How does the knowledge of evolution and population genetics help us understand future effects of environmental changes?

Grade Band: High School • Discipline: LS • Time: Three 50-minute class periods

Lesson Level Performance Expectation

• Communicate science information about how environmental changes lead to adaptation—populations dominated by organisms that are well suited to survive and reproduce. (SEP: 8.5; DCI: LS4.C; CCC: 2.3)

What Students Will Figure Out

• Students’ models can be used to explain what we think might happen to a nonhuman population as the environment changes.
• Students’ models can be used to think about how to protect nonhuman populations.
• There are gaps in our understanding because genes and alleles are complicated and still being studied by scientists.
• Other outcomes, depending on what topics students decide to investigate for the project.
Lesson Snapshot
High school students, as scientists, investigate places that have or are experiencing environmental changes to see how organisms are being affected by these changes. Students research which physiological strategies and traits are helping an organism survive and reproduce in the changed environment. Students evaluate if these physiological strategies or traits have genetic mechanisms involved, and model how evolution by natural selection might change the population over time. Students then create a DIY Exhibit that will be shared with their community. Students use information from their models, articles, and other work from previous lessons to develop possible explanations and use it to talk about the role humans can play in protecting different nonhuman populations. Students receive peer feedback and revise their exhibits for public exhibition.

Phenomenon
The phenomenon will depend on the specific focus of a group’s project.

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
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<tbody>
<tr>
<td>Obtaining, Evaluating, and Communicating Information SEP8.5</td>
<td>DCI. LS4.C: Adaption</td>
<td>Crosscutting Concept</td>
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<tr>
<td>• Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).</td>
<td>• Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS-LS4-3), (HS-LS4-4)</td>
<td>• Cause and Effect CCC2.3: Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about the smaller scale mechanisms within the system</td>
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<tr>
<td>Developing and Using Models SEP2.3</td>
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<td>• Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.</td>
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This lesson could be one in a series of lessons building toward the following Performance Expectation(s):

**HS-LS4-4:** Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges or seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]
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Materials

<table>
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<th>Student Materials</th>
<th>Teacher Materials</th>
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<td>Per Student</td>
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<tr>
<td>• NIH EV Handout 8.1 Species Affected by Changes in the Environment</td>
<td>• Lesson 8 Slide Deck</td>
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<tr>
<td>• Tablet or computer for research and creation of exhibit materials</td>
<td>• Smithsonian National Museum of Natural History: Genome DIY Exhibit</td>
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<td>Per Small Group (2 to 4 students)</td>
<td>• Smithsonian National Museum of Natural History: DIY Exhibit Terms of Use</td>
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<tr>
<td>• NIH EV Handout 8.2 Evolution Genome DIY Project Organizer</td>
<td>• Smithsonian National Museum of Natural History: Genome Resource Guide</td>
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Lesson Preparation

Project: Genome DIY Exhibit

• Determine how students will form groups for the project. We recommend grouping students who want to focus on similar questions.
• Determine how much time students will have to research and put together their Genome DIY Exhibit. We recommend at least two 50-minute class periods for setup and one for sharing their exhibits.
• Determine what elements of the Smithsonian National Museum of Natural History Genome DIY Exhibit you want students to include in their projects. If you are using these materials, we recommend you request access at least two weeks before starting the project.
  - Panels
  - App
• Determine the audience and location for students' DIY exhibits. Examples could include:
  - School gym or auditorium
  - Community center
  - A local middle school
• Determine the system for peer feedback. One option is included in the Teacher Guidance of Investigate the Phenomenon.
• Consider how students will research their exhibit. The Evolution Genome DIY Exhibit Research Guide has information from a variety of sources: news articles, journal articles, and documents created to provide data that is accessible to high school students. Students can do additional research on the internet.
• Review the DIY Exhibit Terms of Use
• Review the DIY Exhibit Resource Guide (PDF in Lesson 8 Folder)
Experience the Phenomenon

What Students Are Doing

In this section, students summarize the challenges populations face when there is a change in the environment and why genetic diversity is important for the survival of a population. Students start to consider how they could share the information they learned about evolution by natural selection and why genetic diversity is important for a population’s survival.

Teacher Guidance

1. **Lead a discussion of how genetic diversity affects a population’s chances of surviving in a changing environment.**

   Remind students that in the previous lesson they figured out why genetic diversity is important in the midst of changing environments. They also wanted to continue to investigate the benefits and how to support genetic diversity. Ask students to consider how and why they should share the information they learned about natural selection and genetic diversity with their community.

   Students should have time to reflect individually, with a partner, and with the class.

   **Suggested prompts**

   - What information about changing environments and their effects on populations would be helpful for everyone to know?
   - What should we research to show how natural selection is changing populations?
   - How can we help the community see how these ideas can be used to preserve and protect populations in the midst of changing environments?

   **Listen for:**

   - It would be helpful for people to understand how natural selection leads to adaptation.
   - People need to see that there are genetic connections to different traits and physiological strategies.
   - People also need to see how certain traits may be advantageous or disadvantageous depending on the environment. When an environment changes, it can lead to a disproportionate number of individuals with advantageous trait(s).
   - We need to show our community how these changes are affecting different populations and communicate to them how we can be a part of the solution to help protect different populations.

2. **Outline the components of the project.**

   Project **SLIDES 3 AND 4** of the Lesson 8 Presentation to introduce the project problem and artifacts. Point out that their exhibit should include a model that accurately explains how genetic variation within a nonhuman population could affect the survival of that species in a changing environment. Students can model this using words and images.

   Let students know the amount of time they will have for each part of the project, including

   - researching the nonhuman population that is experiencing an environmental change,
   - choosing their driving question,
   - creating their exhibit, and
   - presenting their exhibit.

   Let students know that **Species Affected by Changes in the Environment** (NIH EV Handout 8.1) has suggestions for exhibit topics.
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Additional Guidance

Universal Design for Learning: Allowing students to express their ideas using multiple modalities supports student ownership of their learning by giving students choice and freedom to choose and research how organisms are adapting to an ever-changing environment. Students who are high-interest learners may want to find and explore an organism on their own, while other students who may need more support will have the freedom to choose from the list on NIH EV Handout 8.1. Students will then have control over how they apply and present their understanding of the science ideas.

Investigate the Phenomenon

What Students Are Doing

In this section, students investigate a question about a nonhuman population experiencing an environmental change of their choice. Next, they will create a rough draft of the Genome DIY Exhibit, receive peer feedback, and revise it for their presentation.

Teacher Guidance

3. Direct students to begin researching their focal species using the resources provided in the Species Affected by Changes in the Environment (NIH EV Handout 8.1).
   Ask groups to use the Evolution Genome DIY Exhibit Group Project Organizer (NIH EV Handout 8.2) to record their question, the resources they will use, and their plans for the model and audience interaction.

4. Facilitate Peer Feedback
   Tell students that they will now take turns discussing exhibits with another group. Groups will take turns sharing and listening using a discussion protocol.

   Sample Discussion Protocol:
   - Group A: Shares their exhibit
   - Group B: Asks clarifying questions
   - Group B: Shares positive feedback
   - Group B: Shares suggestions for improvement
   - Pairs switch roles

Additional Guidance

During the peer feedback step, keep the focus on sharing ideas clearly, accurately, and persuasively. Make careful decisions about which groups are paired together. The goal is for every group to have good feedback so that they can improve their exhibit. Therefore, avoid pairing teams with the best exhibit plans and lowest exhibit plans together. Remind students the following when giving and receiving feedback:

- We critique ideas, not people.
- We make space for all voices to be heard.
- We listen carefully and ask questions to help us understand the feedback.
Explain the Phenomenon

What Students are Doing
In this section, students will present their Genome DIY Exhibit to the community.

Teacher Guidance

5. Facilitate the setup and presentation of the Genome DIY Exhibits to the community.
   Consider creating a pathway through the exhibits or assigning audience members to specific groups to ensure that each group has a similar number of participants. If there will not be outside participants, set up a gallery walk so that half of the groups can present, and half can be the audience and then switch roles.

Additional Guidance
Consult the Lesson Preparation section and the Genome Resource Guide for further guidance.