Population Genetics
Problem Set 7 Key

1. Consider a rare population where the effective population size equals the census size and is 40. Assume no selection or migration.

a. How long is it expected to take on average for a new neutral mutant allele to become fixed in this population?

Answer: T1(p) = 4 Ne = 4(40) = **160 generations**

b. For a new neutral mutation in this population, what is the probability that it will become fixed in the population?

Answer: 1/(2N) = 1/80 = **0.0125**

c. If the new neutral mutant allele is one of only two alleles in the locus for this population, what is the probability that the original allele will become fixed?

Answer: 1 – (1/(2N)) = 1 – (1/80) = **0.9875**
Note: this is the same probability that the new mutant will be lost.

2. Assuming neutrality for all markers, and similar reproductive success for males and females, for a small population, to what relative degree will each of the following genetic markers be affected by genetic drift? Why?
Markers: autosomal, mitochondrial, X-chromosome, Y-chromosome

(Note: also assumes equal numbers of each sex:) In order from most to least affected: 1. mtDNA and Y-chromosome, 2. X-chromosome, 3. Autosomal. Reason: genetic drift has a greater effect on markers with lower effective population sizes.

3. What are the arithmetic mean and the harmonic mean of the following numbers: 2000, 300, 100

Arithmetic mean: x-bar: (2000 + 300 + 100) / 3 = 2400/3 = 800

Harmonic mean: 3 / ((1/2000) + (1/300) + (1/100)) = 3/0.01383 = 217

4. Two populations are similar except in terms of inbreeding coefficient. The first population has no inbreeding, while the second population has an inbreeding coefficient of ***f*** = 0.1. The first population has an effective population size of 110. What is the effective population size of the second population?

Ne = N / (1+f) = 110 / (1 + 0.1) = 110/1.1 = 100

5. What factors determine the probability of fixation for an allele subject to selection, in a finite population?

The probability of fixation depends on initial frequency of the allele, the amount of

selection, and the size of the finite population. The effects of genetic drift may preclude even a favorable allele from becoming fixed, or may allow fixation of deleterious alleles (especially if they are only slightly deleterious).

6 Give the best definition for the following terms:

a. Bottleneck: periods during which only a few individuals survive to continue the existence of the population.

b. Founder effect: loss of genetic variation when a new population is established by a small number of individuals from a larger founding population. May lead to low genetic variation or, by chance, to unusually high or low frequencies for some alleles.

c. Genetic drift: chance allele frequency changes due to finite population sizes.

d. Absorbing states: The levels at which an allele becomes either lost in the population, or fixed in the population (i.e., where allele frequency becomes 0 or 1), after which allele frequency cannot be changed by drift in subsequent generations (barring mutation, migration, etc).

e. Mutation: change to the nucleotide sequence of the genetic material

f. Frameshift mutant: indel that changes the reading frame of subsequent codons in a transcript

g. Gene conversion: part of the nucleotide sequence from one allele is replaced by the homologous nucleotide sequence of another allele (without the sequence of the first allele replacing that of the second).

h. Mutation-selection balance: mutation that produces new deleterious alleles is counterbalanced by purifying selection against the deleterious alleles, thus keeping constant the frequency of mutant alleles

7. What may cause hybrid dysgenesis, i.e., sterility when two different strains of *Drosophila* are crossed?

Transposable elements (P or I) present in only one of the strains (these are regions of “junk or “selfish” DNA that can move or replicate themselves in the genome)

8. Why is the hypothetical fitness curve of mutations said to be bimodal?

There is one peak of frequency near neutrality (relative fitness near omega-bar) and a smaller peak near lethality (fitness at or near $\omega = 0$).

9. What are two major components of **genetic load**?

(1) **Mutation load** due to deleterious mutants not yet removed by selection, and (2) homozygote genotypes at loci subject to overdominant selection.