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# K-12 Partnership Lesson Plan

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# *The Best Genes for the Job*

# *Exploring genotype by environment interactions*

## Overview

An organism’s genetic composition plays an important role in its chances of survival, but will the same combination of genes always win?  An organism, (or more specifically, a set of genes) that succeeds in one environment or season may not fare so well under different conditions.  In this lesson plan, students will explore how genetics and environmental conditions can affect the survival of different organisms.  This classroom activity simulates how birds with different beak sizes might have a competitive advantage depending on environment.  Students will then graph their data to see how environment influences the success of different genotypes.

**Objectives**

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

* Explain how survival of an organism is affected by both its genotype (nature) and its environment (nurture)
* Understand environmental factors that contribute to the varying success of organisms, including climate, seasonal change, disease, and competition
* Define and differentiate between a *genotype* and a *phenotype*
* Construct and interpret graphs relating to genotype by environment interactions
* Relate patterns to theory
* Use evidence and reason to form a conclusion

**Length of Lesson**

50 minutes (30 minutes for activity + 20 minutes for introduction, follow-up, and graphing)

**Grade Levels**

Grades 6-12

**Standards covered (NGSS)**

Disciplinary Core Ideas:

 *Middle School*

* **MS-LS1-5**: construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms
* **MS-LS4-4**: construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individual’s probability of surviving and reproducing in a specific environment
* **MS-ETS1-2**: evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem

*High School*

* **HS-LS4-4:** construct an explanation based on evidence for how natural selection leads to adaptation of populations

Cross Cutting Concepts:

* Patterns
* Structure and function

Science and Engineering Practices

* Planning and carrying out investigations
* Analyzing and interpreting data
* Engaging in argument from evidence

***Previous Michigan Standards Met:***

* **B1.1**: Inquiry, reflection, and social implications: scientific inquiry
* **B3.4:** Interdependence of living system and the environment: changes in ecosystems
* **B3.5x:** Interdependence of living system and the environment: environmental factors
* **B4.L4.P2:**Genetics: heredity and environment
* **B4.B4.4x:**Genetics: genetic variation
* **B5.3:** Evolution and biodiversity: natural selection

**Materials**

* Textured rubber door mat (with grooves or holes that bean seeds could fit between)
* Table, or similar flat surface
* Spoons (x class size)
* Tweezers (x ½ class size)
* Ice cube trays or cups
* Beans (or similarly-sized small beads)
* Stopwatches

**Background**

How did you get to be the way you are today? Our genes (nature) play an important role in who we are and how we look, but our environments (nurture) also influence and shape us, physically and psychologically. A person’s genetic constitution is called a genotype. The expression of that genotype in a given environment – a set of observable characteristics of that individual – is their phenotype. A genotype by environment (or GxE) interaction causes variability in phenotype when environmental factors affect the success of the associated genotype. Identical genotypes may perform differently across seasons, climates, or geographic regions.

A classic example of GxE is a study that was conducted with lab rats, where 2 lines of rats were selectively bred to be “bright” or “dull.” When both types of rat were raised in a controlled lab setting, the bright rats outperformed the dull rats in maze-running ability. However, when both types of rat were raised with enrichments, like toys and objects to explore in their enclosures, the dull rats performed just as well as the bright rats in maze running competitions. The change in environment altered the phenotype, by altering the genotype’s ability to perform well.

Another example of a GxE interaction is the human disease, sickle-cell anemia. When a person’s parents both carry one allele for sickle-cell anemia, he has a ¼ chance of receiving both alleles and having the disease, a ½ chance of carrying one allele, but not having the disease, and a ¼ chance of not having either of the alleles, and not having the disease. Normally, a recessive trait that reduces fitness is selected out of a population over time, but since the sickle cells cause a resistance to another disease, Malaria, the trait has persisted in environments where Malaria occurs. Even though they don’t have sickle-cell anemia, people who only have 1 of the sickle-cell alleles still have some defective hemoglobin, which the Malaria parasite is unable to digest. This causes people with 1 sickle-cell allele to be more fit in some environments that people without the allele.

What happens when birds with varying beak types forage in different environments? In this lesson, students will pretend to be birds with different beaks, and they will count how many seeds they can collect from different environments in a limited amount of time. Once they have tested the abilities of both beaks in both environments, students will make a graph to compare the success of beak type depending on environment.

### Activities of the session

1. Before the lesson:
	1. It may be useful to cut the rubber mat into smaller pieces, to create multiple “feeding stations”
	2. Cups or ice cube trays should be labeled or marked with different colors to differentiate between the two competing genotypes
	3. Divide beans into bags of 100 beans each, with 1 bag per every 2 students.
2. Explain to the students that they will be acting as birds with 2 different genotypes, which yield 2 different beak sizes. Some of the birds will be “tweezers-billed,” and some will be “spoon-billed.” They will be competing for seeds in 2 different environments.
3. Have students choose a partner, and pass out 1 tweezers per pair and 2 spoons per pair (The 2 spoons may be used together, as one bill, to collect beans).
4. Give each pair a stopwatch, a bag of beans, and a piece of the rubber mat
5. Instruct students to spread out the beans over one of the environments (rubber mat or table).
6. For the first round, have 1 student per pair be the timer, and the other student will be a bird.
7. The timer gives the bird 60 seconds to collect as many beans as possible using his or her bill.
8. Count the number of beans collected and record on the supplemental worksheet (attached)
9. Repeat steps 4-7 until both students have the chance to use both bill types in each type of environment (8 rounds total).
10. Have students graph their results on the worksheet
11. (Optional) compile class data and make a graph for the whole class.

**Resources**

* Supplemental worksheet and powerpoint (available on “The Best Genes for the Job” lesson page on the KBS GK-12 website
* http://en.wikipedia.org/wiki/Gene%E2%80%93environment\_interaction
* http://en.wikipedia.org/wiki/Sickle-cell\_disease

**Extensions and Modifications**

1. Play this game outside, using grass and a flat surface as the two environments.
2. To add a competition component, have multiple students feed on the same environmental surface concurrently. Discuss how competition influences GxE interactions.
3. Have students construct their own bills out of materials such as popsicle sticks or straws, to see who can create the best bill for different environments.

**Assessment**

Students will be assessed with thought questions, discussion and graphing based upon the activity in this lesson.

Name:\_\_\_\_\_\_\_\_\_\_\_\_\_

**The Best Genes for the Job: Student Worksheet**

In this activity you get to become a bird searching for food. You can play the part of a bird with a genotype for a long skinny beak or a genotype for a spoon-shaped beak. You will search for food in two different environments; a smooth, open environment, and a rough environment. What type of beak will be the best and will it depend on the environment?

In the table below record the number of beans you successfully picked up in each trial:

|  |  |  |
| --- | --- | --- |
|  | **Smooth Environment** | **Rough Environment** |
| **Spoon Beak** |  |  |
| **Tweezers Beak** |  |  |

Use the axes below to graph your data. Make sure to include labels.



**Thought Questions:**

**1)** Does your data show an interaction between genes and the environment? How?

**2)** Why do you think these two different genotypes are able to persist?

**3)** Imagine for a moment that you live in a world where unicorns exist. In this world unicorn horns are a highly valuable and the longest horns are the most prized. As a result poachers will hunt unicorns for their horns, and they greatly prefer to hunt unicorns with long horns over those with short horns. Below is a graph showing the survival rates of long horn and short horn unicorns in two different environments, an environment where poachers are present, and an environment where poachers are absent. Look at the graph, do you see an interaction between genotype and environment? Describe this interaction. (what type of unicorn does best in each environment?)



**4)** Now imagine that dragons also exist in this world. Dragons prey upon unicorns but only in areas where poachers are absent (dragons are very afraid of poachers). Long horn unicorns are much better at defending themselves against dragons than short horn unicorns. With this in mind, draw how you think adding dragons will change the above graph (please use the blank graph below).

