MEDIA MAYHEM

WHAT IS THE IMPACT OF DAIRY PRODUCTION ON THE ENVIRONMENT?

Food and Agriculture Center for Science Education

Synopsis

In this unit, students evaluate a series of seemingly conflicting media claims about the impact of dairy production on the environment. Students begin by figuring out what the parts of the dairy system are and how each part works together to produce dairy products. They then analyze the impacts of these parts on parts of the environment that are outside of the design of the dairy system, including air and water pollution. Students then figure out how the dairy industry impacts the climate by first using models to establish the mechanism of the greenhouse effect and then by analyzing data on the relative quantity of greenhouse gas emissions across different industries. Students then investigate how the dairy system impacts biodiversity. Students figure out that the construction of the dairy system can negatively affect biodiversity by clearing land and destroying habitats, but then use engineering design process to evaluate multiple solutions for to design the dairy system can help mitigate the impacts of the dairy system on the environment.

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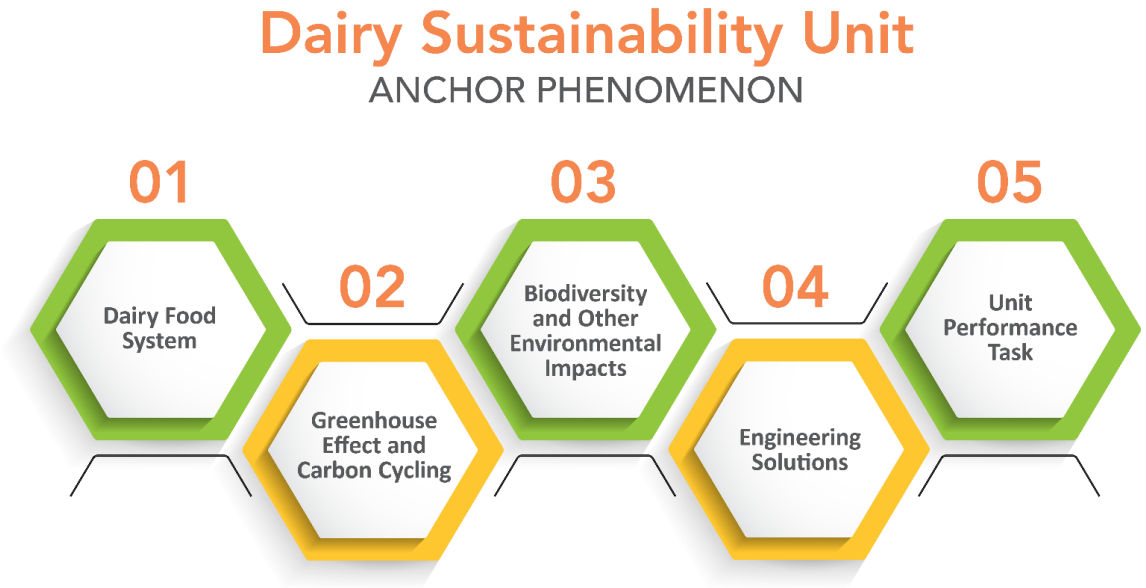
Unit Overview

In this high school 5E unit on the dairy food system and sustainability, students explore media claims about the impacts of the dairy industry on the environment to figure out which ones most accurately represent the impact of the dairy industry on the environment. Across a series of four modules, students figure out how the components of the dairy system impact the environment, including via pollution, greenhouse gas emissions and climate, and impacts on biodiversity. Students then explore solutions for how the dairy system can be improved to have less impact on the environment.



Module Pacing & Summaries

⚓	**Anchor Phenomenon**

Anchor Phenomenon:
Students watch a video that shows people protesting the harmful impacts of the dairy industry and analyze a series of seemingly conflicting claims about the impact of dairy production on the environment. We wonder what is true – is dairy production helpful or harmful for the environment?

Driving Question:
What is the impact of dairy production on the environment?

Lesson #s: 1

Time: 100 minutes
Approximately 2 class periods

What Students Figure Out:
Students acknowledge that dairy plays an important role in many of our lives and nutrition. They consider the different perspectives and make initial arguments about the impact of the dairy food system on the environment.

What Students Do:
- Observe the Anchor Phenomenon through video and media claims
- Share and record areas of agreement and disagreement
- Write an initial argument about dairy's impact on the environment

Navigation to the Next Module:
Students have experienced the Anchor Phenomenon which has left them with many questions about the dairy system's impact on the environment. Students agree that to better understand how the dairy system impacts the environment, it will fist help to understand what the different parts of the dairy system are.

Module 1: Dairy Food Systems

Module Phenomenon:
Students observe a video that shows two examples of systems by which we used to and currently produce dairy products. As students watch, they record what they observe about how dairy products are made and get to our plates today vs. in the past.

Module Question:
How does the dairy system produce dairy products and get them to our table?

Lesson #s: 2-6

Time: 250 minutes
Approximately 5 class periods

What Students Figure Out:
Students figure out that technological systems can be designed to have costs, risks, and benefits. The dairy system was designed to produce the maximum amount of products with little cost – it was designed for efficiency. However, this design had unintended consequences. There are several aspects of the system

What Students Do:
- Share life experiences about exposure to dairy products
- Observe differences in dairy production systems between past and present
- Create and revise models of dairy production systems

that impact the environment outside of the system itself. We call these externalized costs of the system. These include air and water pollution through manure or fertilizer runoff, impacts on worker and nearby community health, and waste from production.	• Sequence dairy system components • Gather evidence from various texts • Achieve consensus through a class model • Analyze the costs and benefits of the dairy system on pollution and human health • Revise initial arguments of the environmental impact of dairy production	
Connection to Anchor Phenomenon: Students use what they figured out to help evaluate the validity of the media claims, 1, 4, 8, and 13, which focus on the dairy industry's impact on human health and environmental air and water pollution. Students then analyze the overall costs, risks, and benefits of the dairy system to update their arguments about if they think the dairy system is overall beneficial or harmful to the environment.		
Navigation to the Next Module: Students review their arguments and the original media claims and see that the arguments have not yet addressed how the dairy system impacts climate or biodiversity. Students determine what needs further investigation to assess the remaining media claims and to resolve the contradictions in their arguments and determine the environmental impact of dairy production.		
 **Module 2: Greenhouse Effect and Carbon Cycling**		
Module Phenomenon: Students observe a video that shows a farmer claiming cow burps may be related to climate change. As students watch, they record what they observe about the connection between cows and climate.		**Module Question:** *How could cow burps be influencing climate change?*

What Students Figure Out:
Students figure out that methane (CH_4) and carbon dioxide (CO_2) are greenhouse gases that contribute to the greenhouse effect and explore how each greenhouse gas impacts the environment. Students see that methane and carbon dioxide are both greenhouse gases, which can influence climate by being a part of the greenhouse effect. They figure out that both gases are a part of the carbon cycle and move into and out of the atmosphere. They see that human activity, such as transit and cattle digestion, produces both gases but the quantity of gases produced by the dairy industry, and agricultural industry overall, are much less than those produced by other major industries such as transit and electricity generation.

What Students Do:
- Create and revise models of how cow burps influence the climate
- Analyze data on human activity, climate change, greenhouse gas residence time, and emissions by industrial sector
- Evaluate multiple models of the greenhouse effect
- Use computer models to investigate future greenhouse gas emissions and rising temperatures
- Use a "science theater" model to show the carbon cycle
- Revise initial arguments of the environmental impact of dairy production

Lesson #s: 7-14

Time: 550 minutes
Approximately 11 class periods

Connection to Anchor Phenomenon:
Students use what they figured out to evaluate the validity of media claims 2, 5, 6, 7, 9, and 10, which focus on the dairy industry's impact on climate. Students then analyze the overall costs, risks, and benefits of the dairy system to update their arguments about if they think the dairy system is overall beneficial or harmful to the environment.

Navigation to the Next Module:
Students review their arguments and the original media claims and see that the arguments have not yet addressed how the dairy system impacts biodiversity. Students determine that there is still more they need to figure out about how dairy impacts the environment.

Module 3: Biodiversity and Other Environmental Impacts

Module Phenomenon:
Students observe two videos that shows examples of how dairy production systems are created and wonder how the construction of dairy buildings and clearing of land might impact local wildlife.

Module Question:
What impact does the dairy production system have on biodiversity?

What Students Figure Out:
Students figure out that the clearing of undisturbed lands to convert them to monoculture crops or infrastructure both reduce the biodiversity in a given space. Students analyze how these changes to biodiversity could happen and conclude that habitat destruction is the leading cause. Students then figure out that loss of biodiversity can affect humans in that it threatens food production systems and degrades landscapes. Finally, students figure out that cattle grazing as opposed to being fed from monocultured crops, can have a positive impact on local biodiversity.

What Students Do:
- Create and revise models of how dairy systems impacts biodiversity
- Analyze and interpret data on biodiversity changes
- Gather evidence from various texts about how changes to biodiversity can impact humans
- Construct explanations about the impacts of loss of biodiversity
- Create and revise models of how cattle grazing can improve biodiversity
- Revise initial arguments of the environmental impact of dairy production

Lesson #s: 15-20

Time: 330 minutes
Approximately 6 class periods

Connection to Anchor Phenomenon:
Students use what they figured out to evaluate the validity of media claims 11 and 12, which focus on the dairy industry's impact on biodiversity. Students then analyze the overall costs, risks, and benefits of the dairy system to update their arguments about if they think the dairy system is overall beneficial or harmful to the environment.

Navigation to the Next Module:
Students have figured out many ways that the dairy system impacts the environment and have had questions about how to improve on these costs and downsides of the dairy system . Students decide they need to see if there are ways to decrease the environmental impact of dairy systems.

Module 4: Engineering Solutions

Module Engineering Problem
Students analyze the costs and risks of the dairy system overall and use these costs and risks to identify environmental impact problems they want to design solutions for.

Module Question:
How can we improve on the costs and risks of the dairy system?

What Students Figure Out:
Students figure out that there are many solutions being considered to reduce the environmental impacts of dairy production. These solutions focus on things like reducing methane emissions via various practices, managing cattle differently to promote biodiversity, and examining feed production strategies to pursue carbon sequestration, all while continuing to provide nutritional benefits in milk and affordable milk to consumers. Students weigh the costs and benefits of various solutions while considering their social, environmental, economic, and geopolitical consequences.

What Students Do:
- List steps of the engineering process
- Assess benefits, costs, and risks of the dairy system
- Define mechanisms of problems within the dairy system
- Determine and refine criteria and constraints of solution design
- Assess potential solutions for dairy production practices
- Propose, review, and finalize solutions

Lesson #s: 21-25

Time: 500 minutes
Approximately 10 class periods

Connection to Anchor Phenomenon:
Students have identified specific mechanisms by which the dairy system is responsible for causing environmental impacts. Students see that human-designed solutions are needed to improve the design of the dairy system and support sustainability.

Performance Task

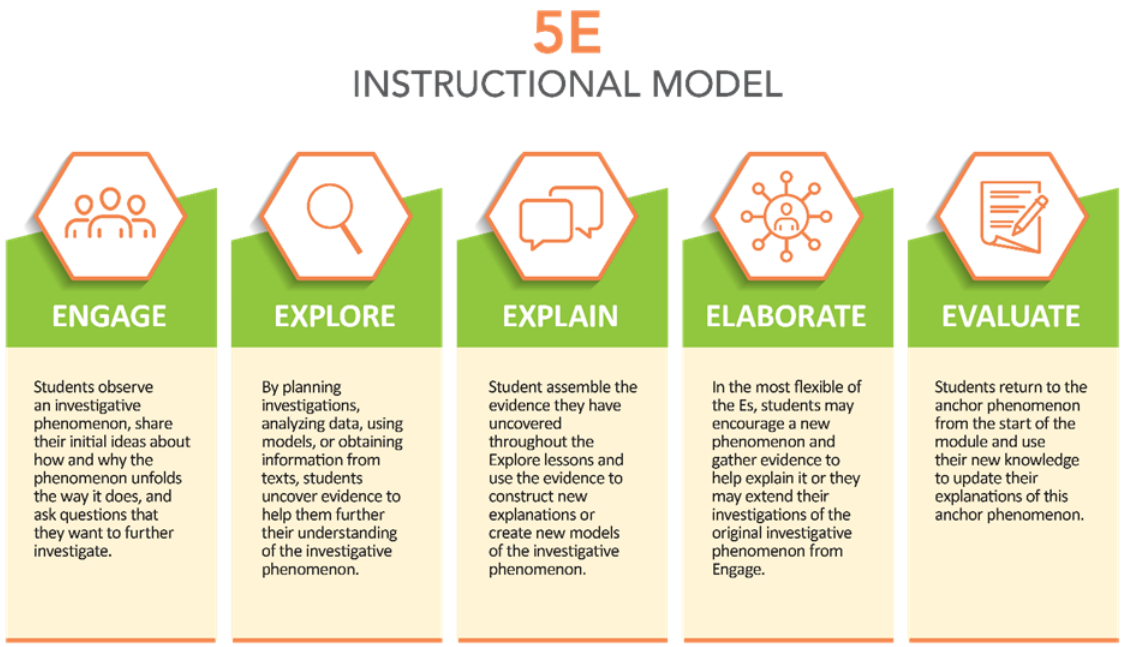
Return to Anchor Phenomenon:
Students are presented with two new media claims about the dairy system. Students use their knowledge from the unit to organize the media claims as valid, misleading and omits important context or details, or invalid.

Driving Question:
What is the impact of dairy production on the environment?

What Students Figure Out:	What Students Do:	
Media claims about dairy production can often be misleading, invalid, or omit important details and context. As consumers of media, it is important that we investigate the evidence that supports or does not support various media claims that we see about all topics.	• Use evidence to categorize media claim validity • Reflect on the importance of media literacy	**Lesson #s:** 26 **Time:** 100 minutes Approximately 2 class periods

Unit Structure & 5E Instructional Model

This unit is designed using the BSCS 5E Instructional Model. This instructional model has five lesson types: Engage, Explore, Explain, Elaborate, and Evaluate. The purpose of each lesson type is shown in the graphic below. Each module of the unit contains a 5E sequence.



In each module, students first observe a module phenomenon in the Engage lesson, which drives their learning within each individual module. Throughout the module, students will drive instruction by investigating different parts of the module phenomenon in the Explore lessons. Students make sense of the module phenomenon through a variety of investigation types, such as developing and using models, analyzing data, and obtaining information from texts. Students have multiple opportunities to share their new understanding (content, vocabulary, ideas) with the teacher and their peer group. Students use their own questions to navigate from one lesson to another. This gives students the opportunity to decide what to figure out next based on their questions about the phenomenon. Students then use the new evidence they have gathered to better help explain the module phenomenon in Explain Lessons. In Elaborate lessons, students extend what they know about the module phenomenon. At the end of each module in Evaluate lessons, students take their knowledge and use it to update their understanding of the unit anchoring phenomenon.

There are a variety of informal opportunities for assessment when using the 5E model of instruction. These opportunities are specifically called out for a teacher during each of the lessons. There are also formal summative assessment opportunities throughout each of the modules in the Evaluate lesson of each module. In these lessons, students demonstrate evidence of their learning from each module.

Supporting NGSS Implementation

Teacher supports in the form of activity type icons, SEC actions icons, and callout boxes are provided throughout the unit to aid in the implementation of these three-dimensional, phenomenon-based materials.

Activity Type Icons

	Anchor Phenomena		Investigation
	Editing		Initial Ideas
	Consensus Building		Building Understanding

SEP Action Icons

	Analyzing and Interpreting Data		Asking Questions and Identifying Problems

	Constructing Explanations/Defining Solutions		Developing and Using Models
	Engaging in Argument from Evidence		Obtaining Evaluating Communicating Info
	Planning and Carrying Out Investigations		Using Math Computational Thinking

Callout Boxes

SEP SUPPORT
This box explains how to best support students in engaging with the associated SEP. It is also used to call attention to progressions of the SEP from prior grade bands or across the unit.

DCI SUPPORT
This box explains how to best support students in engaging with the associated DCI. It is also used to call attention to progressions of the DCI from prior grade bands or across the unit.

CCC SUPPORT
This box explains how to support students in engaging with the associated CCC. It is also used to call attention to progressions of the CCC to from prior grade bands or across the unit.

FORMATIVE ASSESSMENT OPPORTUNITY
This box is used to identify the student artifact that gives evidence of students' current performance of the three-dimensional learning objective(s) for the lesson. These artifacts can be used as formative assessments throughout the unit. In this box, you'll find a description of which artifacts to asses, what to look for, sample student responses, and action items to take for students' who may need additional support.

USE OF PHENOMENA
This box is intended to clarify how the multiple phenomena in the unit are used and how connections can be made by students across the phenomena.

CCSS Support

This box identifies selected Common Core State Standards that students are engaging with at key moments in a lesson.

LOOK FOR
This box is used to provide specific and direct guidance to the teacher to explain what they should be looking for in student work or responses.

TEACHER SUPPORT
This box provides guidance to a teacher on additional context for how to implement or facilitate an action or directive. For example, this may include tips on how to engage with students in conversation, facilitate group discussion, engage participation, or provide directions on how to complete a task. This box is also used to explain how to best implement a particular teaching strategy that a teacher might not be familiar with.

STUDENT SUPPORT
This box is meant to provide additional suggestions for how to support all learners in the classroom via differentiation strategies or other tips. For example, this box may provide an explanation of a strategy, a new series of questions, an additional prompt, or sentence starters.

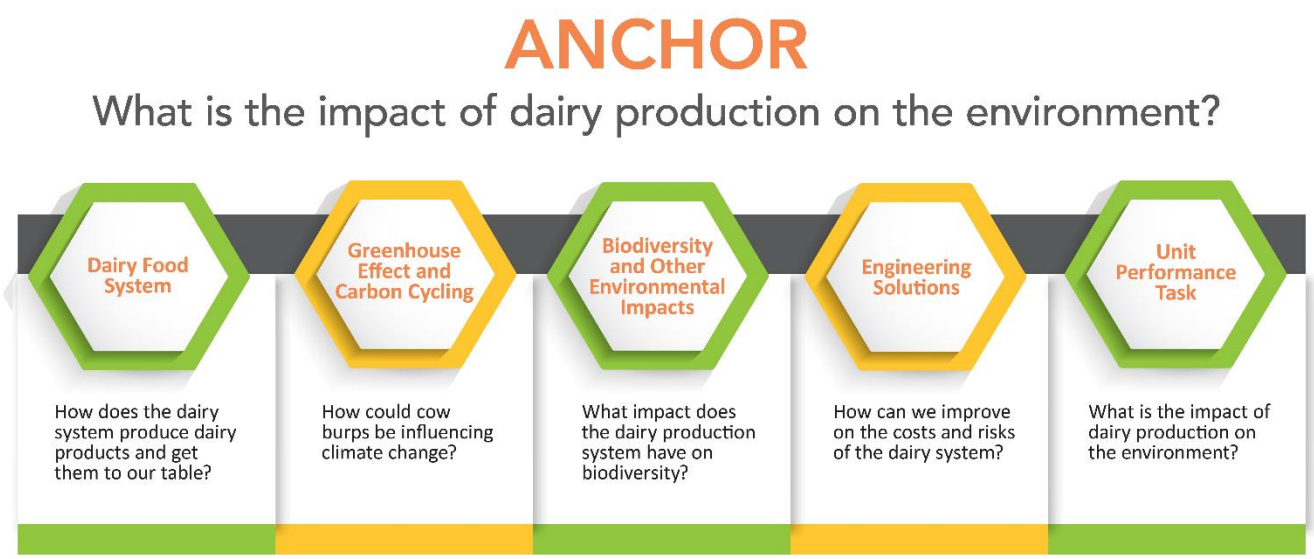
DEFINE TERMS
This box is used when a teacher formalizes the definition of key terminology for all students to be familiar with throughout the remainder of the lesson(s).

Use of Anchor and Module Phenomena

Because the Next Generation Science Standards (NGSS) require students to make sense of phenomena and be able to explain them, supported by the DCIs, SEPs, and CCCs that are selected to frame instruction, they are central to student learning experiences. Phenomena are "observable events that occur in the universe and that we can use our science knowledge to explain or predict" (n.a. 2005). Throughout this unit, we use two types of phenomena to drive student learning – anchoring and investigative.

The anchoring phenomenon is used as the focus for the unit. In each learning module, students return to this phenomenon and revise their explanations about how it works by presenting evidence they gathered throughout each of the lessons. The anchor phenomenon is used across the whole unit. In addition, a module phenomenon is used within each module in the unit. Students will make sense of and be able to provide an explanation for the module phenomenon prior to the end of the module. In contrast, students make sense of the anchor

phenomenon across the entire unit. The descriptions of the anchoring and module phenomenon are outlined in the Module Summaries section of this document.



Assessment System Overview

Summative Assessment

Each module ends with a summative assessment opportunity in an Evaluate lesson. Students are evaluated on a three-dimensional combination of the unit focal elements in one or more tasks. The unit ends with a final performance task in which students demonstrate their proficiency of selected focal elements for the unit. Each summative assessment task comes with a rubric that can be used to assess students' progress towards proficiency in three dimension and a set of Look-Fors that students can use to guide their performance on the task.

Formative Assessment

This unit contains multiple opportunities for formative assessment, including formative assessment opportunities that identify official artifacts of student three-dimensional performance in each lesson and embedded informal formative assessments.

Official Formative Assessment Opportunities
In each lesson, one or more Formative Assessment Opportunity boxes call out a moment in the lesson in which students produce an artifact that shows their performance of the targeted three-dimensional learning objective for that lesson. The teacher can use these artifacts to assess students' understanding of the lesson goal by providing formative feedback and/or a grade or by having students give each other feedback on their artifacts.

Rubrics are provided that the teacher and/or other students can use to evaluate student performance on a lesson's three-dimensional learning target. The 'Proficient' level of performance on each rubric corresponds to a proficient response within that lesson, and the expectations required to reach 'Proficient' gradually build in complexity across the unit. In other words, a 'Proficient' in Lesson 1 does not come with the same expectations and Look-Fors as a 'Proficient' in Lesson 20.

The formative assessments and corresponding rubrics can be used in a variety of ways by the teacher and/or students and their peers:

As students complete the formative assessment:

- The teacher can provide the look-for to students as they complete the assessment artifact, so that students know the expectations of them.
- Students can use the look-for to provide feedback to one another.
- The teacher can use the "To Provide Additional Support for Students" tips to press students to higher levels of performance on the rubric.

After students complete the assessment:

- The teacher can collect the student artifact, score it, and provide feedback on which look for students accomplished and which they can improve on.
- The teacher can give students an opportunity to revise their artifacts based on feedback from their peers or from the teacher.

Informal Formative Assessment Opportunities
Each lesson also includes multiple informal formative assessment opportunities for students and the teacher to monitor and respond to student performance in three dimensions. Through discourse and writing, students are consistently able to share their thinking with peers

and with the teacher and respond to the ideas of their peers. These provide opportunities for the teacher to assess and adjust their teaching approaches to better meet and respond to the current thinking of their students.

Self-Assessment

At the end of each Evaluate lesson in each module, students are provided with an opportunity to self-evaluate their progress in working with one or more of the focal SEP elements for the module. This gives students an opportunity to share how they think they are doing and how the classroom experience is going for them. This also provides the teacher an opportunity to check on how students are perceiving their classroom experience.

Students are also provided with Look-Fors on each Summative Assessment task that they can use to self-assess the artifact that they have produced on the assessment task.

Pre-Assessment

In the Anchor Phenomenon lesson and in the Engage lessons in this unit, students create initial arguments or models of phenomena. In these lessons, students share the knowledge they have about the phenomenon from their own background experience. Accordingly, these are tagged as Pre-Assessment opportunities. The NGSS elements addressed in these lessons are tagged "Pre-Assessment". These elements are not meant to be developed in the given lesson and instead are meant to be used by students for the first time such that the teacher can get a formative assessment on what prior knowledge students have of using these elements.

Supporting Classroom Discourse

Productive discourse in the science classroom can be a challenge for students from a variety of backgrounds. While we want to see students pressing each other for evidence, critiquing each other's claims, evidence, and reasoning, and collaboratively making sense of data, often these are new forms of talk for students compared to their everyday discourse. Further complicating the matter is the challenge to build a culture in which students respect, value, and build on the ideas of all students in their group or in the whole class rather than a select few students. Given these challenges, we have compiled a set of tools intended to support students with discourse with each other. Please see the Science Classroom Discourse Supports and the Teacher Talk Compilation for more details.

NGSS Performance Expectations & DCI, SEP, and CCC Elements

According to the Framework for K-12 Science Education, performance expectations are essential to the standards. The term performance expectation "refers to statements that describe activities and outcomes that students are expected to achieve in order to demonstrate their ability to understand and apply the knowledge described in the disciplinary core ideas….[they] specify what students should know, understand and be able to do" (Framework, pg. 218). We formed the following conceptual bundle of the NGSS PEs to help guide our initial unit planning. We used the DCIs in this PE bundle as the focal DCIs in our unit. The SEPs and CCCs from these PEs are not necessarily those chosen as focal SEPs and CCCs for the unit.

Performance Expectations That Informed Design

HS-ESS2-6

Students who demonstrate understanding can:

Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

[Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

HS-ESS3-2

Students who demonstrate understanding can:

Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

[Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

HS-ESS3-4

Students who demonstrate understanding can:

Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*

[Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

HS-LS2-5
Students who demonstrate understanding can:
Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

[Clarification Statement: Examples of models could include simulations and mathematical models.]
[*Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.*]

HS-LS4-6
Students who demonstrate understanding can:
Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*

[Clarification Statement: Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

HS-ETS1-1
Students who demonstrate understanding can:
Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-3
Students who demonstrate understanding can:
Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Use of NGSS Elements

In each lesson teacher guide, we show the elements of the NGSS that are targeted in that particular lesson. We use bolding in these elements to demonstrate what parts of the elements students have and have not yet built proficiency within each lesson. As the unit progresses, students will become more proficient in the targeted elements and more of the element will gain bolded language. This allows the teacher to build student proficiency of an element across the unit instead of all in one lesson.

In our design, we chose specific DCI, SEP, and CCC elements that students would develop proficiency in across the unit. This unit was designed to support teachers in building student proficiency in these targeted elements across the entire unit, not for mastery within individual lessons. Accordingly, the unit is designed such that students should be supported in developing proficiency in the unit-level targeted DCIs, SEPs, and CCCs, listed below. While a wide variety of additional SEPs and CCCs may also be utilized across the unit as supporting elements, student proficiency in these elements will not be fully built nor assessed.

Unit Focal NGSS Elements

SEP:

ARG-H3:
Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions.

ARG-H4:
Construct, use, and/or present an oral and written argument or counter- arguments based on data and evidence.

INFO-H4:
Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs **that appear in** scientific and technical texts or **media reports**, **verifying the data when possible.**

DCI:

ESS2.D-H3:
Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.

ESS3.A-H2:
All forms of energy production and other **resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits.** ~~New technologies and social regulations can change the balance of these factors.~~

LS4.D-H2:
Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and

CCC:

CE-H3:
Systems can be designed to cause a desired effect.

EM-H2:
Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

SYS-H1:
Systems can be designed to do specific tasks.

SYS-H2:
When investigating or describing a system, the boundaries and initial conditions **of the system need to be defined and their inputs and outputs analyzed and described** using models.

SPQ-H1:

MOD-H3: **Develop**, **revise, and/or use a model based on evidence to illustrate** and/or predict **the relationships between systems or between components of a system.**	climate change. **Thus, sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth.** ~~Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.~~	**The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.**

Focal Element Progression and Use Map

Corresponding Middle School SEP Element	Unit Focal High School SEP Element
MOD-M4: Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.	**MOD-H3:** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
ARG-M2: Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.	**ARG-H3:** Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions.
ARG-M3: 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.	**ARG-H4:** Construct, use, and/or present an oral and written argument or counter- arguments based on data and evidence.
INFO-M4:	**INFO-H4:**

Evaluate data, hypotheses, and/or conclusions in scientific and technical texts in light of competing information or accounts.	Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible

Building on Prior Middle School SEP Learning

This unit builds on students' middle school-level knowledge of Developing and Using Models, Engaging in Argumentation, and Obtaining, Evaluating and Communicating Information.

This unit builds on students' middle school SEP proficiencies as follows:

- In middle school, students develop models of phenomena that demonstrate the relationships between variables at different scales. In this unit, students build on this middle school understanding to show that that models can illustrate not just relationships between two variables at different scales, but also relationships between entire systems or multiple components of a system. For example, in Module 1, students' models show that the dairy system interacts with other outside systems and the components of the dairy system interact with each other and with outside systems.
- In middle school, students engaged in argumentation by respectfully providing critiques of peers' explanations, models, or questions by citing relevant evidence or by posing questions that elicit elaboration from peers. In this unit, they build on this argumentation practice by responding respectfully to diverse perspectives, by challenging the conclusions of their peers, and by determining how to resolve disagreements. For example, in the final lesson of Module 3, students construct arguments that state if they think the dairy system is beneficial or harmful for the environment. Students share their arguments with peers and respectfully press their peers' reasoning and evidence used in their arguments.
- In middle school, students constructed scientific arguments supported by evidence to support or refute an explanation of a phenomenon. In this unit, students build on this argumentation practice by not only constructing arguments based on evidence, but also constructing counter-arguments based on evidence. For example, in the final lesson in Module 3, students listen to their peers' arguments and respond respectfully using counterarguments based on evidence.
- In middle school, students evaluated competing information in texts. This unit builds on this middle school practice by asking students to evaluate the validity of multiple claims in media reports and to use their knowledge from this unit to verify the claims being made. In the first and last lessons in the unit, and in the final lesson of each module, students evaluate the validity of multiple media claims about how the dairy industry impacts the environment.

Corresponding Middle School DCI Element	**Unit Focal High School DCI Element**

ESS3.A-M1: Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.	**ESS3.A-H2:** All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.
LS4.D-M1: Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on – for example, water purification and recycling.	**LS4.D-H2:** Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus, sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.
ESS3.D-M1: Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior, and on applying that knowledge wisely in decisions and activities.	**ESS2.D-H3:** Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.

Building on Prior Middle School DCI Learning

This unit builds on students' middle school-level knowledge of Earth and Human Activity, Biodiversity and Humans, Global Climate Change, and Influence of Engineering, Technology, and Science on Society and the Natural World.

This unit builds on students' middle school DCI proficiencies as follows:

- In middle school, students learned that humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. This unit builds on this middle school knowledge by expanding students' understanding of the economic, social, and environmental consequences of resource extraction. For example, in Module 1, students figure out that the production of dairy products is a form of resource extraction and that it has associated economic, social, and environmental consequences.
- In middle school, students learned that changes in biodiversity can influence humans' resources and ecosystem services. This unit builds on this knowledge in that students figure out that human activity has adverse consequences on biodiversity and that sustaining biodiversity requires responsible management of natural resources. For example, students learn in Module 3 that the conversion of land to monoculture crops for cattle feed can have an adverse impact on biodiversity and that these changes can negatively impact humans through loss of pollinators, soil fertility, and ecosystem services.
- In middle school, students learned that greenhouse gases are major factors in the rise of Earth's mean surface temperature. In this unit, students build on this middle school understanding by establishing the mechanism by which excess production of greenhouse gases by the agricultural and other industries can contribute to changes in changes in average atmospheric temperature. For example, in Module 2, students figure out that the incoming solar radiation passes through the atmosphere to warm the Earth's surface, and this thermal energy re-radiates into the atmosphere. Greenhouse gases trap this thermal energy in Earth's atmosphere, leading to an increase in atmospheric temperatures. Students also learn that different industries contribute different quantities of greenhouse gas to the atmosphere.

Corresponding Middle School CCC Element	Unit Focal High School CCC Element
SYS-M1: Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.	**CE-H3:** Systems can be designed to cause a desired effect.
EM-M2: Within a natural or designed system, the transfer of energy drives the motions and/or cycling of matter.	**EM-H2:** Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.
SYS-M1: Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.	**SYS-H1:** Systems can be designed to do specific tasks.
SYS-M1:	**SYS-H2:**

Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.	When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.
SPQ-M5: Phenomena that can be observed at one scale may not be observable at another scale.	**SPQ-H1:** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

Building on Prior Middle School CCC Learning

This unit builds on students' middle school-level knowledge of Systems and System Models, Energy and Matter, and Scale, Proportion, and Quantity.

This unit builds on students' middle school CCC proficiencies as follows:

- In middle school, students analyzed the design of systems by determining that systems can have sub-systems and be a part of larger systems. In this module, students build on this idea by using their knowledge of a system's interactions to identify the function of the system, including the relationship between its design and the intended and unintended effects the system design has on the environment. For example, in Module 1, students identify how even though the dairy production system is designed to produce dairy products, its design has unintended consequences on the environment. Students also build on this middle school knowledge by now not only defining a system and its interactions, but also by determining a system's boundaries and recognizing that a system's boundaries can be set as needed based on the problem being analyzed. For example, in Module 1, students recognize that the dairy system can be defined as the system that brings dairy products to consumers. This system definition helps analyze the function of the system, but it also reveals what impacts of the system are not considered a part of it and are instead externalized consequences on the environment outside of the system.
- In middle school, students tracked the transfer of energy through a system and how the transfer of energy drives the motion of matter, this unit builds on this middle school knowledge by asking students to carefully track the movement of energy and matter into and out of a system and use that to track how the energy within a system changes. For example, in Module 2, students track the energy inputs and outputs of the Earth system under different atmospheric greenhouse gas concentrations. They use the relative differences in inputs and outputs to track the changes to the average atmospheric temperature of the Earth.
- In middle school, students saw that phenomena that can be observed at one scale may not be observed at another scale. This unit builds on this understanding by describing how phenomena may be significant or insignificant depending on the scale, proportion, and quantity by which they occur.

Focal Element Use Map

Students are given multiple opportunities to build their proficiency with the focal elements for this unit. The lessons in which students build their proficiency for each focal element are shown below.

MOD-H3	1	2	3	4	5	6	7	8	9	10	11	12
		✓		✓	✓		✓		✓	✓	✓	
	13	14	15	16	17	18	19	20	21	22	23	24

ARG-H3	1	2	3	4	5	6	7	8	9	10	11	12
	✓											
	13	14	15	16	17	18	19	20	21	22	23	24
		✓						✓				

ARG-H4	1	2	3	4	5	6	7	8	9	10	11	12
						✓						✓
	13	14	15	16	17	18	19	20	21	22	23	24
		✓						✓				

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