# Ecosystem Lesson: Allele Frequency and Climate

| Created By | Grades | Subjects | Duration |
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| Christa Delaney | 9th-12th | Science | ≅ 95 minutes |

## Lesson Overview

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| **Essential Questions** | • How is climate change changing the environment?<br>• How can changing environments affect the genetics of organisms?<br>• Why is it important to understand allele frequencies?<br>• What are the benefits and drawbacks of allele frequencies within a population? |
| **Learning Outcomes** | Students will be able to<br>• Calculate allele frequency.<br>• Mathematically express how traits may vary over time as a result of climate change.<br>• Identify the benefits and drawbacks of changes in a gene pool.<br>• Explain how climate change affects the diet of Arctic communities. |
| **Summary** | In this lesson, students explore the impact of environmental changes on an organism's allele frequency.<br><br>**Inquire:** Students watch a video on peppered moths and identify vocabulary related to allele frequency.<br>**Investigate:** Students play a game to understand allele frequency changes that can occur in species impacted by changing environments.<br>**Inspire:** Students explore how climate change is impacting native Arctic communities and complete a project describing how climate change is impacting animals in the Arctic. |

## Instructions

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| **Inquire**<br>**≅ 20 minutes** | • Students watch Evolution of the Peppered Moth by Natural Selection.<br>• After watching the video, students answer the following questions in their Student Document:<br>  ○ What facts or data stood out to you?<br>  ○ What do you wonder about this video?<br>  ○ How do you feel after watching this video?<br>  ○ What environmental factor affected the peppered moths?<br>  ○ Was the factor human-caused (anthropogenic) or natural?<br>• Teacher recaps the video, explaining that the peppered moths underwent natural selection due to an environmental change, which led to a change in their genetic variability. If the environment changes, it can have a direct effect on the gene pool of a population.<br>• Teacher reviews vocabulary terms with students using the glossary slide in the Teacher Slideshow, and students write the definitions in their Student Document.<br>• Students watch this video clip (1:38-3:39) from NOAA's 2022 Arctic Report Card as a whole |

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| | class together.<br>• Teacher asks students, "What physical changes are happening in the Arctic's environment? Students may mention any of the following:<br>  ○ The Arctic is warming due to human-induced climate change, and it's warming faster than the rest of the planet.<br>  ○ Precipitation in the Arctic is increasing.<br>  ○ The precipitation is more likely to fall as rain than as snow, causing the Arctic to transition to a "rain-dominated" climate.<br>• Teacher uses the following review questions in the Teacher Slideshow to quiz students on allele frequencies:<br>  ◦ In a snowy climate, which prey animals are more likely to survive: those that are darker in color or those that are lighter in color? *Lighter in color*<br>  ◦ If the alleles for being light in color are recessive, which alleles are more likely to be passed on in this environment from parent to offspring: recessive or dominant? *Recessive*<br>  ◦ What would happen to the gene pool if there were less snow on the ground or less land ice? Would there be more recessive alleles or more dominant alleles in the gene pool? *Dominant*<br>  ◦ How might climate change affect the alleles found in the gene pool of organisms that live in the Arctic in the future? *The genetic diversity will decrease because there will be a lower number of organisms with recessive alleles.* |
| **Investigate**<br>**≅ 45 minutes** | • Students play a game to simulate changing allele frequencies in an Arctic biome. Teacher prints at least 20 of each of the game cards so there is a high number of organisms in the population to start.<br>• Students receive game cards that have imaginary organisms on them.<br>  ○ The cards represent different organisms that live in an Arctic biome.<br>  ○ Some organisms are light in color, and some are dark in color.<br>  ○ Each organism is either adapted to white environments, such as snow, or darker environments, such as soil.<br>• Students complete Round 1 following the instructions for the game below:<br>  ○ As a group, students use the Student Document to fill out their allele frequency sheets with the number of alleles present in their environment at the beginning of the game.<br>  ■ Students look at the back of the cards with the organisms on them and count the number of uppercase B alleles and lowercase b alleles present in their population.<br>  ■ Students add together the uppercase B and lowercase b alleles to see how many alleles total are present in their population.<br>  ■ Teacher reminds students that BB alleles are dominant and the phenotype would be black. The Bb alleles also would present the phenotype as black. The bb alleles are recessive and would present the phenotype as white.<br>  ■ Students find allele frequency percentages.<br>  ○ One student will be the predator. The predator waits outside.<br>  ○ Students place their organism cards on an all-white background. This all-white |

background could be construction paper, a tarp, or a sheet.
    - When the teacher says “go,” the predator walks into the classroom and tries to find as many organisms as they can in 20 seconds.
        - If the predator picks up the card, this means that the organism was eaten.
        - The other students stand outside of the predator’s environment and do not offer help or interfere.
    - After 20 seconds, students, as a class, count the remaining lighter-colored and darker-colored organisms.
        - Teacher explains that Round 1 represents one generation passing.
        - As a group, students flip over their cards to see the genotype of their organisms.
        - Students find the percentage of alleles present in their gene pool after Round 1.
            - Students count the number of alleles left on the tarp.
            - Students count letter B alleles and lowercase b alleles and then add them together to get the total.
            - Students find allele frequency percentages.
    - The predator leaves the classroom to prepare for Round 2 of the game.
- Students complete Round 2 of the game, using the following instructions:
    - Teacher and students place all the cards back in the game for Round 2, even cards that were previously picked up in Round 1. The game completely starts over.
    - This time, students place the organism cards on a dark background. This could be a large sheet of black construction paper, a sheet, or a tarp.
    - When the teacher says “Go,” the predator enters the room.
    - The predator tries to find as many organisms as they can in 20 seconds.
    - Students calculate the allele frequency of the organisms living in this imaginary Arctic biome after Round 2.
        - As a group, students flip over their cards to see the genotype of their organism.
        - Students count how many alleles are present in their population at the end of Round 2.
        - Teacher explains that Round 2 represents one generation passing in this new environment.
        - Students find the percentage of alleles present in their gene pool. This is done by counting the number of alleles left on the tarp. Students count letter B alleles and lowercase b alleles and then add together this number to get the total.
- The rounds of the game can be repeated if needed.
- At the end of the game, students complete the Summary Statement section of the Student Document.
- Students come back together as a large group and discuss the following scenario: Imagine a snowy environment changing to a wetter, forest-like environment where the soil is more visible, similar to the white background changing to a darker background in the game.
- Students discuss the following questions:

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| | ○ What would be potential benefits to organisms if an environment changed from a snowy environment to a forest environment? *Easier to find food, more plants growing in soil, and more habitats and niches for organisms to occupy.*<br>○ What would be potential drawbacks for organisms if an environment changed from a snowy environment to a forest environment? *Less genetic diversity, less habitat diversity, less biodiversity, and unforeseen consequences that humans are unaware of.* |
| **Inspire**<br>≅ **30 minutes** | • Students watch Erosion in Alaska: Youth and Climate, a video about a community that faces challenges due to a changing climate.<br>• Students participate in a group discussion on the video using the following questions:<br>○ How would a change from snowy conditions to a warmer environment affect the lifestyle of this community? *The people might have to change how they get their food and where they live.*<br>○ How could a change from a snowy environment to a more forest-like environment affect the Alaskan community's diet? *There could be less fishing and this would affect the communities' ability to find food. If the tundra becomes a more forest-like environment, the community could plant crops and raise livestock but that cannot happen on unstable, melting permafrost.*<br>○ How does Nelson feel about the changes? *He feels scared that his community will lose their way of life.*<br>• Students independently read this article about climate migrants and watch Alaskan Native Elders Tell Their Climate Change Story: After the Ice. Note: There are three short videos in this series. Teacher can assign the video above, which is the third video, or all three.<br>• Students answer the following questions on their Student Document:<br>○ What does the term *climate migrant* mean to you?<br>○ How could the community in the video be an example of climate migration?<br>○ How would you feel if you had to leave your community?<br>○ How is this community currently being affected by climate change?<br>○ Do you think all communities everywhere are being affected by climate change in the same way?<br>○ What solutions does the article suggest? If you had to choose one solution to focus on, which would you choose? Why?<br>• Students work in small groups to create a mini-project about a group of animals (wild fish, crustaceans, marine mammals, Arctic seabirds, or land animals) that will be affected by climate change in the Arctic.<br>○ Students use this Climate Hub to choose a group of animals. Teacher can also assign each group a different group of animals to research.<br>○ Each group makes a poster, Canva infographic, or Google Slideshow that includes:<br>■ The name of the animal group<br>■ 2 facts about how the animal group is being affected by climate change in Alaska<br>■ 1 fact about how that would affect the diet of the Alaskan communities<br>■ A picture of the animal<br>■ An explanation of how a change in the animal's physical environment may |

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| | affect the allele frequencies of that organism's gene pool.<br>• Students display their work in a virtual gallery walk or a physical gallery walk so that the other student groups can view it.<br>• Students complete an exit ticket or discuss as a class the following reflection questions:<br>  ○ What is one takeaway you want to remember from this lesson?<br>  ○ What was it like learning about the impact of climate change in the Arctic?<br>  ○ What are some actions that individuals can take to help mitigate the impact of climate change or reduce carbon emissions? |

## Accompanying Materials

| Teacher Slideshow | Student Document | Student Game Cards |
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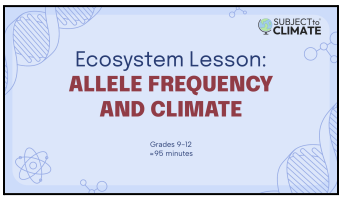
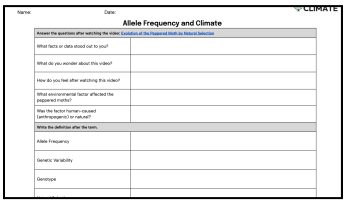
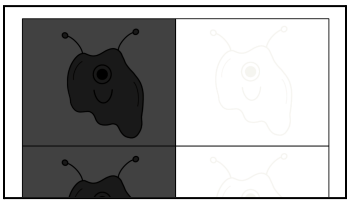
|  |  |  |

## Teaching Tips

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| **Positives** | • This lesson could be used in an environmental science or biology class.<br>• This lesson could be used to supplement a variety of curricular topics such as genetics, population dynamics, or climate change. |
| **Prerequisites** | • Students should have some prior knowledge of genetics.<br>• To prepare in advance for the game in the Investigate section:<br>  ○ Print and cut out the organism cards.<br>  ○ Be sure to have on hand one large white sheet of paper or tarp and one large black sheet of paper or tarp. |
| **Differentiation** | • Teacher can make any of the following adjustments to the game in the Investigate section:<br>  ○ Use the third slide of the Game Cards to add organisms and allele frequencies<br>  ○ Assign different students to be the predator for each round<br>  ○ Add additional camouflage to the sheet such as leaves or other decoy organisms<br>  ○ Add additional student predators to the activity by having the predator have offspring<br>• Higher-level students can investigate further by researching the albedo effect and how albedo is changing as a result of ice melt.<br>• Students can explore climate justice and the impact of climate change on people living in the Arctic through this lesson from ACE and this lesson from CLEAN.<br>• Students can read this article from Arctic Today in small groups, in a large group, or in place of the video. |

## Learning Standards

| Primary Standards |
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| Next Generation Science Standards (NGSS) PS, LS, ESS, ETS |
| HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. |
| 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-LS4-5. 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. |