Name ________________________ **Period** __________

Chapter 23: The Evolution of Populations

This chapter begins with the idea that we focused on as we closed the last chapter: Individuals do not evolve! *Populations* evolve. The overview looks at the work of Peter and Rosemary Grant with Galápagos finches to illustrate this point, and the rest of the chapter examines the change in populations over time. As in the last chapter, first read each concept to get the big picture and then go back to work on the details presented by our questions. Don't lose sight of the conceptual understanding by getting lost in the details! EU 1.A, "Change in the genetic makeup of a population over time is evolution," is thoroughly covered in this chapter. You also need to be able to use the Hardy-Weinberg equation to make predictions about evolving populations, so do the practice problems.

Overview

1. What is *microevolution*?

2. What are the three main mechanisms that can cause changes in allele frequency?

3. What is the only mechanism that is adaptive, or improves the match between organisms and their environment?

Concept 23.1 *Genetic variation makes evolution possible*

4. Differences among individuals show two common patterns. One type of variation is between "either-or" characters, and the other is when the character varies along a continuum. Explain the underlying genetic differences that contribute to each pattern.

5. Perhaps because we tend to focus on mutations that cause changes in phenotypes, it is easy to think that every mutation will lead to a phenotypic change. Use Figure 23.4 to answer the following.

   a. How many total mutations are shown in the alcohol dehydrogenase gene?

   b. How many mutations occurred in the exon areas? How many of these mutations altered the amino acid sequence of the protein?

   c. Explain how a substitution error in an exon could have no effect on the amino acid sequence.

6. Several sources of genetic variation are available. What is the ultimate source of new alleles?

7. *Mutations* are any change in the nucleotide sequence of an organism's DNA. These mutations provide the raw material from which new traits may arise and be selected. What occurs in a *point mutation*? Do point mutations always result in a change of phenotype?

8. What is neutral variation? Give an example from Figure 23.4.

9. Chromosomal changes that delete, disrupt, or rearrange many loci at once are usually harmful. How does *gene duplication* occur? How might it play a role in evolution?

10. Much of the genetic variation that makes evolution possible comes through sexual reproduction. What are the three mechanisms by which sexual reproduction shuffles existing alleles?

    1.

    2.

    3.

Concept 23.2 *The Hardy-Weinberg equation can be used to test whether a population is evolving*

11. What is a *population*?

12. What is a *gene pool*?

13. The greater the number of *fixed* alleles, the lower the species' diversity. What does it mean to say that an allele is *fixed*?

14. The *Hardy-Weinberg principle* is used to describe a population that is *not* evolving. What does this principle state?

15. If the frequency of alleles in a population remains constant, the population is at *Hardy-Weinberg equilibrium.* There are five conditions for Hardy-Weinberg equilibrium. It is very important for you to know these conditions, so enter the conditions on the left side of the chart and a brief explanation of the condition on the right side.

CONDITIONS FOR HARDY-WEINBERG EQUILIBRIUM

Conditions For Hardy-Weinberg Equilibrium	Explanation
1.	
2.	
3.	
4.	
5.	

It is not very likely that all five of these conditions will occur. Allelic frequencies change. Populations evolve. This data can be tested by applying the Hardy-Weinberg equation.

Equation for Hardy-Weinberg Equilibrium

$$p^2 + 2pq + q^2 = 1$$

where p^2 is equal to the frequency of the homozygous dominant in the population, $2pq$ is equal to the frequency of all the heterozygotes in the population, and q^2 is equal to the frequency of the homozygous recessive in the population.

Consider a gene locus that exists in two allelic forms, A and a, in a population.

Let p = the frequency of A, the dominant allele

and q = the frequency of a, the recessive allele.

So,

$$p^2 = AA,$$
$$q^2 = aa,$$
$$2pq = Aa$$

If we know the frequency of one of the alleles, we can calculate the frequency of the other allele:

$$p + q = 1, \text{ so}$$
$$p = 1 - q$$
$$q = 1 - p$$

16. In a plant population, suppose that red flowers (R) are dominant to white flowers (r). In a population of 500 individuals, 25% show the recessive phenotype. How many individuals would you expect to be homozygous dominant and heterozygous for this trait? (A complete solution for this problem is at the end of this *Reading Guide* chapter.)

17. In a population of plants, 64% exhibit the dominant flower color (red), and 36% of the plants have white flowers. What is the frequency of the dominant allele? (There are a couple of twists in this problem, so read and think carefully. A complete solution for this problem is at the end of this *Reading Guide* chapter.)

Concept 23.3 *Natural selection, genetic drift, and gene flow can alter allele frequencies in a population*

18. First, let's try to summarize the big idea from this section. Scan through the entire concept to pull out this information. Three major factors alter allelic frequency and bring about evolutionary change. List each factor, and give an explanation.

Factor	Explanation

19. Which of the factors results in a random, nonadaptive change in allelic frequencies?

20. Which of the factors tends to reduce the genetic differences between populations and make populations more similar?

21. Of the three factors you previously listed, only one results in individuals that are better suited to their environment. Which is it?

22. Explain what happens in each of these examples of *genetic drift*:

founder effect

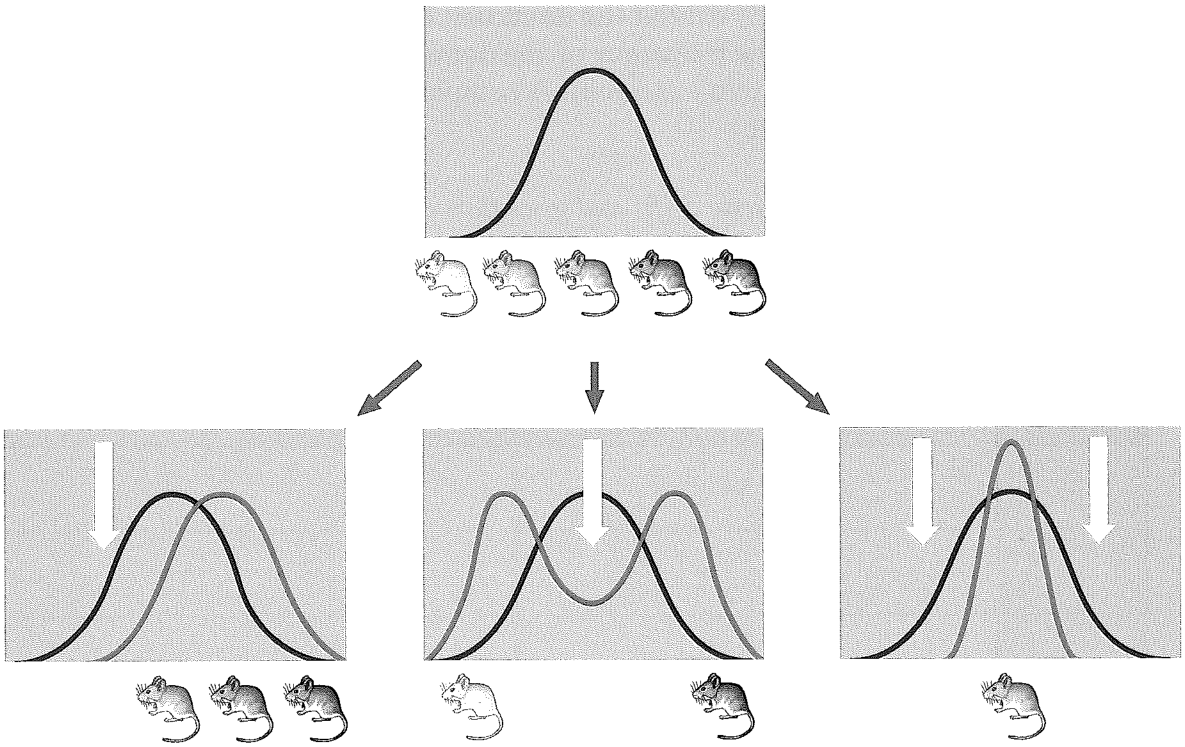
bottleneck effect

Concept 23.4 *Natural selection is the only mechanism that consistently causes adaptive evolution*

23. In evolutionary terms, *fitness* refers only to the ability to leave offspring and contribute to the gene pool of the next generation. It may have nothing to do with being big, or strong, or aggressive. Define *relative fitness*.

24. What is the *relative fitness* of a sterile mule? __________

25. Figure 23.13 in your text is important because it helps explain the three modes of selection. Label each type of selection, and fill in the chart to explain what is occurring.



Type of Selection	How It Works
Stabilizing	
Directional	
Disruptive	

26. What is often the result of *sexual selection*?

27. What is the difference between *intrasexual selection* and *intersexual selection*? Give an example of each type of selection.

28. Explain two ways in which genetic variation is preserved in a population.

29. Natural selection can act to maintain genetic variability due to balancing selection. Explain and give an example of the two mechanisms of balancing selection:

    a. Heterozygote advantage (Read Figure 23.17, Make Connections, to develop your response.)

    b. Frequency-dependent selection

30. Give four reasons why natural selection cannot produce perfect organisms.

Test Your Understanding Answers

Now you should be ready to test your knowledge. Place your answers here:

1. ________ 2. ________ 3. ________ 4. ________ 5. ________

Solution to Question 16

Let p = frequency of the dominant allele (R) and q = frequency of the recessive allele (r).

1. q^2 = frequency of the homozygous recessive = 25% = 0.25. Because $q^2 = 0.25$, $q = 0.5$.
2. Now, $p + q = 1$, so $p = 0.5$.
3. Homozygous dominant individuals are RR or $p^2 = 0.25$, and they will represent (0.25)(500) = **125 individuals.**
4. The heterozygous individuals are calculated from $2pq$ = (2)(0.5)(0.5) = 0.5, and in a population of 500 individuals will be (0.5)(500) = **250 individuals.**

Solution to Question 17

This problem requires you to recognize that individuals with the dominant trait can be either homozygous or heterozygous. Therefore, you cannot simply take the square root of 0.64 to get p. For problems of this type, you must begin with the homozygous recessive group.

Let p = frequency of the dominant allele (R) and q = frequency of the recessive allele (r).

1. q^2 = frequency of the homozygous recessive = 36% = 0.36. Because $q^2 = 0.36$, $q = 0.6$.
2. Now, $p + q = 1$, so $p = 0.4$.
3. Notice that this problem asks for the *frequency of the dominant allele* (p), not the frequency of the homozygous dominant individuals (p^2). So, you are done . . . **the frequency of the dominant allele = 0.4 or 40%.**