18

PROCESSES OF EVOLUTION

INTRODUCTION

Having examined the "big" processes that influenced evolution in the previous chapter, it is time now to focus on how populations change over time. This is called microevolution. This chapter first presents some important terminology regarding variation, and then establishes how to measure change in a population using the Hardy-Weinberg equilibrium equation. Following the introduction to microevolution, the chapter proceeds into a discussion of the many forms of selection, from sexual to disruptive. Perhaps one of the more important aspects of the chapter is the discussion of genetic drift, interbreeding, and gene flow and how these factors work on the allele frequencies in a population. This is a detailed chapter, but one that provides a good working knowledge of how scientists study evolutionary processes.

FOCAL POINTS

- For the Hardy-Weinberg equilibrium [pp.280-281], note especially the five conditions of a population at equilibrium, as this provides the foundation for studying evolution in populations.
- Figure 18.4 [pp.281] shows three modes of natural selection. The text devotes several sections towards understanding the material presented in this figure.

INTERACTIVE EXERCISES

Impacts, Issues: Rise of the Super Rats [pp.276]

18.1. INDIVIDUALS DON'T EVOLVE, POPULATIONS DO [pp.278-279]

18.2. A CLOSER LOOK AT GENETIC EQUILIBRIUM [pp.280-281]

Selected Words: morphological traits [p.278], morpho- [p.278], physiological traits [p.278], polymorphism [p.278], behavioral traits [p.278], qualitative differences [p.278], quantitative differences [p.278], phenotype [p.278], natural selection [p.279], genetic drift [p.279], gene flow [p.279], Hardy-Weinberg equilibrium equation[p.280], hemochromatosis [p.281]

CHAPTER OBJECTIVES / REVIEW QUESTIONS

1. What is a population? [p.278]
2. Distinguish among morphological, physiological, and behavioral traits. [p.278]
3. Distinguish between dimorphism and polymorphism. [p.278]
4. Explain the difference between gene pool and alleles. [p.278]
5. Explain the difference between a lethal and a neutral mutation. [p.279]
6. Define microevolution. [p.279]
7. List the five conditions that must be met for the Hardy-Weinberg rule to apply. [p.280]
8. Calculate allele and other genotype frequencies when provided with the homozygous recessive genotype frequency. [pp.280-281]
9. Define and provide an example of directional selection, stabilizing selection, and disruptive selection. [pp.282-285]
10. Define and give an example of sexual selection. [p.286]
11. Define balanced polymorphism and explain why the relationship between malaria and sickle-cell anemia is used as an example. [p.287]
12. Explain how genetic drift can lead to the fixation of alleles in a population. [p. 288]
13. Distinguish the founder effect from a bottleneck. [pp.288-289]
14. Explain the consequences of inbreeding. [p.289]
15. Explain the influence that gene flow has on the gene pool of a population. [p.289]
16. List the different types of isolating mechanisms. [p.290]
17. Explain the difference between allopatric, sympatric, and parapatric speciation. [p.292-295]
18. Explain the difference between microevolution and macroevolution. [p.296]

INTEGRATING AND APPLYING KEY CONCEPTS

1. What type of selection do diseases such as HIV and SARS exhibit on the human population? What effects do vaccines have on the gene pool?
2. Endangered animals are frequently confined to zoos for protection. How does this contribute to a bottleneck effect? How could a gene pool be increased and what would be the benefit of doing so?
3. What are the similarities between bacterial resistance and insect resistance to pesticides? What should society do in order to avoid the production of "super" bacteria and insects?
4. Give an example of a neutral trait in humans. For this trait predict what conditions may have existed in the past that would have made this trait advantageous.
5. Indicate the positives and negatives of creating pure bred breeds of dogs, horses, cattle, etc.
6. Explain how mutations and gene flow can counter the effects of genetic drift.

Boldfaced, Page-Referenced Terms

[p.278] population _____

_____

[p.278] gene pool _____

_____

[p.278] alleles _____

_____

[p.279] lethal mutation _____

_____

[p.279] neutral mutation _____

_____

[p.279] allele frequencies _____

_____

[p.279] genetic equilibrium _____

_____

[p.279] microevolution _____

_____

Matching [pp.278-281]

1. _____ microevolution
2. _____ gene pool
3. _____ population
4. _____ dimorphism
5. _____ alleles
6. _____ polymorphism
7. _____ quantitative differences
8. _____ qualitative differences
9. _____ lethal mutations
10. _____ morphological traits
11. _____ neutral mutation
12. _____ allele frequencies
13. _____ genetic equilibrium
14. _____ physiological traits
15. _____ behavioral traits

A. Genes that have slightly different molecular forms
B. A trait with three or more forms in a population
C. A range of incrementally small variations in a specified trait
D. Traits that define the form of the body
E. A change in the DNA that does not affect survival or reproduction
F. Traits that determine how an individual will respond to stimuli
G. Small scale change in a population's allele frequencies
H. A group of individuals of the same species in a specified area
I. A trait that disrupts a phenotype and causes death
J. The genes of all individuals and their offspring in a population
K. Traits that help the body function in its environment
L. A trait with two forms in a population
M. The relative abundances of an allele among all individuals of a population
N. A trait that has distinct forms
O. A population that is not evolving with regard to a certain allele

Short Answer [pp.280-281]

16. List the five conditions that must be met if the gene pool is to remain stable and the population is not evolving.

_____

_____

_____

17. For the following situation, assume that the conditions listed in question 16 do exist; therefore, there should be no change in gene frequency generation after generation. Consider a population of hamsters in which the dominant gene B produces a black coat color and the recessive gene b produces a gray coat color (two alleles will produce the coat color). The dominant gene has a frequency of 80% or (.80). The recessive gene will then have a frequency of 20% or (.20). From this, the assumption is made that 80% of all sperm and eggs have gene B and 20% of the sperm and eggs have gene b.

a. Calculate the probabilities of all possible matings in the Punnett square. (see left-hand diagram)

_____

_____

b. Summarize the genotype and phenotype frequencies on the F_1 generation. (see center diagram)

_____

_____

c. Further assume that the individuals of the F_1 generation produce another generation and the assumptions of the Hardy-Weinberg rule still hold. What are the frequencies of the sperm produced? (see right-hand diagram)_____

_____

_____

	Sperm	0.80 *B*	0.20 *b*
Eggs	0.80 *B*	*BB*	*Bb*
	0.20 *b*	*Bb*	*bb*

Genotypes	*Phenotypes*
____ *BB*	
____ *Bb*	___% black
____ *bb*	___% gray

Parents	*B sperm*	*b sperm*
____ *BB*	____	____
____ *Bb*	____	____
____ *bb*	____	____
Totals= ____	____	____

The egg frequencies may be similarly calculated. Note that the gamete frequencies of the F_2 generation are the same as the gamete frequencies of the previous generation. Phenotype percentage also remains the same. Thus, the gene frequencies did not change between the F_1 and F_2 generation. Again, given the assumptions of the Hardy-Weinberg equilibrium, gene frequencies do not change generation after generation.

18. In a population, 81% of the organisms are homozygous dominant, and 1% are homozygous recessive. Find the following:

a. The percentage of heterozygotes

_____

b. The frequency of the dominant allele

_____

c. The frequency of the recessive allele

_____

19. In a population of 200 individuals, determine the following for a particular locus if $p = 0.80$.

a. The number of homozygous dominant individuals

b. The number of heterozygous individuals

c. The number of heterozygous individuals

20. If the percentage of gene D is 70% in a gene pool, find the percentage of gene d.

21. If the frequency of gene R in a population is 0.60, what percentage of the individuals will be heterozygous Rr?

18.3. NATURAL SELECTION REVISITED [p.281]

18.4. DIRECTIONAL SELECTION [pp.282-283]

18.5. SELECTION AGAINST OR IN FAVOR OF EXTREME PHENOTYPES [pp. 284-285]

Selected Words: directional selection [p.281], stabilizing selection [p.281], disruptive selection [p.281], mark-release-recapture method [p.282]

Boldfaced, Page-Referenced Terms

[p.281] natural selection

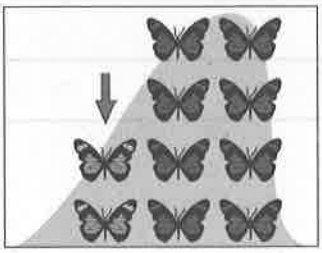
[p.282] directional selection

[p.284] stabilizing selection

[p.285] disruptive selection

Labeling [p.281]

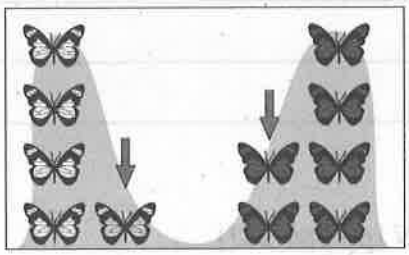
1. For each of the following three curves, first identify the curve as an example of stabilizing selection, directional selection, or disruptive selection; then give the general characteristics of each form of selection.



a. _____

_____

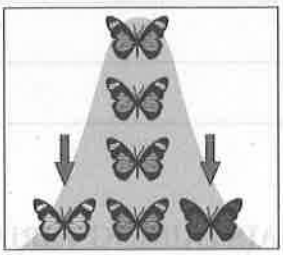
_____



b. _____

_____

_____



c. _____

_____

_____

Choice [pp.282-285]

For each of the following, choose from one of the forms of selection in the lettered list.

a. stabilizing selection b. directional selection c. disruptive selection

2. _____ Intermediate forms of a trait in a population are favored
3. _____ The range of variation in a phenotype tends to shift in a consistent direction
4. _____ The most frequent wing color of peppered moths shifted from a light form to a dark form as tree trunks became soot-darkened because coal was being used for fuel during the English industrial revolution
5. _____ Intermediate forms of a phenotype are selected against, while forms at the end of the range of variation are favored
6. _____ Antibiotic resistance favors resistant bacterial populations
7. _____ An example is the body weight of sociable weavers
8. _____ An example is the selection of bill size in finches of West Africa
9. _____ Coat color of pocket mice favors their environmental surroundings

Short Answer [p.283]

10. Explain the problems that are arising from our misuse of antibiotics.

18.6. MAINTAINING VARIATION [pp.286-287]

18.7. GENETIC DRIFT – THE CHANCE CHANGES [pp.288-289]

18.8. GENE FLOW [p.289]

18.9. REPRODUCTIVE ISOLATION [pp.290-291]

Selected Words: sickle-cell anemia [p.287], malaria [p.287], probability [p.288], Ellis-van Creveld syndrome [p.288], emigration [p.288], immigration [p.289], Prezygotic Isolating mechanism [p.290], Postzygotic Isolating mechanism [p.291]

Boldfaced, Page-Referenced Terms

[p.286] sexual dimorphism

[p.286] sexual selection

[p.287] balanced polymorphism

[p.288] genetic drift

[p.288] fixation

[p.288] bottleneck

[p.289] founder effect

[p.289] inbreeding _____

_____

[p.289] gene flow _____

_____

[p.290] reproductive isolation _____

_____

[p.290] speciation _____

_____

Choice [pp.286-289]

For each of the following, choose the most appropriate category form the list below.

a. balanced polymorphism b. genetic drift c. sexual selection d. gene flow e. inbreeding

1. _____ The random change of allele frequencies over time
2. _____ Immigration and emigration
3. _____ Adaptive traits increase reproductive success
4. _____ The physical flow of alleles between populations
5. _____ This is leading to the spread of genes from transgenic organisms to wild species
6. _____ May result in the fixation of alleles over time
7. _____ The relationship in hemoglobin structure between sickle-cell anemia and malaria
8. _____ An example is the courtship rituals of many species
9. _____ Examples are bottleneck and founder effect
10. _____ The increased frequency of Ellis-van Creveld syndrome is caused by this in Amish populations
11. _____ Is primarily driven by female choice
12. _____ Increases the frequency of homozygous individuals and lowers genetic diversity

Fill-in-the-Blanks [pp.288-289]

Random change in allele (13) _____ leads to the (14) _____ condition and a(n) (15) _____ of genetic diversity over time. This is genetic drift's outcome in all (16) _____; it simply happens faster in (17) _____ ones. Once alleles from the parent population have become (18) _____, their (19) _____ will not change again unless mutation or (20) _____ flow introduces new alleles.

Choice [pp.290-291]

For the following statements, choose the appropriate type of isolating mechanism

a. prezygotic isolating mechanism b. postzygotic isolating mechanism

21. _____ temporal isolation
22. _____ hybrid sterility
23. _____ mechanical isolation
24. _____ behavioral isolation
25. _____ hybrid inviability
26. _____ ecological isolation

18.10. ALLOPATRIC SPECIATION [pp.292-293]

18.11. OTHER SPECIATION MODELS [pp.294-295]

18.12. MACROEVOLUTION [pp.296-297]

Selected Words: archipelago [p.292], honeycreepers [p.293], autopolyploid [p.294], microevolution [p.296], macroevolution [p.296]

Boldfaced, Page-Referenced Terms

[p.292] allopatric speciation _____

[p.294] sympatric speciation _____

[p.294] polyploidy _____

[p.295] parapatric speciation _____

[p.296] coevolution _____

[p.296] stasis _____

[p.296] exaptation _____

_____

[p.296] adaptive radiation _____

_____

[p.297] key innovation _____

_____

[p.297] extinct _____

_____

[p.297] mass extinction _____

_____

Matching [pp.292-297]

1. _____ allopatric speciation
2. _____ sympatric speciation
3. _____ polyploidy
4. _____ parapatric speciation
5. _____ coevolution
6. _____ stasis
7. _____ exaptation
8. _____ key innovation

A. species doesn't change over time
B. 3 or more sets of chromosomes
C. physical barrier separates a population
D. new structure evolves from an existing one
E. two species evolve in response to each other
F. a population extends across a variety of habitats
G. new species form within the home range of the original species
H. structural modification that increases an organism's chance for survival

Choice [pp.292-295]

For the following statements, choose the appropriate type of speciation.

a. allopatric speciation b. sympatric speciation c. parapatric speciation

9. _____ Genetic differences in trees and shrubs due to the Great Wall of China
10. _____ Giant velvet walking worm & blind velvet walking worm
11. _____ Greenish warblers of Siberia
12. _____ Hawaiian honeycreepers
13. _____ Thatch palms on Lord Howe Island
14. _____ Polyploidy resulting in *T. aestivum*

SELF-TEST

__ 1. Selection for the intermediate form of a trait is called _____. [p.284]
   a. stabilizing selection
   b. directional selection
   c. disruptive selection
   d. wayward selection

__ 2. Differences in the molecular structure of a gene are called _____. [p.278]
   a. a gene pool
   b. a bottleneck
   c. gene flow
   d. alleles

__ 3. The sum of all genes in the entire population is the _____. [p.278]
   a. gene pool
   b. genetic variation
   c. gene flow
   d. allele frequency

__ 4. The relative abundance of each type of allele in a population is the _____. [p.279]
   a. gene pool
   b. genetic variation
   c. gene flow
   d. allele frequency

__ 5. According to the Hardy-Weinberg rule, the allele frequencies of a population will not change over successive generations if which of the following is true? [p.280]
   a. The population is infinitely large and all individuals survive and produce equal number of offspring.
   b. There is random mating.
   c. There is no mutation.
   d. The population is isolated.
   e. All of the above.

__ 6. A trait that exists in only two forms in a population is said to be _____. [p.278]
   a. lethal
   b. dimorphic
   c. polymorphic
   d. fixed

__ 7. A _____ is a group of individuals of the same species in a specified area. [p.278]
   a. gene pool
   b. balanced polymorphism
   c. population
   d. species

__ 8. An insect population that becomes increasingly resistant to a class of insecticides is an example of _____ selection. [p.282]
   a. directional
   b. sexual
   c. disruptive
   d. stabilizing

__ 9. If one sex of a species favors a trait in the opposite sex of the species, this is called _____. [p.286]
   a. sexual selection
   b. directional selection
   c. a bottleneck
   d. genetic drift

__ 10. Selection for traits at both ends of a range of variations is called _____ selection. [p.285]
   a. polymorphic
   b. directional
   c. sexual
   d. disruptive
   e. balancing

__ 11. Which isolating mechanism is considered a postzygotic mechanism? [p.290]
   a. hybrid sterility
   b. ecological
   c. behavioral
   d. mechanical