Stanford NGSS Integrated Curriculum
An Exploration of a Multidimensional World

UNIT 3

Adapt or Die?

How do species change over time and should we intervene?

Stanford Center for Assessment, Learning & Equity

Stanford NGSS Integrated Curriculum: An Exploration of a Multidimensional World
Unit 3: Adapt or Die?

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

Total Number of Instructional Days: 25 - 29

Lift-Off Task:	Task 1:	Task 2:	Task 3:	Task 4:
The Case of the Peppered Moths	The Fossil Record and Geologic Time Scale	Evidence of Change Over Time	Natural Selection	Human Intervention

Connect to the Culminating Project using the Project Organizer

Group Culminating Project:
"Think Tank" Discussion: For species affected by a human-caused environmental change, should we intervene or let nature take its course?

Individual Culminating Project
Post-Discussion Report

Unit 3 Pop-Out
Right, Wrong, and In-Between
(*Implement any time after Task 4*)

8th Grade Science Unit 3: Adapt or Die?

Unit Overview

Storyline for Unit 3

In this unit, students will be exploring how species change over time, as well as the various pieces of evidence that exist to document this change over time. The Lift-Off Task hooks students with the classic case of the Peppered Moth, which is a great case to study because the change was human-caused and dramatic since it happened so rapidly. In this Lift-Off Task, students draw on their prior knowledge to generate questions about the phenomenon of the changing Peppered Moth. These student-generated questions will guide their learning throughout this unit.

Over the course of this unit, students will learn that many more species are also being affected by changes in their environment as a result of human activity. As we watch more and more species struggle with the changing environmental conditions, the question for their culminating project becomes: Should we intervene or allow nature to take its course? After the Lift-Off task, student groups will select one species that is negatively affected by human-caused changes in their environment, which will serve as the focus for their culminating project.

While in the last task, students saw a specific example of one species changing over time, Task 1 asks them to take a step back by looking at the evidence we have that all species have changed over Earth's long history and why. In order to do this, they explore the fossil record and how scientists have organized Earth's 4.6 billion-year-old history into the geologic time scale. This serves as the foundation for them to consider how the kind of environmental change that is happening now has happened in the past. Students find that we can learn from the fossil record and past incidents of climate change to predict how current environmental change will affect species in our world today.

In Task 2, students continue their reconstruction of evolutionary history, by looking at two more kinds of evidence that scientists use to infer lines of evolutionary descent: anatomical structures and embryos of different organisms. By the end of this task, students will be able to construct an explanation for how scientists are able to reconstruct evolutionary history, using these examples as evidence to support their explanation. This adds another layer to the story students are constructing about how species change over time, thus better preparing them for their culminating project.

In Task 3, students return to many of the questions they generated about the Peppered Moths in the Lift-Off Task, by zooming in on the process that makes this case possible. Students engage in a simulation of natural selection, generating data they can use to mathematically calculate the percentages of different traits. By identifying trends in the data, they will be able to explain how natural selection may lead to increases and decreases of specific traits in populations over time, pinpointing the process that is changing species as a result of environmental change.

Up until this point, students will have focused on how species naturally change over time, but these changes are not always completely natural. In this final task, students explore ways in which humans have intervened in these natural processes through selective breeding and genetic engineering. Understanding these processes will be essential to the question in their culminating project of whether to intervene or not.

Once students complete all the tasks, they continue their research of a species affected by changing environmental conditions caused by human activity. Using what they have learned throughout the unit, they decide whether humans should intervene to save this species or not and develop an argument to support their position in a Think Tank Discussion. After the discussion, students individually write a Post-Discussion Report, detailing the scientific background on their own species as well as their argument, using the discussion as additional evidence and reasoning.

Three-Dimensional Breakdown of the Performance Expectations

This unit was developed to align with, teach, and assess students' understanding and skills related to these Performance Expectations. Below, we have mapped out the disciplinary core ideas, crosscutting concepts, and science and engineering practices addressed in this unit. Aspects of the dimensions that are not explicitly addressed in this unit are crossed out.

Performance Expectations	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. [Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.] [*Assessment Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them.*]	**Constructing Explanations and Designing Solutions** ▪ Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**ESS1.C: The History of Planet Earth** ▪ The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.	**Scale, Proportion, and Quantity** ▪ Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. **Stability and Change** ▪ Stability might be distributed either by sudden events or gradual changes that accumulate over time. (*Supplementary)*
MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] [*Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for*	**Developing and Using Models** ▪ Develop and use a model to describe phenomena.	**LS3.A Inheritance of Traits** ▪ Genes are located in the chromosomes of cells~~, with each chromosome pair containing two variants of each of many distinct genes~~. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins,	**Structure and Function** ▪ Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to

protein synthesis, or specific types of mutations.]		which can affect the structures and functions of the organism and thereby change traits. **LS3.B: Variation of Traits** ▪ In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.	determine how they function.
MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. [Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.]	**Analyzing and Interpreting Data** ▪ Analyze and interpret data to determine similarities and differences in findings.	**LS4.A: Evidence of Common Ancestry and Diversity** ▪ The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.	**Patterns** ▪ Graphs, charts, and images can be used to identify patterns in data. **Stability and Change** ▪ Stability might be distributed either by sudden events or gradual changes that accumulate over time. (*Supplementary)*
MS-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. [Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.]	**Constructing Explanations** ▪ Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.	**LS4.A: Evidence of Common Ancestry and Diversity** ▪ Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary	**Patterns** ▪ Patterns can be used to identify cause-and-effect relationships.

		descent.	
MS-LS4-3. Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. [Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.] [Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.]	**Analyzing and Interpreting Data** ▪ Analyze displays of data to identify linear and nonlinear relationships.	**LS4.A: Evidence of Common Ancestry and Diversity** ▪ Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.	**Patterns** ▪ Graphs, charts, and images can be used to identify patterns in data.
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** ▪ Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
MS-LS4-5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. [Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.	**Obtaining, Evaluating, and Communicating Information** ▪ Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).	**LS4.B. Natural Selection** ▪ In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.	**Cause and Effect** ▪ Phenomena may have more than one cause, and 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	**Using Mathematics and Computational Thinking** ▪ Use mathematical representations to	**LS4.C: Adaptation** ▪ Adaptation by natural selection acting over generations is one	**Cause and Effect** ▪ Phenomena may have more than one cause, and some cause 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.*]	support scientific conclusions and design solutions.	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.	effect relationships in systems can only be described using probability.

Connections to Common Core Math and ELA Standards:

Over the course of this unit, students will gain knowledge and skills in science, as well as in math and English-language arts. Below we list the Common Core ELA and Math standards for middle school and 8th grade that are relevant to the curriculum tasks in this unit. Within the curriculum, there are opportunities to incorporate components of the following ELA and Math Standards:

Middle School Common Core ELA Standards		Unit Task
Key Ideas and Details	CCSS.ELA-Literacy.RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.	Task 1
Craft and Structure	CCSS.ELA-Literacy. RST. 6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 6-8 texts and topics*.	Task 1 Task 2 Task 3 Task 4
Integration of Knowledge and Ideas	CCSS.ELA-Literacy.RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).	Task 1 Task 3 Task 4
	CCSS.ELA-Literacy.RST.6-8.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.	Task 1 Task 4
Research to Build and Present Knowledge	CCSS.ELA-Literacy.WHST.6-8.9: Draw evidence from informational texts to support analysis, reflection, and research.	Task 1 Task 2
Comprehension and Collaboration	CCSS.ELA-Literacy.SL.8.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.	All Tasks Culminating Project

Presentation of Knowledge and Ideas	CCSS.ELA-Literacy.SL.8.4: Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.	Culminating Project
	CCSS.ELA-Literacy.SL.8.5: Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.	Task 4

Middle School and 8th Grade Common Core Math Standards		Unit Task
Mathematical Practice	CCSS.MATH.MP.4: Model with mathematics.	Task 1 Task 3

Connections to English Language Development (ELD) Standards:
We acknowledge that language development is a key component of disciplinary understanding and helps to support more rigorous and equitable outcomes for diverse students. This curriculum thus takes into account both the receptive and productive language demands of the culminating projects and strives to increase accessibility by including scaffolds for language development and pedagogical strategies throughout learning tasks. We aim to support language acquisition through the development of concept maps; utilizing sentence frames; implementing the Critique, Clarify, Correct technique; employing the Stronger Clearer strategy; and fostering large and small group discussions.

The California ELD Standards are comprised of two sections: the standards and a rubric. Outlined below are the standards from Section One that are met within this curriculum. For additional information, please refer to: https://www.pausd.org/sites/default/files/pdf-faqs/attachments/SS_ELD_8.pdf.

Eighth Grade ELD Standards		
Part I: Interacting in Meaningful Ways	A: Collaborative	1.Exchanging information and ideas with others through oral collaborative discussions on a range of social and academic topics
		2. Interacting with others in written English in various communicative forms (print, communicative technology, and multimedia)
		3. Offering and justifying options, negotiating with and persuading others in communicative exchanges
		4. Adapting language choices to various contexts (based on task, purpose, audience, and text type)
	B: Interpretive	5. Listening actively to spoken English in a range of social and academic contexts
		6. Reading closely literary and informational texts and viewing multimedia to determine how meaning is conveyed explicitly and implicitly through language

		7. Evaluating how well writers and speakers use language to support ideas and arguments with details or evidence depending on modality, text type, purpose, audience, topic, and content area
		8. Analyze how writers and speakers use vocabulary and other language resources for specific purposes (to explain, persuade, entertain, etc.) depending on modality, text type, purpose, audience, topic, and content area
	C: Productive	9. Expressing information and ideas in formal oral presentations on academic topics
		10. Writing literary and informational texts to present, describe, and explain ideas and information, using appropriate technology
		11. Justifying own arguments and evaluating others' arguments in writing
		12. Selecting and applying varied and precise vocabulary and other language resources to effectively convey ideas
Part II: Learning About How English Works	A: Structuring Cohesive Texts	1. Understanding text structure
		2. Understanding cohesion
	B: Expanding and Enriching Ideas	3. Using verbs and verb phrases
		4. Using nouns and noun phrases
		5. Modifying to add details
	C: Connecting and Condensing Ideas	6. Connecting ideas
		7. Condensing ideas

8th Grade Science Unit 3: Adapt or Die?

Unit Overview

<u>Connections to Environmental Awareness:</u>

Over the course of this curriculum, students will explore content related to various environmental principles and concepts that examine the interactions and interdependence of human societies and natural systems. In accordance with the *Education and the Environment Initiative (EEI),* tasks throughout this curriculum explore many of *California's Approved Environmental Principles and Concepts.* The principles relevant to this unit are outlined in the chart below:

<table>
<tr><th>Unit Task</th><th>EEI Principle</th><th>EEI Concept</th></tr>
<tr><td>Culminating Project

Lift-Off Task

Task 3: Natural Selection</td><td>Principle II: The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies.</td><td>Concept A: Students need to know that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.</td></tr>
<tr><td rowspan="2">Culminating Project

Lift-Off Task

Task 3: Natural Selection

Task 4: Genetic Engineering</td><td rowspan="2">Principle IV: The exchange of matter between natural systems and human societies affects the long-term functioning of both.</td><td>Concept B: Students need to know that the byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect.</td></tr>
<tr><td>Concept C: Students need to know that the capacity of natural systems to adjust to human-caused alterations depends on the nature of the system as well as the scope, scale, and duration of the activity and the nature of its byproducts.</td></tr>
</table>

8th Grade Science Unit 3: Adapt or Die?
Teacher Materials List

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

Overall Unit – All Tasks
- Unit 3, Task Cards Student Version, Lift-Off and Tasks 1 through 4
- Culminating Project Student Task Card
- Project Organizer
- Projector with Audio and/or interactive whiteboard (for video or images, whenever needed)

Lift-Off Task (2 days)

Per Student
- Task Card Student Version: Lift-Off
- Post-Its (Optional)
- Task Card Student Version: Culminating Project
- Project Organizer

Per Group
- Poster paper and markers

Whole Class
- Poster paper and markers
- *See Instructions in task for other optional materials to use for the class concept map

Task 1 (3-5 days)

Per Student
- Task Card Student Version: Task 1
- Project Organizer
- Article Resource Card

Per Group
- Rock Sample Resource Cards (1-2 per group). Optional: laminate or put in sheet protectors

Task 2 (4 days)

Per Student
- Task Card Student Version: Task 2
- Project Organizer

Per Station
- Station Cards in sheet protectors for each station (2 per station – color preferable)

Task 3 (3 days)

Per Student
- Task Card Student Version: Task 3
- Project Organizer

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.

Task 4 (4-5 days)
Per Student
- Task Card Student Version: Task 4
- Project Organizer

Per Group
- Markers or Colored Pencils
- Poster Paper

Whole Class (or Per Student)
- Hand-held devices, computers, or projector and speakers for video

Culminating Project (6-8 days)
Per Group: Think Tank Discussion
- Computers with internet capabilities for research
- Lined Paper or Index Cards

Per Student: Post-Discussion Report
- Blank Paper, print-outs of project template, or computer with word processing software
- Color pencils/pens

Optional Online Resources
- Article of Species Affected by Climate Change: https://www.smithsonianmag.com/science-nature/ten-species-are-evolving-due-changing-climate-180953133/
- TedEd Video of wildlife adapting to climate change: https://www.youtube.com/watch?v=ZCKRjP_DMII (Stop at 3:56)

Unit 3 Pop-Out (3 days)
Per Student
- Student Version: Unit 3 Pop-Out
- Zambia Scenario
- Designer Babies Article

Per Group
- Presentation materials: computers OR posters and markers

Whole Class
- Computer and Projector for video
- Four Corners Posters (See instructions in teacher guide)

8th Grade Science Unit 3: Adapt or Die?
Building on Prior Knowledge

In Unit 1, students began to analyze the fossil record for patterns of biodiversity and events of mass extinction. In this unit, students build on that knowledge and skill set, as they continue to analyze the fossil record and use it to form a more cohesive picture of Earth's history, which they will come to know as the geologic time scale. From here, students find that the fossil record is not the only piece of evidence that helps tell the story of life on Earth. There is also anatomical and embryological evidence to explain common ancestry, as well as mechanisms like natural selection and human intervention to explain change over time. In exploring these concepts, Unit 3 thus becomes the unit with the most life science content of the 8th grade integrated curriculum.

The integrated model requires students to access and use a wide range of ideas from prior grades. This content knowledge spans six different Disciplinary Core Ideas: ESS1.C: The History of Planet Earth, LS3.A: Inheritance of Traits, LS3.B: Variation of Traits, LS4.A: Evidence of Common Ancestry and Diversity, LS4.B: Natural Selection, and LS4.C: Adaptation.

As students explore these core ideas, they build on their skills in the following science and engineering practices: Developing and Using Models; Analyzing and Interpreting Data; Using Mathematics and Computational Thinking; Constructing Explanations; Engaging in Argument From Evidence; and Obtaining, Evaluating, and Communicating Information. In addition to science and engineering practices, students also continue to build on their knowledge of the following crosscutting concepts: Patterns; Cause and Effect; Scale, Proportion, and Quantity; Structure and Function; and Stability and Change.

*This summary is based on information found in the NGSS Framework.

K-8 Progression of Disciplinary Core Ideas, Science And Engineering Practices, and Crosscutting Concepts for Unit 3

Disciplinary Core Ideas	K-2	3-5	6-8
ESS1.C The History of Planet Earth	Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe.	Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed.	The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.
LS3.A Inheritance of Traits	Young animals are very much, but not exactly, like, their parents. Plants also are very much, but not exactly, like their parents.	Many characteristics of organisms are inherited from their parents. Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment.	Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes)

			inherited.
LS3.B Variation of Traits	Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.	Different organisms vary in how they look and function because they have different inherited information. The environment also affects the traits that an organism develops.	In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.
LS4.A Evidence of Common Ancestry and Diversity	N/A	Some living organisms resemble organisms that once lived on Earth. Fossils provide evidence about the types of organisms and environments that existed long ago.	The fossil record documents the existence, diversity, extinction, and change of many life forms and their environments through Earth's history. The fossil record and comparisons of anatomical similarities between organisms enables the inference of lines of evolutionary descent.
LS4.B Natural Selection	N/A	Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.	Natural selection leads to the predominance of certain traits in a population, and the suppression of others. In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.
LS4.C Adaptation	N/A	For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.	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.

8th Grade Science Unit 3: Adapt or Die?

Building on Prior Knowledge

Science and Engineering Practices	K-2	3-5	6-8
Developing and Using Models	Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. • Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).	Modeling in 3–5 builds on prior experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop and/or use models to describe and/or predict phenomena.	Modeling in 6–8 builds on prior experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and/or use a model to predict and/or describe phenomena.
Analyzing and Interpreting Data*	Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations. • Use and share pictures, drawings, and/or writings of observations. • Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems.	Analyzing data in 3-5 builds on prior experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings. • Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships.	Analyzing data in 6-8 builds on prior experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings. • Analyze displays of data to identify linear and nonlinear relationships.

8th Grade Science Unit 3: Adapt or Die?
Building on Prior Knowledge

Using Mathematics and Computational Thinking	Mathematical and computational thinking in K-2 builds on prior experiences and progresses to recognizing that mathematics can be used to describe the natural and designed world(s). • Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs.	Mathematical and computational thinking in 3-5 builds on prior experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions. • Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems.	Mathematical and computational thinking in 6-8 builds on prior experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. • Use mathematical representations to support scientific conclusions and design solutions.
Constructing Explanations*	Constructing Explanations in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena. • Use information from observations (firsthand and from media) to construct an evidence-based account for natural phenomena.	Constructing Explanations in 3-5 builds on prior experiences and progresses to the use of evidence and ideas in constructing explanations that specify variables that describe and predict phenomena. • Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.	Constructing Explanations in 6-8 builds on prior experiences and progresses to include constructing explanations supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.
Engaging in Argument From Evidence*	Engaging in argument from evidence in K-2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s).	Engaging in argument from evidence in 3-5 builds on prior experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).	Engaging in argument from evidence in 6-8 builds on prior experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Construct, use, and/or present an oral and written argument supported by

	• Construct an argument with evidence to support a claim.	• Construct and/or support an argument with evidence, data, and/or a model. • Use data to evaluate claims about cause and effect.	empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.
Obtaining, Evaluating, and Communicating Information	Obtaining, evaluating, and communicating information in K-2 builds on prior experiences and uses observations and texts to communicate new information. • Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s).	Obtaining, evaluating, and communicating information in 3-5 builds on prior experiences and progresses to evaluating the merit and accuracy of ideas and methods. • Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence. • Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices	Obtaining, evaluating, and communicating information in 6-8 builds on prior experiences and progresses to evaluating the merit and validity of ideas and methods. • Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).

*These SEPs are summatively assessed using Task 2 or the Culminating Project.

Crosscutting Concepts	K-2	3-5	6-8
Patterns*	Students recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. • Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.	Students identify similarities and differences in order to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and to use these patterns to make predictions. • Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products. • Patterns of change can be	Students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data. • Graphs, charts and images can be used to identify patterns in data. • Patterns can be used to identify cause-and-effect relationships.

		used to make predictions. • Patterns can be used as evidence to support an explanation.	
Cause and Effect*	Students learn that events have causes that generate observable patterns. They design simple tests to gather evidence to support or refute their own ideas about causes. • Events have causes that generate observable patterns.	Students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationship. • Cause and effect relationships are routinely identified, tested, and used to explain change. • Events that occur together with regularity might or might not be a cause and effect relationship.	Students classify relationships as causal or correlational, and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
Scale, Proportion, and Quantity	Students use relative scales (e.g., bigger and smaller; hotter and colder; faster and slower) to describe objects. They use standard units to measure length. • Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower).	Students recognize natural objects and observable phenomena exist from the very small to the immensely large. They use standard units to measure and describe physical quantities such as weight, time, temperature, and volume. • Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods.	Students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale. They use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes. They represent scientific relationships through the use of algebraic expressions and equations. • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
Structure and Function*	Students observe the shape and stability of structures of natural and designed objects are related to their function(s). • The shape and stability of structures of natural and designed objects are	Students learn different materials have different substructures, which can sometimes be observed and substructures have shapes and parts that serve functions. • Substructures have shapes and parts that serve functions.	Students model complex and microscopic structures and systems and visualize how their function depends on the shapes, composition, and relationships among its parts. They analyze many complex natural and designed structures and systems to determine how they function. They design structures to serve particular functions by taking into account properties of different materials, and how materials can be shaped

	related to their function(s).		and used. • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.
Stability and Change*	Students observe some things stay the same while other things change, and things may change slowly or rapidly • Things may change slowly or rapidly.	Students measure change in terms of differences over time, and observe that change may occur at different rates. Students learn some systems appear stable, but over long periods of time they will eventually change. • Change is measured in terms of differences over time and may occur at different rates. • Some systems appear stable, but over long periods of time will eventually change.	Students explain stability and change in natural or designed systems by examining changes over time, and considering forces at different scales, including the atomic scale. Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time. • Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

*These CCCs are summatively assessed using Task 2 or the Culminating Project.

Progression of Knowledge from Kindergarten - 8th Grade

ESS1.C. The History of Planet Earth: In Kindergarten - second grade, students begin to engage in this DCI as it relates to the crosscutting concept of Stability and Change. In other words, students compare examples of sudden changes on Earth to gradual changes on Earth. In third – fifth grade, students move past this CCC to look more specifically at changes to rock formations and many students at this level will get an introduction to the fossil record as a form of evidence. Within this fourth grade performance expectation, students move towards using the crosscutting concept of Patterns to analyze changes they see. In this eighth grade unit, students continue their analysis of rock and their use of both crosscutting concepts mentioned above, but begin to form a greater picture of Earth's 4.6 billion-year-old history. The previous years have set the stage for students to consider Scale, Proportion, and Quantity at a grander scale, thus formulating a concept of the geologic time scale. At all levels, students use evidence to construct explanations of phenomena related to the history of planet earth.

The following is the progression of the Performance Expectations for this DCI:

2-ESS1-1 Use information from several sources to provide evidence that Earth events can occur quickly or slowly.

4-ESS1-1 Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.

MS-ESS1-4 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.

LS3.A. Inheritance of Traits: In Kindergarten - second grade, students make observations based on examples they can see in order to conclude that plants and animals look like their parents. This physical observation-based understanding sets the foundation for them to engage with the science behind this phenomenon in third – fifth grade. At this level, students continue to look for Patterns in data, but start using content-specific vocabulary and concepts, such as traits, inheritance, and variation. Furthermore, they continue on to consider that it is not just genetics that can influence traits, but also environment. This sets the stage for this eighth grade unit as students dive into the mechanism at play—that certain genes result in specific proteins, which influences the trait. Variation thus results from both inheritance and mutation processes. In earlier grades, students focus on Analyzing and Interpreting Patterns in Data to Construct Explanations. In this eighth grade unit, students build on these skills and this crosscutting concept to Develop Models that describe the underlying mechanisms, utilizing the crosscutting concept of Structure and Function.

The following is the progression of the Performance Expectations for this DCI:

1-LS3-1 Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.

3-LS3-1 Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.

3-LS3-2 Use evidence to support the explanation that traits can be influenced by the environment.

MS-LS3-1 Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

LS3.B. Variation of Traits: As you can see by the performance expectations listed below, this DCI is heavily linked to LS3.A Inheritance. Recall that in Kindergarten - second grade, students are making observations based on examples they can see in order to conclude that plants and animals look like their parents. This also includes a conclusion that plants and animals do not look exactly like their parents, thus laying the foundation for this concept of variation. In third – fifth grade, they continue to explore this idea of variation in more depth, analyzing data sets for evidence of variation that result from both genetics and environment. While in sixth grade, students discover that variation occurs because of the processes in sexual reproduction, this eighth grade unit focuses on variation that occurs because of mutation. Due to the nature of the performance expectations at the different levels, students start by Analyzing and Interpreting Patterns in Data in order to Construct Explanations, but move toward Developing Models using Structure and Function in this eighth grade unit.

The following is the progression of the Performance Expectations for this DCI:

1-LS3-1 Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.

3-LS3-1 Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.

3-LS3-2 Use evidence to support the explanation that traits can be influenced by the environment

MS-LS3-1 Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

LS4.A. Evidence of Common Ancestry and Diversity: Students do not engage with this DCI until the third grade. In third – fifth grade, students begin to ask the question: How are plants, animals, and environments of the past similar or different from current plants, animals, and environments? This gives students a first exposure to the fossil record, which they will study more in depth in eighth grade. At the third grade level, students only make isolated connections between organisms and their environment, comparing data between the past and the present. As in Unit 1, students in this unit attempt to form a much more cohesive and complex picture of the history of life on Earth. In Unit 1, however, they use the fossil record mostly as a tool to show biodiversity and events of extinction over time. Here, they move past just the fossil record to explore relationships between species, looking at anatomical and embryological evidence. Thus, students move from a focus on Scale, Proportion, and Quantity in early grades to a focus on Patterns to organize the fossil record and compare anatomical and embryological features in eighth grade. Regardless of the grade level, however, students focus on Analyzing and Interpreting Data as they look at the fossil record and other pieces of evidence.

The following is the progression of the Performance Expectations for this DCI:

3-LS4-1 Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.

MS-LS4-1 Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.

MS-LS4-2 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

MS-LS4-3 Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.

LS4.B: Natural Selection: This DCI is not introduced in kindergarten – second grade and first appears in the third grade. Before students are ready to understand the mechanism of natural selection, they must first understand the cause-and-effect reasoning behind it by looking at examples. At this level, students are using evidence to conclude that variations in organisms can provide advantages in surviving, finding mates, and reproducing. This sets the stage for students to learn the step-by-step mechanism of natural selection in this eighth grade unit. Students are able to apply these new concepts as they continue with the same science and engineering practice and crosscutting concept as they practiced in third grade: Constructing Explanations and Cause and Effect. At this eighth grade level, students are also beginning to incorporate mathematical representations to support their explanation of natural selection, thus adding the skill of Using Mathematics and Computational Thinking. Students should then be able to apply these knowledge and skills to processes of selective breeding and genetic engineering.

The following is the progression of the Performance Expectations for this DCI:

3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.

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.

MS-LS4-5 Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

LS4.C.Adaptation: This DCI is also not introduced until the third grade, when students explore examples of how some organisms can survive well, some survive less well, and some cannot survive at all in a given environment. Not only are students looking at examples, they are also thinking about why this is the case, thus using Cause-and-Effect reasoning that will be built on in this eighth grade unit. In this unit, students look not just at examples, but also at actual mathematical representations showing increases and decreases of specific traits over time. Students use the crosscutting concept of Cause and Effect again to explain this phenomenon in terms of natural selection. Thus this DCI is heavily related to the previous LS4.B: Natural Selection.

The following is the progression of the Performance Expectations for this DCI:

3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

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.

8th Grade Science Unit 3: Adapt or Die?

Culminating Project

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

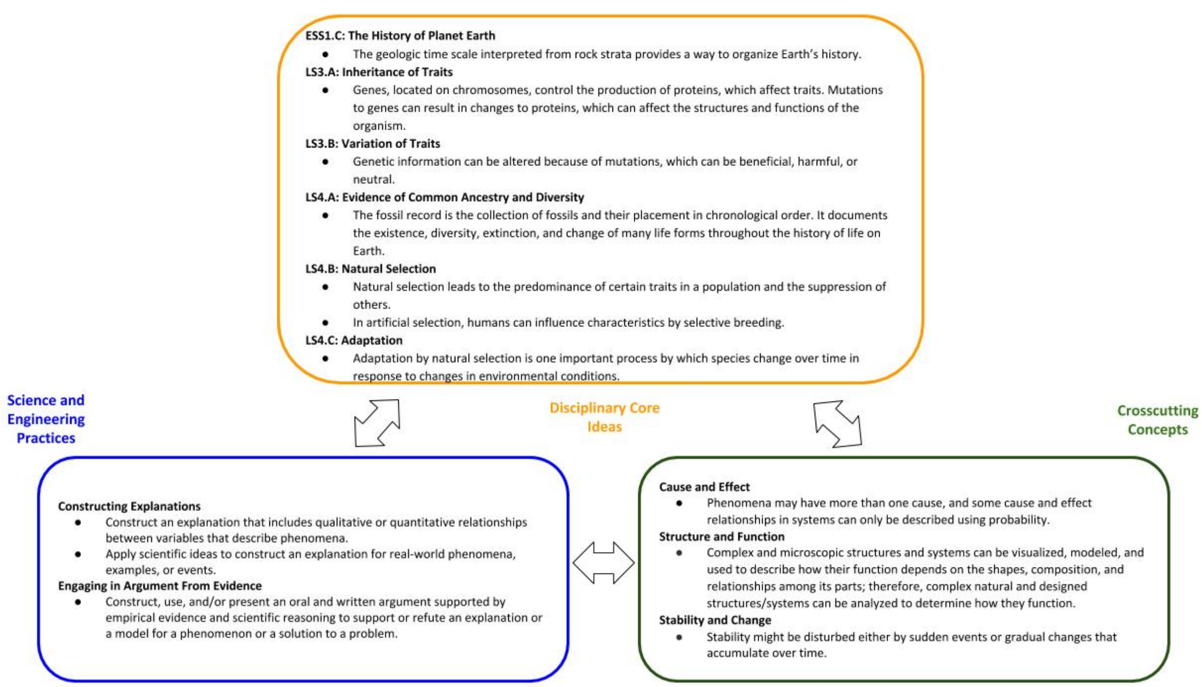
Introduction

In this unit students are examining the ways in which species and populations change over time and the mechanisms for those changes. The culminating project has students consider these changes in a particular context. Humans are causing changes in our environment—pollution, climate change, loss of habitat, etc.—which are having a huge impact on many species around the world. As these plants and animals struggle to adapt to rising temperatures and other effects of environmental change, we see the list of endangered species growing longer and longer. While we already know there are actions we can take to prevent more harmful environmental changes, some of the damage we've done can't be undone. As we watch more species struggle with the changing environmental conditions, the question becomes: Should we intervene or allow nature to take its course?

In this project, students' task is to develop an argument that answers this question, contextualized within research they do on one species affected by changing environmental conditions. Each group will select one species affected by an environmental change and use their own research and the scientific concepts they learn throughout the unit to decide whether humans should intervene or not. Each group will then prepare for a whole-class Think Tank Discussion* centered around the question: Should humans intervene on the behalf of threatened or endangered species or allow nature to take its course? As individuals, they will then write a Post-Discussion Report, detailing the scientific background on their own species as well as their argument, using the discussion as additional evidence and reasoning.

*Note: A "Think Tank Discussion" provides students an opportunity to address a specific issue in a structured, interactive workshop. Specific questions are used to allow for participants to problem-solve approaches to a common problem—in this case the problem of species that are affected by environmental change.

3-Dimensional Assessment



Time Needed (Based on 45-Minute Periods)

6-8 Days at end of unit

- Group Project: 2-3 periods
- Individual Project: 4-5 periods
  - First draft: 2-3 periods
  - Feedback: 1 period
  - Revision: 1 period

Materials

- Computers or hand-held devices with internet capabilities for research
- Lined Paper or Index Cards
- Blank Paper, print-outs of project template, or computers with word processing software
- Color pencils/pens
- Optional Online Resources
  - Article of Species Affected by Climate Change: https://www.smithsonianmag.com/science-nature/ten-species-are-evolving-due-changing-climate-180953133/
  - TedEd Video of wildlife adapting to climate change: https://www.youtube.com/watch?v=ZCKRjP_DMII (Stop at 3:56)

Instructions for The Culminating Project

1. Introduce the Culminating Project at the end of the Lift-Off task, including both the group and individual components outlined in the Challenge.

2. Read over the Culminating Project Task Card with the students. We recommend only reading the challenge and group criteria for success at this time in order to not overwhelm students with information.
   - Take questions for clarification
   - Optional: You may want to show a video to spark student interest. The following link is one option: https://www.youtube.com/watch?v=QwLyscT3NgI (Show until 0:38).

3. Remind students that as they go through the Project Organizer, they will be planning parts of their argument and recording information they may need for their individual project. However, there is nothing wrong with going back and changing their ideas over the course of the unit. The students won't fully develop their argument and prepare for the Think Tank Discussion until the end of the unit, so change is acceptable and often experienced.

4. Make sure the students fill out the Project Organizer after each task, which will help the students think about how their chosen species may have changed over time and how it might be affected by environmental changes. This process allows students to both apply and document relevant scientific concepts as they move through the unit. This will inform both their group and individual projects.
   - We recommend that students complete the Project Organizer individually. They might discuss ideas first as a group, but should then respond individually. This allows students time to process concepts on their own and generate their own ideas, which can be used later when it comes to developing their group project. In this particular unit, there is one exception to this guideline—after the Lift-Off task, each student group should research and pick a species, so that all group members are working with the same species throughout the unit.

5. The table below summarizes how the Project Organizer guides the students through developing different components of the Think Tank Discussion and Post-Discussion Report:

Task	Project Organizer	Group and Individual Culminating Projects
Lift-Off The Case of the Peppered Moths	Select and research a species that is being negatively affected by a change in their environment that is caused by humans. • Describe the change in the environment and its effect on this species.	• Discussion and Post-Discussion Report give background on species.
Task 1 The Fossil Record and Geologic Time Scale	• Draw a pretend fossil record. • How might the fossil record in the last 50 years show the species changing over time? • Given how our planet is changing, predict what future layers might look like?	• Discussion uses examples of previous incidents of climate change in the fossil record. • Post-Discussion Report contains a pretend fossil record depicting how species may have changed in the past and will change in the future due to an environmental change. Uses fossil record to explain relative dating.
Task 2 Evidence of Change Over Time	• Draw in a pretend common ancestor at the beginning of your fossil record and a pretend modern species also related to this common ancestor. • What similar anatomy or embryological development might your species have with this related species?	• The Culminating Project does not assess the Performance Expectations addressed in this task. These Performance Expectations are assessed with rubrics provided in this task.
Task 3 Natural Selection	• 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"?	• Discussion and Post-Discussion Report explain how environmental change affects species in terms of natural selection.
Task 4 Human Intervention	• What change in trait might help that species survive? • Model the process of changing this trait, using what you have learned in this task.	• Discussion and Post-Discussion Report argue for or against human intervention. • Post-Discussion Report contains a model and explanation of genetic intervention (gene to trait), including emphasis on structure and function.

6. After all the learning tasks are completed, and the Project Organizers are completed, the students can start to plan how they will participate in the Think Tank Discussion. We highly recommend that students use the Group Project Criteria for Success to draft notes they can use during the class Think Tank Discussion. Students may also want to transcribe these notes onto notecards. Different members of the group can be responsible for different notecards during the Think Tank Discussion to ensure more equitable participation. Both the Project Organizer and Criteria for Success should be used as reference for the students to remind them of all that they have learned throughout the task to include in their project.

- As always, we recommend the use of group roles for Culminating Project work time (See "How to Use This Curriculum" document for details). We recommend changing the roles every work day.

7. For an authentic experience, we recommend setting up chairs in a circular format so that students may face each other as they discuss. There are many ways to facilitate a large group discussion, like this Think Tank Discussion, but some suggestions are listed below:
    - We recommend reviewing discussion norms that you use in your classroom to ensure more equitable discussion (For example, "Step Up – Step Back). Throughout the discussion, you will likely need to facilitate by calling on different groups who have not had as much sharing time.
    - As stated above, we recommend student groups come to the discussion with notes or note cards prepared.
    - Optional: Start the discussion by having each group present their background on their species. Then open up the discussion to the argument: Should humans intervene on the behalf of threatened or endangered species or allow nature to take its course? We recommend keeping the Group Project Criteria For Success in front of you, both for assessment purposes and also as a source of facilitating questions to guide the discussion as needed.
    - It may be helpful for students to have some writing time right after the discussion, so they may note any additional piece of evidence or reasoning from the discussion that they would like to include in their individual project.

8. Once the Think Tank Discussion is complete, students are ready to move on to their individual project. Students will write a Post-Discussion Report that details the scientific background on their species as well as their argument, using the discussion as additional evidence and reasoning. Remind students to check that their Post-Discussion Report meets all the criteria in the student handout.
    - Depending on the needs of your students, you may want to provide a template to help them organize the information they will include in their Post-Discussion Report. An option is provided at the end of this teacher guide.

9. Conduct a peer review of the Post-Discussion Report after students have completed a first draft.
    - Copy the Post-Discussion Report Peer Review Feedback form found in the Student Instructions. Another option is to use the Student 3-Dimensional Individual Project Rubric.
    - Assign each student a partner, preferably a partner from a different group.
    - Students switch drafts and assess them using the peer review feedback form or 3-Dimensional Rubric.
        - Remind each student to give one positive comment and one constructive comment for each section on the checklist.
        - Allow students time to present their feedback to their partner, so their partner may ask clarifying questions if needed.

10. After receiving feedback, allow students time to complete a final draft based on the feedback they received.

Assessment

The Project Organizer can be formatively assessed using:

- *Criteria of your choice*. We recommend using the 3-Dimensional Assessment matrix from the Unit Overview to inform your criteria.

The Group Culminating Project will be summatively assessed using:

- The *Group Project Criteria for Success* Checklist

The Individual Culminating Project will be summatively assessed using:

- The *3-Dimensional Individual Project Rubric*.
- Keep in mind that the Proficient level indicates that the student has successfully demonstrated understanding of the criteria. Because we are in the early stages of NGSS adoption, it may take multiple opportunities throughout the course of the year for students to reach Proficient.
- If you wish to give students a numeric score, you could take the average score of all of their rubrics or add up rubric scores to give students a summation out of the total. Because of the note above, this scoring may not correlate to traditional grading systems.
- While we recommend scoring all of the project criteria with the rubrics for each student, we understand the burden of that level of scoring.
    - One option is to select the rubrics that you wish to focus on for this project and use those to assess each student's individual project.
    - Another option is to review the Proficient level of each of the project's rubrics and use the descriptions to generally analyze all student work for trends.

Post-Discussion Report

Background on ___________________________

My Pretend Fossil Record for ___________________

Caption 1:

Caption 2:

Caption 3:

Caption 4 (Additional Information):

How a Change in Environment is Affecting ____________________

Technologies That Humans Can Use to Affect Traits in Organisms

The Most Appropriate Technology for Human Intervention
A Model of Genetic Engineering

My Argument: Should humans intervene on the behalf of threatened or endangered species or allow nature to take its course?

8th Grade Science Unit 3: Adapt or Die?

3-Dimensional Individual Project Rubric

Overview: The following rubrics can be used to assess the individual project: Post-Discussion Report from a Think Tank Discussion. Each rubric is aligned to one section of the *Individual Project Criteria for Success*, located on the Culminating Project Student Instructions. *If student provides no assessable evidence (e.g., "I don't know" or leaves answer blank), then that student response cannot be evaluated using the rubric and should be scored as a zero.

Below we provide an alignment table that details the dimensions assessed for each criterion.

	Student Criteria for Success	Disciplinary Core Idea	Science and Engineering Practice	Crosscutting Concept
1	☐ Draw a pretend fossil record using accurate scientific concepts to demonstrate how your species may have changed over time. ○ Show how your species may have changed over the last 50 years due to environmental change. ○ Predict and show how your species might be shown in future layers due to environmental change. ○ Use fossil record data from past incidents of climate change to explain whether you think future changes to your species would be sudden or gradual. ○ Provide captions that describe your pretend fossil record and explain how the fossil record shows relative dating of the history of your species.	ESS1.C: The History of Planet Earth • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. LS4.A: Evidence of Common Ancestry and Diversity • The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.	N/A	Stability and Change • Stability might be distributed either by sudden events or gradual changes that accumulate over time.
2	☐ Apply the idea of natural selection to explain the relationship between environmental change and the trait(s) of your species. ○ How does the cause-and-effect relationship of natural selection help you predict what your species will likely look like in the future? ○ Compare your species to the "Insect"	LS4.B: Natural Selection • Natural selection leads to the predominance of certain traits in a population, and the suppression of others. LS4.C: Adaptation • Adaptation by natural selection acting over generations is one important process by which species change over	Constructing Explanations • Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events. • Construct a scientific explanation based on valid and reliable evidence obtained from sources	Cause and Effect • Some cause and effect relationships in systems can only be described using probability.

	simulation and use the results of the simulation as evidence for why you think your species will be affected this way.	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.	(including one's own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	
3	Explain the multiple technologies that humans can use to affect traits in organisms. Use evidence from Task 4 to describe the processes and give examples.	LS4.B: Natural Selection • In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.	Constructing Explanations • Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.	Cause and Effect • Phenomena may have more than one cause.
4	○ Draw a model to show how a scientist could create a structural change to the genes of your organism. Explain how the change in genes would affect the structure and function of the organism.	LS3.A Inheritance of Traits • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. LS3.B: Variation of Traits • In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some	N/A	Structure and Function • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.

		changes are beneficial, others harmful, and some neutral to the organism.		
5	☐ Construct your argument to the question: Should humans intervene on the behalf of threatened or endangered species or allow nature to take its course? Include: ○ Your claim. ○ Evidence and scientific reasoning from your research and the Think Tank Discussion. ○ A description of what the other side might say and a counter-argument to respond to the other side.	LS4.B: Natural Selection • In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring. 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.	Engaging in Argument From Evidence • Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	N/A

8th Grade Science Unit 3: Adapt or Die?

3-Dimensional Individual Project Rubric

Rubric 1: Student creates a pretend fossil record for the past and future, which uses ideas of relative dating to show a sudden or gradual change of their species due to an environmental change.

- Dimensions Assessed: DCI – LS4.A. Evidence of Common Ancestry and Diversity, DCI – ESS3.C. The History of Planet Earth, CCC – Stability and Change

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student creates a pretend fossil record for the past and future, which uses **inaccurate** ideas of relative dating **and/or does not** show a sudden or gradual change of their species due to an environmental change.	Student creates a pretend fossil record for the past and future, which uses **inaccurate** ideas of relative dating to **partially** show a sudden or gradual change of their species due to an environmental change.	Student creates a pretend fossil record for the past and future, which uses **accurate** ideas of relative dating to **partially** show a sudden or gradual change of their species due to an environmental change.	Student creates a pretend fossil record for the past and future, which uses **accurate** ideas of relative dating to **completely** show a sudden or gradual change of their species due to an environmental change.

Look Fors:
• Student draws a mock fossil record inaccurately. For example, the oldest layers may be at the top (earliest form of their species) and the most recent at the bottom (most recent form of their species).
• And/or student does not show the sudden or gradual change of their species over time. Their mock fossil record may show no change over time, is not specific to their species, or is not relevant to an environmental change caused by humans.
	Look Fors:
	• Student draws a mock fossil record inaccurately. For example, the oldest layers may be at the top (earliest form of their species) and the most recent at the bottom (most recent form of their species).
	• Student still shows a change of their species over time that is relevant to their environmental change, but it is not accurately documented because their layers are incorrect (See Advanced Look-Fors for description of this).
		Look Fors:
		• Student draws a mock fossil record accurately with the oldest layers at the bottom (earliest form of their species) and the most recent at the top (most recent form of their species). Student accurately describes this in captions.
		• Mock fossil record and captions are accurate but incomplete:
		  o Drawings of their species within the layers likely show a gradual change of a specific trait or population size over time, but this might not be explicit in captions. The change in species is relevant to a specific environmental change caused by humans.
		  o OR drawings of their species only show past layers but not future layers, in accordance with the prompt, or vice versa.
			Look Fors:
			• Student draws a mock fossil record accurately with the oldest layers at the bottom (earliest form of their species) and the most recent at the top (most recent form of their species). Student accurately describes this in captions.
			• Captions and drawings of their species within the layers likely show and explain a gradual change of a specific trait or population size over time. This change is relevant to a specific environmental change caused by humans.

8th Grade Science Unit 3: Adapt or Die?

3-Dimensional Individual Project Rubric

Rubric 2: Student explains the cause-and-effect relationship between an environmental change and their species' population, applying the idea of natural selection and incorporating probability statements from the "insect" simulation.

- Dimensions Assessed: DCI – LS4.B. Natural Selection, DCI - LS4.C. Adaptation, SEP – Constructing Explanations, CCC – Cause and Effect

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student **inaccurately** explains the cause-and-effect relationship between an environmental change and their species' population, applying **no** ideas of natural selection and incorporating **no** relevant probability statements from the "insect" simulation.	Student **incompletely** explains the cause-and-effect relationship between an environmental change and their species' population, applying a **partial** idea of natural selection **but** incorporating **no** relevant probability statements from the "insect" simulation.	Student **generally** explains the cause-and-effect relationship between an environmental change and their species' population, applying a **partial** idea of natural selection and incorporating **relevant** probability statements from the "insect" simulation.	Student **accurately** explains the cause-and-effect relationship between an environmental change and their species' population, applying the **complete** idea of natural selection and incorporating relevant probability statements from the "insect" simulation.
Look Fors: ● Student explanation is inaccurate, is not specific to their species, does not use knowledge of natural selection, and/or does not include relevant evidence from the simulation. For example, "climate change is making the owls overheat and die."	**Look Fors:** ● Student explanation is specific to their species, uses some principles of natural selection, but does not incorporate evidence from the simulation. ● Student explanation includes the basic concept of natural selection depicted in the Proficient Look-Fors, using a chain of cause-and-effect reasoning. For example, "climate change and the resulting brown landscape are leading to a population with more brown bunnies because that trait better camouflages." No relevant evidence from the "insect" simulation is given.	**Look Fors:** • Student explanation is specific to their species, uses some principles of natural selection, and incorporates evidence from the simulation. • Student explanation includes most of the Advanced components connected by cause-and-effect reasoning, but lacks some of the steps and details in natural selection. For example, it includes: a specific change in environment; process of some individuals with a certain trait surviving and why; comparison to an insect from the simulation, how that insect changed over time, and how that justifies how their species will likely change (probability statements).	**Look Fors:** • Student explanation is specific to their species, uses all principles of natural selection, and incorporates evidence from the simulation. • Student explanation includes all of the following components connected by cause-and-effect reasoning: the environmental pressure (ex: warming temperatures); description of variation in their species traits; process of some surviving and some dying based on a trait; the passing on of favorable traits by survivors; identification of change in population over time; comparison to an insect from the simulation, how that insect changed over time, and how that justifies how their species will likely change (probability statements).

8th Grade Science Unit 3: Adapt or Die?

3-Dimensional Individual Project Rubric

Rubric 3: Student constructs an explanation of multiple technologies that humans use to affect traits in organisms, using evidence from a past task to support their explanation.

- Dimensions Assessed: DCI – LS4.B: Natural Selection, SEP – Constructing Explanations, CCC – Cause and Effect

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student constructs an **inaccurate or irrelevant** explanation of multiple technologies that humans use to affect traits in organisms.	Student constructs an **accurate** explanation of multiple technologies that humans use to affect traits in organisms, using **no** evidence from a past task to support their explanation. OR Student constructs a **partial** explanation of multiple technologies that humans use to affect traits in organisms, using **partial** evidence from a past task to support their explanation.	Student constructs an **accurate** explanation of multiple technologies that humans use to affect traits in organisms, using **partial** evidence from a past task to support their explanation.	Student constructs an **accurate** explanation of multiple technologies that humans use to affect traits in organisms, using **complete** evidence from a past task to support their explanation.
Look Fors: • Student explanation inaccurately describes the process of selective breeding and/or genetic engineering. For example, "humans could intervene by forcing brown bunnies to choose brown fur color as their trait." • Thus any evidence from Task 4 is also inaccurate.	**Look Fors:** • Student explanation accurately describes the processes of selective breeding AND genetic engineering. Student does not use any evidence from Task 4. • Student explanation accurately describes the process of selective breeding or genetic engineering, but not both. Student uses examples from Task 4 that are relevant to the process they describe.	**Look Fors:** • Student explanation accurately describes the processes of selective breeding AND genetic engineering. • Student implicitly or explicitly references the article from Task 4, but explanation lacks complete detail. For example, the student may not include relevant examples for each process or does not completely and accurately describe the steps for each process.	**Look Fors:** • Student explanation accurately describes the processes of selective breeding AND genetic engineering. • Student implicitly or explicitly references the article from Task 4, including relevant examples of how each process has been used successfully. For example, a dairy farmer selecting bulls from large-growth herds to breed with cows that have the best milk production in order to create the best dairy cattle and inserting a gene for insect-resistance in tomatoes.

8th Grade Science Unit 3: Adapt or Die?

3-Dimensional Individual Project Rubric

Rubric 4: Student draws a model that shows how a pretend human-created mutation could lead to a favorable change in trait, describing and depicting a structural change to genes that affects the structure and function of their organism.

- Dimensions Assessed: DCI – LS3.A. Inheritance of Traits, DCI – LS3.B. Variation of Traits, CCC – Structure and Function

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student draws an **inaccurate** model that shows how a pretend human-created mutation could lead to a favorable change in trait**.**	Student draws an **accurate but partial** model that shows how a pretend human-created mutation could lead to a favorable change in trait, **AND/OR does not explicitly** describe and depict a structural change to genes that affects the structure and function of their organism.	Student draws an **accurate and complete** model that shows how a pretend human-created mutation could lead to a favorable change in trait, **partially** describing and depicting a structural change to genes that affects the structure and function of their organism.	Student draws an **accurate and complete** model that shows how a pretend human-created mutation could lead to a favorable change in trait, **completely** describing and depicting a structural change to genes that affects the structure and function of their organism.
Look Fors: • Student model is inaccurate or is not specific to their chosen organism. For example, student model may show humans inserting a protein into their organism, which creates a gene that affects the trait in the organism.	**Look-Fors** • Model identifies a relevant trait that would help their organism to survive an environmental change. • Student accurately models some of the steps in the process from gene to trait. For example, they may show the mutated gene creating the new desired trait, but skipping the protein step. • AND/OR Student model does not explicitly show and describe how structure affects function, for whichever part is present in their model.	**Look-Fors** • Model identifies a relevant trait that would help their organism to survive an environmental change. • Student accurately models all steps in the process from gene to trait: The mutated gene produces a different protein, which creates the new desired trait. • Student model also shows and describes structure and function at either the gene to protein step or the protein to trait step, but not both.	**Look Fors:** • Model identifies a relevant trait that would help their organism to survive an environmental change. • Student accurately models all steps in the process from gene to trait: The mutated gene produces a different protein, which creates the new desired trait. • Student model also shows and describes how the change in the structure of the gene affects the structure and function of the protein, which changes the structure and function of the organism (trait).

8th Grade Science Unit 3: Adapt or Die?

3-Dimensional Individual Project Rubric

Rubric 5: Student constructs an argument for whether or not humans should intervene on the behalf of threatened or endangered species, and uses evidence and scientific reasoning to support their argument.

- Dimensions Assessed: DCI – LS4.C. Adaptation, DCI – LS4.B. Natural Selection, SEP – Engaging in Argument From Evidence

Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Student constructs an argument for whether or not humans should intervene on the behalf of threatened or endangered species and uses **no** evidence or scientific reasoning to support their argument.	Student constructs an argument for whether or not humans should intervene on the behalf of threatened or endangered species, but uses **insufficient** evidence and scientific reasoning to support their argument.	Student constructs an argument for whether or not humans should intervene on the behalf of threatened or endangered species, and uses **multiple sources of** evidence and **accurate but partial** scientific reasoning to support their argument.	Student constructs an argument for whether or not humans should intervene on the behalf of threatened or endangered species, and uses **multiple sources of** evidence and **accurate and complete** scientific reasoning to support their argument.
Look Fors: • Student makes a clear claim for human intervention or natural process. • Student uses no scientific reasoning and evidence to support his or her claim. For example, "I think we should intervene on the behalf of threatened or endangered species, because we caused this and it is the right thing to do."	**Look Fors:** • Student makes a clear claim for human intervention or natural process. • Student uses some scientific reasoning to support his or her claim, but the reasoning is not convincing. • Student cites only one source of evidence or a few sources that do not strongly support the claim.	**Look Fors:** • Student makes a clear claim for human intervention or natural process. • Student uses scientific reasoning to support his or her own claim, but does not counter-argue the other claim. • Student cites multiple sources of evidence to support their reasoning. For example, their mock fossil record, the article about past incidents of climate change in Task 1, the simulation of natural selection in Task 3, the article in Task 4, any of their own research.	**Look Fors:** • Student makes a clear claim for human intervention or natural process. • Student uses scientific reasoning to support his or her own claim and to counter-argue the other claim. • Student cites multiple sources of evidence to support their reasoning. For example, their mock fossil record, the article about past incidents of climate change in Task 1, the simulation of natural selection in Task 3, the article in Task 4, any of their own research.

Additional Notes:

- Additional rubrics are provided in Task 2 to provide assessment for the Performance Expectations MS-LS4-2 and MS-LS4-3 (including the corresponding dimensions), which are not assessed explicitly in this Culminating Project.

8th Grade Science Unit 3: Adapt or Die?

Lift-Off Task: The Case of the Peppered Moths

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

Introduction

In this unit, students will explore how organisms change over time, as well as the various pieces of evidence that exist to document these changes. This Lift-Off Task hooks students with the classic case of the Peppered Moth. It is a case of natural selection that is easy to study because it happened so rapidly. This task also introduces students to an environmental change directly caused by human beings that had a dramatic effect on a species. Students will select a similar case as the focus of their culminating project. In this lift-off task, students draw on their prior knowledge to generate questions about the phenomenon of the changing Peppered Moth. These questions will guide their learning throughout this unit.

Alignment Table

Because the Lift-Off tasks focus on student-generated questions, we do not identify specific Disciplinary Core Ideas or Science and Engineering Practices in this table.

Crosscutting Concepts (*depending upon student-generated questions)

- Patterns:
  - Graphs, charts and images can be used to identify patterns in data.
  - Patterns can be used to identify cause-and-effect relationships.
- Cause and Effect:
  - Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
- Scale, Proportion, and Quantity
  - Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
- Structure and Function
  - Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.
- Stability and Change
  - Stability might be distributed either by sudden events or gradual changes that accumulate over time.
  - Small changes in one part of a system might cause large changes in another part.

Equity and Groupwork

- Share and listen to broad and diverse student contributions.
- Make connections between each other's ideas.
- Work together to co-construct a concept map.

Language

- Use connector words to link ideas.
- Generate and write questions about the phenomenon.
- Organize key questions in a concept map.

8th Grade Science Unit 3: Adapt or Die?

Lift-Off Task: The Case of the Peppered Moths

Learning Goals

This learning task introduces students to the concept of a species changing over time and begins generating questions that will guide them through this unit. More specifically, the purpose is to:

- Individually generate a list of questions about the case study of the peppered moth.
- Make connections between related questions.
- Generate possible answers to questions based on prior knowledge.
- Select and research an organism currently affected by an environmental change that is caused by humans.

Content Background for Teachers

In this unit, students will be thinking about how and why organisms change over time and what evidence exists for us to study and draw conclusions about these changes. This task jumpstarts their exploration about the first part of these objectives: how and why organisms change over time.

The phenomenon in this task is the case of the changing Peppered Moths. This is one of the best known cases of natural selection, and is particularly interesting for this unit since the change of environment was human-caused. Before the industrial revolution in England, the dominant form of the moth was a lighter color (as shown in the picture above on the right). These lighter moths were very difficult for predators to pick out against the light-colored bark of many trees common in England. In the mid-1800s, however, a new form of the moth began to appear. This version of the moth was a dark-colored peppered moth, first appearing in 1848 (as shown in the picture above on the left). By 1895, scientists reported that 98% of the peppered moth population was this darker color. This increase in darker moths corresponded with the industrial revolution. Factories produced soot that turned the bark of the trees darker. This made the lighter moths easier to spot by predators, so they were eaten, while the darker-colored moths survived to reproduce and pass on their genes.

The case of the Peppered Moth serves as an interesting phenomenon for students to begin to think about how organisms might change over time and why they might change over time. This sets the stage for their culminating project, in which students consider whether or not we should save all threatened and endangered species or let some die.

8th Grade Science Unit 3: Adapt or Die?

Lift-Off Task: The Case of the Peppered Moths

In this task, students create a concept map, which is a graphical representation that helps students to organize and represent knowledge, and supports their academic language development. As students learn more about the ways in which species change over time, they will add more questions and ideas to this concept map. If your students have not had previous experience making concept maps, please see instructions in Part B below for strategies on teaching this skill.

Academic Vocabulary

- Population
- Species
- Peppered Moth
- Think Tank
- Environmental

*Additional academic vocabulary will vary by class

Time Needed (Based on 45-Minute Periods)

2 Days

- Introduction, Part A and B: 1 period
- Part C, Project Organizer, and Reflection: 1 period

Materials

- Unit 3, Lift-Off Task Student Version

Part B

- Poster paper and markers
- Post-Its (Optional)

Part C

- Class Poster Paper and Markers
- *See instructions below for other optional materials to use for the class concept map

Connecting to the Culminating Project

- Culminating Project Handout
- Project Organizer Handout

Instructions

Part A

1. Introduce students to the unit by reading or projecting the Unit Essential Question aloud. Introduce the phenomenon of the unit by reading the first sentence on the student guide aloud as a class.

2. In this Lift-Off task, students will be generating questions to help them make sense of the phenomenon. Ask students to think about the case of the peppered moths and take a few minutes to answer the question: If you wanted to understand more about how and why this happened to the Peppered Moth, what questions would you ask? Students should individually record any of the questions that they would need to ask to get a better understanding of how and why this happened.

- For students who need more support, encourage them to look at the picture on their student guide and make observations.
- Some potential questions students may generate: Why are the moths different colors? What was the cause of the color change? Does it help them to be black? Does it help them to be peppered? Did the genes change or just their appearance? Did they ever change back? What was happening in England at that time? Are there other colors of these moths? Did other animals change colors too?
- This should be done independently, as students will have time in the next section to share ideas.

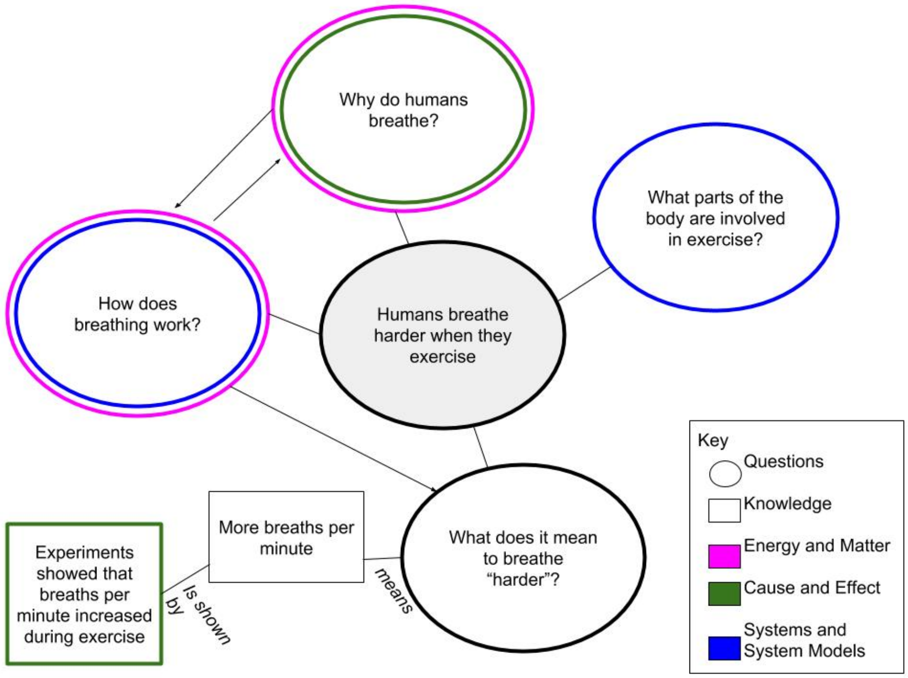
Part B

1. In this part of the task, students create a concept map as a group.
    - Remind students to refer to the directions on their student guide to help them make their concept map. First, students should compare each member's list of questions and record/connect key questions on a piece of poster paper. They will then draft possible answers to the questions, using prior knowledge.
    - Remind students that there are no right or wrong questions or ideas, so students feel encouraged to contribute any and all questions and ideas they think of.
    - Because this is a collaborative task, it is recommended that you remind students of group work norms and assign group roles, such as Resource Manager, Facilitator, Recorder, and Harmonizer (See "How to Use this Curriculum" for more details).

2. Students will post their posters on a wall and then walk around and look at each group's ideas. One suggestion for gallery walks is for students to interact with the posters in some way. For example, students are required to initial or leave post-its on three questions that they are also excited about on other posters.

How to Concept Map

For students who have not had a lot of experience making concept maps, we have detailed a strategy below for introducing concept mapping using more familiar content. An example is also provided, but this will vary depending on what your students come up with as you make your own model.



1. Write the phenomenon in the middle of the poster, in this case "Humans breathe harder when they exercise."

2. Ask students to share questions they might ask to make sense of this phenomenon and make a list of these questions on the board.

3. Model the process of reviewing the list and finding similarities amongst the questions.
   - Place these key questions on the concept map poster, modeling how to put similar questions near each other on the poster. Circle these to signify that these are questions, not content knowledge.

4. Ask students to look at the key questions and see if any of the questions are connected: Would answering one question lead to one of the other questions? Model making these connections by drawing arrows between the circles.

5. In this Lift-Off task, students will only be drafting possible answers to the questions, not actually gathering and recording learned concepts. However, throughout the unit, they will be adding content they have learned. Model this by recording a student's prior knowledge to one of the questions, using boxes to signify that these are pieces of content knowledge rather than questions.
   - Use connector words to identify the relationships between the content boxes (See image above for an example).

6. Optional: To emphasize crosscutting concepts using a concept map, make a key of different colors for the crosscutting concepts emphasized in this unit. Identify questions that clearly show evidence of the different crosscutting concepts and circle them with the corresponding colors. Explain to students how you made that choice by pointing out the language that hints at that crosscutting concept. *Note: not all boxes and circles will necessarily have a crosscutting concept.

Part C

1. Construct a whole-class concept map that begins to help students to make sense of the phenomenon of The Changing Peppered Moth.
    - Start with the phenomenon in the middle.
    - Then ask students to share out the questions that were most common across all the posters in the classroom. As you record questions on the poster, organize them based on connections you see. Draw circles around each question (as you add to the concept map throughout the unit, you'll also be adding concepts learned, which can be written in boxes to distinguish them from the questions).
    - Ask students to identify any connections they see between the questions and record these as lines between the questions.
        - Recommended: Give pairs of students think time to come up with 1-2 connections to add to the class concept map and call on pairs using equity sticks. This encourages more equitable participation in a class-wide activity.
    - 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.
    - This whole class concept map will be revisited at the end of each task, asking students questions like: Are there any new questions you have about the phenomenon? Are there any connections you want to add or change? What is your reason for that addition/revision? Are there more connections we can make between the questions/ideas already on the map? Do you want to add any new ideas/concepts to the map?

2. Because this concept map will be added to and revised throughout the unit, here are some practical options for implementation.
    - If you have access to white board paper, we encourage you to use these for class posters since it will allow you and your students to make revisions throughout the unit.
    - Another option is to use smaller pieces of paper for each class and project using a document camera; this will save space as opposed to doing large class posters.
    - We highly recommend students keep their own version of this concept map in their notebooks, adding questions and concepts as they go through the unit.

3. Once the draft concept map is complete, introduce students to the crosscutting concepts for this unit. We recommend posting posters of each crosscutting concept in your classroom (See beginning of teacher guide for templates).
    - The crosscutting concepts for this unit are: Patterns, Cause and Effect, Scale, Proportion, and Quantity, Structure and Function, and Stability and Change. Assign a color for each crosscutting concept that can be used throughout the unit.
    - Have students analyze the class concept map for as many examples of the crosscutting concepts as they can find. Depending on the questions they have, they may be able to find an example of each of the crosscutting concepts or perhaps just some.

- We recommend modeling this process by picking a question, identifying the crosscutting concept, and tracing the circle in the corresponding color. Explain the key words that helped you identify the crosscutting concept in this question. Some identifying words that students might look for are:
    - **Patterns**: These could be phrases such as, “has in common with” “shares,” “is also shown in,” “is the same as,” “looks the same as,” etc.
    - **Cause and Effect:** These could be phrases such as, “which results in,” “which causes,” “that explains why,” “is due to,” etc.
    - **Scale, Proportion, and Quantity:** These could be phrases such as, “is proportional to,”“compared to,” “has a ratio of,” “is bigger/smaller than,” “is longer/shorter than,” etc.
    - **Structure and Function**: These could be phrases such as, “which shape affects”, “and its function comes from,” “which structure leads to,” etc.
    - **Stability and Change**: These could be phrases such as, “remains the same”, “is changed by”, “is disrupted by”, “changes”, “disrupts,” etc.

Connecting to the Culminating Project

1. Hand out the Culminating Project Task Card and read aloud the Challenge and Group Project Criteria for Success.
    - Take questions for clarification.
    - Optional: You may want to show a video to spark student interest. The following link is one option: https://www.youtube.com/watch?v=QwLyscT3NgI (Show until 0:38).

2. Pass out their Project Organizer and explain that they will complete a section of this after each task in class. Students independently complete the Lift-Off Task section of the Project Organizer in class. Revisions can be done for homework, depending upon student’s needs and/or class scheduling.
    - Students have been tasked with arguing whether humans should intervene on the behalf of threatened species of organisms or let nature take its course. The student prompt is as follows:
        - Select and research a species affected by a change in their environment that is caused by humans.
        - Describe the change in the environment and its effect on this species.
    - Optional: You may want to show the following TedEd video to help set the context for the culminating project: https://www.youtube.com/watch?v=ZCKRjP_DMII (Stop at 3:56) This video shows examples of species that are affected by climate change but surviving. Be sure to emphasize that there are also species that will likely not survive climate change.
    - Optional resource: https://www.smithsonianmag.com/science-nature/ten-species-are-evolving-due-changing-climate-180953133/. This may serve as a jump-off point for students to begin their research about threatened/endangered organisms.

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 made a list of all the questions you have about what happened to the Peppered Moth. Look back at your list: think about the questions your peers asked that

you did not initially write down. How are their questions different from the ones you originally asked?

- In this unit, we will be focusing on five crosscutting concepts:
  - **Patterns**: Patterns can be used to identify cause-and-effect relationships;
  - **Cause and Effect**: Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability;
  - **Scale, Proportion, and Quantity**: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small;
  - **Structure and Function:** Models can be used to describe how function depends on the structure;
  - **Stability and Change:** Stability might be interrupted by sudden events or gradual changes that accumulate over time.

  Looking at your class concept map, give one example of how one of the crosscutting concepts came up in today's task.
- Now that you understand a little more about the project that you'll be working on over the course of this unit, what else do you need to know? What additional questions do you have?

2. 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 to their list 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.

8th Grade Science Unit 3: Adapt or Die?

Task 1: The Fossil Record and Geologic Time Scale

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

Introduction

In the last task, students saw how a species can change over time, using the specific example of Peppered Moths. In this task, they take a step back by looking at what evidence we have that species have changed over Earth's long history. In order to do this, they explore the fossil record and how scientists have organized Earth's 4.6 billion-year-old history into the geologic time scale. This will serve as the foundation for them to think about how the kinds of environmental changes that are happening now have happened in the past. Students will find that we can learn from the fossil record and past incidents of environmental change to predict how current environmental change caused by humans might affect species in our world.

Alignment Table

Performance Expectations	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. [Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.] [*Assessment*	**Constructing Explanations and Designing Solutions** • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**ESS1.C: The History of Planet Earth** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.	**Scale, Proportion, and Quantity** ▪ Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

8th Grade Science Unit 3: Adapt or Die?

Task 1: The Fossil Record and Geologic Time Scale

Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them.]			
MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. [Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.]	**Analyzing and Interpreting Data** ▪ Analyze and interpret data to determine similarities and differences in findings.	**LS4.A: Evidence of Common Ancestry and Diversity** • The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.	**Patterns** • Graphs, charts, and images can be used to identify patterns in data. • Patterns can be used to identify cause and effect relationships. (*Supplementary)*
Supplementary Crosscutting Concepts • Stability and Change ○ Stability might be distributed either by sudden events or gradual changes that accumulate over time.			
Equity and Groupwork • Construct a shared analysis of a rock sample. • Discuss a scientific article.			
Language • Orally discuss data. • Read and annotate an article. • Write an explanation using evidence.			

8th Grade Science Unit 3: Adapt or Die?

Task 1: The Fossil Record and Geologic Time Scale

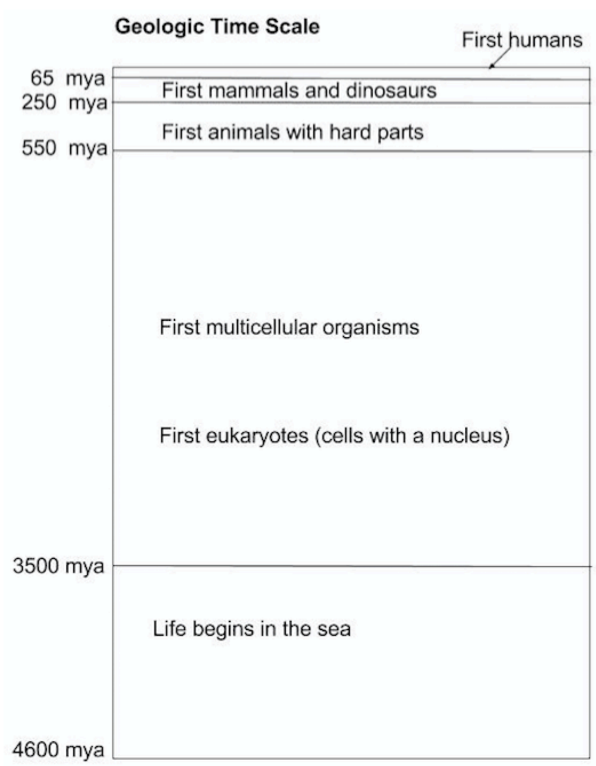
Learning Goals

This learning task explores how the fossil record can be used as evidence for how the geologic time scale organizes Earth's 4.6 billion-year-old history. More specifically, the purpose is to:

- Use a common example to engage student understanding of time scale.
- Explore a rock sample as evidence of the fossil record.
- Write a CER report explaining how the geologic time scale is used to organize Earth's history.
- Read and annotate an article linking mass extinctions and changes in the Earth's climate.
- Apply knowledge of the fossil record and geologic time scale to make a mock fossil record showing a change in species over time due to climate change and/or other environmental changes.

Content Background for Teachers

In 7^{th} grade, students experienced the history of Earth in terms of geologic processes, such as plate tectonics and the rock cycle. In this task, students revisit Earth's history, focusing in on the history of life on Earth. This requires them to build on learning experiences from previous units and courses that looked at distribution of fossils and rocks.



Geologists organize this huge time scale in a variety of ways, based on data from fossils that were found in layers of sedimentary rock. This is known as the fossil record. Each layer of rock provides a snapshot of what the world looked like when that layer was formed, including the species that were present at that time. By looking at the sequence of layers, scientists are able to develop a relative timeline showing how environmental conditions and species have changed over time. Generally, the higher layers correspond to later periods of time and lower layers correspond to earlier periods of time. It is important that students realize that the fossils in rock strata provides evidence of relative ages of rock layers but does not reveal absolute ages. Note: radioactive dating is taught at later age levels.

By looking at the fossil record, scientists have developed a geologic time scale to organize Earth's 4.6-billion-year-old history. This is very difficult for students to experience and understand since it is such a long period of time, so offering multiple ways for students to visualize such a timeline is helpful.

Academic Vocabulary

- Scale
- Geologic time scale
- Fossil record

- Diversity
- Extinction
- Stability and change
- Climate
- Species

Time Needed (Based on 45-Minute Periods)
3-5 Days
- Engage and Explore: 1-2 periods
- Explain and Elaborate: 1-2 periods
- Evaluate and Reflection: 1 period

Materials
- Unit 3, Task 1 Student Version

Explore
- Rock Sample Resource Cards (1-2 per group). Optional: laminate or put in sheet protectors

Elaborate
- Article Resource Card (1 per person)

Evaluate
- Project Organizer Handout

Instructions

Engage
1. Introduce Task 1: In the Lift-Off Task, we saw an example of a population of moths that changed 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 1: The Peppered Moths were a unique example because the change in population happened very quickly. Most changes in species take place slowly, over thousands or hundreds of thousands of years. How can we visualize such a large amount of time?
   - Now pass out their Task 1 student guide.

3. One way to think about such a large amount of time is to create a timeline broken up by important events. Have students try this out with something familiar: a timeline of their life from birth to today.
   - You may want to show your own timeline of events in your life from birth to today. You can then compare your timeline and students' timelines to show differences in scale (i.e., one year on your timeline will be relatively shorter than the students).

4. In pairs, have students imagine that the timeline on their student guide represents their life, including big milestones from birth to today (we recommend that students pick 10 important events in their life). Have students brainstorm how they might break up this timeline with important events and how the resulting periods would be described. They should answer the questions on their student guide to guide them through this process.
    - This exercise helps students to familiarize them with the process of creating a time scale, similar to the way scientists create the geologic time scale. In doing so, students are engaging with the crosscutting concept of **Scale, Proportion, and Quantity**, as they create a scaled model that shows significant life events and the time between those events.
    - This activity also emphasizes the crosscutting concept of **Stability and Change**, as students observe periods of their life that are relatively stable, periods that show gradual change, and periods that experience sudden events.

5. Optional: Share out a few timelines. 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 connects the student timeline to scientific timelines to help them explore the science content in this section.
    - It also highlights two terms that are potentially new to students—**fossil record** and **geologic time scale**—so we recommend reviewing these first.

2. Introduce the students to the geologic time scale pictured on the student guide, discussing the type of details annotated on the image.

3. Assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Materials Manager, Facilitator, Reporter, Harmonizer.
    - Ask Facilitator to read the directions and to make sure everyone understands the task.
    - Ask the Materials Manager to gather any materials needed to complete the task.
    - Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone's voice is heard.
    - Ask the Reporter to make sure each person in the group is recording their analysis in the student guides.

4. Pass out the Rock Sample resource card to each group (We recommend providing 1-2 copies so students collaborate and share ideas). In this section of the task, groups analyze the rock sample and compare it with the geologic time scale.
    - This gives students an opportunity to engage with the science and engineering practice of **Analyzing and Interpreting Data**, specifically asking students to determine similarities and differences in fossils between the different layers.

5. As students complete the questions to help them analyze the rock sample, they will be emphasizing the three different crosscutting concepts described below:

- **Stability and Change**: Students find examples of species that have remained stable over multiple time periods while others have gradually changed over time. Students should also observe that certain components in the soil and the disappearance of species in the fossil record may illustrate sudden changes in stability.
- **Patterns:** Students use images of a rock sample and the geologic time scale to identify patterns in the data, specifically patterns of extinction.
- **Scale, Proportion, and Quantity:** Using the same scale, students place the rock sample within the correct portion of the geologic time scale.

6. Possible responses to the questions are as follows:
    - 1a and 1b: Ammonites remain stable over the first two layers. There are some changes in species over the first two layers while others remain the same, but there appears to be a big extinction and appearance of new species between layers 2 and 3.
    - 2 and 2a: Between layers 1 and 2 and between layers 2 and 3, there are extinctions and new species arise. I think both were caused by some environmental change since the soil between the layers contains ash and iridium. Both a volcanic eruption and asteroids could lead to a big environmental change and leave those markers in the soil.
    - 3: I think this sample belongs in the top three layers because there are three layers separated by major events. In the geologic time scale, the notes about what species existed match up with the rock sample.

Explain

1. This section asks students to explain their analysis from the Explore. This CER paragraph emphasizes the crosscutting concept of **Scale, Proportion, and Quantity**, by asking students to explain how the geologic time scale is a model that helps us study Earth's 4600 million-year-old history, which is otherwise too large to visualize. They should use evidence from the rock sample and geologic time scale to help support their explanation, thus also practicing the skill of **Constructing Explanations.**
    - Facilitating questions are provided on their student guide, including:
        i. What does the geologic time scale show?
        ii. Why is it helpful?
        iii. What seem to be the rules for how the geologic time scale is broken up and organized?
    - Optional scaffold: Agree on a claim together as a class and brainstorm an example of a piece of evidence that could be used to support the claim.

Optional Sentence Stems to Provide:

Claim	The geologic time scale is a model that helps us study Earth's 4.6 billion-year-old history by…

Evidence & Reasoning	The geologic time scale is helpful because… The geologic time scale is made up of… Scientists use evidence from… For example, in the rock sample… From layer to layer, you can see.. Between the layers… _____....shows evidence of some environmental change. This matches the geologic time scale because… Analyzing the rock sample helps us understand geologic time scale because… The geologic time scale is separated according to… The geologic time scale tells us… _____…explains how the geologic time scale is organized.

Sample CER Report

Claim	The geologic time scale is a model that helps us study Earth's 4.6 billion-year-old history by separating the long history using major events.
Evidence & Reasoning	The geologic time scale is helpful because it breaks up Earth's long chunks into smaller periods that we can see. It is made up of layers, separated by major events in Earth's history. Scientists use evidence from the fossil record to decide how to organize the time scale. Analyzing the rock sample is a similar process to the way scientists made the geologic time scale. In the rock sample, there were multiple layers of soil containing different species. From layer to layer, some species disappeared while new ones reappeared. Between the layers, there were layers of soil that showed evidence of some environmental change; such as ash from a volcanic eruption or iridium from an asteroid collision. This matches the geologic time scale, which is also split into three layers at the top and has similar species. The geologic time scale thus tells us the timeline of when species disappear and new species appear.

2. 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 multiple pieces of evidence from the rock sample in their explanation. See "How to Use This Curriculum" for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

Elaborate

1. This part of the task begins to connect the content of this task to their culminating project. So far, students have explored evidence that species change over time and have begun to predict why. Scientists have engaged in the same endeavor, examining mass extinctions throughout Earth's history to try to figure out the causes behind it and the resulting effects.
    - Students may remember this from when they explored this Performance Expectation in Unit 1.

2. We recommend reading the introduction and the instructions on the student guide aloud as a class. Students will individually read and annotate the article you provide in order to learn more about past climate change and current climate change.

- We recommend instructing students to use whatever annotation strategy they are most comfortable with within your classroom.
- Optional: *Newsela* also has a geological time scale article entitled "Earth's Systems: Geological Time," which may be a helpful additional reading for students.

3. Students then answer the reading questions on their student guides as a group. Assign roles to each group. You may choose to assign students to the same roles as the Explore or switch students up within the roles. Possible responses to the questions are below:
   - 1: The author claims that incidents of climate change in the past have been linked with past extinctions.
     - Here students are using patterns in past data to identify the cause-and-effect relationship between changes in climate and extinction, thus emphasizing the crosscutting concept of **Patterns.**
   - 2: He uses the Permian extinction and the end of Ordovician period as evidence. In the Permian extinction, there were high temperatures. At the end of the Ordovician period, it was a cooling period.
   - 3: This article implies that since climate is currently drastically changing, we may be headed towards another mass extinction.

4. Optional: Share out students' responses to the article in a class-wide discussion, using equity sticks for a more equitable discussion. Make explicit connections to how this inspires their culminating project.

5. 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 geologic time scale, the fossil record, the connection between climate and mass extinctions.
   - 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:
     - **Patterns**: These could be phrases such as, "has in common with" "shares," "is also shown in," "is the same as," "looks the same as," etc.

    - **Scale, Proportion, and Quantity**: These could be phrases such as, "is proportional to,""compared to," "has a ratio of," "is bigger/smaller than," "is longer/shorter than," etc.
    - **Stability and Change**: These could be phrases such as, "is changed by," "is disrupted by," "changes," "disrupts," "keeps the same," 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 1 section of the Unit 3 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 endangered or threatened species or let nature take its course. Their prompt is as follows:
   Think about the species your group chose.
   - Draw a pretend fossil record showing how the species has changed over time.
   - How might the fossil record in the last 50 years show the species changing over time?
   - Given how our planet is changing, predict what future layers might look like?

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 draw a timeline of your life from birth to now. Look back at your timeline: after collecting all the evidence today, what additional similarities do you see between this timeline and the geologic time scale? What differences do you see in these two time scales? Use evidence from the two time scales to justify your response below.
   - In this task, we focused on the crosscutting concepts of:
     - **Patterns:** Graphs, charts, and images can be used to identify patterns in data.
     - **Scale, Proportion, and Quantity***:* Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
     - **Stability and Change**: Stability might be distributed either by sudden events or gradual changes that accumulate over time.

     Where did you see examples of **Patterns**; **Scale, Proportion and Quantity;** or **Stability and Change** in this task?
   - Now that you have learned more about how we know that species have changed over time, what questions do you still have?

2. 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 to their ideas and questions based on what they have learned through this task. By generating more of

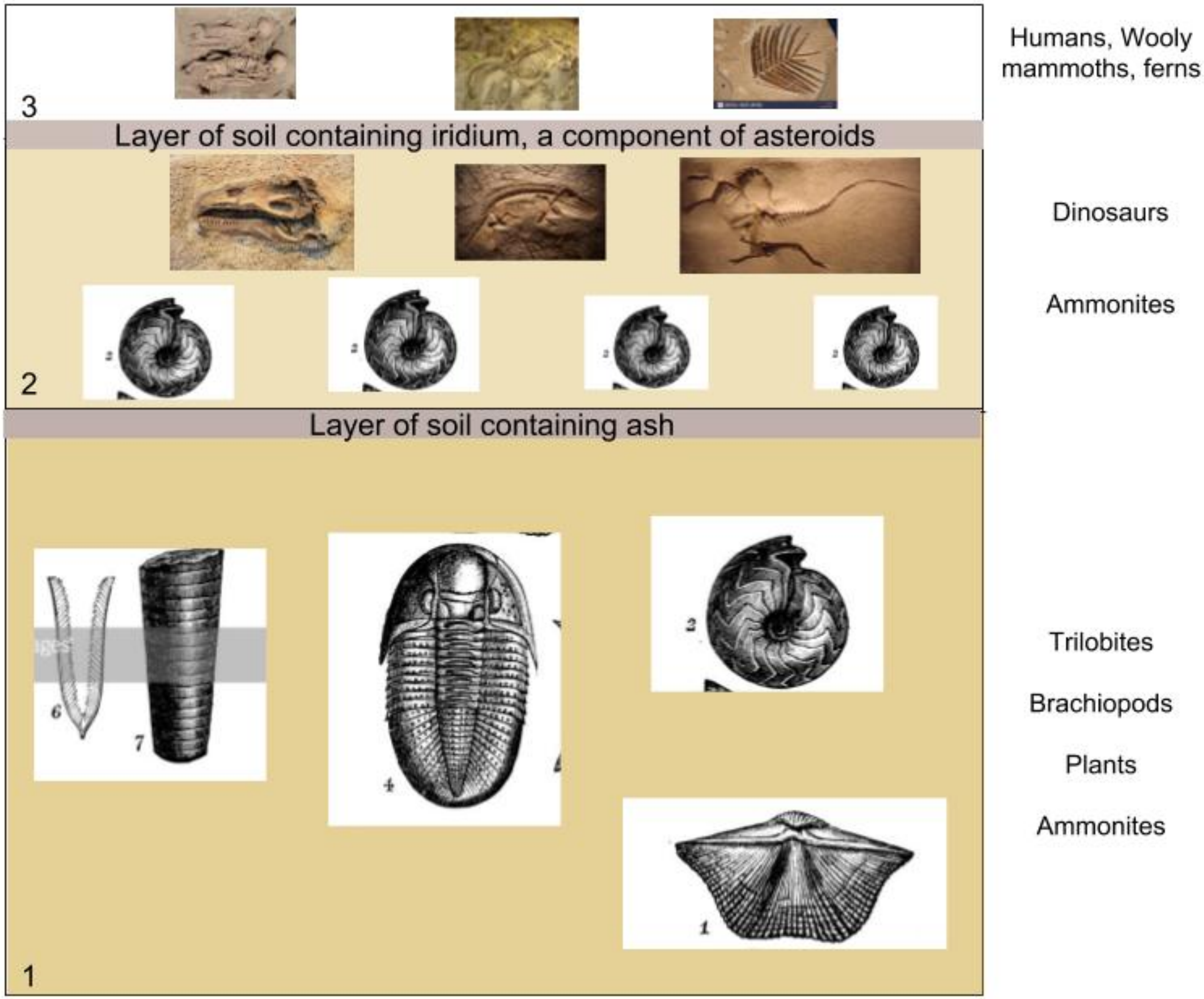
their own questions, students continue to engage in sense-making of the phenomenon and gathering knowledge and skills for their final projects.

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.

Rock Sample


3
Humans, Wooly mammoths, ferns
Layer of soil containing iridium, a component of asteroids
Dinosaurs
Ammonites
2
Layer of soil containing ash
Trilobites
Brachiopods
Plants
Ammonites
1

Mass Extinctions Tied to Past Climate Changes

(Adapted from a Scientific American article by Davied Biello, 10/24/07)

Fossil and temperature records over the past 520 million years show a correlation between extinctions and climate change.

Roughly 251 million years ago, an estimated 70 percent of land plants and animals died, along with 84 percent of ocean organisms—an event known as the end Permian extinction. The cause is unknown but it is known that this period was also an extremely warm one. A new analysis of the temperature and fossil records over the past 520 million years reveals a common connection: global warming is consistently associated with planetwide die-offs.

Ecologist Peter Mayhew of the University of York in England led the research examining the fossil and temperature records. He says, "The fossil record and temperature data sets already existed but nobody had looked at the relationships between them."

He looked at the relative number of different shallow sea organisms still in existence during a given time period and the record of temperature of that time period. This revealed that eras with relatively high concentrations of greenhouse gases bode ill for the number of species on Earth. "The rule appears to be that greenhouse worlds negatively affect biodiversity," Mayhew says.

This paints a scary picture for the fate of species currently on Earth. As the global temperatures continue to rise to levels similar to those seen during the Permian, many species are at risk. "The risk of future extinction through rapid global warming is expected," notes Mayhew and his colleagues write in *Proceedings of the Royal Society B: Biological Sciences.*

That is not to say that global warming was the cause of this Permian wipeout or that all mass extinctions are associated with warmer worlds. For example, 60 percent of marine organisms disappeared during the cooling at the end of the Ordovician period roughly 430 million years ago. But these scientists argue that the evidence of a link between any type of climate change and mass extinctions gives reason to be concerned for the future. "We need to know the mechanism behind the associations," Mayhew says. "That will help us decide if this is really a worry for the next generation or if the threat is merely a distant future threat."

8th Grade Science Unit 3: Adapt or Die?

Task 2: Evidence of Change Over Time

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

Introduction

So far, students have begun to think about why organisms might change over time and have explored some evidence of organisms changing over time. In the last task, students looked at the fossil record to begin their reconstruction of evolutionary history. In this task, they take this a step further by looking at two more kinds of evidence that scientists use to infer lines of evolutionary descent. By looking at anatomical structures and embryos of different species students will begin to see how these pieces of evidence might be used to infer evolutionary relationships. By the end of this task, students will be able to construct an explanation for how scientists are able to reconstruct evolutionary history, using these examples as evidence to support their explanation. This adds another layer to the story students are constructing about how species change over time, thus better preparing them for their Think Tank Discussion. Note: The performance expectations for this task will not be included in the Culminating Project; rubrics are provided at the end of this document to assess students' tasks.

Alignment Table

Performance Expectations	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. [Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.]	**Constructing Explanations** • Apply scientific ideas to construct an explanation for real world phenomenon, examples, or events.	**LS4.A: Evidence of Common Ancestry and Diversity** • Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.	**Patterns** • Patterns can be used to identify cause-and-effect relationships.
MS-LS4-3. Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not	**Analyzing and Interpreting Data** • Analyze displays of data to identify linear and nonlinear relationships.	**LS4.A: Evidence of Common Ancestry and Diversity** • Comparison of the embryological development of	**Patterns** • Graphs, charts, and images can be used to identify patterns in data.

evident in the fully formed anatomy. [Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.] [Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.]		different species also reveals similarities that show relationships not evident in the fully-formed anatomy.	
Equity and Groupwork • Discuss data in groups			
Language • Orally discuss data • Interpret pictorial data and record as written data analysis • Write a CER paragraph			

Learning Goals

This learning task explores the embryological and anatomical data that can be used as evidence for common ancestry. More specifically, the purpose is to:

- Predict which pair of species is more closely related.
- Analyze embryological and anatomical evidence for patterns in data.
- Write a CER paragraph explaining how this data can be used to reconstruct evolutionary history.
- Use patterns from the data to explain two organisms that are not related but have similar functions.
- Apply knowledge of common ancestry to add to a mock fossil record.

Content Background for Teachers

There are many sources of evidence for evolution, but this unit focuses on the macroscopic rather than the molecular level. At the macroscopic level, we can analyze the anatomical structures as well as the embryological development of different species in order to draw conclusions about which species are closely related and which ones are not. This will help students complete their picture of how species have changed over time by looking at species that may have come from a common ancestor but evolved differently over time.

Students examine multiple sources of evidence comparing anatomical structures and embryological development. One of the most common examples of anatomical evidence is to look at the underlying bone structures that allow humans to throw, bats to fly, whales to swim, frogs to jump, and lizards to run. Students will recognize that even though all of these species use this appendage for very different functions, they will see a pattern of similarity in bone structure, including the number of bones and their relative position. All of these appendages have a single upper bone (Humerus) attached at a joint to two different bones (Radius and Ulna), which are then attached in the wrist area to the carpal bones and fingers. This implies that all these species descend from a distant common ancestor, but each has evolved over time due to specific environmental pressures. For other examples of anatomical evidence, please see the station cards provided to students in the Explore.

Sometimes relationships not evident in the fully-formed anatomy can be seen by comparing the embryological development of different species. Each species inherits its embryological development from its ancestors, so this would imply that species that are more closely related would have more similar embryos. Over time, natural selection modifies the embryos in different ways, causing the differences seen in related, but distinct species. The exception to this rule is vestigial structures that may remain from a common ancestor. For specific examples of embryological evidence, please see the station cards provided to students in the Explore.

Academic Vocabulary

- Embryological Development
- Anatomical structures
- Evolve
- Common Ancestor
- Evolutionary History
- Related

Time Needed (Based on 45-Minute Periods)

4 Days

- Engage: 0.5 period
- Explore: 1 period
- Explain: 1 period
- Elaborate: 0.5 period
- Evaluate and Reflection: 1 period

Materials

- Unit 3, Task 2 Student Version

Explore

- Station Cards, laminated or in sheet protectors (2 Per Station, preferably in color)

Evaluate

- Project Organizer Handout

Instructions

Engage

1. Introduce Task 2: In the last task, you looked at one source of evidence for how species change over time—the fossil record. 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 2: Scientists can also look at species today to help them understand its evolutionary history. Today you will look at two kinds of evidence that help scientists to identify which species have a common ancestor. This helps them continue to answer the question of how organisms have changed over time.
    - Now pass out their Task 2 student guide.

3. In pairs, have students look at the pairs of pictures on their student guides: a prawn and a wood louse, a dolphin and a shark. Using whatever prior knowledge they have of these species as well as what they observe in the pictures, students make a prediction about which species are more closely related. The purpose of this question is to engage whatever background knowledge students bring to this lesson. Students may be surprised by some of the comparisons.

4. There are no right answers, as these are only predictions. After students make their predictions, share out a few. The use of equity sticks is encouraged for more equitable participation (See "How To Use This Curriculum" for more details).
    - Then tell students that prawns and wood lice are actually more closely related than sharks and dolphins, despite how similar dolphins and sharks look. This will lead them into the next section.

Explore

1. We recommend reading this introduction aloud with students as a transition and to set the context for this segment of the task: As you saw in the Engage, things are not always what they seem when it comes to evolution—or the change of living organisms over time. Even though species may look alike or seem similar, they may not actually be related. To figure out which species are actually related, scientists need to use other sources of evidence—embryological development and anatomical structures. The more similar these are between species, the more likely they evolved over time from a recent common ancestor. This allows scientists to reconstruct evolutionary history.

2. Set up 6 stations around the room with the station cards associated with this task. We recommend putting at least two copies of the station card at each station, laminated or in sheet protectors. These station cards should also be in color as it is necessary for a few of the stations. Another option is to set up an iPad or computer at each station depicting a PDF of that station card in color.
    - Optional: To spread students out at more stations, you can set up duplicates of each station.

3. Assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Materials Manager, Facilitator, Reporter, Harmonizer.
    - Ask Facilitator to read the directions and to make sure everyone understands the task and what the directions are asking.
    - Ask the Materials Manager to be responsible for the materials needed to complete the task, by reading information/questions from the station cards aloud.
    - Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone's voice is heard.
    - Ask the Reporter to make sure everyone is recording their data.

4. In groups, students visit the stations around the room, analyzing different pieces of embryological and anatomical evidence. We recommend you encourage them to use the guiding questions on the station cards to help them with their analysis.
    - Optional: Model how to analyze a station card as a whole group, so students understand the process. We recommend using Station 4, since this is the most complex resource.
    - Students should take notes in the data collection table, which will help them look for patterns in the data. This emphasizes the science and engineering practice of **Analyzing and Interpreting Data** and the crosscutting concept of **Patterns** as students analyze displays of pictorial data to identify patterns in data and then use these patterns to identify cause-and-effect relationships (common ancestor resulting in similarities in embryological and/or anatomical structures).
    - Optional: You may want students to split the third column into a T chart with "similarities" and "differences" on each side. This may guide their search for patterns in the data.

2. The students' data table should be collected and assessed using a rubric at the end of this task. A sample data collection table is shown below:

Station #	Embryological or Anatomical Evidence?	Use the images to identify patterns in the data: What similarities and differences are there?	What does this information tell you about how organisms are related?
1	*Embryological*	• *The organisms start to develop differently after Stage C.* • *The bat and mouse look the most similar in the later stages of development.*	*The bat and mouse are likely more closely related than the turtle and the bat or the turtle and the mouse.*
2	*Anatomical*	• *As you go back in time, the horse-like organisms have more bones in the front limb, which are smaller. This is a gradual process.* • *The Pilohippus is the first horse-like organism to not have the finger-like bones.*	*It is likely that all these organisms are related. The Hycracoterium is the oldest ancestor and over time, that species evolved into species with less toes and larger toes.*
3	*Embryological*	• *At this stage of development the fish and salamander seem the most similar and the chicken, rabbit, and human seem the most similar.* • *The rabbit and human seem to have the most similar features at this stage.*	*The rabbit and human are likely the most closely related by a common ancestor. The human and the fish are likely the most distantly related.*

4	*Anatomical*	• *Most of the bivalves have the same organs present.* • *The scallop and oyster both have a large central muscle in the middle, unlike the others that have them at the ends.* • *The mussel and ark clam are the only ones with attaching threads.*	*These are all likely related, but some seem more related than others. The scallop and oyster seem closely related, but more distantly related from the mussels and ark clams.*
5	*Anatomical*	• *All of these have the same types of bones (radius, ulna, humerus, wrist bones, finger bones) connected in the same way.* • *The bones are different sizes.*	*This implies that all of these organisms are related, even though they use these appendages differently.*
6	*Embryological*	• *Major differences don't seem to start until the third row.* • *The amphibian seems the most different in shape.* • *Monkey and human are most similar in latest stage of development.*	*The monkey and human are likely the closest related, and the amphibian is the most distant.*

Explain

1. Using the evidence they have collected in the stations, students will now individually write a paragraph to answer the following question: What do similarities and differences in anatomical structures and embryological development tell us about the relationships between organisms?
    - This asks students to use the science and engineering practice of **Constructing Explanations** as they apply scientific ideas about anatomical structures and embryology to explain the inference of evolutionary relationships**.**
    - Optional scaffold: Model the process by collectively constructing a claim together as a class and identify one example of evidence that can be used to back up that claim.

Optional Sentence Stems to Provide:

Claim	Analyzing anatomical structures and embryological development of different organisms can tell us…
What is the evidence and how does it support your claim?	In the stations showing embryological data… In the stations showing anatomical evidence… For example, in station…. This is because… This means that…

Sample Paragraph

Claim	Analyzing the anatomical structures and embryological development of different organisms can tell us which organisms are more closely related and which are more distantly related.
What is the evidence and how does it support your claim?	In the stations showing embryological data, the embryos that looked more similar at later stages in development were from more closely related organisms. For example, in station 6, the monkey and human embryos looked much more similar than the human and amphibian embryos in the late fetal stage. This means that humans and monkeys have a more recent common ancestor. In the stations showing anatomical evidence, having structures in common implies organisms are related. For example, in station 5, all 4 organisms had the same bones joined in the same way. Even though they have different functions, these organisms are related.

2. Optional peer review: Have table partners switch CER reports and make suggestions for revisions.
    - This should be collected and assessed using a rubric at the end of this task.

Elaborate

1. So far, students have looked at a lot of evidence showing organisms that are related. Here students use the knowledge they have gained to confront an opposite situation. Bats and butterflies are not related by a common ancestor, and yet both are able to fly.

2. In pairs, students think about this scenario with a partner and discuss the questions that follow.
    - The first question asks them to use patterns from their data to think about what the opposite might look like. How would the embryological development and anatomical structures of bats and butterflies look if they are *not* related? Most students will write that the structures will look very different anatomically and in the embryos.
    - The second question asks them to propose a possible reason why they still have a similarity in function even though they are not related. Answers will vary, but students should use their prior knowledge to think about how environmental pressures may have led to both of these species evolving to have the trait of flight.

3. Optional: Share out a few responses to the questions class-wide and engage in some debate about why students made their various predictions. Again, the use of equity sticks is encouraged.

4. 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: evolutionary relationships between organisms, anatomical structural evidence, and embryological evidence.
  - 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:
    - **Patterns**: These could be phrases such as, "has in common with" "shares," "is also shown in," "is the same as," "looks the same as," 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 2 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: Look back at the fossil record you created after Task 1.
   - Draw in a pretend common ancestor at the beginning of your fossil record and a pretend modern species also related to this common ancestor.
   - What similar anatomy or embryological development might your organism have with this related species?

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 guess which pair of organisms is more closely related. Look back at your prediction: after collecting all the evidence today, how would you change your prediction or add to your reasoning? Use evidence from the task to justify your response and record below.
   - In this task, we focused on the crosscutting concept of:
     - **Patterns:** Patterns can be used to identify cause-and-effect relationships and/or graphs, charts, and images can be used to identify patterns.

     Where did you see examples of **Patterns** in this task?
   - Now that you have learned more about how scientists can identify how species may be related, what questions do you still have?

2. 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.

3. Collect Task 2 Student Version and assess the *Explore* and *Explain* using:
    - 3-Dimensional Task 2 Rubrics, below

8th Grade Science Unit 3: Adapt or Die?

Task 2: Evidence of Change Over Time

Overview: The following rubrics can be used to assess the relevant Performance Expectations for Task 2. Each rubric is aligned to the Explore or Explain sections of this task. *If student provides no assessable evidence (e.g., "I don't know" or leaves answer blank), then that student response cannot be evaluated using the rubric and should be scored as a zero.

Below we provide an alignment table that details the dimensions assessed for each criterion.

	Part of Task to Assess	Disciplinary Core Idea	Science and Engineering Practice	Crosscutting Concept
1	**Explore**: Data Table, Station 1 and Station 5 ○ Use the images to identify patterns in the data: What similarities and differences are there? ○ What does this information tell you about how species are related?	**LS4.A: Evidence of Common Ancestry and Diversity** • Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.	**Analyzing and Interpreting Data** • Analyze displays of data to identify linear and nonlinear relationships.	**Patterns** • Graphs, charts, and images can be used to identify patterns in data.
2	**Explain**: Individually write a paragraph to answer the following question: What do similarities and differences in anatomical structures and embryological development tell us about the relationships between organisms? Use evidence from the stations to help support your explanation.	**LS4.A: Evidence of Common Ancestry and Diversity** • Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.	**Constructing Explanations** • Apply scientific ideas to construct an explanation for real world phenomenon, examples, or events.	**Patterns** Patterns can be used to identify cause-and-effect relationships.

8th Grade Science Unit 3: Adapt or Die?

Task 2: Evidence of Change Over Time

Task 2 Rubric 1: Student writes analysis of pictorial data of embryological development and anatomical structures across multiple species and uses patterns in the data to identify relationships.

- Dimensions Assessed: DCI – LS4.A. Evidence of Common Ancestry and Diversity; CCC – Patterns, SEP – Analyzing and Interpreting Data

Emerging (1)	Developing (2)	Approaching – Proficient (3)	Advanced (4)
Student writes **inaccurate** analysis of pictorial data of embryological development and/or anatomical structures across multiple species, and **inaccurately** identifies relationships.	Student writes **relevant** analysis of pictorial data of embryological development and anatomical structures across multiple species, but **does not use** patterns in the data to **accurately** identify relationships.	Student writes **relevant** analysis of pictorial data of embryological development **OR** anatomical structures across multiple species and uses **relevant** patterns in the data to **accurately** identify relationships.	Student writes **relevant** analysis of pictorial data of embryological development and anatomical structures across multiple species and uses **relevant** patterns in the data to **accurately** identify relationships.
Look Fors: ● In column 3 of their data table, student's analysis is inaccurate. For example, in station 5, a student may write, "All of these organisms have different bones." ● In column 4 of their data table, student identifies an inaccurate relationship between organisms, either not related to patterns or related to inaccurate patterns. For example, in station 5, "All these organisms are different and not related."	**Look Fors:** ● In column 3 of their data table, student's analysis notes observations of the data, but does not identify patterns. For example, in station 1, a student may write, "The turtle embryo has a curved shape." ● In column 4 of their data table, student identifies an accurate relationship between organisms, but it is not related to a pattern, which they should have noted in column 3. For example, in station 1, "The bat and mouse are likely more closely related than the turtle and the bat or the turtle and the mouse." This may be true, but is not backed up by a pattern in the data. ● This may be done with one or both of the Station rows being assessed.	**Look Fors:** ● In column 3 of their data table, student's analysis notes relevant patterns of similarity and/or differences between organisms. For example, in station 5, a student may write, "All of these organisms have the same types of bones connected in the same way (ulna, radius, humerus, wrist bones, and finger bones." ● In column 4 of their data table, student identifies an accurate relationship between organisms that is related to a pattern they noted (see previous bullet). For example, in station 5, "This implies that all of these organisms are related, even though they might use these appendages differently." ● Unlike an Advanced response, this would only be done for either embryological (Station 1) or anatomical (Station 5) evidence, but not both.	**Look Fors:** ● In column 3 of their data table, student's analysis notes relevant patterns of similarity and/or differences between organisms. For example, in station 1, a student may write, "All organisms start to develop differences after Stage C. The bat and mouse look most similar at later stages of development." ● In column 4 of their data table, student identifies an accurate relationship between organisms that is related to a pattern they noted (see previous bullet). For example, in station 1, "The bat and mouse are likely more closely related than the turtle and the bat or the turtle and the mouse."

8th Grade Science Unit 3: Adapt or Die?

Task 2: Evidence of Change Over Time

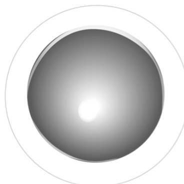
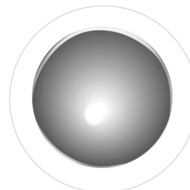
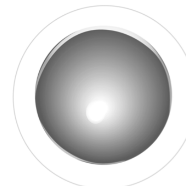
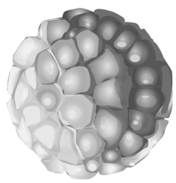
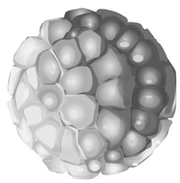
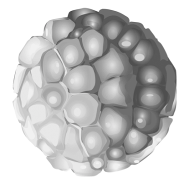
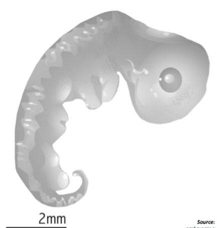
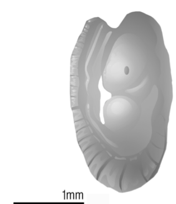
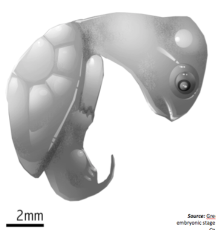
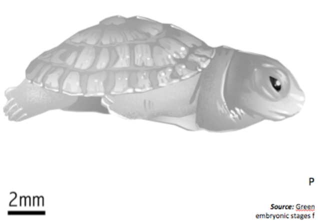
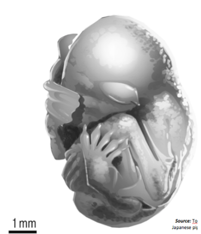
Task 2 Rubric 2: Student writes a claim explaining how similarities and differences in anatomical structures and embryological development help us infer evolutionary relationships, using patterns in data to explain these relationships.

- Dimensions Assessed: DCI – LS4.A. Evidence of Common Ancestry and Diversity; CCC – Patterns, SEP – Constructing Explanations Using Evidence

Emerging (1)	Developing (2)	Approaching – Proficient (3)	Advanced (4)
Student writes an **inaccurate** claim explaining how similarities and differences in anatomical structures and embryological development help us infer evolutionary relationships.	Student writes an **accurate** claim explaining how similarities and differences in anatomical structures and embryological development help us infer evolutionary relationships, using **no** patterns in data to explain these relationships.	Student writes an accurate claim explaining how similarities and differences in anatomical structures and embryological development help us infer evolutionary relationships, using **multiple patterns in data** to **generally** explain these relationships.	Student writes an accurate claim explaining how similarities and differences in anatomical structures and embryological development help us infer evolutionary relationships, using multiple patterns in data to **explicitly** explain these relationships.
Look Fors: • Student claim is inaccurate. For example, "Similarities and differences in anatomical structures and embryological development tell us that organisms are part of the same species." • Any evidence that is given will not match the claim.	**Look Fors:** • Student claim is accurate, referencing how these can serve as evidence of evolutionary relationships. For an example, see first bullet in Advanced Look-Fors. • Student states general rules, but does not cite evidence. For example, "Embryos that look more similar at later stages in development are from more closely related organisms. Also, having anatomical structures in common implies organisms are related."	**Look Fors:** • Student claim is accurate, referencing how these can serve as evidence of evolutionary relationships. For an example, see first bullet in Advanced Look-Fors. • Student uses multiple patterns in data from the station cards. For example, "In station 5, all 4 organisms had the same bones joined in the same way." Students would cite at least one more source of evidence, at least one for embryological. • Student then makes a general connection between the data and the claim. For example, "the more similar structures or embryos are, the more closely related they are."	**Look Fors:** • Student claim is accurate, referencing how these can serve as evidence of evolutionary relationships. For example, "Analyzing the anatomical structures and embryological development of different organisms can tell us which organisms are more closely related and which are more distantly related." • Student uses multiple patterns in data from the station cards. For example, "In station 6, the monkey and human embryos looked much more similar than the human and amphibian embryos in the late fetal stage." • Student then explicitly connects evidence to the claim. For example, "This means that humans and monkeys have a more recent common ancestor." • Students should do this for at least one more source of evidence, and at least one should be anatomical evidence.

Station 1

The table that follows shows images of different animals at similar stages of embryological development.

	Turtle	Bat	Mouse
Stage A			
Stage B			
Stage C			 G
Stage D			 I
Stage E			 J

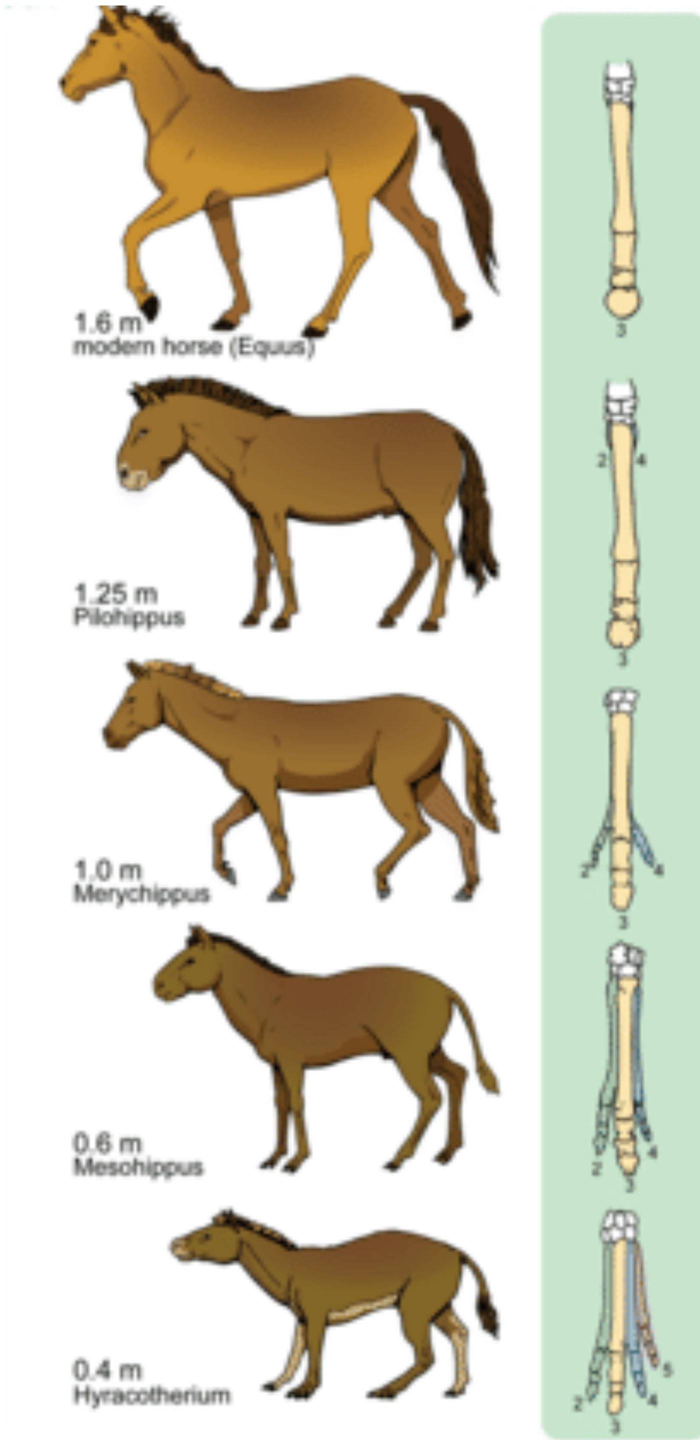
Guiding Questions

1. At what stage(s) do you notice the various organisms begin to develop different parts?
2. Which organisms have the most similar pattern of development?
3. What does this information tell you about how organisms are related?

Station 2

The image below shows the modern horse and other similar-looking organisms throughout Earth's history. The column on the right shows the anatomy of each organism's front limb.

Most Recent



Oldest

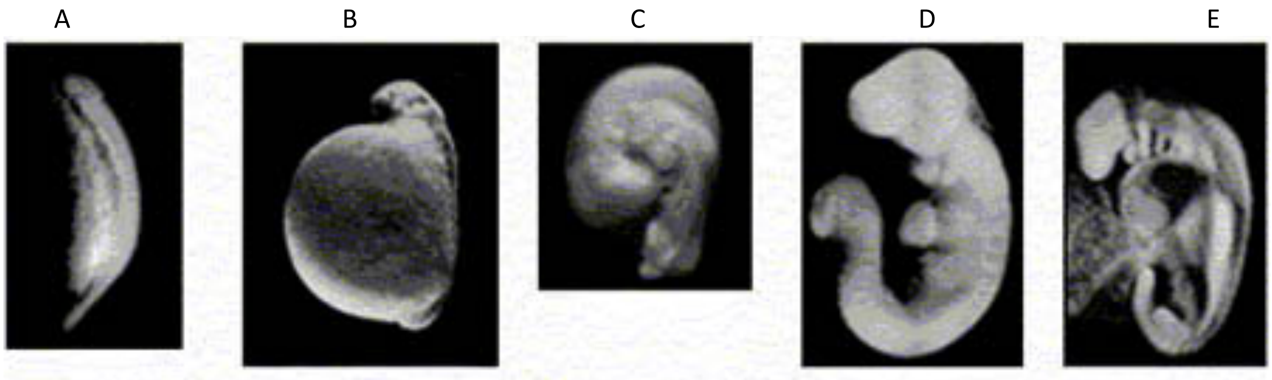
https://www.ck12.org/section/Evidence-for-Evolution-::of::-The-Theory-of-Evolution/

<u>Guiding Questions</u>

1. How many toes do modern horses have? How does this differ from other species in Earth's history?
2. What trends do you notice about the number and size of toe bones over time?
3. What does this information tell you about how organisms are related?

Station 3

The images below show the embryos of different organisms at one stage in development.



http://www.citruscollege.edu/lc/archive/biology/Pages/Chapter17-Rabitoy.aspx

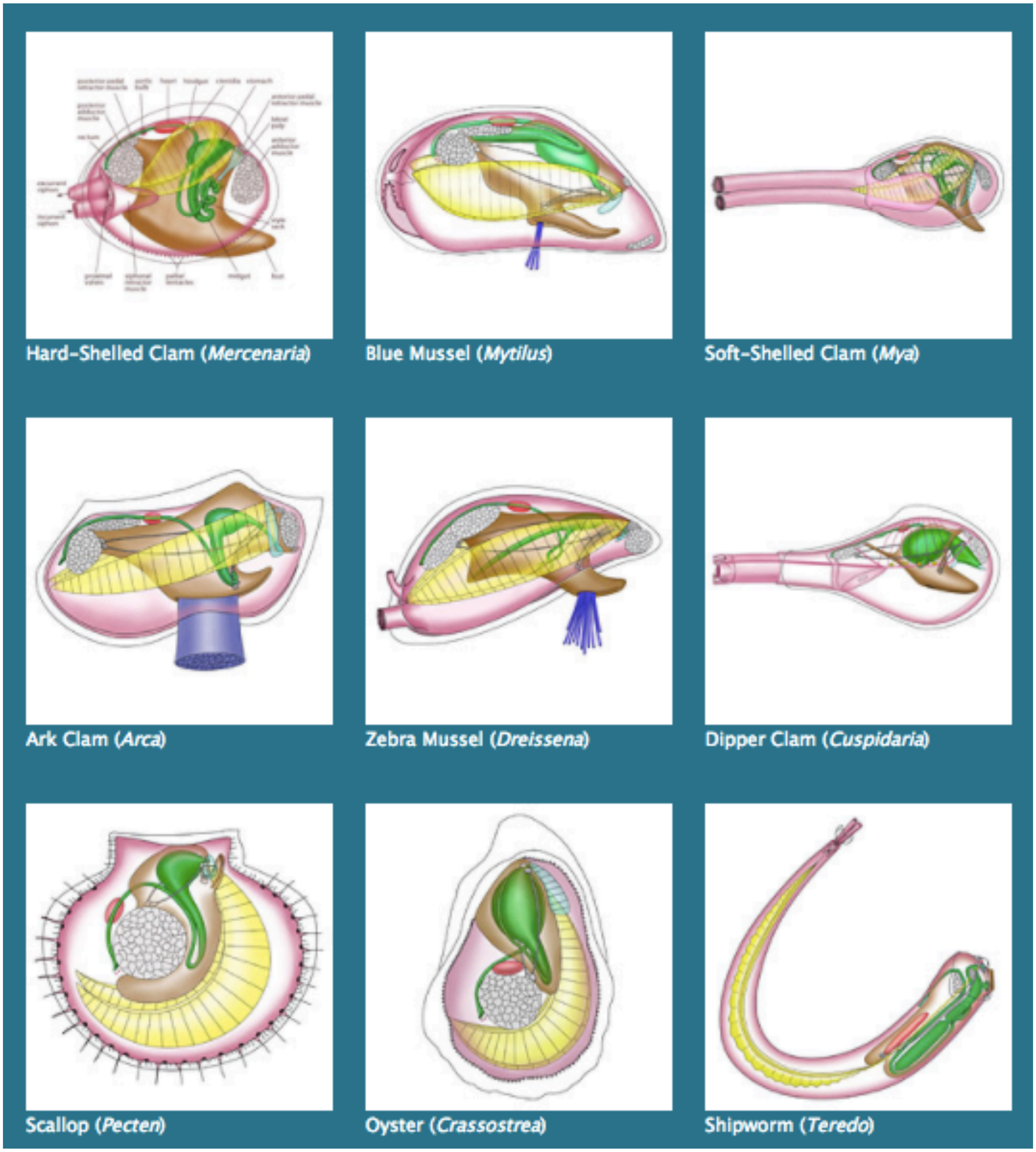
<u>Guiding Questions</u>

1. Which organisms seem to be most similar at this stage of embryological development? Most different?
    a. Turn this paper upside down and look at the key at the bottom of the page. Now that you know what organism is shown in each picture, did any of this surprise you?
2. What does this information tell you about how organisms are related?

A – Fish, B – Salamander, C – Chicken, D – Rabbit, E - Human

Station 4

The images below show the anatomical structures of 9 different organisms, which are all known as bivalves. They are color-coded to help you compare structures: digestive systems in green, gills in yellow, foot in brown, muscles and nervous system in gray, heart in red, attaching threads in dark blue, and shell tissue in pink.



Hard-Shelled Clam (*Mercenaria*) | Blue Mussel (*Mytilus*) | Soft-Shelled Clam (*Mya*)

Ark Clam (*Arca*) | Zebra Mussel (*Dreissena*) | Dipper Clam (*Cuspidaria*)

Scallop (*Pecten*) | Oyster (*Crassostrea*) | Shipworm (*Teredo*)

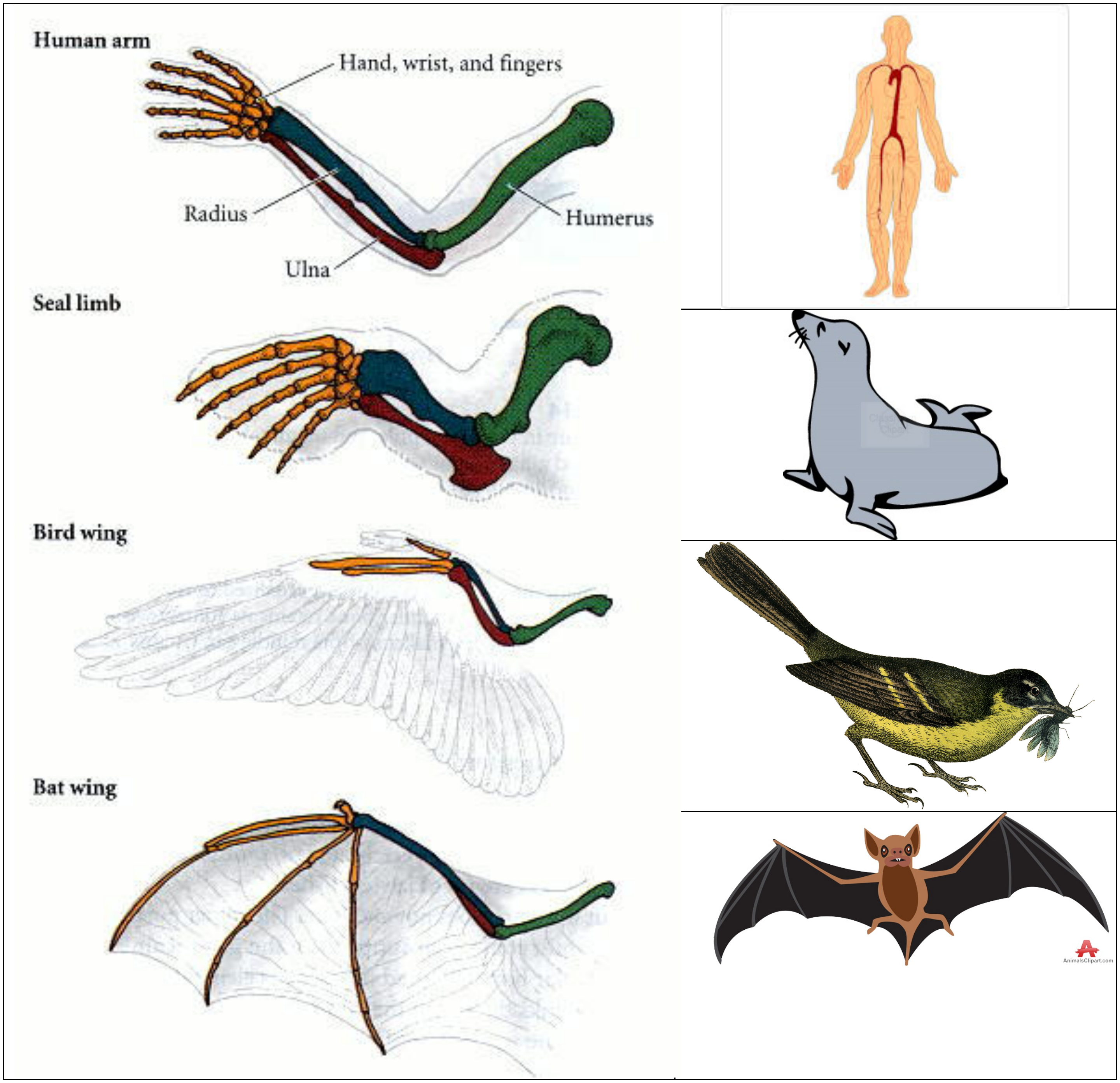
http://bivalves.teacherfriendlyguide.org/index.php?option=com_content&view=article&id=13&Itemid=135

Guiding Questions

1. Which organisms have the most similarity in anatomical structure? Most differences?
2. What does this information tell you about how organisms are related?

Station 5

The images below show the anatomical structures of a human arm, a seal forelimb, a bird wing, and a bat wing.



https://www.ncbi.nlm.nih.gov/books/NBK10049/

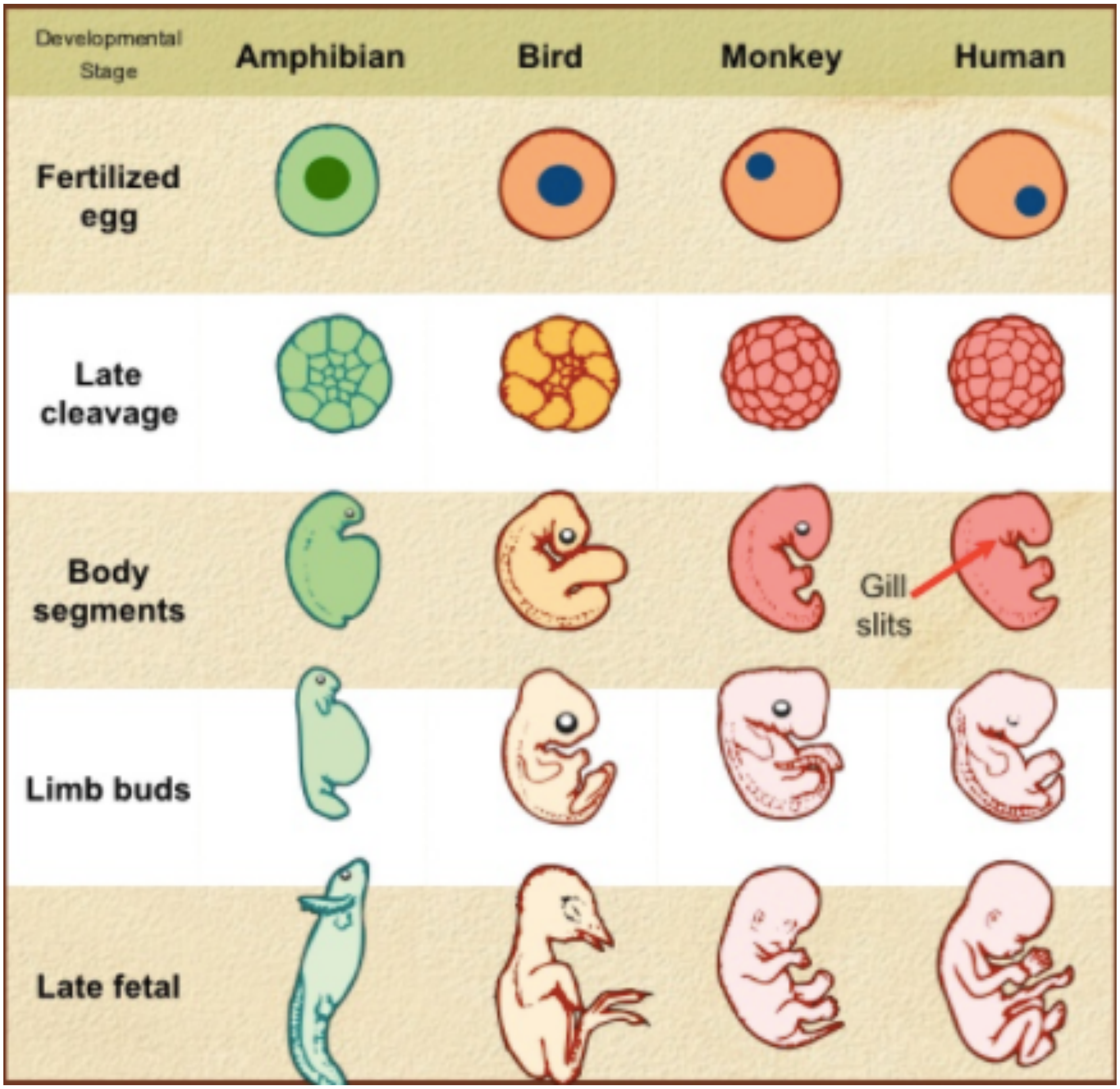
clipart.com

<u>Guiding Questions</u>

1. What similarities and/or differences do you notice in anatomical structure?
2. Do these structures have the same function in all organisms?
    a. If not, hypothesize what caused them to evolve different functions over time?
3. What does this information tell you about how organisms are related?

Station 6

The images below show the embryos of different organisms at five different stages of development.



<u>Guiding Questions</u>

1. At what stage(s) do you notice the various organisms begin to develop different parts?
2. Which organisms have the most similar pattern of development?
3. What does this information tell you about how organisms are related?

8th Grade Science Unit 3: Adapt or Die?

Task 3: Natural Selection

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

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	**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	**Cause and Effect** • Some cause and effect relationships in systems can only be described using probability.

populations over time.] [*Assessment Boundary: Assessment does not include Hardy Weinberg calculations.*]		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.	
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.

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.

2. 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.

3. 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.

4. 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.

5. 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.

2. 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:

Critique, Clarify, and Correct: Natural Selection In pairs: 1. Critique: Analyze the claim. 2. Clarify: Look back at what the prompt really asks and identify what Ms. _____ did wrong. 3. Correct: Write a claim that is more accurate. Prompt: Individually, construct an explanation that describes **how** natural selection may lead to increases and decreases of specific traits in populations over time. Use evidence from the

simulation above, including your mathematical calculations, and your own scientific reasoning to help support your explanation. Ms. ____'s 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. Your New 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.

3. 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:

Climate change → Higher Temperatures → Snow melts → White rabbits stand out → Wolves eat white rabbits → Less white rabbits over time

3. 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.

4. 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.

5. 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?

2. 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.

8th Grade Science Unit 3: Evolution Explains Adapt or Die?

Task 4: Human Intervention

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

Introduction

Throughout this unit, students have learned how organisms have naturally changed over time, looking at evidence in the fossil record and exploring the actual process behind these changes in simulations and case studies. However, these changes are not always completely natural. For thousands of years, humans have been influencing the changes of some organisms in the form of selective breeding—a practice that is still common today. Students will learn that selective breeding was only the beginning of human intervention. In the last 50 years, we have entered a new era of genetic technology in which scientists can actually insert desired genes into the genomes of the organisms themselves. To investigate these technologies, students practice critical reading skills to gather information, which will serve as the foundation to the question in their culminating project.

Alignment Table

Performance Expectations	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
MS-LS4-5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. [Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.]	**Obtaining, Evaluating, and Communicating Information** ▪ Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).	**LS4.B. Natural Selection** ▪ In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.	**Cause and Effect** ▪ Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the	**Developing and Using Models** ▪ Develop and use a model to describe phenomena.	**LS3.A Inheritance of Traits** ▪ Genes are located in the chromosomes of cells. Each distinct gene chiefly controls the production of specific proteins,	**Structure and Function** ▪ Complex and microscopic structures and systems can be visualized, modeled, and

structure and function of the organism. [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] [*Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.*]		which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. **LS3.B: Variation of Traits** ▪ In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.	used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.
Equity and Groupwork • Co-develop two models • Co-construct a flowchart			
Language • Read and annotate a scientific article • Write conclusions • Depict relationships in a flowchart			

Learning Goals

This learning task explores how humans are able to influence certain characteristics of organisms. More specifically, the purpose is to:

- Make a prediction about why organisms may change.
- Read and annotate an article on how humans can enhance desirable traits in living things.

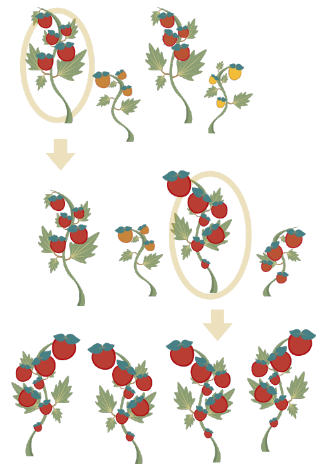
8th Grade Science Unit 3: Evolution Explains Adapt or Die?

Task 4: Human Intervention

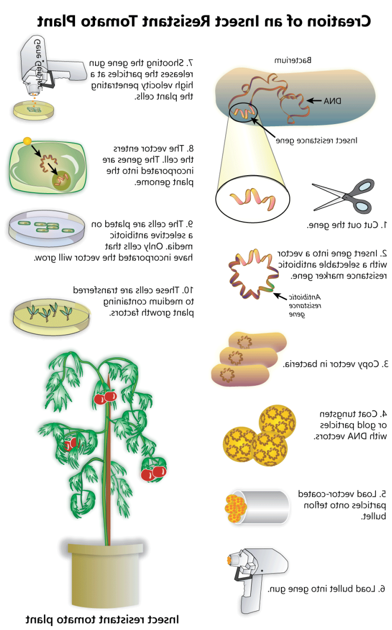
- Develop two models showing selective breeding and genetic engineering and use the models to compare and contrast the two processes.
- Draw a flowchart depicting one process in relation to a specific example.
- Apply knowledge of selective breeding and genetic engineering to develop a potential solution for a climate-threatened organism.

Content Background for Teachers

In this task, students learn about two ways humans can influence the traits of organisms—selective breeding and genetic engineering. Both of these processes rely on the fact that organisms have genetic variation and new genetic variations arise through the process of mutations. With a mutation, the number and/order of bases in a gene is changed. This structural change in genes results in a structural change in the protein created, thus resulting in some change in structure or function of the organism. With both selective breeding and genetic engineering, humans pick desired mutations in order to create organisms with the traits they desire. Thus, student understanding and knowledge of this process from gene to trait is essential to understanding these technologies.



http://b4fa.org/bioscience-in-brief/plantbreeding/



In selective breeding, humans are merely guiding the natural breeding process by selecting the organisms with the desired traits to breed together. By doing this repeatedly, they end up with more organisms with the desired trait (See diagram above). They might also choose to breed two organisms with two desired traits to create an organism with both desired traits. For more information, read the article in the Explore section of the student guide.

In genetic engineering, humans interfere on the genetic level by harvesting the desired gene from an organism and then transplanting it into the desired organism. This is a faster method to end up with organisms with the desired trait. The process is depicted with the example of an insect-resistant tomato plant in the diagram to the left. For more information, read the article in the Explore section of the student guide.
http://learn.genetics.utah.edu/content/science/gmfoods/

Academic Vocabulary

- Selective breeding
- Genetic engineering
- Transplant
- Gene
- Protein
- Trait

- Mutation
- Resistance
- Generation

Time Needed (Based on 45-Minute Periods)
4-5 Days
- Engage and Explore: 1 period
- Explain: 1-2 periods
- Elaborate: 1 period
- Evaluate and Reflection: 1 period

Materials
- Unit 3, Task 4 Student Version

Explore
- Tablets, computers, or projector and speakers for video

Explain (Per Group)
- Markers or Colored Pencils
- Poster Paper

Evaluate
- Project Organizer Handout

Instructions
Engage
1. Introduce Task 4: In previous tasks, you have seen how species naturally 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 4: You have seen how species naturally change over time, but this is not the only way organisms can change over time. Because of new technology, humans are able to influence the traits of some organisms.
   - Now pass out their Task 4 student guide.

3. In pairs, have students observe the image and answer the questions on their student guides. The image shows two tomatoes, one small and one large. Students predict what could have naturally caused these two tomatoes to be different and how humans may have intervened to create this difference. The purpose of this question is to engage whatever background knowledge students bring to this lesson.
   - For the first question, students will likely come up with a natural difference in genes or a difference in environmental conditions (soil nutrients, sunlight, water, etc).
   - For the second question, some students may guess that the larger one is genetically modified. Others may have never heard this term.

- These predictions emphasize the crosscutting concept of **Cause and Effect**, as students begin to consider how this case of the different-sized tomatoes, like many other phenomena, can have more than one cause.

4. Optional: Share out a few predictions and explanations. The use of equity sticks is encouraged for more equitable participation and to get the conversation started (See "How To Use This Curriculum" for more details).
   - Keep in mind that while many students may know the term "GMO", they may not truly understand what it means for an organism to be genetically modified. Many students, without knowing much about GMOs, come with a bias that GMOs are bad.

Explore

1. To learn more about the ways that humans have been able to influence certain characteristics of organisms, students will read and annotate a scientific article adapted from two sources: *GCSE Bitesize* and *Learn Genetics Utah*. They will also view a short video that will better help them understand the process that takes a gene to make a protein to result in a trait.
   - The purpose of this is not only to provide them with the content, but also to give them practice at **Obtaining, Evaluating, and Communicating Information,** by critically reading two scientific texts adapted for classroom use to determine the central ideas related to genetic engineering and selective breeding.

2. This activity also gives students much-needed practice at reading scientific text and extracting information that they will need to build their models. We recommend you ask students to annotate the article, either using whatever strategy they are most familiar with in your classroom or the strategy detailed in their student guide.

3. Since all students read at a different pace, you may want students to move on to the Explain and begin planning their group models individually on their student guides.

4. This section includes a lot of new information and vocabulary. We recommend reviewing some of the main ideas of the article in a class-wide discussion before all students move on to the next segment.
   - Depending on the needs of your students, this may include a PowerPoint presentation, a class discussion, re-watching the video and pausing to diagram the different parts of the process, etc.

Explain

1. With the knowledge they have gathered through the article, students will make two models showing the processes of selective breeding and genetic engineering. In both models, they should emphasize how a change in genes results in a change in traits.
   - This asks students to use the science and engineering practice of **Developing and Using Models** to describe two different processes. By creating a model to describe how the function of traits depends on the composition of the gene and the shape of the protein, student are also engaging with the crosscutting concept of **Structure and Function**.
   - We recommend this task be completed in groups since these are new and complex concepts.

2. You may wish to have students do some independent planning first in the student guides before discussing as a group.
    - Then provide groups with poster paper and writing utensils to create their group models on poster paper.

3. Assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Materials Manager, Facilitator, Reporter, Harmonizer.
    - Ask Facilitator to read the directions and to make sure everyone understands the task and what directions are asking.
    - Ask the Materials Manager to gather any materials needed to complete the task.
    - Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone's voice is heard.
    - Ask the Reporter to make sure everyone is contributing to the models on paper.

4. Optional gallery walk: You may want to conduct a brief gallery walk so students can see how their peers are modeling the same processes.
    - Then give students time to revise and add to their posters based on exemplars they see around the classroom.

5. Students are then given a Venn diagram and reflection questions that are meant to both help them revise their models and clarify their understanding. Students use their models to compare the two processes and conclude how changes in structure lead to changes in function in both processes.
    - Students will likely note that both processes entail a change in genes leading to a change in protein and thus a change in trait (a more desirable trait). However, the first few steps of the model to get to that change in gene varies. Selective breeding selects organisms with desired traits, while genetic engineering selects the desired gene itself.
    - The last question asks students to notice that the structural change in DNA leads to a structural change in protein, which leads to a change in trait, either structure or function. This continues to help students emphasize the crosscutting concept of **Structure and Function**, as described above.
    - Once complete, we recommend reviewing these questions as a class. One option is to hang a few exemplar posters at the front of the room to use as a reference during the discussion.

Elaborate

1. Students return to the original question from the Engage, equipped with their new knowledge of selective breeding and genetic engineering.
    - Previously they made predictions as to why the tomato on the right is larger. Now, they pick which process or processes they think are responsible for the larger tomato.

2. In pairs, students discuss the two processes and decide on one process—selective breeding or genetic engineering. Using the tomato as the context, students draw a flowchart describing how selective breeding or genetic engineering created the larger tomato.
    - This brings students back to the crosscutting concept of **Cause and Effect** from the beginning of the task, as they consider the multiple causes that could be in play but use their knowledge to identify which process probably led to this difference in size.

- This flowchart may mimic many aspects of their models from the Explain, but will be specific to the tomato context, thus giving extra practice with these concepts and the practice of **Developing and Using Models.**
- Students may use pictures and/or words.

3. Optional: Match each pair up with another pair who selected the other process. Have each pair present their own flowchart to the other pair and get feedback.

4. 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: genetic engineering; selective breeding; mutation; and/or the structure-and-function relationship between genes, proteins, and traits.
    - 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.
        - **Structure and Function**: These could be phrases such as, “this shape affects ____,” “and “it can only function if,” “this structure leads 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 4 section of the Unit Project Organizer in class. Revisions can be done for homework, depending upon student’s needs and/or class scheduling.

2. For their project, students will be arguing whether humans should intervene on the behalf of climate-threatened organisms or let nature take its course. Their prompt is as follows: Think about how your species is being affected by an environmental change caused by humans.
    - What change in trait might help the species survive this environmental change?
    - Model the process of changing this trait, using what you have learned in this task.

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 humans might have intervened to create the larger tomato. Look back at your prediction: how does it differ from the process you outlined in the Elaborate? What have you learned over the course of this task?
    - In this task, we focused on two crosscutting concepts:
        - **Cause and Effect:** Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
        - **Structure and Function**: Models can be used to describe how function depends on the structure.

      Where did you see examples of **Cause and Effect** and **Structure and Function** in this task?
    - Now that you have learned more about the ways in which humans can influence the traits of some species, what questions do you still have?

2. 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.

<u>**Assessment**</u>

1. You may collect the Project Organizer and assess using:
    - *Criteria of your choice.* We recommend using the Alignment Table 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.