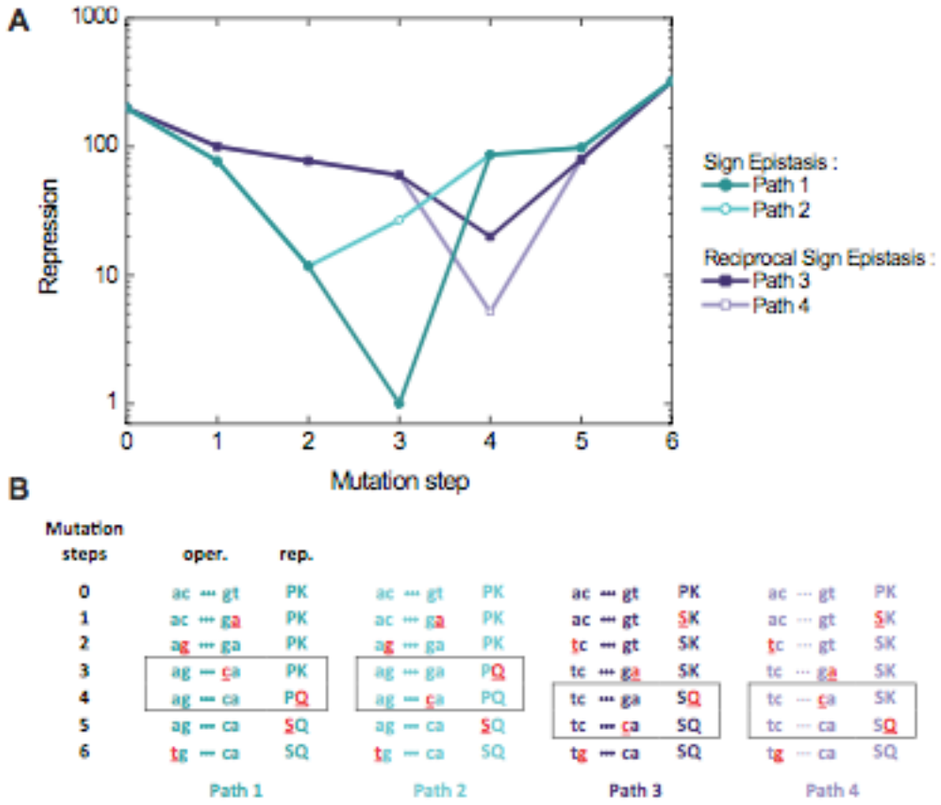


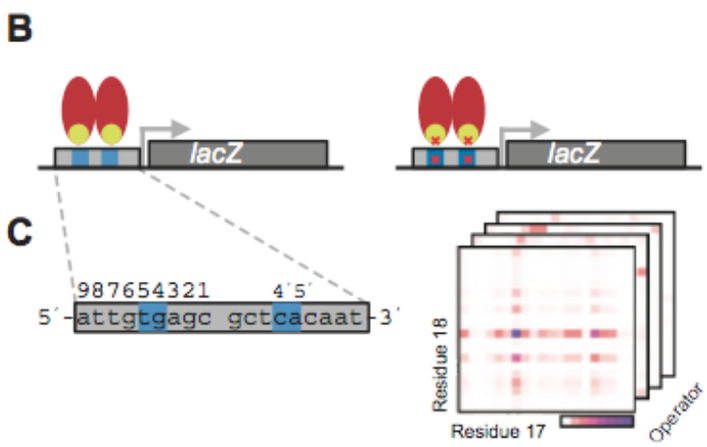
Empirical fitness landscapes reveal accessible evolutionary paths
Frank J. Poelwijk, Daniel J. Kiviet, Daniel M. Weinreich and Sander J. Tans

NATURE Vol 445 25 January 2007









Multiple peaks and reciprocal sign epistasis in an empirically determined genotype-phenotype landscape
Alexandre Dawid, Daniel J. Kiviet, Manjunatha Kogenaru, Marjon de Vos, and Sander J. Tans

CHAOS 20, 026105 2010