Activity 8: Natural Selection

In the third activity of the animal sequence, students explore how changes in the environment affect both the plants and animals in a field ecosystem. Some organisms will be well adapted to the new environment and be able to survive while some will die before they have offspring. This process by which traits become more or less common in a population is called natural selection.

In this activity, students work with a model of the Virtual Ecosystem with two species living in it: grass and rabbits. They will first build a dam in the middle of the field. This will divide the ecosystem in half. This division of a population is called geographic isolation, which students previously experienced in the plant activity with the mountain and in the Lego activity. One half of the field will become dry, affecting the grass and rabbit populations. Both populations shift from a group with variation to a group where only the fittest individuals can survive. Students will then remove the dam and watch the field slowly return to its original state. They watch as both populations shift back to their original makeup.

In the activity, students are first reminded that variation exists in any population of plants or animals. The population of grass contains three varieties: short, medium, and tall. Students have already learned that small rabbits like to eat the short grass, medium rabbits like to eat the medium grass, and large rabbits like to eat the tall grass. The tall grass is drought resistant, so in an environment with limited water, only the tall grass will grow. Students watch as natural selection allows the large rabbits that prefer the taller grass to live and reproduce more successfully than other rabbits.

It is important to note that this activity is different than the Mountain Model from Activity 4. Whereas the mountains grew over millions of years and the plants had time to evolve, the dam models illustrate a "shift" in the plant and rabbit populations. This shift is similar to the shift that occurred in the quintessential evolution studies of the peppered moths during the Industrial Revolution in England. Just as the moth population changed over a hundred years or so, the population of rabbits changes in a relatively short time. Similarly, the rabbit population – like the peppered moth population – returns to its original state after an environmental change.

To prepare for the activity, please read this guide carefully and run the activity before you run it with students.

Learning Goals

Big Idea 6: Interactions Between Species

- An ecosystem is a collection of interacting organisms, as well as their physical environment.
- Other plants and animals, as well as the environment, can affect the survivability of plants and animals.

Big Idea 7: Intra-specific differences

- Individuals of the same species may differ.
- Not all offspring from the same parents look alike, even with respect to inherited traits.

Big Idea 8: Adaptation/Evolution

- Species are adapted to their environments and species adapt to changes in their environment. If the environment changes only certain species survive.
- Organisms with traits best suited to their environment have better chances of survival.
- Those organisms carrying traits that are better suited for a particular environment will have more offspring.
- The student will be able to explain how selection pressure could lead to a change in the characteristics of a population.
- The student will understand that adaptation requires both variability and selection pressure.

Big Idea 9: Heritability of Traits

- Offspring inherit some, but not all, of their traits from their parents.
- Students should be able to distinguish between traits that are inherited and traits that are not.

Model: Building a Dam

In this activity, your students will run the "Building a dam" model (page 4). This experiment illustrates geographic isolation. A population of rabbits, with three variations in size, is living in the Virtual Ecosystem. When the dam is built, the amount of water in half of the field (below the dam) changes. How will the population of rabbits respond?

The individual elements that make up an ecosystem are interdependent. In a food web, if one population of plants or animals is removed, connected populations will be affected. Similarly, in an ecosystem, the plants and animals are dependent on the environment. In the "Building a dam" model, students will first observe a stable ecosystem where all varieties of grass are getting enough water to grow and the different varieties of rabbits are getting enough grass to eat.

Both the grass and rabbit populations will change when the student builds a dam in the middle of the Virtual Ecosystem. Because the dam decreases the amount of water in the lower half of the ecosystem, the grass is affected. One type of grass (the tall grass) does well in drought conditions whereas the other two types die out. One variety of rabbit (the larger one) eats the tall grass and is, therefore, able to survive in this low water condition. The small and medium rabbits die out. Note, however, that large rabbits can have medium offspring, so students may see medium rabbits living below the dam. These rabbits will not have enough food and will not survive long enough to reproduce.

To run the model, students add rabbits and grass to the model and press Play. After watching the Virtual Ecosystem for a few seconds, they press the "Build Dam" button, which places a dam horizontally across the center of the model. In this model, the environment *above* the dam stays the same. The plant and

animal populations there will remain stable with three variations of rabbits and grass. Below the dam, there is less and less water. The plant population adapts to the changing water and shifts to favor the taller grass. The bigger rabbits prefer the taller grass as students learned in Activity 7. A shift in the grass that can grow in the field means a corresponding shift in the rabbits.

The goal of the experiment is to see what happens to the rabbit population as the water level affects the plant population. Students will see that the physical environment affects all populations in the ecosystem.

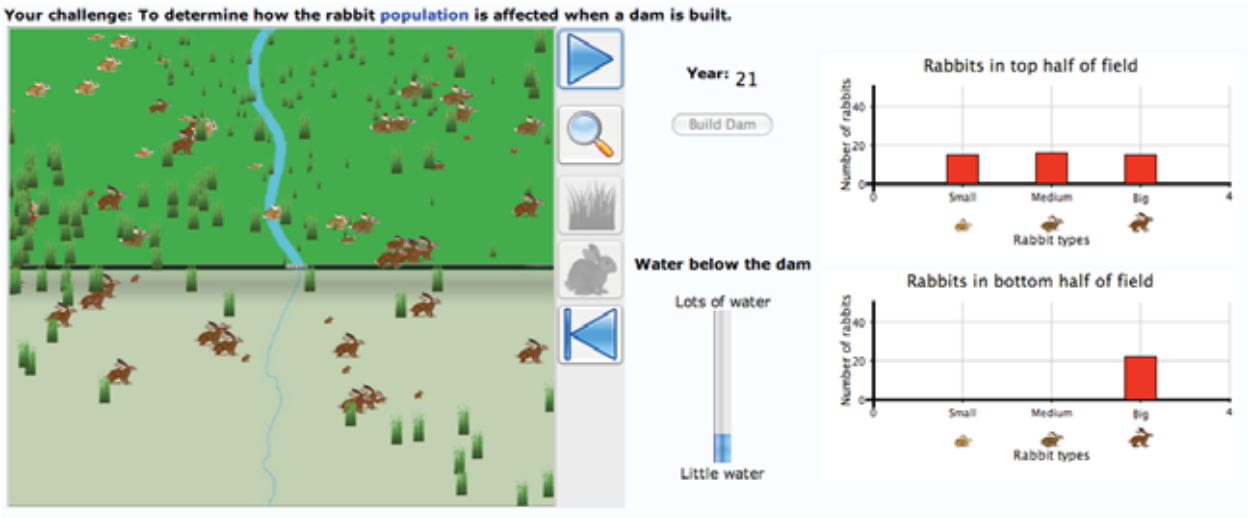

Figure 1. The Dam model at year 21. The population has shifted to favor large rabbits in the bottom half of the field. If you look carefully, you will see that large rabbits sometimes give birth to medium rabbits, but because there is no grass for those rabbits to eat, they will usually not survive long enough to have babies.

Students will watch several years pass as the population of rabbits above and below the dam live happily and reproduce. The graph shows the population of small, medium, and large rabbits. Students will note that the number of each type is NOT equal. In fact, the graphs for each type will fluctuate. This is a good time to stop and discuss how a stable population always has variation. Students will also note that below the dam, the environment is getting drier and more tall grass is growing than any other type of grass. As a result, the larger rabbits are able to find enough food to eat and can reproduce more. The rabbit population shifts to the animals with the trait for large size.

Encourage students to watch both the model AND the two graphs: **Rabbits in top half of field** and **Rabbits in bottom half of field**. It may help some students to pause the model.

Model: Removing the Dam

If the dam is removed, what will happen to the population of rabbits? Over time, the land below the dam returns to its original level of water. The short and medium grasses can grow again, which will allow the small and medium rabbits to live below the dam. (Tall grass continues to grow well and serves as food for the large rabbits.) Rabbits are also able to move through the entire field to find food.

After answering the prediction question, students run the "Removing the dam" model (page 6). They press the “Remove the Dam” button to reverse the environmental change.

The graph showing the rabbits at the bottom of the field will fluctuate, but students should start to see all three sizes of rabbits living throughout the field.

Remember, the rabbits in the population are all one species, even though there is variation. Large rabbits are able to have both large and medium offspring. If a large rabbit has a medium-sized baby in a field of only tall grass, the baby will not live and not be able to have its own babies. If medium grass is available, then the medium rabbit baby will live and be able to have offspring of its own.

Also note that medium rabbits can have small, medium, or large offspring. Small rabbits can have small or medium offspring. The same is true of the grass. Tall grass can have tall or medium offspring. Medium grass can have all three types of offspring. Short grass can have short or medium offspring.

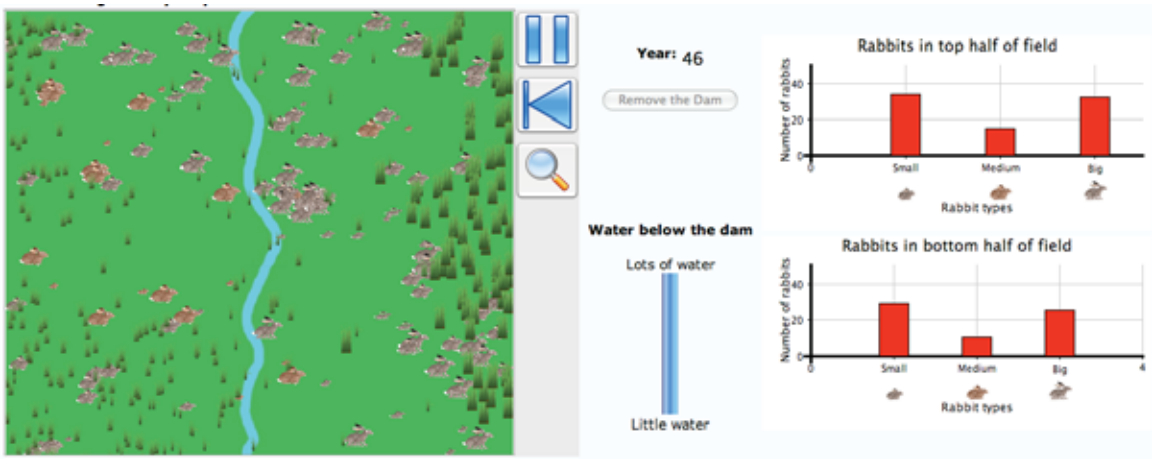

Figure 2. The Reverse Dam model at year 46. The population in the bottom half of the field has returned to its original distribution of small, medium, and large rabbits.

Model buttons

Make sure you run the model before your students start this activity to ensure that you are familiar with the model and the control buttons. Below are descriptions of the control buttons.

Review the use of these buttons with your students before they run the activity.

Click the Play button to start the model. Use the Pause button to stop it.

Click the Plant button to add three types of grasses to the field.

Click the Rabbit button to add three types of rabbits to the field.

Use the magnifying glass to get more information about a plant or rabbit.

Click the Reset button to reset the model to its original condition.

The glossary contains definitions for the vocabulary words (in blue) used in this activity. Students can click on individual blue words for pop-up definitions or click the Glossary icon for the complete glossary.

Lesson Plan

1. Estimated time

This activity should take approximately 45 minutes.

2. Introduce the activity (Engage)

When a dam is introduced to an environment, it separates the animals living on either side of the dam. If a population of animals is divided in this way, it is called geographic isolation. If the environment on either side of the dam changes, the populations of plants and animals living on that side will need to change along with the environment in order to survive. (Of course, plants and animals do not choose to change to better fit in! If there is variation in a population, there may be variants that are well adapted to the new environment and can live and reproduce.) Remember the Lego activity? A mountain or river split the population and new species evolved over time. Dams are just one way that plants and animals in the same population can be divided.

Note: Students should be told that dams are not inherently bad! They should understand that dams block the flow of water on one side of a river or lake from going to the other side. Some dams block the water completely and some can control the amount of water that goes through. Dams can be used to control floods or to generate electricity from the power of the water flowing through them. Hydroelectric power is generated from dams. The Hoover Dam, one of the largest dams in the world, is an example of a hydroelectric dam. Has anyone in the class seen a real dam? If so, where?

As students run the activity you may want them to keep the following discovery question in their minds. Write this question on the board so that students can see it during the class period.

What makes a trait more likely be passed on to a new generation?

3. Guided inquiry (Explore)

Have students run the activity. If students are working in pairs or small groups, explain to them that they should discuss their answers with classmates, and then type their answers directly into the computer.

Page 1
No questions.

Page 2
No questions.

Page 3

Q1. What do you think will happen to the grass population if there is less water?
A. Only Grass C will survive.

Q2. What do you think will happen to the rabbit population if there is less water?
A. Only certain types of rabbits will survive.

Note that the two questions on this page are prediction questions, so students will not see pop-up messages to let them know if they are correct.

Page 4
No questions.

As the class is watching the model run, make sure students notice the difference between the two graphs.

- Ask: "What does the top graph show?" (Answer: The number of rabbits of each type on the TOP of the dam.)
- Ask: "What does the bottom graph show?" (Answer: The number of rabbits of each type BELOW the dam.)
- Ask: "What is happening to the rabbits below the dam?" Students should understand that the lack of water means that only one type of grass can survive. That type of grass is eaten by only the large rabbit, so only the large rabbits will be able to live in the environment below the dam.

Page 5

Q3. Over time, what happened to the water level below the dam?
A. There was less water below the dam.

Q4. After the dam had been around for many years, which types of rabbits were living in the population under the dam?
A. The population was made up of mostly larger rabbits.

Q5. Explain why the population of rabbits below the dam changed.
A. Student answers will vary. The lack of water shifted the grass population toward the taller grass. The larger rabbits eat the taller grass, so they were better able to survive in the drier environment.

Page 6

Q6. Will the rabbit population in the bottom half of the field change or stay the same if the dam is removed?
A. The population of rabbits will change.

Note that the above is a prediction question, so students will not see a pop-up message to let them know if they are correct.

- As students are running the model, make sure they are looking at the graphs.
- Ask them to pause at **Year 25** and tell you how many of each type of rabbit are above and below the dam. Write these numbers on the board. They will be different for each student.
- Remind students that this is a model and the population will never be perfectly balanced (with exactly equal numbers of each of the three types of rabbits).
- Note that in some students' models, there may be more large rabbits below the dam than there are above. The fact that the population below the dam is shifting from the larger rabbits to all three types of rabbits is more important than the actual numbers.

Page 7

Q7. The rabbit population below the dam shifted back to the way it was before the dam was built. How did this happen?
A. Student answers will vary. The area below the dam was no longer too dry to support the medium and short grass. When these different varieties of grass were able to grow, the medium and small rabbits were also able to live there. The tall grass and large rabbits continued to do well in this field.

Q8. If the dam had NOT been removed, what do you think the rabbit population would look like after thousands of years?
A. Student answers will vary. The rabbits below the dam would all be large rabbits, eating tall grass. There would be no medium or small rabbits.

Page 8
No questions.

Wrap up the activity with the discussion below.

4. Discuss the activity (Explain)

After your students run this activity you may want to discuss what students concluded from the activity. In addition, it is important to discuss the discovery question with your students.

What makes a trait more likely be passed on to a new generation?

Traits that give an individual an advantage over others in the population and help it survive and reproduce will be passed on to new generations. These offspring also are more likely to survive and pass on the advantageous traits. Individuals in a population with less desirable traits may not live long enough to have offspring. Over time, the advantageous traits become more common in the population. In the dam example, the ability to eat the tall grass was an advantage that the large rabbits had over the other two types of rabbits. After many years, the population of rabbits below the dam shifted to contain more rabbits of this type.

This process is the basis of natural selection. Use the information below to guide your discussion on natural selection and population shift.

Natural selection

Natural selection requires the following:

1) Variation in a population
2) Only the fittest individuals reproduce
3) Offspring inherit the traits of their parents
4) More advantageous traits become more common in the population

Here's how natural selection works in the Virtual Ecosystem dam experiments: The dam changes the environment below the dam such that only the tall grass can live. The large rabbits can eat the tall grass. So, the large rabbits will live longer and be able to reproduce. Their offspring that also have the large trait will survive and the cycle will continue. The population shifts from a mix of small, medium, and large rabbits to mostly large rabbits. While the shift does not take very long (less than 100 years as opposed to millions of years), it is the basis of evolution by natural selection. Students can imagine what would happen if this pattern continued over millions of years.

Remember the Lego Tree of Life activity. When geographic isolation sets a group in a population apart, and their environment changes, they begin to adapt to their new environment. Over millions of years, separate species can evolve. Show the timeline. It took a very long time for species to change from little organisms living in the water to dinosaurs!

In a shift situation, like students see with the dam, the population moves to favor one trait or another. With a shift, however, the population can move back to its original state because the variation still exists in the population (large rabbits can have medium offspring, as well as large; medium offspring can have small, medium, or large offspring). When the dam was removed and the medium and short grass started to grow again, the variation in rabbit offspring meant that when a medium rabbit was born it could find enough food to live and to have babies. Once the environmental pressure of the drought was over, variation helped the population to shift back to its normal state.

Population shift

If the environment changes, all the plants and animals in an ecosystem must adapt to the new environment. Over a long period of time, species change, adapt, and can evolve into different species. Sometimes a population can change over a short time – like the rabbits and grass in the models in this activity. And even change back again!

Read the peppered moth story (below) to students, then ask students: why did the trees turn black? Why did the black moths survive? When the air became cleaner, why did the peppered moth population shift back to mostly white? What would happen if the population shifted and never went back? (Answer: Over millions of years, a new species may evolve.)

Peppered moths

Show the peppered moth posters included in your bin. In England, during the Industrial Revolution, new factories with lots of machines were invented. These machines ran on coal power, which put lots of smoke in the air. This smoke turned the bark of some trees black. A type of moth, called the peppered moth, lived on those trees. The moths were usually white with black speckles, but there were some black moths with white speckles, too. When the moths were sitting on the blackened trees, it was easy for birds to find the white moths and eat them!

Over just a few years, the moth population shifted from mostly white moths to mostly black moths. There was still variation in the population, but the amounts of each color in the population changed. The black moths had an advantage. Their color hid them well! They were not eaten and they lived to have more babies. This process, where some members of a population have an advantage and can live to have more babies, is called natural selection. As people invented cleaner machines that didn't cause so much smoke, the tree bark slowly turned white again. What do you think happened to the moth population? (Answer: The white moths returned!)