STUDY GUIDE *- Ch. 23.3 - Natural Selection, Genetic Drift, and Gene Flow can Alter Population Allele Frequencies*
- Ch. 23.4 - Natural Selection is the ONLY Mechanism that Consistently Causes Adaptive Evolution

NAME: _____

- **PHYSICALLY PRINT OUT this PDF and HANDWRITE (with a black or blue pen) your answers directly on this PDF.** *Typed or digitally-written work is **not** accepted. Do **not** answer questions on separate paper.*
- **Importantly, study guides are NOT GROUP PROJECTS!!!** *You, and you alone, are to answer the questions as you **read** your assigned textbook. You are **not** to share answers with other students. You are **not** to copy any answers from any other source, including the internet.*
- **Get in the habit of writing LEGIBLY, neatly, and in a medium-sized font.** *AP essay readers and I will skip grading anything that cannot be easily read so start perfecting your handwriting, and don't write so large you can't add all the relevant details and key elaborations in the space provided.*
- **SCAN physical documents in color and with good resolution. Then, upload your final work as PDFs to Archie.** *Avoid uploading dark, shaded, washed-out, sideways, or upside-down scans of homework. Keep completed physical study guides organized in your biology binder to use as future study and review tools.*
- **READ FOR UNDERSTANDING and not merely to complete an assignment.** ***First**, read a section quickly to get an overview of the topic covered. Then, read it a **second** time slowly, paraphrasing each paragraph **out loud** and analyzing every figure. Finally, read it a **third** time as you answer the study guide questions if assigned and start building your memory. Try to write answers out in your own words, when possible, and try to purposefully and accurately use all new terminology introduced.*

To review...

The Hardy-Weinberg Law states: In a large, random-mating population that is not affected by the evolutionary processes of mutation, migration (gene flow), or (natural) selection, both the allele frequencies and the genotype frequencies are constant from generation to generation. For a population to evolve, the frequency of the alleles (p and q) **must change.** A population in Hardy-Weinberg equilibrium is not evolving.

In order for a population to be in Hardy-Weinberg equilibrium, or a non-evolving state, it must meet five major assumptions:

1. **No mutation**. No new alleles are generated by mutation, nor are genes duplicated or deleted.
2. **Random mating.** Organisms mate randomly with each other, with no preference for particular genotypes or no sexual selection.
3. **No gene flow.** Neither individuals (through migration) nor their gametes (e.g., wind-borne pollen) enter or exit the population.
4. **Very large population size.** The population should be effectively infinite in size.
5. **No natural selection.** All alleles confer equal (biological) fitness, making organisms equally likely to survive and to reproduce.

If any one of the 5 assumptions is not met, the population will not be in Hardy-Weinberg equilibrium. In fact, **populations are usually not in Hardy-Weinberg equilibrium** (at least, not for all of the genes in their genome). Instead, **populations tend to evolve:** the allele frequencies of at least some of their genes change from one generation to the next. Allele and genotype frequencies within a single generation may also fail to satisfy the Hardy-Weinberg equation.

Gene flow, genetic drift (especially in smaller populations)**, and natural selection can be a strong agent of evolution!**

- **Note:** Mutations passed on to offspring introduce new alleles into a gene pool. Since this process happens infrequently, however, mutations **do not have a major effect on allelic frequencies from one generation to the next**.
- **Note:** As it turns out, nonrandom mating **tends to alter the genotype frequencies (p^2, 2pq, and q^2)** from generation to generation, **but does not tend to have too much of an effect on changing the individual allelic frequencies (p or q).** A change in the frequency of heterozygotes and homozygotes in a population keeps the population from being in Hardy-Weinberg equilibrium, but it's debatable, therefore, whether this change counts as evolution, since the allele frequencies often stay the same.

1. Natural selection alters the frequency of alleles in populations and so acts as a mechanism (cause) for evolution. Natural selection is the reason organisms experience differential survival and reproductive success. Explain **natural selection**:

2. **Among all five mechanisms for evolution, *only* natural selection is nonrandom and adaptive, *causing adaptive evolution*.** What is **adaptive evolution**?

3. Which of the factors above **results in a *random*, *nonadaptive* change in allelic frequencies due to chance**? Why?

4. Explain what happens in each of these **examples of the evolutionary mechanism genetic drift**.

   a. **Founder Effect**

   b. **Bottleneck Effect**

5. Two neighboring islands host large populations of the same species (populations A and B). It is known that one island's population (population B) experienced a bottleneck effect due to a tsunami several generations ago that, at the time, caused a sudden decrease in population size. A student claims, however, that the two present-day island populations should once again exhibit the similar amount of allelic variability, just as they both did prior to the natural disaster, since the once small population B has now grown, over many generations, to be once again equal in large size to that of the island that was not affected by the tsunami (population A). **Evaluate this student's claim**. *(**Evaluate** = Make a judgment or form an opinion, supplying the reasons why a claim holds validity or not).*

6. Describe the **four key points highlighted about Genetic Drift** in your textbook. *These are important to memorize and especially understand!*

   1.

   2.

   3.

   4.

7. In what sense is **natural selection more predictable than genetic drift**? *(Check your answer by going to the Ch.23.3 **Concept Check Question #1** in Appendix A of your textbook)*

8. **Allele frequencies can also change in *nonrandom*, yet still *nonadaptive* ways due to a mechanism termed Gene Flow.** What is **Gene Flow**?

9. a. What is the **effect of gene flow** between two existing populations **on the genetic differences between two populations**?

   b. Read and text and analyze Figure 23.12. If natural selection was the only mechanism exerting an effect on the evolution of the population of snakes on the islands. How would natural selection influence the evolution of snake color-type phenotype on the islands? Provide the **reasoning** behind your claim. (***Explain what is happening at the level of phenotypes and how that influences genotypic and thus allelic frequencies in the population).***

c. Suppose a severe weather event caused island populations to decrease in size but did not affect the size of mainland populations. **Predict** how gene flow from the mainland would affect color patterns in island populations in the year immediately after the storm. Provide the **reasoning** behind your prediction. (***Explain exactly what would happen at the level of the gene pool, in terms of its alleles, and the effect the gene pool's allelic make-up would have on the phenotypes of organisms present in the population.***

*(Check your answers to 9.c. by going to the Ch.23 **Figure Questions** for **Figure 23.12** in Appendix A of your textbook)*

10. In what way can **gene flow increase the ability AND decrease the ability of a population to adapt** to their environment (to have adaptations spread among members of the population through natural selection)?

Gene Flow Benefiting to the Ability of a Population to Adapt Over Time to the Environment =

Gene Flow Harming the Ability of a Population to Adapt Over Time to the Environment =

11. Let's see if you now understand the concepts of Genetic Drift and Gene Flow.

a. Distinguish between how **genetic drift versus gene flow occur**.

Genetic Drift =

Gene Flow =

b. Discuss the **implications of genetic drift versus gene flow on the future genetic variation in a population**.

Future Genetic Variation Following Genetic Drift =

Future Genetic Variation Following Gene Flow =

*(Check your answer to 11.a. & b. by going to the Ch.23.3 **Concept Check Question #2** in Appendix A of your textbook)*

12. Suppose two plant populations exchange pollen and seeds. In one population, individuals of genotype AA are most common (9000AA, 900Aa, 100aa), while the opposite is true in the other population (100AA, 900Aa, and 9000aa). If neither allele has a selective advantage, what will happen over time to the **allele AND genotype frequencies** of these populations? Why?

    Consequence of Allelic Frequencies in the Two Populations =

    Consequence of Genotypic Frequencies in the Two Populations =

    *(Check your answer by going to the Ch.23.3 **Concept Check Question #3** in Appendix A of your textbook)*

13. Of the three factors you learned about in this section of your textbook, which one again is the only one that **results in individuals that are better suited to their environment** ***(individuals with ADAPTATIONS)?***

14. a. In evolutionary terms, being fit may have nothing to do with being big, or strong, or aggressive. Define the term **relative fitness** (relative biological fitness).

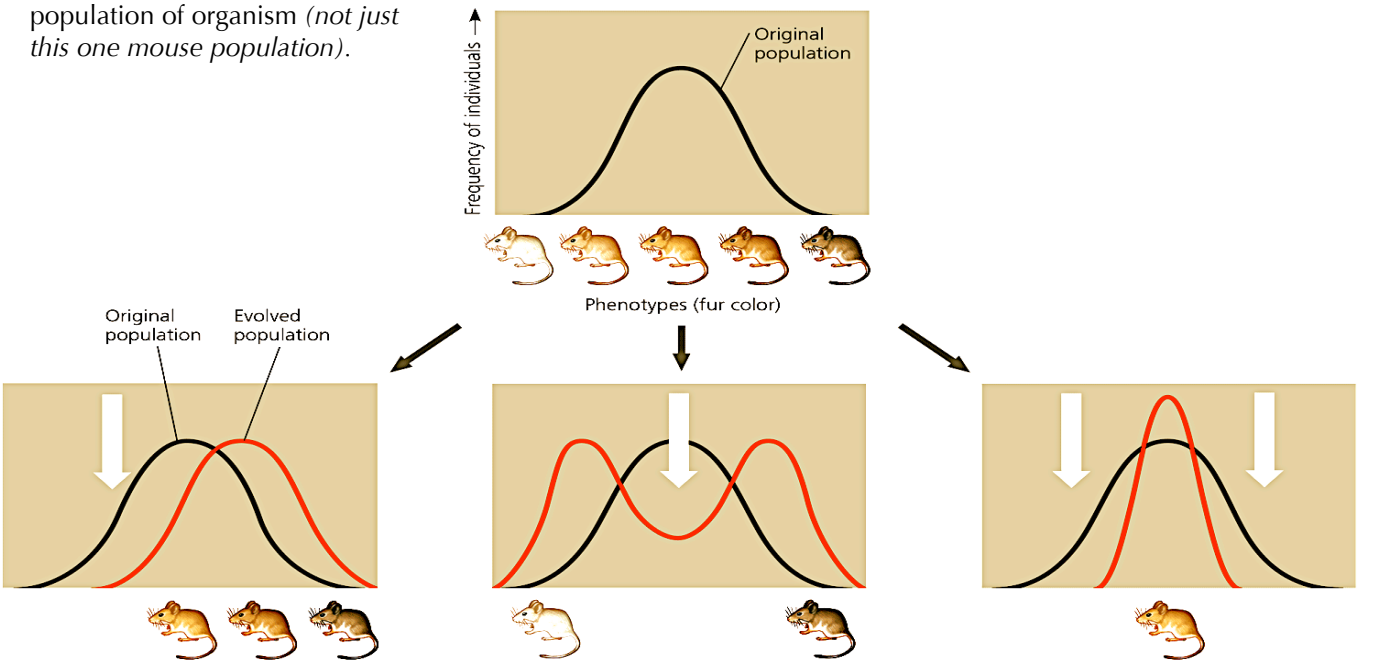
    b. What is the relative fitness of a sterile mule? *(Check your answer to 14.b. by going to the Ch.23.4 **Concept Check Question #1** in Appendix A of your textbook)*

    c. Which organism has the greatest relative fitness in a certain population: the beetle that lived to the very old age of 3 years old before passing and which produced 17 offspring, the beetle that lived to be 2 1/4 years old and produced 142 offspring, the beetle that lived to be only 10 months old and produced 17 offspring every month after reaching sexual maturity at the age of 1 month?

15. Why is it said that **natural selection acts on phenotypes and not genotypes**?

16. Why do we say that **adaptive evolution is a continuous and dynamic process**?

17. Natural selection can alter the frequency distribution of heritable traits in three ways, depending on which phenotypes in a population are favored. The diagram below shows these **three different modes of selection** affecting a hypothetical mouse population with heritable variation in fur color. The graph shows the change in phenotype frequencies and the white arrows symbolizing selective pressure against the ancestral populations phenotype. Name each mode of selection, then **describe** (in the boxes below) **WHEN each type of selection would occur** in any population of organism *(not just this one mouse population)*.



Selection Mode = _____ _____ **Occurs when …**	**Selection Mode =** _____ _____ **Occurs when …**	**Selection Mode =** _____ _____ **Occurs when …**

17. Return to the example of evolution in the soapberry bug described in Ch.22 Section 3, Figure 22.13. Which mode of selection has occurred in soapberry bug populations that feed on the introduced golden rain tree? **Explain** *(compare the average beak length phenotype and the variation of beak length, if relevant, within the population before and after introduction of the golden rain tree)*

18. Consider a population in which heterozygotes at a certain locus have an extreme phenotype, such as being larger than homozygotes, that also confers a selective advantage. Does such a situation represent directional, disruptive, or stabilizing selection? Why? *(Check your answer to 18 by going to the Ch.23.4 **Concept Check Question #3** in Appendix A of your textbook)*

19. a. What is **sexual selection**?

b. What is often the **result of sexual selection**? *Be sure to **define** the term as well.*

20. a. What is the difference between **Intrasexual Selection** and **Intersexual Selection** *(Mate Choice)*?
Intrasexual Selection =

Intrasexual Selection *(Mate Choice)* **=**

b. Give an example of each type of selection.
Example of **Intrasexual Selection =**

Example of **Intrasexual Selection** *(Mate Choice)* **=**

21. **One hypothesis about how female preference for certain male characteristics evolves, is that females who have a tendency to like males whose appearance is correlated with "good genes" have healthier offspring and pass those genes for the preference of these types of males to their offspring as well in higher numbers.** Review Figure 23.16 and remember what you learned about setting up a Controlled Experiment. Why did the researchers split each female frog's eggs into two batches for fertilization by different males? Why did they not just mate different females with each of the different males?

*(Check your answers to 21 by going to the Ch.23 **Figure Questions** for **Figure 23.16** in Appendix A of your textbook)*

22. Genetic variation may be preserved in a population despite natural selection's tendency to reduce unfavorable genotypes (because of the unfavorable phenotype produced) and despite directional or stabilizing selection. When **Balancing Selection** occurs (either in the case of Frequency-Dependent Selection or Heterozygote Advantage) **two or more phenotypic forms in a population are maintained over time**. Describe both types of Balancing Selection.

Frequency-Dependent Selection =

Heterozygote Advantage =

23. Analyze the graph in **Figure 23.17**. For 1981, 1987, and 1990, compare the frequency of left-mouthed individuals among breeding adults to the frequency of left-mouthed individuals in the entire population. What do the data indicate about when natural selection favors left-mouthed individuals over right-mouthed individuals (or vice versa)? Explain. *(Check your answers to 23 by going to the Ch.23 **Figure Questions** for **Figure 23.17** in Appendix A of your textbook)*

24. Review **Figure 23.18**. Sickle-cell anemia is a largely lethal disease caused in individuals who inherit the homozygous recessive genotype.
    a. How is the **sickle-cell anemia allele's presence in the sub-Saharan desserts' population related to heterozygote advantage**?

    b. In a region free of malaria, would individuals who are heterozygous for the sickle-cell allele be selected for or selected against? Explain. *(Check your answers to 24.b. by going to the Ch.23 **Figure Questions** for **Figure 23.18** in Appendix A of your textbook)*

25. Summarize the **four reasons why natural selection cannot produce "perfect" organisms**.

    1.

    2.

    3.

    4.

26. Proceed to the TEST YOUR UNDERSTANDING section at the end of the chapter. **Study your chapter sections and all Ch.23 study guides first!** *Then, do your best to try to answer these from memory first in order to test how well you grasped the material before. If you are unsure, return to the relevant section of your chapter and restudy any pertinent material to refresh your memory. (Check some of your answers by going to the **Ch.23 Test Your Understanding** answers in Appendix A)*

    1. _____ 2. _____ 3. _____ 4. _____ 5. _____