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# K-12 Partnership Lesson Plan

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# *Survivor: Extreme Environments*

# *How invasive plants outwit, outplay and outlast their competitors*

## Overview

This lesson plan provides a simple introduction to the mechanism of natural selection for students who are already familiar with concepts such as ecosystems, species, and variation. The lesson includes a short walk (can be done with nature photos) to identify the types and scales of variation in the natural world. Students then work in groups to adapt organisms (seeds) to different environments (soil types) in a fun, interactive exercise. Once seeds are well adapted to their environments, students will try to determine what made some of the organisms better than others, and try to predict how a new seed type will fare. The entire lesson is framed around how adaptions may help invasive species, but is equally applicable to native species. Teacher scripts are provided for the lesson introduction and accompanying power point.

This lesson would be appropriate in sections covering: natural selection, evolution, variation, invasive species, and adaptation.

**Objectives**

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

* Explain the role of the environment in natural selection and evolution
* Explain how variants lead to evolution through natural selection
* Explain how invasive species create competition with native species
* Explain how invasive species can affect natural selection and evolution

**Length of Lesson**

Two 60-minute lessons, however, could be shorter if only some activities are performed

**Grade Levels**

Grades 9th & 10th General Biology course but could be adapted for a middle school life science course or an advance biology course such as Advanced Placement Biology

**Standards covered (NGSS)**

Disciplinary Core Ideas:

 *Middle School*

* **MS-LS1-4**: Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively
* **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 increase and decreases of specific traits in populations over time

*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:***

* **B1.1A**: generate new questions that can be investigated in the laboratory or field
* **B1.1B**: evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.
* **B1.1E**: describe a reason for a given conclusion using evidence form an investigation
* **B1.1F:** predict what would happen if the variables, methods, or timing of an investigation were changed
* **B1.1G**: use empirical evidence to explain and critique the reasoning used to draw a scientific conclusion or explanation
* **B3.4B**: recognize and describe that a great diversity of species increases the chance that at least some living organisms will survive in the face of cataclysmic changes in the environment
* **B3.5C**: predict the consequences of an invading organism on the survival or other organisms
* **B3.5D**: describe different reproductive strategies employed by various organisms and explain their advantages and disadvantages
* **B5.1B**: describe how natural selection provides a mechanism for evolution

**Materials**

Based on a classroom of 24, with groups of 3

* 4 different environments represented by pans of various substrates (soil, sand, pebbles, etc)
* 8 shallow pans
* 5 different seed populations (about 150 seeds per type)- any garden seeds will do, but each type should be easily distinguishable, and should blend fairly well into at least one of your environments
* Small cups for holding seeds (5 per group)
* Graph paper (1 sheet per student)
* Power Point- available on KBS-GK12 website (replace soil types, and seed photos and facts with seeds that match the ones you purchased)
* Teacher script for nature walk- available on “Survivor: extreme environment” lesson page on the KBS-GK12 website
* Teacher script for introducing lesson- provided below
* Worksheets- provided below and on the GK-12 website. Remember to swap in your environment names and seed types! (you can find/replace: seed1, seed2, seed3, seed4, seed5)

**Background**

Biological evolution is driven by biotic and abiotic environmental changes. Within a population of similar organisms, each individual is genetically different (variation) giving them different abilities to survive and reproduce. If the environment changes through natural or human processes, some organisms will be better adapted to that new environment than others. These individuals will do better (on average) than less adapted individuals, and will tend to have more reproductive success. This differential selection within a population will result in local adaptation as individuals who have low fitness in the environment die, while those that have high fitness survive and reproduce.

Invasive species or non-native species in an ecosystem face the same pressures as native species for adaptations but they often lack predators, or reproduce rapidly, which may give them an advantage. However, potentially invasive species often move into completely new habitats for which they may be poorly adapted, and must compete with native species for resources. They also tend to start with very small population sizes, which can inhibit breeding. For these reasons, it is estimated that only 1 in 1,000 species that introduced to new ecosystems can establish themselves to become invasive species.

### *Teacher Introduction Script*

Today we’re going to learn about variation, and how differences between individuals impact each ones survival. Selection in an ecosystem is a lot like a reality television show. Ecosystem players vote on who is selected against rather than voting who to keep. Those voters are the selective agent: biotic and abiotic factors that determine degree of survival. Players, in both a reality show and ecosystems, also have variation in that each individual has different skills and is a different size and shape. In each show, players face a different challenge. A season usually has many different challenges: Swimming, running, jumping, etc, so the winner is typically a generalist, or someone who can do many things reasonably well. If a reality show had all swimming challenges, we would expect the winner to be a specialist, e.g. an individual who is really good at one task. Reality TV generally doesn’t include a very important part of natural selection – differential reproduction, but if all of the winners of survivor paired off and had children, we would expect that those children would be better than the children of the losing players, on average.

### Activities of the session

1. Observation of variation in plants within school yard ecosystems (outside activity!). This can be performed in any outdoor area with a variety plants. A suggested teacher script is provided on the “Survivor: extreme environments” lesson page on the KBS GK-12 website. This activity can be omitted if weather or time does not permit.
2. Observation of variation within seed populations. This can be done with plant seeds outside or inside with the plant seeds used for the activities below.
3. Discussion of adaptations, variations and invasive species. Powerpoint with script is provided on the KBS GK-12 website
4. Round 1: Selection for the best type of seed within a given environment (instructions also included in the powerpoint)
5. Give each student group a shallow pan with one of the substrates. This is their “ecosystem”. Different groups should work with different “ecosystems” to illustrate how the best adapted seeds will depend on the environment
6. Give each student group 40 seeds (10 each of 4 different types). At least one type should blend into the “ecosystem” environment.
7. Answer pre-lab questions on student worksheet
8. Have one student randomly sprinkle the seed population in your ecosystem.
9. When the teacher instructs you, have another student pick 20 seeds in 60 seconds. Be sure to choose randomly by looking away between each seed and grabbing the first one that you can find. Put all these seeds in your Selected Against 1 bin.
10. When done, count up the seeds you have collected and use the data table #1.
11. Calculate the number of seeds remaining in your environment by subtracting from the starting population. Rotate jobs.
12. For generations 2 & 3, double the amount of the remaining of each type of seeds (for example, if you pulled out 3 seed2 in generation #1, 7 still remain in the ecosystem. You will need to add 7 new seeds to get to a total of 14 for generation #2).
13. As a team, find all the remaining seeds and put them in your Survivor bin
14. Answer post-lab questions
15. Round 2: Different reproductive strategies such as those in invasive species are applied to the different variations
16. Follow the same procedure as above, except one seed type is now an invasive species and reproduces twice as fast as the others. (additional instructions on student worksheet)

**Resources**

* Vignieri, S. N., Larson, J. G., & Hoekstra, H. E. (2010). THE SELECTIVE ADVANTAGE OF CRYPSIS IN MICE. *Evolution*. 64:2153-2158. (doi:10.1111/j.1558-5646.2010.00976)
* Williamson, M., & Fitter, A. (1996). The varying success of invaders. *Ecology*. 77:1661-1666.
* Booth, B. D., Murphy, S. D., & Swanton, C. J. (2010). *Invasive Plant Ecology in Natural and Agricultural Systems (Modular Texts)* (2nd ed.). CABI.

**Extensions and Modifications**

Extension with germination: To actually measure adaptation ability, teacher or students could grow the seeds in the environment to see which plants actually germinate in their given environments.

Graphing modifications: Graphs can vary for level of students. Higher performing or older students can be given a blank graph while lower performing or younger students can be given a graph that can be filled in. Teachers could also use excel to graph class data together and then have students form conclusions based on the graph instead.

**Assessment**

Teachers can use post-lab conclusion questions to assess student knowledge. Teacher could also have students use their knowledge to hypothesis what might happen in other selection scenarios. Teachers can also use graph of data to assess student knowledge by giving a graph of data from similar research and having students compare their data to actual field data.

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

**Survivor: Extreme Environments (Student Edition)**

*Part 1: Adaptation leads to Evolution*

Introduction:

Organisms have many traits that help them to survive and adapt to their environment. These traits can be physical and easy for us to see like height, or they can be molecular traits which need to be tested for in a lab, like being faster than average at processing sugar. For the exercise, we’re going to focus on the physical traits of coloration, size and shape, but ANY trait could be selected for in the same basic ways.

Student Objectives: At the conclusion of these lessons, you will be able to:

* Explain the role of the environment in natural selection and evolution
* Explain how variants lead to evolution through natural selection
* Explain how invasive species create competition with native species
* Explain how invasive species can affect natural selection and evolution

Pre-Lab Observations

1. Describe some of the variation observations you saw while outside. Describe how each variation could help the organism survive and reproduce.

|  |  |  |
| --- | --- | --- |
| Variant  | Observations of characteristics / adaptations. | Possible advantages due to characteristics / adaptations. |
| 1 | *
*
*
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| 2 | *
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1. Now, pick two different seeds and compare and contrast them.

|  |  |  |
| --- | --- | --- |
|  | Observations of characteristics / adaptations. | Possible advantages due to characteristics / adaptations. |
| 1 | *
*
*
*
 | *
*
*
*
 |
| 2 | *
*
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 | *
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 |

1. Describe your ecosystem.
2. Describe your seed population.

Experiment:

You have an ecosystem that can support 40 seeds each generation. Your group will distribute the seeds within your ecosystem, and then perform 3 rounds of selection to see which seeds are best adapted.

Prediction:

 Which seed do you think will be best adapted to your ecosystem? Which of its traits do you think will be adaptive? Is that trait exactly the same in all the seeds or do they vary?

Procedures:

1. Please check that you have 40 seeds in your seed population (10 each of 4 different types of seeds).
2. Have one student randomly sprinkle the seed population in your ecosystem.
3. When the teacher instructs you, have another student pick 20 seeds in 60 seconds. Be sure to choose randomly by looking away between each seed and grabbing the first one that you can find. Put all these seeds in your Selected Against 1 bin.
4. When done, count up the seeds you have collected and use the data table #1.
5. Calculate the number of seeds remaining in your environment by subtracting from the starting population. Rotate jobs.
6. For generations 2 & 3, double the amount of the remaining of each type of seeds (for example, if you pulled out 3 seed2 in generation #1, 7 still remain in the ecosystem. You will need to add 7 new seeds to get to a total of 14 for generation #2).
7. As a team, find all the remaining seeds and put them in your Survivor bin

Post Lab Analysis.

1. Which seed (or seeds) did the best in your ecosystem? Was the best seed for your ecosystem the one you thought it would be?
2. Compare the seeds that survived to the ones that didn’t. What do the survivors have in common? Was there more than one way to survive?
3. Make a claim about how adaptation can change the variation within a population based on the ecosystem. Be sure to support your claim with data from this lab.

Claim:

Evidence supporting:

1. Compare and contrast your data to the other ecosystems. Explain why your data is similar to or different from the other ecosystems. Was there one seed that was best everywhere (a generalist)? Or were some seeds only good in one or two ecosystems (specialists)?

Critical Thinking

1. What has happened to the amount of variation in your surviving population? If you kept selecting in this way for hundreds of generations, what would you expect to happen? What other processes might change this result?

*Part 2: Invasive species*

There are lots of ways to be an invasive plant, and although scientists have been trying to figure out what they all have in common for over 50 years, we still don’t have a good answer. However, many invasive plant species do reproduce more quickly and with many more seeds.

Pre-lab questions

1. What is an invasive species? Are they common?
2. Although we hear about invasive species all the time, relatively few species actually are invasive. Only about 1 in every 1,000 species that could be an invasive species actually ends up an as one. What conditions might make it difficult for a non-native species to establish itself in a new ecosystem?

Experiment:

You again have an ecosystem, however, one of your species now reproduces *twice as fast* as the others. Your group will distribute the seeds within your ecosystem, and then perform 3 rounds of selection to see which seeds are best adapted. However, one of your species now reproduces twice as fast as the others.

Predictions:

If the reproductive rates change for your seeds (for example, instead of doubling – it triples or quadruples each generation), how would the population change over time?

Your invasive seed can reproduce twice as fast as the other seeds; do you think that it will be able to successfully invade your environment? Why or why not?

Procedures:

1. Please check that you have 40 seeds in your seed population (10 each 4 different types of seeds).
2. Have one student randomly sprinkle the seed population in your ecosystem.
3. When the teacher instructs you, have another student pick 20 seeds in 60 seconds. Be sure to choose randomly by looking away between each seed and grabbing the first one that you can find.
4. When done, count up the seeds you have collected and use the data table #1.
5. Calculate the number of seeds remaining in your environment by subtracting from the starting population.
6. For generations 2 & 3, multiply the amount of the remaining of each of your native seeds by 2 (for example, if you pulled out 3 seed3 seeds in generation #1, 7 still remain in the ecosystem. You will need to add 7 to get to 14 for generation #2).
7. For your invasive species in generations 2 & 3, triple the amount of remaining seed (for example, if you pulled out 3 invasive species seeds in generation #1, 7 still remain in the ecosystem. You will need to add 14 seeds to get to 21 for generation #2).

Post Lab Analysis.

1. Compare your results with those of other ecosystems. Was the invasive equally successful in all ecosystems? Why or why not?
2. Make a claim about how reproductive rates along with adaptation can alter biodiversity within an ecosystem. Be sure to support your claim with data from this lab.

Claim:

Evidence supporting:

1. Compare and contrast your data to the other ecosystems. Explain why you have similar or different data for each other ecosystem.
2. Another way to be an invasive plant is to grow in a place where you have few or no predators. If we replaced one of your seed types with seeds covered in painful spines, how would it affect the diversity of your ecosystem?
3. Radish has become an invasive weed by flowering much earlier than its ancestors. How could flowering earlier let you become invasive?

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| --- | --- | --- | --- | --- | --- |
| Population | Starting # | Seeds Collected | Seeds Remaining(A) | Seeds Remaining times 2 (B) | Seeds Needed:B – A =  |
| Seed1 | 10 |  |  |  |  |
| Seed2 | 10 |  |  |  |  |
| Seed3 | 10 |  |  |  |  |
| Seed4 | 10 |  |  |  |  |

**First Generation**

Experiment 1

Environment: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Population | Starting # | Seeds Collected | Seeds Remaining(A) | Seeds Remaining times 2 (B) | Seeds Needed:B – A = |
| Seed1 |  |  |  |  |  |
| Seed2 |  |  |  |  |  |
| Seed3 |  |  |  |  |  |
| Seed4 |  |  |  |  |  |

**Second Generation**

|  |  |  |  |
| --- | --- | --- | --- |
| Population | Starting # | Seeds Collected | Seeds Remaining |
| Seed1 |  |  |  |
| Seed2 |  |  |  |
| Seed3 |  |  |  |
| Seed4 |  |  |  |

**Third Generation**

**Title: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**



Key

* Seed1
* Seed2
* Seed3
* Seed4

 **First Generation**

Experiment 2

Environment: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Population | Starting # | Seeds Collected | Seeds Remaining(A) | Seeds Remaining times 2 (B) | Seeds Remaining times 3 (C) | Seeds Needed: |
| Seed5 | 10 |  |  |  |  | C – A =  |
| Seed2 | 10 |  |  |  |  | B – A = |
| Seed3 | 10 |  |  |  |  | B – A = |
| Seed4 | 10 |  |  |  |  | B – A = |

**Second Generation**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Population | Starting # | Seeds Collected | Seeds Remaining(A) | Seeds Remaining times 2 (B) | Seeds Remaining times 3 (C) | Seeds Needed: |
| Seed5 |  |  |  |  |  | C – A =  |
| Seed2 |  |  |  |  |  | B – A = |
| Seed3 |  |  |  |  |  | B – A = |
| Seed4 |  |  |  |  |  | B – A = |

**Third Generation**

|  |  |  |  |
| --- | --- | --- | --- |
| Population | Starting # | Seeds Collected | Seeds Remaining |
| Seed5 |  |  |  |
| Seed2 |  |  |  |
| Seed3 |  |  |  |
| Seed4 |  |  |  |

**Title: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**



Key

* Invasive Seed5
* Seed2
* Seed3
* Seed4