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# K-12 Partnership Lesson Plan

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# *How do mutations or invasions affect populations?*

## Overview

Students participate in an activity that models natural selection or the introduction of an invasive species by competing for limited “resources”, and observing how the presence of an advantageous trait can change over time. Students graph the population’s change over time and participate in a guided discussion about factors that may influence natural selection.

**Objectives**

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

* Describe the effects of natural selection on a population, or the effects of an invasive species on a native population
* Understand the factors contributing to extinction, including displacement and competition
* Discern patterns of population growth, including exponential growth and the relationship between a population’s environment and its carrying capacity
* Construct and interpret graphs relating to population growth
* Relate patterns to theory
* Use evidence to reason and draw conclusions
* Differentiate between a theory, hypothesis, and observation

**Length of Lesson**

50 minutes (30 minutes for activity + 20 minutes introduction and follow-up discussion). If take-home questions are assigned, at least 10-15 minutes of further discussion may be desired in a subsequent class session.

**Grade Levels**

3rd-12th grade

(if used as invasive species model, grades 3-12. If used as natural selection model, may be used for grades 6-12)

**Standards covered (NGSS)**

Disciplinary Core Ideas:

*Elementary School*

* **3-LS4-3**: construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all
* **3**-**LS4-2**: use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing

*Middle School*

* **MS-LS2-1:** analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem
* **MS-LS4-4**: construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals’ probabilities of surviving and reproducing in a specific environment
* **MS**-**LS4-6**: use mathematical representations to support explanations of how natural selection may lead to increase and decreases of specific traits in populations over time

*High School*

* **HS-LS2-1:** use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales
* **HS-LS4-2**: construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variations of individuals in species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better to survive and reproduce in the environment
* **HS-LS4-4**: construct an explanation based on evidence for how natural selection lead to adaptation of populations

Cross Cutting Concepts:

* Cause and effect
* Structure and function
* Stability and change of systems

Science and Engineering Practices

* Planning and carrying out investigations
* Analyzing and interpreting data
* Using mathematics and computational thinking
* Engaging in argument from evidence

**Materials**

* Red beanbags\* x 1/3 total number of students in the class
* Blue beanbags\* x 1/3 total number of students in the class
* Clipboard
* Recording sheet
* Bench or chairs- not necessary but helpful for “dead” individuals

\*or any similar available objects

**Background**

### What happens when a new species is introduced to an ecosystem, through invasion or a genetic mutation? The new species may be in direct competition with a native or established species for resources. This activity assumes that the new species can utilize resources more efficiently than native or established species, and is set up to demonstrate the effects of this competitive advantage over time. Possible outcomes include extinction of the established/native species, and a demonstration of exponential growth in the new species, over multiple rounds of the activity. Projections about further trials or rounds allow students to consider the fate of each species and to predict how growth will be inhibited by the carrying capacity. Upper-level classes can discuss the ability of the activity to actually model evolution.

### Activities of the session

### Students play a game to explore the idea of mutation (or invasion, depending on which topic the teacher wishes to develop) and how the introduction of a novel and advantageous change in a gene can change a population or community over time, via competition for resources. In this scenario, students act as one of two types of organisms competing for resources. Small objects (e.g. beanbags) may be used to represent resources, and heterogeneous resource values are represented by contrasting colors of those objects. For instance, red objects are worth 2 life points, and blue objects are worth 1 life point. The number of “resources” should be 2/3 the total class size, to represent competition for limited resources.

1. Explain that the students will be playing a game that models competition between 2 different species, and can be used to predict what would happen in this situation in nature. Tell the students that their job, as organisms in this game, is to survive and increase their population (If desired, students may be offered a reward for surviving throughout the duration of the game, and for gaining the most life points/producing the most offspring)
2. Designate a starting point, and place blue “resources” ~8 meters away, and red “resources” ~ 16 meters away.
3. Designate an “abiotic factor zone” where “dead” students will wait to rejoin the game as biotic factors new organisms)
4. Set up the population ratio so that there are 2 “runners” for every 15 students in the class (Use 2 “runners” at >20 total students, and 4 as class size approaches 30). All other students are designated as “hoppers”, and must hop on 2 feet (like a kangaroo).
5. Explain the following rules of the game:
   1. Cheaters (e.g. “hoppers” who try to run) may be declared dead immediately.
   2. Each student must attempt to acquire a single resource from either of the two resource areas
   3. Blue resources are worth 1 point, and red resources are worth 2 points. Points for each students will be recorded at the end of every round.
   4. Any student that does not obtain a resource in a given round is considered “dead”.
   5. For every 4 points gained by an active organism, they may recruit an individual from the “abiotic factor zone” to their respective species. This recruitment simulates reproduction.
   6. Students must wait in the “abiotic factor zone” in the order that they “died” and reenter the game in that same order
   7. When a student reenters the game, none of their previously acquired points may count towards recruitment.
6. Explain that there are trade-offs in nature, and students may choose whatever strategy they wish (as long as they follow the rules outlined above) to survive or reproduce
7. Give the command for students to begin running or hopping to obtain resources
8. Run 5-7 rounds, replacing the resources after each round and using the same starting point each time
9. At the end of each round, record the points earned by each individual, and the population totals for each species, as well as the number of casualties for that round.
10. After returning to the classroom, make the data table available to the class and graph the population totals for each species for each round.
11. Discuss the outcome of the game (example discussion questions included below) and assign take home questions, if desired.

**Resources**

* Oh Deer! Project WILD sample activity: <http://cibt.cornell.edu/labs-activities/labs/oh-deer-mary-bowman/>
* Game materials including score sheet, instructions, discussion questions and teacher guide included in the “How do mutations and invasions affect populations” lesson page on the KBS GK-12 website.

**Extensions and Modifications**

* Any 2 colors (not necessarily red and blue) may be used
* For older students, the instructor may wish to have the “established species” walk heel-to-toe every step, rather than hopping.
* For younger age levels, replacing the term “reproduction” with “recruitment” may be appropriate.

