Answers to Exercise 33

Adaptation: Persistence in a Changing Environment

1. In the second scenario, it is most likely that the population will immediately go extinct. This is because, with the allele frequencies set as they are, no individuals exist who have a phenotype of 12. In fact, the only way to get a phenotype of 12 is to have the genotype $A_2A_2B_2B_2C_2C_2$.

   You can use probability rules to determine the likelihood of generating the above genotype given the initial allele frequencies. It would be the probability of obtaining a sperm with the genotype $A_2B_2C_2$ and an egg of the genotype $A_2B_2C_2$ multiplied together. With the "2" alleles (A_2, B_2, and C_2) having frequency 0.2, the probability of a gamete having this genotype is 0.2 _ 0.2 _ 0.2, or 0.008. The probability of generating an offspring from an egg and a sperm of these genotypes is 0.008 _ 0.008, or 0.000064, or 0.0064%—a miniscule probability. Under this scenario, if there were 10,000 individuals in the population, only about 64 of them would have the necessary genotype to survive. More individuals would have the necessary phenotype if the frequencies of the "2" alleles were higher.

   The extinction rate for the situation in which the change in precipitation occurs more abruptly is much higher. A slower change in climate gives time for the "2" alleles to increase in frequency and for the genotype $A_2A_2B_2B_2C_2C_2$ to become more abundant.

2. The higher the frequency of the "2" alleles initially, the more likely the population is to survive the drought if the drought occurs in year 2.

3. If the allele frequencies of any of the "2" alleles was 0, the population would never be able to adapt to a to an extreme dry spell because you can not get a phenotype of 12 unless the individual is homozygous for all of the "2" alleles.

4. See the answer for Question 1. In our abrupt change example, we started out with 20% of all the alleles being the "2" alleles (A_2, B_2, and C_2). Theoretically, it was possible for there to be an individual with the genotype $A_2A_2B_2B_2C_2C_2$ necessary to survive, but the actual probability of that genotype occurring was 0.000064 and too small in a finite population for that individual to exist. Thus, even though the "2" alleles were present in the population, they were too scarce for the population to survive. With a gradual drying of the environment (a "mild" year preceding a "dry" year), the "2" alleles increased in frequency sufficiently to make the $A_2A_2B_2B_2C_2C_2$ genotype more prevalent.