Molecular Evolution C3020

Population Genetics Exercises – **Corrected**

These problems will be hard the first time you do them. After you work through them with the answers, you should be able to do equivalent problems without a lot of trouble.

1. Rh blood types in humans are determined by a single locus, in which the Rh+ allele is completely dominant. In a study of 400 humans in the Basque region, 230 were found to have Rh+ blood; the remainder were Rh-. What are the frequencies of the + and – alleles in the population? What do you expct the proportions of the 3 genotypes to be under Hardy-Weinberg equilibrium? If the population were genetically tested using restriction fragment length polymorphisms and the frequency of heterozygotes were found to be lower than anticipated, what might be the reason(s)?

2. In the fly *Drosophila mauritania*, a transposable element called mariner exists at a several loci in the genome. Each copy is deleted from the genome with a frequency of 1 percent per generation. In a population in which mariner is fixed at a specific locus, how many generations will it take until the frequency of individuals that are homozygous for the deletion is 5 percent? Hint: this question involves both Hardy-Weinberg and one-way mutation calculations.

3. Consider a locus with two alleles, A and a. If the mutation rate from A to a is $0.86 * 10^{-3}$ mutations per generation and the mutation rate from a to A is $0.47 * 10^{-3}$, what is the expected equilibrium frequency of a?

4. In a haploid organism, with the same mutation rate, what is the expected equilibrium frequency of a? Suppose there is no back-mutation -- only foreward mutation (A to a) at the rate given in #3 – and A is 10% more fit than a. What is the expected equilibrium frequency of a? Hint: you will have to derive an expression for the equilibrium value, using the same technique we used for the diploid case in class.

5. Imagine two gene loci, each with two alleles. In both cases, the homozygote AA has 1 percent greater fitness than the homozygote aa, and BB has 1 percent greater fitness than bb. When the experiment begins, both A and B have an allele frequency of 1 percent. If A displays complete dominance over a, and B displays additive codominance with b, which gene will be evolving faster after 100, 500 and 1000 generations? Assume that at these times, the frequencies of A and B respectively are about 0.031 and 0.017; 0.471 and 0.130; and 0.816 and 0.679, respectively.

6. What is the expression for the expected equilibrium value of an allele frequency (p) under the influence of mutation (at rate u) and selection (coefficient of selection = s), if the advantageous allele is codominant? Hint: Adapt what we did in class for a dominant allele for this case.

7. Consider a lethal gene for the enzyme phosphodiesterase, with two alleles, PDE and PDE-. PDE is mutated to PDE- at the rate $5 * 10^{-6}$ mutations per generation with no back mutation. If PDE- is completely recessive, what is its equilibrium frequency? What is the equilibrium frequency if the heterozygote is 40 percent less fit than the AA genotype? What assumption did you make to make this calculation? Is it valid? If you had not made this assumption, how would your answer have changed (answer qualitatively -- higher or lower -- don't try to calculate the amount).

8. Imagine a small diploid population of 10 individuals. Consider a gene for an enzyme that has two alleles (A and a), which begin at equal frequency and are selectively equivalent. What is the probability that A will be completely lost from the population in the next generation? About how many generations will it take before A has frequency 0.1? Hint: the expected value of p at time t is given as $p_t q_t / p_0 q_0 = (1-1/2N)^t$.

9. Imagine a large population split into 50 subpopulations (demes), each with 20 individuals in it. All populations begin with the frequency of A at 0.3. After 1000 generations, how many demes do you expected to be fixed for A? In how many will A have been lost completely? After 30 generations, what do you expect the proportion of heterozygotes in the total population to be? (See hint for #8.)

10. Consider a diploid population of a plant species that can either self or mate with other individuals with equal probabilities. The population begins with 30 unrelated individuals. What is the probability that any one individual will be autozygous (inbred, with gametes derived from the same parent) in the first generation of offspring) in the first generation? On average, how many individuals in the population will be autozygous in the first generation? What is the probability that any one individual will be autozygous after 100 generations?

11. For the population in #10, consider a two-allele locus with initial frequency p=.3. After 100 generations, what is the change in p due to inbreeding? What is the expected proportion of heterozygous individuals in the population after 100 generations, considering only the effect of inbreeding? What is the expected proportion of heterozygotes at this time due to the effect of drift? What is the expected proportion of heterozygotes at this time when both inbreeding and drift are considered.? (Hint: think about the way that each process affects heterozygosity. Then think how one might compound the other.)

12. Consider two populations of mountain goats separated by a high pass that is snowed over most of the year and difficult to get over. In these goats there is a gene (B, b) for which the frequencies are 0.3 and 0.7. If the populations have 100 goats each – of which 2 are migrants at each generation – what proportion of the population is expected to be heterozygous? What is the equilibrium heterozygosity if the populations have 1000 goats each, of which 2 are migrants in each generation?

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