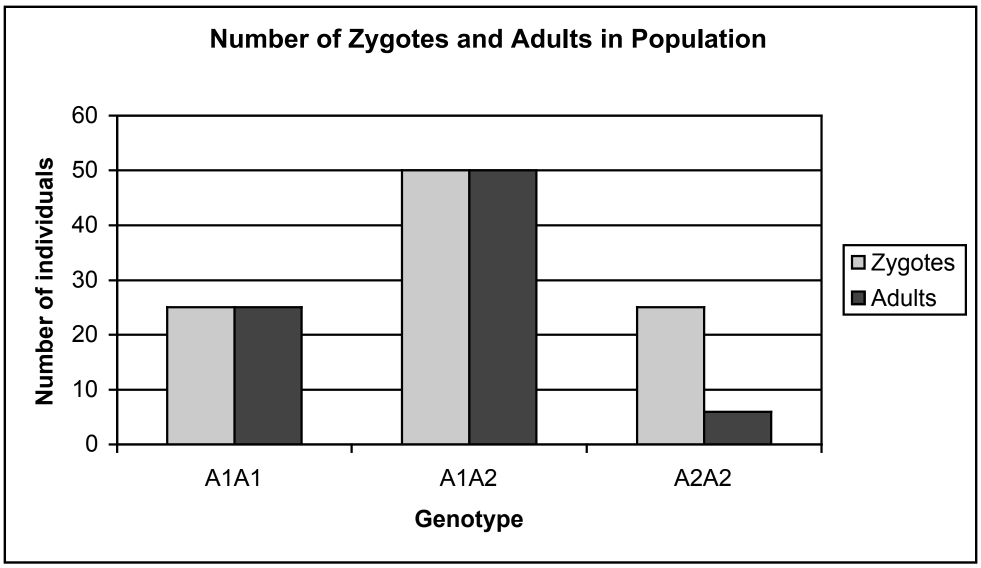
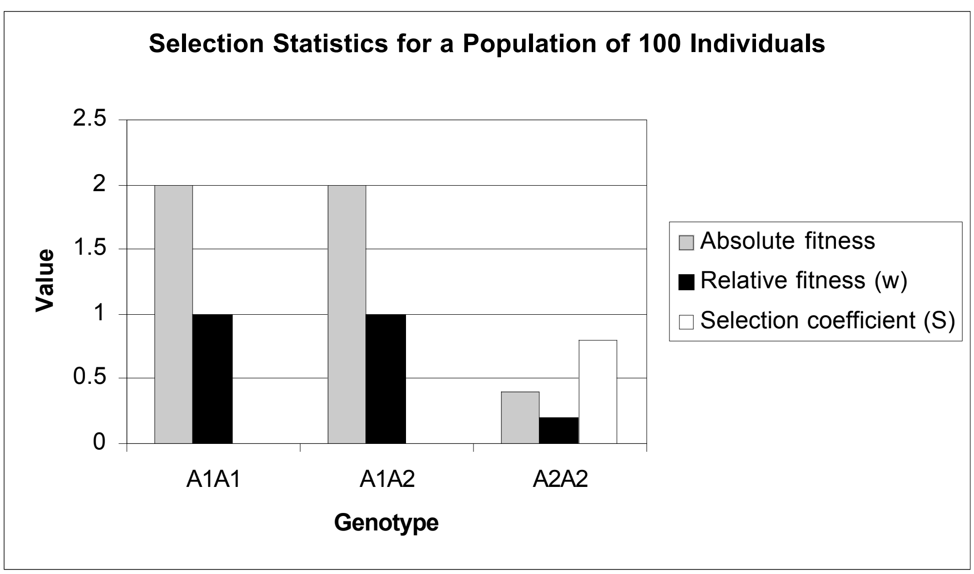
Answers to Exercise 32

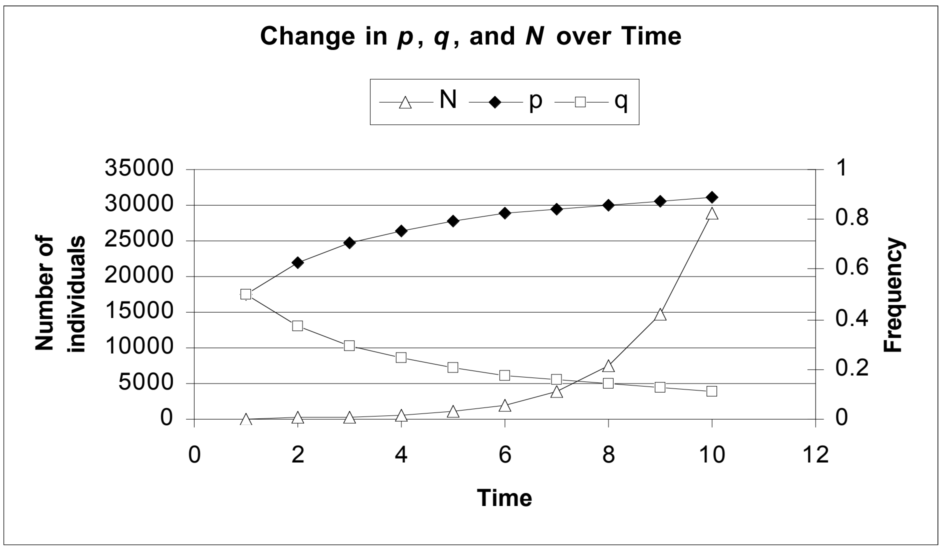
Natural Selection and Fitness

1. The first graph shows how natural selection selected differentially among the different genotypes in terms of survival to adulthood. This graph emphasizes that natural selection can work ***within*** a generation of individuals, changing the genotype frequencies of the population. However, for evolution to take place, we need to consider how allele frequencies change ***across*** generations as a result of natural selection. The second graph gives an indication of which genotypes have the greatest impact on the next generation's gene pool, relative to other genotypes. W is the absolute fitness, or the growth rate of genotypes from one generation to the next; w is the relative fitness; and S is the selection coefficient, which indicates how natural selection affects genotypes across generations relative to other genotypes.





2. The A_2 allele persists in the population because the heterozygote has a high fitness in the population. Since heterozygotes are able to survive and reproduce as well as the A_1A_1 genotype, its gametes will be incorporated into the next generation. Approximately _ of its gametes will be A_1, and _ will be A_2. Thus, the A_2 allele will persist because selection works on ***genotypes***, not on alleles. If you extend your model to 100 years (by copying the formulae in cells **I27:L27** down to row 117, you will see that the A_2 allele "stabilizes" in frequency at around 0.012.



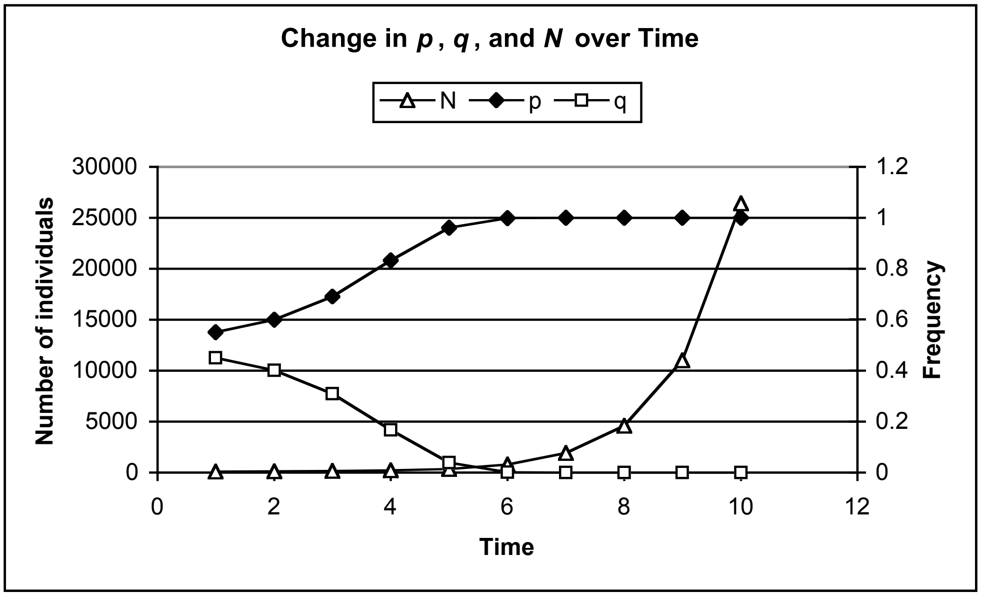
3. Although A_2A_2 has a lower survival probability, those individuals that survive to adulthood now contribute a large number of gametes to the next generation's gene pool. The result is that the A_2A_2 genotype has the same absolute fitness as the A_1A_1 and A_1A_2 genotypes. Thus, an important point to keep in mind is that fitness has two components: survival and reproduction, and both need to be considered when predicting the impacts of natural selection on evolutionary change.

4. You should see that, although W has changed for each genotype, w remains the same. You should also see that p and q remain unchanged in the next generation because relative fitness (the growth of genotypes relative to some standard) is the important factor in determining the frequencies of p and q in the next generation.

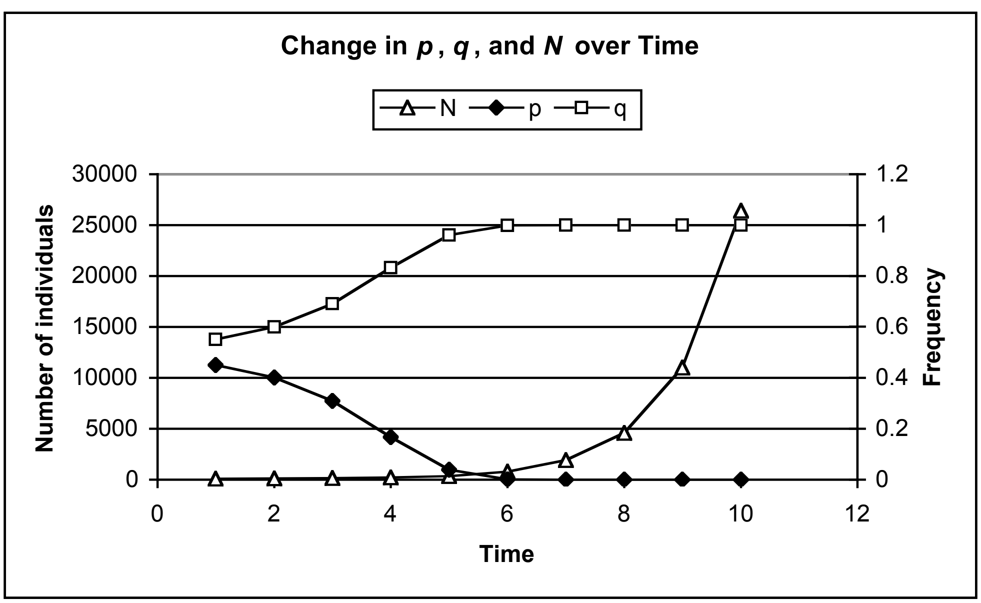
5. The weighted average of the W_{ij}'s is **=C12*C9+D12*D9+E12*E9**. The computation for λ in cell M18 is **=L19/L18**. Both should yield the same result: 1.2, which indicates that the population has grown by 20% from time t to time $t + 1$. This general relationship should hold no matter what values are entered, because the weighted average of the absolute fitness is the same thing as λ, the finite rate of increase for the population. Each W is multiplied by the frequency of individuals of a given genotype. For example, W_{11} is multiplied by p^2, W_{12} is multiplied by $2pq$, etc. This weighting is necessary because it reflects the number of individuals in the population. Thus, if A_1A_1's and A_2A_2's make up 80% and 20% of the population, respectively, W_{11} is multiplied by 0.8 and W_{22} is multiplied by 0.2. This puts more "weight" on the W_{11} fitness because this genotype (and hence W) dominates the population. When the weighted W's are added,

the result is □.

6. When there is selection against the heterozygote, the course of evolution for the p and q depends on the starting genotype frequencies in the population. When $p > q$, and there is strong selection against the heterozygote, p increases in frequency until fixation ($q = 0$).



However, when $q > p$, and there is strong selection against the heterozygote, q increases in frequency until fixation ($p = 0$).



7. You should see that when there is selection for the heterozygote and when the homozygotes have the same relative fitness, *p* and *q* will eventually reach an equilibrium at 0.5 (The symbols overlap each other on the graph).