

Genetic drift and mutation explains important features of molecular evolution

What is molecular evolution?

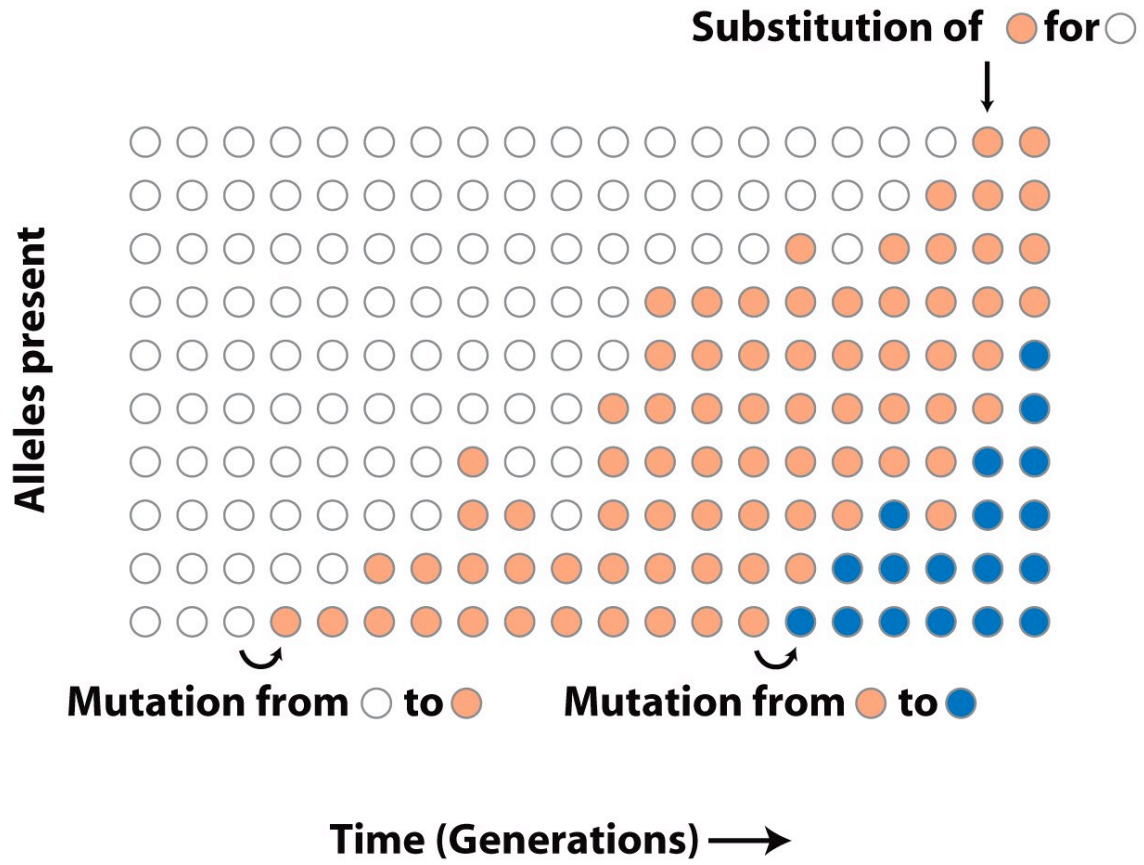


Figure 7-20 Evolutionary Analysis, 4/e  
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What is the rate of evolution according to the mutation-genetic drift model?

# The Neutral Theory

## Predictions of the Neutral Theory

Prediction #1: The Molecular Clock

Evidence that sequence evolution occurs largely independently of morphological evolution:

## Predictions of the Neutral Theory

Prediction #2: Molecular sites which are less evolutionarily constrained should evolve faster:

## The Nearly Neutral Theory:

The Nearly Neutral Theory (NNT) was proposed because the Neutral Theory, while successful in explaining many aspects of molecular evolution, fails to explain some important observations:

Including the fact that the molecular clock ticks per year, not per generation

The NNT is conceptually similar to the Neutral Model, because it maintains that most substitutions are the result of genetic drift, not selection.

However, the NNT makes the surprising assertion that most substitutions are not truly selectively neutral, but slightly deleterious. If selection is weak enough, these alleles can behave effectively as if they were neutral (because selection is so weak).

How weak?

If  $s \leq 1/2N_e$ , then alleles behave effectively as if they were neutral.

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How does this help with our molecular clock problem?

Now, the (effective) neutral mutation rate is a function of population size ( $N_e$ ). Therefore the substitution rate (which is equal to the effective neutral mutation rate) is also a function of population size.

To see this, consider two populations, one of (effective) size 50 and another of size 5000.

Why the the molecular clock ticks per year rather than per generation (or why mice evolve at the same rate per year as elephants):

Small populations evolve faster (experience more substitutions) per generation under the NNT

But small populations have longer generation times, which means they evolve more slowly on a per year basis

These effects tend to cancel

A hypothetical example comparing the rate of evolution of mice vs. elephants:

The NNT fits the data better.

It also provides the following fundamental insight into the (molecular) evolution in populations:

Small populations evolve more by genetic drift,

whereas large populations evolve more by selection.

In small populations a larger fraction of new mutations are effectively neutral, therefore: