**Unit Essential Question:** *Why do species change over time and should we intervene?*

**Introduction**

Students began exploring the concept of natural selection with a real-life example in the Lift-Off Task—the case of the changing peppered moths. At that point, they observed a change in species over time and generated questions as to how and why this phenomenon occurred. In this task, they take a step further and zoom in on the process that makes this phenomenon possible. Students will use various contexts to explain how natural selection may lead to increases and decreases of specific traits in populations over time. By engaging in a simulation of natural selection, they will be able to mathematically calculate percentages of traits, which they can use to explain trends in changes to populations over time. By the end of this task, they will be able to explicitly connect to their culminating project by describing the process that is changing their chosen species as a result of environmental change.

**Alignment Table**

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| --- | --- | --- | --- |
| **Performance Expectations** | **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| **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.** [Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.] | **Constructing Explanations**   * Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena. | **LS4.B: Natural Selection**   * Natural selection leads to the predominance of certain traits in a population, and the suppression of others. | **Cause and Effect**   * Some cause and effect relationships in systems can only be described using probability. |
| **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.** [Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.] [*Assessment Boundary: Assessment does not include Hardy Weinberg calculations.*] | **Using Mathematics and Computational Thinking**   * Use mathematical representations to support scientific conclusions and design solutions. | **LS4.C: Adaptation**   * Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. | **Cause and Effect**   * Some cause and effect relationships in systems can only be described using probability. |
| **Equity and Groupwork**   * Play specific roles in a simulation * Co-construct a flowchart | | | |
| **Language**   * Write a CER Report * Depict relationships in a flowchart | | | |

**Learning Goals**

This learning task explores how natural selection leads to the predominance of traits that support successful survival and reproduction in an environment. More specifically, the purpose is to:

* Make a prediction about how species may change over time.
* Model natural selection and do mathematical calculations to draw conclusions.
* Write a CER report explaining how natural selection changes populations.
* Draw a flowchart connecting a specific environmental change to a change in species over time.
* Apply knowledge of natural selection to one species affected by environmental change.

**Content Background for Teachers**

Natural selection is one of the basic mechanisms that drives the evolution of species throughout Earth’s long history of life. Charles Darwin originally came up with this theory in the 1800s when he was visiting the Galapagos Islands. There he observed finches that looked similar to ones on the mainland, but each island had a finch with a different beak shape, suited to what that finch ate. He concluded that these finches must have migrated to the islands and evolved over time based on the different environments of the different islands.

Evolution was not a new theory. However, in his book, *The Origin of Species*, Darwin was the first to explain *how* it worked. In his explanation, he described the process of natural selection, which consists of four main principles.



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1. There is variation in traits. New variations happen all the time due to mutation and recombination of genes.
2. There is differential reproduction. Populations tend to overproduce, and the environment cannot support unlimited population growth. This means that not all individuals will survive and reproduce.
3. There is heredity. Those with the traits best suited to that specific environment will survive and reproduce, passing on their genes. And vice versa.
4. Populations change over time. Over time, there will be more organisms with the best suited trait to that environment in a population.

While students can and have used fossil evidence and case studies to show that this is likely true, they can also use simulations to model exactly how this process works. Simulations, like the one in this task, can also yield mathematical representations, which can serve as further evidence for natural selection.

**Academic Vocabulary**

* Population
* Reproduce
* Predator
* Natural Selection
* Trait

**Time Needed (Based on 45-Minute Periods)**

3 Days

* Engage and Explore: 1 period
* Explain and Elaborate: 1 period
* Evaluate and Reflection: 1 period

**Materials**

* Unit 3, Task 3 Student Version

Explore (Per Group)

* 30 white paper squares (1”x1”)
* 30 black paper squares (1”x1”)
* 30 newspaper squares (1”x1”)
* 1 large newspaper, opened up
* Small box (shoebox, pencil box, etc.)

Evaluate

* Project Organizer Handout

**Instructions**

**Engage**

1. Introduce Task 3: So far in this unit, you have looked at evidence throughout Earth’s long history that species do change over time. Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?
   * Before you pass out their student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.
2. Transition to Task 3: While looking at evidence has given us a hint at why species change over time, today you will ask yourselves what process leads to the kinds of changes we have observed.
   * Now pass out their Task 3 student guide.
3. In pairs, have students observe the image on their student guides. We recommend also projecting this image on the board so students can see it large and in color. Have pairs answer the questions on their student guide to help them make observations.
   * They should notice that the environment is snowy and white, there are both brown and white rabbits, and there are wolves present as predators.
4. Using this information, pairs then make a prediction about how they think the population of rabbits will look in 100 years and explain why. Likely, students will predict that most of the rabbits will be white because those rabbits blend in and aren’t eaten by predators as often.
   * While not describing the full mechanism of natural selection, this lays the foundation for students to begin thinking about this process.
5. Optional: Share out a few predictions and explanations. The use of equity sticks is encouraged for more equitable participation (See “How to Use This Curriculum” for more details).

**Explore**

1. The introduction on the student guide sets the stage for the simulation they will be conducting to model natural selection.

* At this point, they have not learned this term explicitly because the focus should be on the process they will observe.

1. Introduce the students to the context: In the simulation, small pieces of paper represent one species of insect with three variations in trait (color). These “paper insects” now live in the “paper forest” that you will provide (newspaper).
   * In groups, students will follow the procedure on their student guide.
   * Optional: You may want to review the procedure together and model the simulation by doing one round together. If you have a document camera, this is a great time to use it.
   * Emphasize to students that they should always have 30 insects at the end of each round after reproducing…this is how they will know if they are doing the simulation correctly. Circulate the room as students go through the simulation to guide them if necessary.
2. Assign roles to each group. These roles differ from their usual group roles because of the simulation.
   * One person will be the Caretaker. The Caretaker’s job is to repopulate the forest after each round.
   * The other three people will be the Predators. The predators job is to “eat” insects each round.
   * After each round, the caretaker should double the number of each color insect that is left in the “paperforest” and enter the numbers of white, black, and newspaper colored insects in the table.
3. After students complete the simulation, they should record the number of each color insect that remains and then calculate the percentage each represents of the total population.
   * This gives students an opportunity to engage with the science and engineering practice of **Using Mathematical and Computational Reasoning**. This will give them probability statements and proportional reasoning to use to support their explanation in the next section as they explain trends in changes to populations over time.
   * This activity also emphasizes the crosscutting concept of **Cause and Effect** as the simulation shows students that there is a high probability of more of one color in the end population because of natural selection.
4. Optional: After students calculate percentages and analyze the trends in the different colors of insects over time, share out a few trends as a class and discuss. This will help set the stage for the Explain.
   * Again, the use of equity sticks is encouraged for more equitable participation (See “How to Use This Curriculum” for more details).

**Explain**

1. This section asks students to explain the process and trends in data they observed in the Explore. Now that students have explored the process for themselves, you may explicitly introduce the term—natural selection. Natural selection is the process in which organisms with traits better suited to that environment tend to survive and reproduce, creating more offspring with those traits.

* Depending on the needs of your students, you may want to spend some additional time reviewing this term using whatever language routine your students are familiar with. One suggestion is to give students a series of images that depict the process of natural selection and then have them write captions describing each step of the process in pairs.

1. Students then individually write a CER explanation that describes how natural selection may lead to increases and decreases of specific traits in populations over time. They should use evidence from the simulation (including mathematical calculations) and scientific reasoning to support their explanation**.**
   * Here students are practicing the skill of **Constructing Explanations**, as they use evidence to explain the relationship between traits and environment. They are also practicing the skill of **Using Mathematics and Computational Thinking** as they include mathematical representations (percentages and trends) from the simulation to support their explanation of how populations change over time.
   * Optional scaffold: Conduct a Critique, Clarify, and Correct language exercise for the claim in pairs before students write their own. We recommend sharing out a few pair’s corrected claims as a class after this exercise, using equity sticks. An example protocol and graphic organizer is below:

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| --- |
| **Critique, Clarify, and Correct: Natural Selection**  In pairs:   1. Critique: Analyze the claim.   *Natural selection can lead to an increase in one trait over time when an animal knows that the trait will help them survive and tries to adapt to have that trait.*   1. Correct: Write a claim that is more accurate in your student guide. 2. Clarify: Describe how and why you corrected the claim. |

Optional Sentence Stems to Provide:

|  |  |
| --- | --- |
| **Claim** | Natural selection means...which leads to… |
| **Evidence & Reasoning** | In most populations, there is…  In the simulation…  There were originally…  Some…  This is because…  As a result…  That leads to…  By the end of the simulation, there were…  This meant that… |

Sample CER Report

|  |  |
| --- | --- |
| **Claim** | Natural selection means that the organisms with the best traits for that environment survive and reproduce, which leads to more organisms with that trait over time. |
| **Evidence & Reasoning** | In most populations, there is a variation of different traits. In the simulation, the variation was in color: white, black, and newspaper. There was approximately 33% of each color insect at the beginning. Some, like the newspaper color in the simulation, fit the environment best because they camouflaged with the newspaper forest better than the white or black insects. As a result, they are the ones to survive and reproduce, creating more offspring with that trait. That leads to an increase of specific traits in a population, such as newspaper color at 100%, and the decrease of others, such as black and white, over time. |

1. Optional peer review: Have table partners switch CER reports and make suggestions for revisions.

* This can also be a good option for formative assessment. Collect student work to identify trends in students’ ability to use mathematical representations from the simulation to support scientific conclusions. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

**Elaborate**

1. Here students return to the original scenario from the Engage, armed with their new knowledge of the process of natural selection.
   * Students take the original context and consider how an environmental change (such as those caused by climate change) would affect the picture they see. This provides a conceptual connection to their culminating project.
2. In groups, students discuss how the environment in the image might be affected by environmental change. From there, they design a flowchart depicting the chain of causes and effects that might occur.

* This again emphasizes the crosscutting concept of **Cause and Effect**, as students use the cause-and-effect relationship of natural selection to explain the probable chain of causes and effects in this scenario.
* Questions are provided on their student guides to help facilitate this process.
* One possible example is shown below:

1. Optional: To review this process and the flowcharts groups have created, co-construct a class flowchart on the board. Call on different groups using equity sticks to contribute what they think comes next in the class flowchart.

* After you have a class flowchart, make explicit connections to how this relates to their culminating project.

1. Because all of the examples in this task deal with a camouflage adaptation, we recommend emphasizing to students that there are other types of adaptations. For example, succulents have thick stems and leaves to store water in dry climates. Giraffes have long necks that allow them to reach leaves on high branches. Guppies have brightly colored scales to attract mates. One option is to have students do a Think-Pair-Share of other traits that they think would help an organism survive and reproduce in their environment. Share these out as a class using equity sticks.

1. Return to the whole-class concept map from the Lift-Off Task.

* In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See “How To Use This Curriculum” for more details).
  + Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
  + Draw circles around each question and boxes around each concept.
  + Write connector words to describe connections between the concept boxes.
  + For this task, students may begin to connect some of their previous question circles to concept boxes about the following: the relationship between environment and traits, changes in populations, and natural selection.
* Have students analyze the additions to the class concept map for as many examples of this task’s crosscutting concepts as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
  + **Cause and Effect**: These could be phrases such as, “which results in,”   
    “which causes,” “that explain why,” “is due to,” etc.
* Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content but will also help their oral and written language development.

**Evaluate: Connecting to the Culminating Project**

1. Students independently complete the Task 3 section of the Unit Project Organizer in class. Revisions can be done for homework, depending upon student’s needs and/or class scheduling.
2. Students have been tasked with arguing whether humans should intervene on the behalf of threatened or endangered species or let nature take its course. Their prompt is as follows: How would changes in the environment that are caused by humans affect your species?

* Explain within the context of natural selection. You may choose to explain using a paragraph or a flowchart with pictures.
* Compare your species to the “insect” simulation. Is the situation for your species more similar to the black “insects”, the white “insects”, or the newspaper “insects”? Explain how.

**Reflection**

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:

* At the beginning of this task, you were asked to predict how a population of rabbits might change over time and explain why. Look back at your prediction: after collecting all the evidence today, what detail could you add to your explanation?
* In this task, we focused on the crosscutting concept of:
  + **Cause and Effect:** Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Where did you see examples of **Cause and Effect** in this task?

* Now that you have learned more about how natural selection may lead to increases or decreases of specific traits, what questions do you still have?

1. There are no right answers but encourage students to look back at their student guides and their class concept map. They should not change their initial responses, but rather use this reflection space to add ideas and questions based on what they have learned through this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and gathering knowledge and skills for their final projects.

**Assessment**

1. You may collect students’ Project Organizer and assess using:
   * *Criteria of your choice.* We recommend using the 3-Dimensional Assessment matrix at the beginning of this document to inform your criteria.
   * This can be a formative tool to periodically look for trends in student understanding after the completion of a task*.* You can then use this formative data to inform any re-teaching as necessary.
2. You may also give students time to make revisions with one of the two options:

* Students may make changes to their Project Organizer according to your comments OR
* Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.