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| **Task-level phenomenon:**  Students are shown a video segment of barnacle geese hatchlings leaving the nest for the first time to pursue their initial meal in the Ostead Dal valley in Greenland.  **Synopsis of high-quality task:**  Nesting at the top of approximately 400’ cliffs, the offspring, unable to fly, must jump off the cliff to reach the grass lowlands below. As they plummet down the rock face, inevitable impacts with outcroppings terminate a simple freefall descent. Students use this observation to generate an (early-understanding) explanation for why this behavior might be advantageous. Later, once a nuanced understanding of natural selection has been acquired, students produce an explanation representing a more fully-informed reexamination of the barnacle geese hatchlings’ behavior.  **Anticipated student time spent on task:** 70 minutes  **Type of Task (check one):**  \_\_\_\_ 1. Investigation/experimentation/design challenge  \_\_\_\_ 2. Data representation, analysis, and interpretation  \_X\_\_ 3. Explanation  **Student task structure(s):** Individual work |
| **STE Standards and Science and Engineering Practices:**  **Standards:**  **HS-LS4-2**. Construct an explanation based on evidence that Darwin’s theory of evolution by natural selection occurs in a population when the following conditions are met: (a) more offspring are produced than can be supported by the environment, (b) there is heritable variation among individuals, and (c) some of these variations lead to differential fitness among individuals as some individuals are better able to compete for limited resources than others.  **Science and Engineering Practice(s):**   * Constructing Explanations |
| **Prior Knowledge:**  Previous Standard from [Strand Map](http://www.doe.mass.edu/stem/standards/StrandMaps.html):  **8.MS-LS4-4.** Use a model to describe the process of natural selection, in which genetic variations of some traits in a population increase some individuals’ likelihood of surviving and reproducing in a changing environment. Provide evidence that natural selection occurs over many generations.  Previous Topics:   * Adaptations * Genetic Variation |
| **Connections to the real-world:**  The video serves as an arresting introduction to evolution through natural selection, and starkly communicates facets central to its action: survival of the fittest and lack of a goal-oriented approach. Survivability is inherent upon both luck and genetic traits.  While barnacle geese in Greenland may be somewhat exotic to most US students, it would be easy to follow-on the activity with an examination of a population students might be familiar with that would exemplify the steps of natural selection, if not with such a dramatic sequence: grey squirrels, raccoons, opossums, white tailed deer, etc.  A complete analysis of natural selection should include the caveat that all populations, including humans, are constrained by the parameters of natural selection. As such, any local or familiar population would be applicable as either a substitution or supplemental examination of the Darwinian process of natural selection. This can be expanded to include human demographic trends and the impact of climate change on human and/or natural populations. |
| **Mastery and Language Goals:**  Learning Objective:   * Construct an explanation for the occurrence of natural selection within a population of barnacle geese. * Use the general sequential steps of Darwin’s mechanism of evolution, natural selection, as scientific evidence to support the claim that this specific event of geese hatchling leaving their nest, has an evolutionary effect within the population of barnacle geese across generations. * Use scientific evidence and observation to construct an explanation about how ‘survival of the fittest’ plays out within a population over time.   Performance Objective:   * Construct an explanation of natural selection in a population of geese using evidence observed from the behavior of geese hatchlings leaving the nest to find food. * Use research and scientific evidence to support the claim that the conditions for Darwin’s theory of evolution by natural selection were met in the Mother Goose and Breast Milk scenarios.   Language Objective:   * Describe the process of natural selection orally and in writing, using content related vocabulary to effectively communicate how the process of natural selection plays out in populations. |
| **Teacher Instructions:**  Lesson 1:   1. Introduction: Scenario #1 Mother Goose    1. Students should read this section of the worksheet including the description for Scenario #1. Instructor should then show the video clip, <https://youtu.be/rxGuNJ-nEYg>, which serves as an exemplar of the general situation just described. Students should be advised that the clip shows the last of 5 healthy barnacle geese chicks to leave its nest atop 400’ granite cliffs in Greenland in an attempt to reach grass-rich tundra at the base and access to their only food source. Parents are visible in the video but are unable to assist chicks in their descent. Advise students that the video contains some striking and jarring footage, but that the intent in showing it is to communicate a process of evolution and not for its gratuitous sake.    2. During the video, instruct students to record their observations (noticings) and wonderings (questions) in the table provided. The video is compelling; if students were not writing during the video, show the video again with the instruction to write specific observations this time, or allow students 2 minutes to record everything they remember from the video.    3. Ask students to share out their observations and record their noticings and wonderings on the board - acknowledge all information shared, even if it is incorrect. When the class has shared, ask students (either individually or in pairs) to try to explain why they think this is happening.    4. NOTE TO THE TEACHER: At the outset of the unit, students lack the knowledge to accurately perceive and describe the selective advantage of this behavior. At this point, instructors can simply acknowledge student’s incredulity and disbelief, but foreshadow that following their examination of natural selection in class, they will be able to dissect and understand this behavior in the light of natural selection.    5. Ask students to share their possible explanations with partners and whole class.    6. Have students flip over the page and read about natural selection. Identify key points of the reading as a class, and ask students to try to explain why this is happening using Darwin’s theory       1. LOOK FOR: Students should be using the reading AND the experience from the video as evidence in their explanation. If either are missing, encourage them to use both resources. 2. Instructor should lead a discussion with students about their explanations. To push the discussion forward, you can ask students...    1. How does [evidence] connect to natural selection?    2. How does [part of theory] tie back to the video of the geese?    3. Why would it be ok for geese to die with natural selection? 3. Scenario #2 Breast Milk    1. Allow students to read through and discuss with a partner to complete the explanations.    2. Have students share their initial explanations with the class.    3. NOTE TO TEACHER: The oligosaccharide components in milk exist to encourage the growth of beneficial bacteria in the infant digestive tract. This is a very big intuitive jump for students to make. To provide support, have students read an article from Abbott Laboratories, http://www.nutritionnews.abbott/healthy-moms-babies/breakthroughs-in-infant-nutrition.html, after students take their first attempt at #2. Allow them to write a revised explanation on the back of the page.       1. LOOK FOR: Students making an attempt to find a benefit for HMO’s in breast milk that might increase its composition in breastmilk over generations. If students are really stuck, allow them to read the article, or ask them the following:          1. Why do you think lactose and fat are so high? Could this apply to HMOs?          2. What is the difference between lactose and HMOs? [Lactose is a disaccharide, and HMOs are short chain polysaccharides, so HMOs are larger molecules made up of the same building blocks]   Lesson 2:   * During this lesson, students should work independently but supported by the instructor to develop an explanation using the CER format to show how an example they are familiar with demonstrates the necessary conditions for evolution by natural selection.   + TEACHER NOTE: While the steps delineated by Darwin are attainable, students will need to adapt them to specific occurrences within the population under examination. As individual students will focus on different traits within the population, each student will need to have mastery of the concept to correctly depict how the mechanism of natural selection plays out over time.     - LOOK FOR: Students using specific evidence from the population examples they have seen in class. If you do not see specific examples from the populations in this lesson (or otherwise), encourage students to describe what they have seen (evidence) and HOW that relates (reasoning) to the steps in Darwin’s process.   + While students attain a solid degree of fluency with natural selection, they find it challenging to individually adapt that understanding to a specific population. Wrestling with that process serves to nuance their understanding to a real-life scenario.     - LOOK FOR: Again, look for specific examples and reasoning that applies to Darwin’s overall process. * Students should complete the worksheet for lesson 2. |
| **Instructional Materials/Resources/Tools:**  Include:   * Student Worksheet Lesson #1 * Student Worksheet Lesson #2 * Link to Video: YouTube: <https://youtu.be/rxGuNJ-nEYg>   (YouTube snippet from BBC *Life Story*; S1E1)   * Link to Abbott Laboratories Article on HMOs in Breastmilk: http://www.nutritionnews.abbott/healthy-moms-babies/breakthroughs-in-infant-nutrition.html |
| **Task Source:**  YouTube video of Barnacle Geese:<https://youtu.be/rxGuNJ-nEYg> (CC-BY-4.0)  Abbott Laboratories Article on HMOs in Breastmilk: http://www.nutritionnews.abbott/healthy-moms-babies/breakthroughs-in-infant-nutrition.html (https://creativecommons.org/licenses/by-nc-nd/2.0/) |
| **Accessibility and Supports:**  Notes/Idea Catcher  Observations and Wonderings T-chart  CER Graphic Organizer  Key academic vocabulary:   * Natural Selection * Adaptation * Mutation * Variation * Differential survival and reproduction (Survival of fittest) * Trait * Phenotype |

**Evolution “Quandaries” Lesson #1 Worksheet**

**Introduction:**

**Scenario #1: Mother Goose**

A mother goose has built her nest some distance away from her preferred food source. Weeks ago, she laid 5 eggs and two days ago, welcomed 5 healthy and very cute baby goslings into the world. In ‘chaperoning’ her baby goslings from the nest to the distant food source, however, several of the chicks succumb during the arduous trip, leaving mother goose with a significantly diminished brood. Despite these casualties, she will return to this nesting site next year and repeat this process; as her species has done for millennia.

------------------------------------------------Stop here to watch video -------------------------------------------------------

During the video, record observations and wonderings you have about this phenomenon!

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| Observations | Wonderings |
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Try to explain **why** the barnacle geese might do this.

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What other examples of seemingly reckless behavior have you seen in the animal kingdom?

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**The Theory of Natural Selection:**

Charles Darwin’s theory of natural selection states that organisms possess certain physical traits and behavioral characteristics because they impart a benefit or advantage to the organism.

Within any population, there is a broad range of expression around any single trait, however, over time, the environment will ‘select’ for those organisms that possess, by chance, traits that help them to survive. “Select” is a fancy word for survival. If you are surviving, you are also more likely to be reproducing and birthing organisms with these same adaptive or beneficial traits. When this selective process plays out over extended time, one finds a population within which the beneficial trait is usually more common than not.

In short, Darwin would say:

* Trees are tall for a reason
* A whale’s blowhole is on the top of its head for a reason
* Polar bears are white for a reason
* Certain trees drop their leaves in the fall for a reason

That reason? It imparts an advantage to the organism in its present environment and makes it more likely that organism will survive.

Now that you have read about Darwin’s theory, provide a possible reason why this nesting behavior persists in the face of an atrocious and seemingly unacceptable outcome. Take the point of view of Charles Darwin, and cite specific evidence from the video in your explanation....

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**Scenario #2: Human Breast Milk**

The composition of dissolved substances in human breast milk by abundance follows by percentage:

* Lactose: a type of sugar…………………………………………………………7%
* Fat………………………………………………………………………………….5%
* HMO (human milk oligosaccharide) a short chain of sugar molecules…….2.5%
* Protein……………………………………………………………………………..1%
* Vitamins/Minerals/Antibodies/Enzymes………………………………………..<1%

1. Please provide a short statement as what you believe the purpose/function of breast milk is:

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Fact: HMO’s are the 3rd most abundant component of breast milk, but HMO’s cannot be digested until the baby is older. In other words, they serve no nutritional value.

1. Remember...you’re Charles Darwin. Provide a possible reason why breast milk contains a sugar in abundance that is of no nutritional value to the baby?

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After reading the article from Abbott Laboratories, re-write your explanation using this new evidence on the back of this page.

**Evolution “Quandaries” Lesson #2 Worksheet**

Darwin’s theory of evolution by natural selection occurs in a population when the following conditions are met:

* More offspring are produced than can be supported by the environment.
* There is heritable variation among individuals.
* Some of these variations lead to differential fitness among individuals as some individuals are better able to compete for limited resources than others.

Select an example of natural selection with which you are familiar. Based on the discussions and work previously, make a claim supported by evidence and reasoning related to how the conditions written above exist and lead to natural selection.

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| Claim: |
| Evidence: |
| Reasoning: |