Lecture 15

Complete Genetic Drift
Begin Selection
Readings: Article 14, Chapter 5 S&S

Genetic drift

Genetic drift is an intrinsic, stochastic process that results in change in allele frequencies due to chance. The smaller the population, the more rapid the change, and the greater the likelihood of fixation.

Principles of Genetic Drift

1. If $N=\infty$, there is no genetic drift.
2. The smaller the population, the greater $\Delta p$.
3. The direction of change is random.
4. Eventually, populations will become fixed for allele $A_1$ or $A_2$, with more rapid fixation in small populations.
5. Drift may be important even in large populations if $N_e < N_{tot}$. This is true if:
   - a population is not 'panmictic' or
   - the sex ratio is skewed
Effective Population Size

- Even if a population is panmictic (randomly mating with no distance limitation), $N_e < N$ because not all individuals in a population are reproductive
- Skewed sex ratio may lower $N_e$

Real World

- Rare plants and animals (defined as those with small $N$) will tend to have lower genetic diversity than common species
- This can be reflected in: (a) greater fixation, (b) fewer alleles at a locus, (c) lower heterozygosity.

**Wolverine (Gulo gulo):**
250-300 individuals in the lower 48 states. Has been proposed for listing on the Endangered Species List. Small, fragmented populations in southern part of range
Drift-Related Phenomena:
(1) Population Bottlenecks
- Populations naturally fluctuate in size. When N is low, the stochastic process of drift can reduce genetic variation.

Victims of Population Bottlenecks
- Cheetahs contain almost no allelic variation!
- Population bottlenecks:
  - 10,000 ybp due to ice age,
  - 100 ybp due to overhunting

Subsequent Consequences of Reduced Genetic Variability
- Cheetah - concern about reduced resilience in the face of environmental challenges, including disease.

Let S = susceptible
R = resistant
Victims of Population Bottlenecks

Elephant seals found to have no allelic variation at 24 enzyme-coding loci. Reduced to 20 animals in the late 1890’s (overhunting). Now N>30,000.

Genetics of Turtles

Demonstration of population bottleneck

GG=Dark Green Turtles
Gg=Dark Green Turtles
gg=Light Green Turtles

Drift-Related Phenomena:
(2) Founder Effect

Difference in allele frequency in an isolated population due to chance ‘founding’ of the population by a random subset of a ‘mainland’ population; associated lower genetic variation in the isolated population is due to small N of the founding population.
Founder Effect Demonstration

And the difference between chance and selection

Summary of Drift

- Drift is a powerful force for changing allele frequencies in small populations
- Drift generally results in loss of genetic variation over time

Thought Question: In the DEMO, if natural selection was acting, how would this be reflected in $\Delta p$ (and therefore DIFFER from genetic drift?)

- A. $\Delta p = 0$
- B. $|\Delta p| > 0$
- C. $\Delta p$ would always be +
- D. $\Delta p$ would always be –
- E. $\Delta p$ would be non-random
The above diagrams show simulations of genetic drift for a 1 gene two allele system. The populations may be both \(N=100\), both \(N=10\), or one may be \(N=10\) and the other may be \(N=100\). Based on what you know about genetic drift, what can you say about the populations depicted in diagrams A and B, above?

(A) \(N=10\) in diagram A, and \(N=100\) in diagram B  
(B) \(N=100\) in diagram A, and \(N=10\) in diagram B  
(C) \(N=100\) in both  
(D) \(N=10\) in both  
(E) It is impossible to infer which diagram depicts a population with \(N=10\) or \(N=100\) because genetic drift is stochastic.

Regardless of your answer to the question above, in which population would you expect the allele to reach fixation more quickly?

(A) The population in A  
(B) The population in B  
(C) Neither. They would reach fixation equally quickly  
(D) Neither allele would reach fixation  
(E) It is impossible to infer which population would reach fixation more quickly

Yet another

After a VERY long time of genetic drift (thousands of generations), what can be said with virtual certainty about one particular population of 10 individuals?

(A) \(p\) will reach 1  
(B) \(q\) will reach 1  
(C) either one allele or the other will reach fixation  
(D) neither allele will reach fixation  
(E) It is impossible to infer what will happen after a VERY long time
Natural Selection

Charles Darwin

ON
THE ORIGIN OF SPECIES
BY MEANS OF NATURAL SELECTION,
OR THE
PRESERVATION OF FAVOURED RACES IN THE STRUGGLE
FOR LIFE
1859

Verbal Model:

If a population:

Then, a population will

Summary

Evolutionary change by natural selection occurs when (a) there is phenotypic variation in a population, (b) at least some of this variation is heritable, and (c) the phenotypic variation affects fitness.