ENVIRONMENTAL SCIENCE JOURNAL FOR TEENS

How do organisms adjust to a changing climate?

LESSON

Introduction

This lesson plan has students learn about the process of natural selection by exploring how it can lead to changes in survival characteristics of a species over time, such as beak size or color. Then they will expand into how natural selection can also bring about changes in reproductive traits over time in response to climate change.

Learning Objectives

After the lesson, the students should be able to:

- Explain how natural selection can cause change in a population over time
- Differentiate between a survival trait and a reproductive trait
- Describe lifestyle modifications that reduce an individual's carbon footprint

Key Terms

- natural selection
- evolution
- adaptation
- trait
- carbon footprint

Time Requirement

Minimum 4 class periods (could be on separate days).
With extensions: up to 5 - 6 class periods.

Grade Level

Grades 7-8 or 10-11 depending on the handout versions used

Teaching standards

NEXT GENERATION SCIENCE STANDARDS:

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 variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

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 this trait.

HS-LS4-4
Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

HS-LS5-5
Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

HS-ESS3-4
Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

MS-LS4-4
Construct an explanation based on evidence that describes how genetic variations of traits in a population increase the 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.

AP ENVIRONMENTAL SCIENCE:

- Unit 2 - The Living World - Biodiversity
- Topic 2.6 - Adaptation
- Essential Knowledge:
  - ERT-2.H.1 - Organisms adapt to their environment over time, both short- and long-term scales, via incremental changes at the genetic level.
  - ERT-2.H.2 - Environmental changes, either sudden or gradual, may threaten a species' survival, requiring individuals to alter behaviors, move, or perish.

Materials

- A smartboard or laptop and projector
- Large pieces of paper, poster boards, or whiteboards
- Printed copies of Handout 1, "May the Best Beak Win!" (included following this lesson plan in both middle and high school versions)
- Printed copies of Handout 2, "Reducing My Carbon Footprint" (included following this lesson plan)
- Small plastic cups
- "Beak" items (Ex: binder clips, chopsticks, spoons, tweezers, etc.)
- "Food" items (Ex: paper clips, rubber bands, toothpicks, macaroni, peas, etc.)
- Printed article and question handout **How will dragonflies adapt to a warmer Earth?** from Science Journal for Kids and Teens (if reading in class)
- Optional: printed copies of Handout 3, "Natural Selection with PhET" (included following this lesson plan in both middle and high school versions)

Note: Editable versions of the handouts can be downloaded here: **https://drive.google.com/drive/folders/1OkgNh7W7_nd3oONLlamao5_94n7jJtOz?usp=sharing**

Lesson Plan

1 GETTING STARTED

- **What is Evolution and How Does It Happen? (~5 minutes)**

  Show students a video that describes the way that natural selection leads to the evolution of a species. Video examples include:

  - **The Five Fingers of Evolution** from Paul Anderson. This video reviews the five processes that cause the evolution using the fingers on your hand. This video is appropriate for upper high school students.

  - **Living Things Change** from Crash Course Kids. This video reviews how adaptations help animals live in a changing environment using the story of the peppered moth. This video is appropriate for middle school and lower high school students.

- **Evolution and Adaptation Think-Pair-Share (~10 minutes)**

  After viewing the video, instruct students to answer the question, "How do living organisms survive in a changing environment?" individually. After a few minutes, ask them to pair with another student and share their answer. The pair should select one of their answers or work together to create a new answer to share with the class.

- **Evolution and Adaptation Consensus Discussion (~20 minutes)**

  Ask one pair to volunteer to be first in sharing their answer to the question, "How do living organisms survive in a changing environment?" The rest of the groups should either add to or refine the answer until the class comes to a consensus on how living organisms survive in a changing environment. Next, have students brainstorm why environments change. Once they have a list, invite them to think about which of these changes are natural and which are human driven. Prompt them to think about whether environmental changes are "bad" for organisms, and what that means.

Duration 35-45 min, depending on grade level

2 HANDS-ON ACTIVITY: MAY THE BEST BEAK WIN!

Students will experience how the process of natural selection leads to changes in a population over time by pretending to be birds with different "beaks". (For older students, you might want to frame it as a simulation.)

General Instructions:

- Students should sit in a circle. There can be one large circle that includes the entire class or 2-4 smaller circles.
- Each student receives a cup that will be their stomach. All students will receive an object (binder clip, spoon, chopsticks, etc.) that will act as their beak.
- Explain to the students that they are now hungry birds (or will be simulating them). When instructed to start, they will feed on the food that is available in their feeding area. To eat, they must pick up the food with their "beak" and place it in their "stomach."
- **Note:** Make sure that students are aware that they should behave appropriately during the simulation. If they are unable to behave properly (e.g. pecking other students or throwing things), they will become bird watchers instead.
- Scatter food in the center of the circle. Food can be toothpicks, paperclips, macaroni, etc. Students should place one hand behind their back and have their "beak" in their free hand. Say "go," and let them feed for 1-2 minutes or until the food is gone.

- Say "stop" to end feeding. Have students empty the contents of their stomach to see their success.
- Tell the students the threshold for survival. This threshold is dependent on the food and beak type. You can determine the threshold by trying the activity yourself with the "beak" and "food" you decide on. For example, if you are only able to pick up 3 paperclips in the allotted time, consider setting the threshold at 5.

PART 1: THE IMPORTANCE OF GENETIC VARIATION

Follow the general instructions for playing the game. To highlight the importance of genetic variation in a population, start with only one type of food and only one beak type. Select a beak type that is difficult for the students to pick up the food, such as paper clips for food and chopsticks for beaks. (The hope is that very few students will get food.) When students finish their first feeding session, ask them what they think will happen to this bird population over time. Students should say that they will not survive unless they are able to get enough food. They will likely suggest finding a different food source. Highlight that another option is that beak type could change.

Distribute Handout 1 and have students record their beak type and the amount of food they collected in the first data table. Next, give a few students a different beak type that will more easily pick up the paper clips. Have the students return their food items to the feeding area, and then have them feed again for 1 -2 minutes. When they finish, discuss the difference between the first feeding season and the second. Example questions include:

- How did the first feeding season differ from the second?
  Answer: More birds were able to survive when there was the second type of beak because the first beak type was too difficult to grab the food.
- What does this experience tell us about the importance of genetic variation in a population?
  Answer: Without variation, the population would not have survived. Having variation allows some individuals to survive and continue on in the given environment.
- What causes some birds to have different beaks?
  Answer: Mutation or gene flow from migration.

This question provides an excellent opportunity to correct a key misconception. Many students think that natural selection creates the characteristic that helps the organism survive, but in fact it just gives a "thumbs up" to a characteristic that the organism already possessed. It is very important that students understand that the characteristics are a result of random mutation or gene flow, while natural selection sees successful characteristics passed on more frequently.

PART 2: NATURAL SELECTION

Follow the general instructions for playing the game. During this part of the game, students are able to select their beak type from four different types by rolling a dice (assign a number to each type). The beak types should be evenly distributed amongst students, so limit the number of beaks laid out for the first round and have students roll again if their number give them a beak type that has already been sufficiently assigned.

When told to start, students should feed for 1-2 minutes or until the food is gone. When time is called, students should check their stomachs to see if they have food. For high school students, they will follow the instructions on Handout 1 to determine how many "birds" with their beak type survived. For middle school students, you will need to determine a threshold for survival for each beak type, similar to the threshold that was set for Part 1. If a group doesn't eat enough food, they will earn fewer "birds". The "birds" that don't survive will trade their beaks for a different kind (once again rolling a dice, this time perhaps with odds vs evens to decide between the most successful types) and will become the offspring of a more successful species. Students will collect data to see how the beak type changes over time.

PART 3: RESOURCE PARTITIONING [EXTENSION FOR UPPER HIGH SCHOOL ONLY]

If time permits, have more than one type of food with the different beak types. Before they feed, let students experiment with their beaks and different food types. Have the students return all the food to the feeding area. Let them feed for 1 - 2 minutes. When finished, the students with different beak types should share which food they prefer. Ask them to compare survival rates of the different beak types in this round as compared to the second round. Students should see that a more diverse group of birds could survive. They should recognize that when there are more resources in an ecosystem, biodiversity is higher. Transition to a discussion of resource partitioning (morphological, temporal, and spatial). Explain how competition between bird species was reduced by feeding on different food.

Duration 60 - 120 min, depending on grade level and extensions

3 READING ASSIGNMENT

- **Reading**

  Individually or in groups, have students read the article **How will dragonflies adapt to a warmer Earth?** published in *Science Journal for Kids and Teens*. Have the students answer the first four "Check Your Understanding" questions at the end of the article (teacher's key available on the same page)

- **Application**

  In pairs or groups, students should discuss their answers to the first four questions. Then they should access the iNaturalist website that the researchers used for their study using a computer or mobile device. Using the explore feature, they should look at different dragonflies in the database. They should select one dragonfly of their choice and they should write a short paragraph that states a claim about what they think will happen to this specific dragonfly species if climate trends continue. They should then support their claim with evidence from the picture and reasoning from the article for their prediction.

- **Sharing**

  Groups should share their selected dragonfly and their prediction for what will happen. When everyone has shared, review what they have learned from the article about natural selection and climate change. Focus on why it is important to understand how animals will change in the future in response to climate change. If time permits, pose the question "Should humans invest in conserving species that cannot adapt to climate change, or should we let things live and die as natural selection chooses?" Let students discuss their thoughts and ideas.

Duration 45-60 min, depending on reading level

4 APPLICATION: REDUCING CLIMATE CHANGE

Transition to the impact of climate change on ecosystems by reading through the final "Check Your Understanding" question at the end of the article. This question asks students to develop a list of additional ways they can reduce their carbon footprint. It also asks them to determine which one they would most likely commit to. To complete this question, it is helpful for students to know how big their carbon footprint is and what activities are contributing to it.

- **Option 1:** If students already are familiar with their individual carbon footprint and the activities that define it, they can break into pairs or groups and brainstorm a list. Then they can rank the activities they identified based on how likely they are to commit to this lifestyle change. Each student in the pair or group should determine which one they are most willing to do. They can then share with the class, or they can create a carbon footprint commitment poster to hang up in the classroom.

- **Option 2:** If students are not familiar with their carbon footprint, then have them navigate to **Conservation International's Online Carbon Footprint Calculator**. Once there, students will answer questions about their homes, diet, cars, and travel. They may need help answering some questions. Remind them that this calculator is just an estimate and their answers don't have to be perfect. Make sure that they take a look at the Did You Know statements on each page of the calculator.

  When students complete the calculator, they should record their results using Handout 2: "Reducing My Carbon Footprint". Then they should use their results to make a carbon reduction commitment.

  When students finish, they can share their commitments out loud. Alternatively, give students index cards to write their commitments on, then post them on a section of the classroom wall or a board if space is available.

Duration 60 - 120 min, depending on grade level and extensions

Writing Extension

These assignments can be completed individually or in small groups. They can also be assigned for homework or completed during class time.

Evolution and Adaptation Poster

- As a summative assignment, students can work in pairs or groups to create a poster that explains how living organisms survive on a warming Earth. Their poster should include key ideas and vocabulary from the activities in the lesson. They should support what they have written with pictures. The poster can be on a whiteboard, poster board, or large piece of paper.
- After a given amount of time, or after students finish their posters, have them travel around to view the posters of other groups. As groups rotate through, they should leave feedback for their peers. Feedback may include ideas that they think are missing from the poster, questions that they have, or positive comments about what they see. When students have walked through some or all the posters, they should return to their own and review the feedback left by their peers. They should adjust their poster to address the feedback.

Campaign to Reduce Climate Change

- Students can write a letter to a local politician persuading them to take action against climate change so that organisms aren't negatively impacted by changes in their environment.
- Students can make posters to hang up around their school and/or community promoting simple ways to reduce their carbon footprint.

Online Learning

Natural Selection Simulation

This could be done as an alternative to the hands-on activity or be assigned for additional enrichment. Direct students to the **Natural Selection PhET Simulation**. Students will use the simulation to see how natural selection can change the bunny population over time when exposed to different environmental factors. Students should use the simulation to collect population data for the wolves at the Equator and in the Arctic. Middle and lower high school students should focus on fur color. Upper high school students should explore fur color first, but then can explore different mutations and environmental factors using the Lab tab. Handout 3, "PhET Natural Selection," offers useful instructions and comprehension/reflection questions.

NAME: _____ **DATE:** _____

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Natural Selection: May the Best Beak Win!

When an environment changes, evolution can occur through natural selection. If an individual has a characteristic that will help them survive in the new environment, it will reproduce and pass the characteristic on to the next generation. If an individual does not have any characteristics that will help them survive, they will die and their characteristics will not continue. So, with natural selection, the environment selects certain characteristics to continue. In this activity, we will simulate the process of natural selection by becoming birds to see how a population changes over time.

Scenario: You are a member of a bird species with a distinctively-shaped beak. Environmental changes have occurred so that only one type of bird food is available and its availability is limited. Therefore, when you arrive at the feeding area, you must battle the other birds to get enough food for your survival.

General Rules:

- Sit in a circle as instructed by your teacher. Food will be scattered inside the circle, which will be the feeding area.
- Take the provided cup and place it on the floor in front of you. This will be your stomach. All food that you collect during feeding must go into your stomach to be considered eaten.
- Pick up your "beak" in one hand. Place your other hand behind your back.
- When instructed to start, use your "beak" to pick up food and place it into your "stomach." Collect as much food as you can until your teacher calls time.
- Determine how much food you ate during this feeding season.

Note: All "birds" must feed appropriately. If you are unable to behave properly, then you will be transformed into a birdwatcher instead.

Round 1:

In this round of the game, during the first feeding season, all birds will have the same type of beak. During the second season, a few birds will receive a different beak type. At the end of each season, record your results in the table below.

Feeding Season	Beak Type	Amount of Food Eaten
1		
2		

1. Compare the results of feeding season 1 and 2 with your peers. Which of the following best describes how a change in beak type affected a bird's success at eating?

☐ It increased a bird's success.

☐ It decreased a bird's success.

☐ It did not impact a bird's success.

2. Why is it important that individuals in a population have differences?

3. What caused some birds to have different beaks?

Round 2:

In this round of the game, there will be 4 different beak types, and we will feed for three seasons. At the end of each feeding season:

- Record your beak type in the table below.
- Count up how much food you collected with your beak.
- Determine what happened to you based on the amount of food required for survival, which your teacher will tell you. If you collected enough food, you survived and reproduced (S&R). If you didn't, you died (D).
- If you as an individual with a certain beak type don't feed enough to survive, that bird will die. However, you will get to participate in the next round as the offspring of a successful species. You will be given a new beak type for the next feeding season.

Feeding Season	Beak Type	Amount of Food Eaten	What happened to me? (S&R or D)
1			
2			
3			
4			

Now let's look at how the bird population has changed over time. Determine the total number of birds of each type at the beginning of the game and at the very end. Record your results in the data table below.

Time	Number of Birds with Beak 1	Number of Birds with Beak 2	Number of Birds with Beak 3	Number of Birds with Beak 4
Initial Population				
Final Population				

Use your understanding of natural selection to explain what happened to the beak type of our bird population over time.

NAME: _____ **DATE:** _____

_____

Natural Selection: May the Best Beak Win!

When an environment changes, evolution can occur through natural selection. If an individual has a characteristic that will help them survive in the new environment, they will reproduce and pass the characteristic on to the next generation. If an individual does not have any characteristics that will help them survive, they will die and their characteristics will not continue. So, with natural selection, the environment selects certain characteristics to continue. In this activity, we will simulate the process of natural selection to see how a population changes over time.

Scenario: You are a member of a bird species with a distinctively shaped beak. Environmental changes have occurred so that only one type of bird food is available and its availability is limited. Therefore, when you arrive at the feeding area, you must battle the other birds to get enough food for your survival.

General Rules

- Sit in a circle as instructed by your teacher. Food will be scattered inside the circle, which will be the feeding area.
- Take the provided cup and place it on the floor in front of you. This will be your stomach. All food that you collect during feeding must go into your stomach to be considered eaten.
- Pick up your "beak" in one hand. Place your other hand behind your back.
- When instructed to start, use your "beak" to pick up food and place it into your "stomach." Collect as much food as you can until your teacher calls time.
- Determine how much food you ate during this feeding season.

Round 1:

In this round of the game, during the first feeding season, all birds will have the same type of beak. During the second season, a few birds will receive a different beak type. At the end of each season, record your results in the table below.

Feeding Season	Beak Type	Amount of Food Eaten
1		
2		

1. Compare the results of feeding season 1 and 2 with your peers. Which of the following best describes how a change in beak type affected a bird's success at eating?

- ☐ It increased a bird's success.
- ☐ It decreased a bird's success.
- ☐ It did not impact a bird's success.

2. What does this experience tell us about the importance of genetic variation in a population?

3. What caused some birds to have different beaks?

Round 2:

In this round of the game, there will be 4 different beak types, and we will feed for three seasons. At the end of each feeding season, we will:

- Calculate the total amount of food eaten for each beak type and record it in the provided table.
- Calculate the total food collected by all birds
- Calculate the percent of food eaten by each beak type.
- Determine the number of birds of each beak type in the next generation using the following formula:

Beak Type Final Number of Birds = Percent Food Eaten by Your Beak Type X Total Number of Birds

If you as an individual with a certain beak type don't feed enough to survive, that bird will die. However, you will get to participate in the next round as the offspring of a successful species. You will be given a new beak type for the next feeding season.

Feeding Season 1

Beak Type	Initial Number of Birds	Total Amount of Food Eaten	Percent of Food Eaten	Final Number of Birds
Total			100	

Feeding Season 2

Beak Type	Initial Number of Birds	Total Amount of Food Eaten	Percent of Food Eaten	Final Number of Birds
Total			100	

Feeding Season 3

Beak Type	Initial Number of Birds	Total Amount of Food Eaten	Percent of Food Eaten	Final Number of Birds
Total			100	

Now let's look at how the bird population has changed over time. Using the initial bird population for each feeding season, calculate the percent of birds represented by each beak type. Record your results in the data table below.

Beak Type	Feeding Season 1	Feeding Season 2	Feeding Season 3

Use your understanding of natural selection to explain what happened to the beak type of our bird population over time.

Round 3:

In this round of the game, there will be 4 different beak types and 4 different types of food. Before we feed, take a moment to experiment with your beak and the different food types. Then, when instructed, feed on the available food. When you are done, record the amount of each food type you collected.

Beak Type	Amount of Food Type 1 Eaten	Amount of Food Type 2 Eaten	Amount of Food Type 3 Eaten	Amount of Food Type 4 Eaten

1. Compare the results of this feeding session with other birds. What are three observations you notice?

2. How did the biodiversity of this ecosystem compare to our original? Explain.

3. When there is a resource shared by multiple individuals or species, there will be competition for that resource. How did our bird population reduce competition for food in this last round of the game?

NAME:_____ **DATE:** _____

Reducing My Carbon Footprint

As the Earth gets warmer, organisms have three options. They have to migrate to new locations that are a comfortable temperature, they have to adapt to a warmer climate, or they die out. No matter what happens, ecosystems across the planet will change as a result of a changing climate, and there is no way to know for sure all the ways this will impact human life. One way to deal with the growing concern about climate change and the change in biodiversity it can cause is to reduce the amount of climate change that occurs over time.

To reduce the amount of climate change, we must reduce the amount of greenhouse gases, such as carbon dioxide and methane, that are released into Earth's atmosphere as a result of our actions. Scientists developed the carbon footprint as a way to measure an individual or country's impact on the atmosphere. By knowing your impact, you can make changes in your life that reduce it.

In this activity, you are going to use an online carbon footprint calculator to determine your carbon footprint. Then you are going to use the results of this tool to determine a commitment that you are willing to make to reduce your carbon footprint.

Part 1: What's Your Footprint?

Navigate to Conservation International's Carbon Footprint Calculator. Use what you know about yourself and your family to answer the questions to the best of your ability. It is okay to answer a question with an educated guess. Just do the best that you can! When you reach the results page, use the provided information to answer the following questions.

1. How big is your annual carbon footprint in tons? _____

2. How many trees would you need to plant to offset your annual carbon footprint? _____

Scroll down to the bottom of your results page. Use this information to answer the following questions.

3. Your carbon footprint is a combination of your home life, transportation choices, and travel choices. Rank these categories from greatest contributor (1) to smallest contributor (3) to your footprint.

Rank	Category
	Home life
	Transportation
	Travel

4. How do you compare to the average American in each category? Is your footprint larger (>), equal to (=), or smaller (<)? Record your comparison for each category in the table below.

Activity Type	Comparison to Average American
Household	
Transportation	
Travel	

5. Reflect on your carbon footprint. How do you feel about it? Explain fully.

Part 2: Reducing Your Carbon Footprint

Now that you know how big your footprint is, let's think of how you can reduce it. Read through the *Quick Tips to Reduce Your Footprint* section of your results page. Use this information to complete the following tasks.

1. Make a list of what you can do in the space below.

2. Add any additional ways that you could reduce your carbon footprint that were not mentioned on the calculator results page.

3. Read through your options and determine which reduction technique you are most willing to commit to and which reduction technique you can absolutely not do. Then explain why you selected these reduction techniques.

I am most willing to…	
To reduce my carbon footprint because…	

I absolutely CANNOT	
To reduce my carbon footprint because…	

NAME: _____ **DATE:** _____

Natural Selection

Natural selection is a process that changes a species over time. If an individual has a characteristic that will help them survive in the environment, it will reproduce and pass the characteristic on to the next generation. If an individual does not have any characteristics that will help them survive, they will die and their characteristics will not continue. So, with natural selection, the environment selects certain characteristics to continue. In this activity, we use a simulation to see how natural selection changes a population over time.

Part I: Getting to Know the Simulation

Before using a simulation, it's important to understand how it works. Let's play with PhET's Natural selection simulation before we use it to conduct an experiment.

- Navigate to **PhET's Natural Selection simulation**.
- Click on *Intro*.
- When the simulation loads, click on *Add Mate*. Let the simulation run.

1. What happens to the bunnies? Why does this happen?

- Click *Start Over* and *Add Mat*e. Let the simulation run for 2 generations. Just after 2 generations, click on *Fur* under *Dominant*. Let the simulation run.

2. What did you observe about your bunny population?

Part II: Natural Selection

Now that you are familiar with the simulation, we are ready to use it to see how mutations and environmental changes affect a population.

Procedure:

- Restart the simulation and click on *Fur* under *Dominant*. Then click *Add* a *Mate*.
- Let the bunny population grow for 3 generations. Pause the simulation.
- In the menu to the left of the table, click on the box in front of *Data Probe*.
- Use the probe to determine the population of each bunny type at generation 3. Record these numbers as the initial population of bunnies in the table below.
- In the menu titled *Environmental Factors*, click on the box in front of *Wolves*. Then click *Play*.
- Let the simulation run until it reaches Generation 7. Pause the simulation.
- Use the data probe to determine the population of each bunny type for the remaining generations in the data table.

Table 1: Bunny Populations at the Equator

Bunny Type	Initial Population (Generation 3)	Population Generation 4	Population Generation 5	Population Generation 6
Total				
White				
Brown				

1. Where did the original brown bunnies come from?

2. What happens to the number of white bunnies in the population over time?

☐ It increases.

☐ It decreases.

☐ It remains the same.

3. What happens to the number of brown bunnies in the population over time?

☐ It increases.

☐ It decreases.

☐ It remains the same.

4. Using the concept of natural selection, explain why the bunny populations change the way they do.

Make a prediction! How will the results of this experiment change if it took place at the poles instead of at the equator? Explain your thoughts.

- Restart the simulation. Click the snowflake in the upper right corner of the simulation to change to the poles.
- Click on *Fur* under *Dominant*. Then click *Add* a *Mate*.
- Let the bunny population grow for 3 generations. Pause the simulation.
- In the menu titled *Environmental Factors*, click on the box in front of *Wolves*. Then click *Play*.
- Let the simulation run until it reaches Generation 6. Pause the simulation.
- In the menu to the left of the table, click on the box in front of *Data Probe*.
- Use the probe to determine the population of each bunny type at generation 3. Record these numbers as the initial population of bunnies in the table below.
- Use the data probe to determine the population of each bunny type for the remaining generations in the data table.

Table 2: Bunny Populations at the Poles

Bunny Type	Initial Population (Generation 3)	Population Generation 4	Population Generation 5	Population Generation 6
Total				
White				
Brown				

5. Where did the original brown bunnies come from?

6. What happens to the number of white bunnies in the population over time?

- ☐ It increases.
- ☐ It decreases.
- ☐ It remains the same.

7. What happens to the number of brown bunnies in the population over time?

- ☐ It increases.
- ☐ It decreases.
- ☐ It remains the same.

8. Using the concept of natural selection, explain why the bunny populations change the way they do at the poles.

9. The snowshoe hare is a reddish-brown color in the spring and summer. In the winter, its fur changes to white. Global warming is expected to cause the winter snows to come later and melt earlier. How do you think the snowshoe hare will be affected by global warming?

NAME:_____ **DATE:** _____

Natural Selection

When an environment changes, evolution can occur through natural selection. If an individual has a characteristic that will help them survive in the new environment, it will reproduce and pass the characteristic on to the next generation. If an individual does not have any characteristics that will help them survive, they will die and their characteristics will not continue. So, with natural selection, the environment selects certain characteristics to continue. In this activity, we use a simulation to see how natural selection changes a population over time.

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- Navigate to **PhET's Natural Selection simulation**.
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1. What happens to the bunnies? Why does this happen?

- Click *Start Over* and *Add Mat*e. Let the simulation run for 2 generations. Just after 2 generations, click on *Fur* under *Dominant*. Let the simulation run.

2. What did you observe about your bunny population?

Part II: Natural Selection of Fur

Now that you are familiar with the simulation, we are ready to use it to see how mutations and environmental changes affect a population.

Procedure:

- Restart the simulation and click on *Fur* under *Dominant*. Then click *Add* a *Mate*.
- Let the bunny population grow for 3 generations. Pause the simulation.
- In the menu to the left of the table, click on the box in front of *Data Probe*.
- Use the probe to determine the population of each bunny type at generation 3. Record these numbers as the initial population of bunnies in the table below.
- In the menu titled *Environmental Factors*, click on the box in front of *Wolves*. Then click *Play*.

- Let the simulation run until it reaches Generation 7. Pause the simulation.
- Use the data probe to determine the population of each bunny type for the remaining generations in the data table.

Table 1: Bunny Populations at the Equator

Bunny Type	Initial Population (Generation 3)	Population Generation 4	Population Generation 5	Population Generation 6
Total				
White				
Brown				

1. Where did the original brown bunnies come from?

2. What happens to the number of white bunnies in the population over time?

☐ It increases.
☐ It decreases.
☐ It remains the same.

3. What happens to the number of brown bunnies in the population over time?

☐ It increases.
☐ It decreases.
☐ It remains the same.

4. Using the concept of natural selection, explain why the bunny populations change the way they do.

Make a prediction! How will the results of this experiment change if it took place at the poles instead of at the equator? Explain your thoughts.

- Restart the simulation. Click the snowflake in the upper right corner of the simulation to change to the poles.
- Click on *Fur* under *Dominant*. Then click *Add* a *Mate*.
- Let the bunny population grow for 3 generations. Pause the simulation.
- In the menu titled *Environmental Factors*, click on the box in front of *Wolves*. Then click *Play*.

- Let the simulation run until it reaches Generation 6. Pause the simulation.
- In the menu to the left of the table, click on the box in front of *Data Probe*.
- Use the probe to determine the population of each bunny type at generation 3. Record these numbers as the initial population of bunnies in the table below.
- Use the data probe to determine the population of each bunny type for the remaining generations in the data table.

Table 2: Bunny Populations at the Poles

Bunny Type	Initial Population (Generation 3)	Population Generation 4	Population Generation 5	Population Generation 6
Total				
White				
Brown				

5. Where did the original brown bunnies come from?

6. What happens to the number of white bunnies in the population over time?

☐ It increases.

☐ It decreases.

☐ It remains the same.

7. What happens to the number of brown bunnies in the population over time?

☐ It increases.

☐ It decreases.

☐ It remains the same.

8. Using the concept of natural selection, explain why the bunny populations change the way they do at the poles.

9. The snowshoe hare is a reddish-brown color in the spring and summer. In the winter, its fur changes to white. Global warming is expected to cause the winter snows to come later and melt earlier. How do you think the snowshoe hare will be affected by global warming?

Part III: More Natural Selection

Now that we see how the wolves can select a fur color for our bunnies, let's see how other characteristics evolve. Click on the *Lab* tab at the bottom of the screen. In this section, you will use the simulation to see which of the other traits (teeth and ear length) are selected by one of the environmental factors, wolves, tough food, and limited food.

1. Select a dominant mutation that you would like to explore.

☐ Ear Length ☐ Teeth length

2. Select a location.

☐ Equator ☐ Poles

3. Select an environmental factor.

☐ Wolves ☐ Tough Food ☐ Limited Food

4. Use the simulation to collect data for the bunnies to determine which bunnies, if any, are more successful in the environment you have selected. Record your data in a data table of your own design in the space below.

5. Based on your data, how did your bunny populations change over time?

6. Using the concept of natural selection, explain why you think the bunny populations changed the way they did.

7. Do you think the results of your experiment would be different in a different location? Explain your answer.

8. Use the simulation to see if you are correct. Compare the results of the experiment in the two locations.

Part IV: Things To Think About…

Humans change ecosystems in many ways, including climate change, pollution, and the introduction of invasive species. Use what you have learned about natural selection to answer the following questions.

1. An invasive species is a species that is introduced to an area that they never lived in before, and in which they out-compete a resident species. Why do you think this happens?

2. How do you think pollution relates to natural selection?