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# K-12 Partnership Lesson Plan

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# *Variety is the Spice of Life!*

# *Why genetic variation is important*

## Overview

Variation is all around us in nature and genetic variation underlies these phenotypic differences among individuals. Natural selection acts on this genetic variation. It is important for populations of organisms to have genetic variation so that they are able to respond to changing conditions such as climate or predators. In this lesson students will learn why genetic variation matters if selection changes through time and get a hands-on demonstration on how alleles make up the genotypes in a population.

**Objectives**

At the conclusion of the lesson, students will be able to:

* Understand genetic drift
* Understand why genetic drift has larger effects on small populations than large populations
* Explain the terms “heterozygous” and “homozygous”
* Be able to calculate genotype frequencies from allele frequencies using the Hardy-Weinberg equilibrium equation
* Explain why genetic variation is important for a population’s long-term persistence

**Length of Lesson**

2 hours (30 minutes for each activity + 1 hour for introduction, follow-up and graphing)

**Grade Levels**

Grades 6-12

**Standards covered**

Disciplinary Core Ideas:

*Middle School*

* **MS-LS4-4**: construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals’ probability of surviving and reproducing in a specific environment
* **MS-LS4-6**: use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

*High School*

* **HS-LS3-3:** apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population
* **HS-LS4-3**: apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking the trait

Cross Cutting Concepts:

* Stability and change of systems

Science and Engineering Practices

* Developing and using models
* Using mathematics and computational thinking

***Previous Michigan Standards Met:***

* **B1.1**: inquiry, reflection, and social implication: scientific inquiry
* **B4.2**: genetics: genetics and inherited traits
* **B4.4x**: genetics: genetic variations
* **B5.1**: evolution and biodiversity: theory of evolution
* **B5.2x**: evolution and biodiversity: molecular evidence
* **B5.3**: evolution and biodiversity: natural selection

**Materials**

* Several decks of cards
* A pair of dice
* Chairs set up two-by-two
* A chalkboard or something to write on

**Background**

Underlying the variation we see among biological organisms is variation in their genes. Just like there is variation among people for many traits, including height, other organisms differ in traits as well. These differences are caused by differences in their genes and this variation provides the raw material for evolution to act upon.

Evolution is defined as a change in allele frequencies across generations in a population. Alleles are different forms of a gene. If the proportion of one type of gene (an allele) changes across generations, evolution has occurred. Evolution can occur due to natural selection- individuals that carry a certain allele reproduce more than other individuals; therefore their offspring carry that allele to the next generation and make up a bigger proportion of the population. Evolution can also occur due to genetic drift. Genetic drift causes changes in allele frequencies due to sampling error.

Genetic drift is more prominent in populations that are small than populations that are large. This is because sampling error may have more drastic effects when the sample size is small. Imagine flipping a coin 100 times. You are likely to get heads pretty close to 50% of the time. Now imagine flipping a coin 10 times. It is much more likely that you will get a more skewed ratio of heads and tails, just by chance. This is how genetic drift works. In small populations, by chance some alleles may be lost. This overall reduces the genetic variation present.

What happens when the genetic variation in a population is reduced? This lesson will demonstrate how genetic drift acts on large vs. small populations, and how the reduction in genetic variation may affect a population’s ability to respond to future selection pressures.

### Activities of the session

1. Before the Lesson
   1. Line up chairs two by two with ample space around them
   2. Shuffle several decks of cards and put them together, making sure that the black cards and red cards are at equal frequencies
   3. Make a pile of black only and another pile of red only cards
2. Introduce evolution by genetic drift.
3. Draw some Punnett Squares on the board for the class. Explain the terms “allele”, “heterozygous” and “homozygous”
4. Introduce the Hardy-Weinberg equilibrium equation (p2 + 2pq + q2). Explain the logic of this equation, perhaps using an example such as flipping a coin twice and predicting how many times you will get heads twice, tails twice, or 1 of each.
5. Explain the rules of the game and hand out two cards to each student. Explain that the black cards and red cards represent two alleles of one gene. Refer to your examples with Punnett Squares.
6. Allow students to mingle around the chairs (can play music as in musical chairs) and when the music stops, they all take a seat. Each pair “mates” by exchanging 1 card with each other (without looking at the card). To introduce some statistical “noise” have 1 student exchange 1 card at random with the deck. (This allows allele frequencies to change slightly).
7. After each generation, allele frequencies (the number of red and black cards) and genotype frequencies (the number of each homozygote and heterozygote) are calculated and written on the board.
8. The game repeats itself several times and the change in frequencies of the alleles and genotypes are calculated each time
9. After several rounds, some of the chairs are taken away. (The number depends on the starting number of students, but ~1/2 the chairs should be removed). Habitat fragmentation and population loss can be discussed as a comparison.
10. Musical chairs is played again and only some of the students will occupy the chairs. It is important to note that this is random (the chance of occupying a chair does not depend on an individual’s genotype). Explain to the students that the ones that haven’t occupied chairs are out of the game.
11. The simulation is performed several more times. Allele and genotype frequencies are recorded each time.
12. Discuss with the class how the changes in alleles and genotypes differ when there is a smaller population.
13. The next simulation will introduce selection into the game. The game starts over (move the chairs back to their original positions).
14. Collect all the cards and pass out new ones at random to each student. Explain that this time, a roll of the dice will represent selection. 1-2 will select against one homozygote; 3-4 will select against the heterozygote; and 5-6 will select against the other homozygote. Whichever genotype gets selected against has “died” and is unable to reproduce.
15. These students will now become the offspring of the other individuals that have reproduced. At random, assign students as offspring to the remaining individuals and give them identical genotypes as their parents (using the decks of all blacks and all reds may help facilitate this).
16. The allele and genotype frequencies are calculated.
17. Allow random mating to occur again and determine allele and genotype frequencies. Ask students why the genotypes that were selected against in the last generation are still present in the current generation.
18. Roll the dice again and repeat the process of selecting against one genotype and making the students who have “died” the offspring of the other students.
19. Each generation, note the allele and genotype frequencies.
20. After a few generations, take a portion of the chairs away again. Repeat the process of selection each generation.
21. Look at the changes in allele and genotype frequencies over time and discuss how it differs from when the population was large.
22. At a certain point, it is possible that the entire population may die out. If this occurs, discuss how this could happen in nature.
23. As an optional activity, have the students graph the changes in allele frequencies and genotype frequencies over time for each simulation.

**Resources**

* “Variety is the Spice of Life” powerpoint (found on “Variety is the Spice of Life” lesson page on the KBS GK-12 website)
* http://www.michiganradio.org/post/decision-time-isle-royale-only-8-wolves-left

**Extensions and Modifications**

Can introduce non-random mating. Have students find other students with a different genotype as their own to “mate” with. Observe how genotype frequencies change relative to allele frequencies. Can do the same thing with similar genotypes mating. Discuss how this relates to diseases and immune systems.

**Assessment**

Students can be assessed through graphing allele frequencies through time and solving problems using the Hardy-Weinberg equation.