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New Mexico STEM Ready! Science Standards Implementation Guide

Overview

A Framework for K-12 Science Education marks a leap forward in how we think about science education and captures the advancements made in understanding how students best learn science that have been made over the last 30 years. The New Mexico Public Education Department and New Mexico public school teachers worked together over the course of June 2021 to construct an Instructional Scope document for the New Mexico STEM Ready! science standards. There are many public schools where high quality instructional materials (HQIM) are present, and these should be used in the teaching of science. In public schools where HQIM may be absent, the New Mexico Instructional Scope for Science (NMIS Science) should be used in conjunction with the New Mexico STEM Ready! science standards to plan science instruction.

The following describes the layout of the NMIS Science document and how it has been designed to be implemented. New Mexico science teachers worked collaboratively to identify and construct sample phenomena, classroom assessment items, common misconceptions, multi-layered systems of supports (MLSS), and culturally and linguistically responsive (CLR) instructional strategies for each performance expectation in the New Mexico STEM Ready! science standards. The best practice of bundling related standards together to capture multiple aspects of a single phenomenon was not done, as local public schools should determine how best to bundle New Mexico STEM Ready! science standards based on their needs.

The standards

<u>What:</u> Each performance expectation begins with links to the *Next Generation Science Standards* and a snapshot of the performance expectation with the relevant Science and Engineering Practices (SEP), Disciplinary Core Ideas (DCI), and Cross Cutting Concepts (CCC). Also captured are the connections across the grade level or band (horizontal), connections across grade levels or bands (vertical), and connections to the *Common Core State Standards* (CCSS) in math and English language arts.

The Performance Expectation describes what a student is expected to be able to do at the completion of instruction. They are intended to guide the development of assessments, but they are not the assessment as such. They are not instructional strategies or instructional objectives, but they should influence and guide instruction. Most performance expectations contain a clarification statement and an assessment boundary statement to provide clarity to the performance expectation and guidance to the scope of the expectation, respectively.[1]

The foundation box, which is located below the performance expectation, contains the learning goals that students should achieve and that will be assessed using the performance expectations. The three parts to the foundation box are the science and engineering practices, the disciplinary core ideas, and the crosscutting concepts. The information contained in the foundation box is taken directly from *A Framework for K-12 Science Education*. Also included in the foundation box, where appropriate, are connections to engineering, technology, and applications of science as well as connections to the nature of science. These supplemental goals are related to the other material in the foundation box and are intended to guide instructions, but the outcomes are not included in the performance expectation.

The connections box identifies connections to other disciplinary core ideas at this grade level that are relevant to the standard, identifies the articulation of disciplinary core ideas across grade levels, and identifies connections to the *Common Core State Standards (CCSS)* in mathematics and in English language arts and literacy that align to this standard. The connections box helps support instruction and development of instructional materials.

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[1] Pratt, Harold (2013) *The NSTA Reader's Guide to the Next Generation Science Standards.*

Why: The first step of any teacher in planning instruction is to deeply understand the end result that is required. The standards section of the NMIS Science document is placed first so that teachers have quick access to these requirements. The *NGSS* describe the essential learning goals and how those goals will be assessed at each grade level or band.

How: It is generally accepted that planning for instruction begins with the selection of the endpoint, or desired results of the instruction, and working backward through an instructional sequence to the beginning knowledge students have coming into the instruction. The description of such a process has been documented by Wiggins and McTighe in *Understanding by Design* (1998).

For the purpose of the NMIS Science document, a process for moving from the New Mexico STEM Ready! science standards to classroom instruction should minimally include the following[2]:

- Read the performance expectation, clarification statement, and assessment boundary.
- Read the disciplinary core idea in the foundation box.
    - Read the applicable disciplinary core idea essay in *A Framework for K-12 Science Education*, located in chapters 5, 6, 7, and 8. As you read, consider the following questions:
        - What are some commonly held student ideas about this topic?
        - How could instruction build on helpful ideas and confront troublesome ideas?
        - What prior ideas or concepts do students need to learn to understand this core idea?
        - What level of abstractness is expected of students?
        - What are some phenomena and experiences that could provide observational or experimental evidence that the DCI is an accurate description of the natural world?
        - What representations or media would be helpful for students to use in making sense of the core idea?
- Read the science and engineering practices associated with the performance expectation.
    - Read the applicable SEP essay in *A Framework for K-12 Science Education* located in chapter 3, consider the following questions:
        - While the PE describes one SEP to be used, others will be needed in the instructional sequence, which ones and in what order will you use them?
        - How will each SEP be used to develop an understanding of the DCI?
        - What practices could students engage in to explore phenomena?
- Read the crosscutting concept associated with the performance expectation.
    - Read the applicable CCC essay in *A Framework for K-12 Science Education* located in chapter 4, consider the following questions:
        - How will the CCC indicated in the PE support the understanding of the core idea?
        - Are there other CCC that could also support learning the core idea?

[2] Bybee, Rodger W. (2013) *Translating the NGSS for Classroom Instruction.*

- Read the connections box
  - When reading the connections to other DCI at this grade level that are relevant to the standard, consider the following question:
    - How can instruction be designed so that students note the connections between the core ideas?
  - When reading the articulation of DCI across grade levels that are relevant to the standard, consider the following questions:
    - Examine the standard at earlier grade levels, do they provide an adequate prior knowledge for the core ideas in the standard being reviewed?
    - Examine the standard at later grade levels, does the standard at this level provide adequate prior knowledge for the core ideas in the later standards?
  - When reading the *CCSS* in mathematics and English language arts (ELA), consider the following questions:
    - Should students have achieved these mathematics and ELA standards to engage in the learning of science, or could they be learned together?
    - In what ways do the referenced mathematics and ELA standards help clarify the science performance expectations?
    - Can any of the science core ideas be included as examples in the mathematics or ELA instruction?
- Create one or more descriptions of the desired results or learning goals for the instruction integrating the three dimensions in the foundation box.
- Determine the acceptable evidence for the assessment of the desired results.
- Create the learning sequence
  - The NMIS Science document includes sample phenomena, classroom assessment items, common misconceptions, general and targeted supports, and CLR considerations that can be used to assist with this process.
- Create the summative assessment and check its alignment with the performance expectation.

Sample Phenomena

What: Natural phenomena are observable events that occur in the universe and that we can use our science knowledge to explain or predict. The goal of building knowledge in science is to develop general ideas, based on evidence, that can explain and predict phenomena. Engineering involves designing solutions to problems that arise from phenomena and using explanations of phenomena to design solutions. In this way, phenomena are the context for the work of both the scientist and the engineer.

Why: Despite their centrality in science and engineering, phenomena have traditionally been a missing piece in science education. Anchoring learning in explaining phenomena supports student agency for wanting to build science and engineering knowledge. Students are able to identify an answer to “why do I need to learn this?” before they even know what “this” is. By centering science education on phenomena that students are motivated to explain, the focus of learning shifts from learning about a topic to figuring out why or how something happens. Explaining phenomena and designing solutions to problems allow students to build general science knowledge in the context of their application to understanding phenomena in the real world, leading to deeper and more transferable knowledge. Students who come to see how science ideas can help explain and model phenomena related to compelling real-world situations learn to appreciate the social relevance of science. They get interested in and identify with science as a way of understanding and improving real-world contexts.

Learning to explain phenomena and solve problems is the central reason students engage in the three dimensions of the *NGSS*. Students explain phenomena by developing and applying the DCI and CCC through use of the SEPs. Phenomena-centered classrooms also give students and teachers a context in which to monitor ongoing progress toward understanding all three dimensions. As students are working toward being able to explain phenomena, three-dimensional formative assessment becomes more easily embedded and coherent throughout instruction.

How: We use phenomena to drive instruction to help students engage in practices to develop the knowledge necessary to explain or predict the phenomena. Therefore, the focus is not just on the phenomenon itself. It is the phenomenon plus the student-generated questions about the phenomenon that guides the learning and teaching. The practice of asking questions or identifying problems becomes a critical part of trying to figure something out.

There could potentially be many different lines of inquiry about the same phenomenon. Teachers should help students identify different aspects of the same phenomenon as the focus of their questions. Students also might ask questions about a phenomenon that motivates a line of investigation that isn't grade appropriate or might not be effective at using or building important disciplinary ideas. Teacher guidance may be needed to help students reformulate questions so they can lead to grade appropriate investigations of important science ideas.

It is important that all students – including English language learners and students from cultural groups underrepresented in STEM – are supported in working with phenomena that are engaging and meaningful to them. Not all students will have the same background or relate to a particular phenomenon in the same way. Educators should consider student perspectives when choosing phenomena and should prepare to support student engagement in different ways. When starting with one phenomenon in your classroom, it is always a good idea to help students identify related phenomena from their lives and their communities to expand the phenomena under consideration.

Not all phenomena need to be used for the same amount of instructional time. Teachers could use an anchoring phenomenon as the overall focus for a unit, along with other investigative phenomena along the way as the focus of an instructional sequence or lesson. They may also highlight everyday phenomena that relate investigative or anchoring phenomena to personally experienced situations. A single phenomenon doesn't have to cover an entire unit, and different phenomena will take different amounts of time to figure out.

The most powerful phenomena are culturally or personally relevant or consequential to students. Such phenomena highlight how science ideas help us explain aspects of real-world contexts or design solutions to science-related problems that matter to students, their communities, and society. An appropriate phenomenon for instruction should help engage all students in working toward the learning goals of instruction as described by the DCIs, SEPs, and CCCs in the foundation box of the standard.

The process of developing an explanation for a phenomenon should advance students' understanding. If students already need to know the target knowledge before they can inquire about the phenomenon, then the phenomenon is not appropriate for initial instruction. Students should be able to make sense of anchoring or investigative phenomena, but not immediately, and not without investigating it using sequences of the science and engineering practices. Phenomena do not need to be flashy or unexpected. Students might not be intrigued by an everyday phenomenon right away because they believe they already know how or why it happens. With careful teacher facilitation, students can become dissatisfied with what they believe they already know and strive to understand it in the context of the DCI that the teacher is targeting.[3]

Classroom Assessment Items

What: Classroom assessments (sometimes referred to as internal assessments) is used to refer to assessments designed or selected by teachers and given as an integral part of classroom instruction. This category of assessment may include teacher-student interactions in the classroom, observations of students, student products that result directly from ongoing instructional activities, quizzes tied to instructional activities, formal classroom exams that cover material from one or more instructional units, or assessments created by curriculum developers and embedded in instructional materials for teacher use. [4]

Classroom assessments can be designed to guide instruction (formative purposes) or to support decisions made beyond the classroom (summative purposes). Assessments used for formative purposes occur during the course of a unit of instruction and may involve both formal tests and informal activities conducted as part of a lesson. They may be used to identify students' strengths and weaknesses, assist students in guiding their own learning, and foster students' sense of autonomy and responsibility for their own learning. Assessments for summative purposes may be administered at the end of a unit of instruction. They are designed to provide evidence of achievement that can be used in decision making, such as assigning grades, making promotion or retention decisions, and classifying test takers according to defined performance categories. The results of all these assessments are evaluated by the teacher or sometimes by groups of teachers. These assessments play an integral role in students' learning experiences while also providing evidence of progress in that learning.

Why: In *Developing Assessments for the Next Generation Science Standards*, the National Research Council shared the following conclusions regarding assessing three-dimensional learning:[5]

- Measuring the three-dimensional science learning called for in the framework and the NGSS requires assessment tasks that examine students' performance of scientific and engineering practices in the context of crosscutting concepts and disciplinary core ideas. To adequately cover the three dimensions, assessment tasks will generally need to contain multiple components. It may be useful to focus on individual practices, core ideas, or crosscutting concepts in the various components of an assessment task, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given performance expectation.
- The Next Generation Science Standards require that assessment tasks be designed so they can accurately locate students along a sequence of progressively more complex understandings of a core idea and successively more sophisticated applications of practices and crosscutting concepts.
- The NGSS places significant demands on science learning at every grade level. It will not be feasible to assess all the performance expectations for a given grade level with any one assessment. Students will

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[3] Penuel, W. R., Bell, P., Neill, T., Morrison, D., & Tesoriero, G. (2018). *Selecting Anchoring Phenomena for Equitable 3D Teaching*. [OER Professional Development Session from the ACESSE Project] Retrieved from http://stemteachingtools.org/pd/sessione
[4] National Resource Council. (2014). *Developing Assessments for the Next Generation Science Standards.* Committee on Developing Assessments of Science Proficiency in K-12. Board on Testing and Assessments and Board on Science Education, J.W. Pellegrino, M.R. Wilson, J.A. Koenig, and A.S. Beatty, *Editors*. Division of Social Sciences and Education. Washington, DC: The National Academies Press.
[5] National Research Council. (2014). *Developing Assessments for the Next Generation Science Standards.* Committee on Developing Assessments of Science Proficiency in K-12. Board on Testing and Assessment and Board on Science Education. J.W. Pellegrino, M.R. Wilson, J.A. Koenig, and A.S. Beatty, *Editors*. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

need multiple – and varied – assessment opportunities to demonstrate their competence on the performance expectations for a given grade level.

- Effective evaluation of three-dimensional science learning requires more than a one-to-one mapping between the NGSS performance expectations and assessment tasks. More than one assessment task may be needed to adequately assess students' mastery of some performance expectations, and any given assessment task may assess aspects of more than one performance expectations. In addition, to assess both understanding of core knowledge and facility with a practice, assessments may need to probe students' use of a given practice in more than one disciplinary context. Assessment tasks that attempt to test practices in strict isolation from one another may not be meaningful as assessments of the three-dimensional science learning called for by the NGSS. (Developing assessments for NGSS, NRC, pp.44-46)

How: The amount of information that has been generated around designing and creating three-dimensional assessment tasks to meet the conclusions laid out above by the National Research Council has been overwhelming. The following free resources are available through STEM teaching tools to help you navigate this flood of information and translate it into your classroom. You should start by familiarizing yourself with the following STEM Teaching Tools[6]:

- Practice Brief 18 on how teachers can develop formative assessments that fit a three-dimensional view of science learning.
- Practice Brief 26 on how to design formative assessments that engage students in three-dimensional learning.
- Practice Brief 30 on integrating science practices into assessment tasks
- Practice Brief 41 on integrating cross cutting concepts into assessment and instruction
- Practice Brief 33 on designing assessments for emerging bilingual students

In general, one can use the following process to develop classroom assessment tasks:

1. Identify specific learning goals for the desired assessment
2. Brainstorm assessment scenarios that involve phenomena that clearly foreground the identified learning goals
3. Prioritize and select a scenario that best fits the following criteria:
    a. it should allow students from non-dominant communities (e.g., ELLs, students from poverty-impacted communities) to fully engage with the task,
    b. it should involve a compelling phenomenon related to one or more of the DCIs being assessed—and not feel like a test-like task,
    c. it should be quickly understandable by students, and
    d. it should lend itself to a broad range of science and engineering practices.

[6] STEM Teaching Tools (n.d.), http://stemteachingtools.org/tools accessed on July 7, 2021

4. The task formats (practice briefs 30 and 41) provide detailed guidance on how to design assessment components that engage students in the science and engineering practices. Identify the practices that relate to the scenario and use the task formats to craft assessment components
5. Write hypothetical student responses for each prompt: some that reflect limited, partial, and full levels of understanding
6. Share tasks with colleagues and ask for feedback about the alignment of goals, scenarios, and hypothetical student responses

Common Misconceptions

What: This planning support identifies some of the common misconceptions students develop about a scientific topic.

Why: Our brains are highly advanced cause and effect reasoning machines. From birth, we begin to analyze effects to determine causes and provide some sort of reasoning for the whole event. The more events that support our reasoning, the stronger that learning becomes. So, every student in your classroom brings their own unique background knowledge into your classroom. Some of this is aligned to scientific understanding and some of this is misaligned to scientific understanding but aligned to that student's personal experiences. As science educators, we must always create space for students to bring their current understanding about a topic into our classroom so that we can begin to address understandings that are misaligned to scientific understanding. Some of these misunderstandings are not unique to a single student; rather, they are common to many students.

How: When planning with your HQIM look for ways to directly address with students some common misconceptions. The planning supports in this document provide some possible misconceptions and your HQIM might include additional ones. The goal is not to avoid misconceptions, they are a natural part of the learning process, but we want to support students in exploring the misconception and modifying incorrect or partial understandings.

Multi Layered System of Supports (MLSS)

What: The Multi-Layered Systems of Support (MLSS) is designed to support teachers in planning instruction for the needs of all students. Each section identifies general supports (layer 1) for supporting pedagogically sound whole class science instruction and targeted supports (layer 2) for supporting those scholars that teachers identify as not understanding the topic. We recognize there is a need for intensive support (layer 3) for those students needing longer duration or otherwise more intense support with a given topic; however, this was not part of the NM IS Science 1.0 work.

Why: MLSS is a holistic framework that guides educators, those closest to the student, to intervene quickly when students need additional support. The framework moves away from the "wait to fail" model and empowers teachers to use their professional judgement to make data-informed decisions regarding the students in their classroom to ensure academic success with grade level expectations of the New Mexico Science Standards.

How: When planning with your high-quality instructional materials (HQIM) use the suggested universal supports embedded in the sequence of instruction. If you do not have access to HQIM in your school, the universal (layer 1) support in this document can be used in planning your instruction.

Culturally and Linguistically Responsive Instruction

What: Culturally and Linguistically Responsive Instruction (CLRI), or the practice of situational appropriateness, requires educators to contribute to a positive school climate by validating and affirming students' home languages and cultures. Validation is making the home culture and language legitimate, while affirmation is affirming or making clear that the home culture and language are positive assets. It is also the intentional effort to reverse negative stereotypes of non-dominant cultures and languages and must be intentional and purposeful, consistent and authentic, and proactive and reactive. Building and bridging is the extension of validation and affirmation. By building and bridging students learning to toggle between home culture and linguistic behaviors and expectations and the school culture and linguistic behaviors and expectations. The building component focuses on creating connections between the home culture and language and the expectations of school culture and language for success in school. The bridging component focuses on creating opportunities to practice situational appropriateness or utilizing appropriate cultural and linguistic behaviors.

Why: Student understanding of science is shaped by their interactions with phenomena throughout their lives. Science educators must intentionally and purposefully legitimize the home culture and languages of students and validate their ways of knowing and understanding. In addition, create connections between the cultural and linguistic behaviors of the students' home culture and language and the culture and language of scientific understanding.

How: When planning instruction it is critical to consider ways to validate/affirm and build/bridge from your students' cultural and linguistic assets. There has been an overwhelming amount of guidance within STEM education about CLRI. The following STEM teaching tools can be a good place to start wrapping your mind around this topic.[7]

- Practice Brief 15: Promoting equity in science education
- Practice Brief 47: Promoting equitable sensemaking
- Practice Brief 54: Building equitable learning communities
- Practice Brief 11: Indigenous ways of knowing and STEM
- Practice Brief 27: Engaging English language learners in science and engineering practices
- Practice Brief 71: Advancing equity and justice in science education
- Practice Brief 53: Avoiding pitfalls associated with CLRI

The planning supports for each performance expectation provide an example of how to support equity-based teaching practices. Look for additional ways within your HQIM to ensure all students are included in the pursuit of scientific understanding in your classroom.

[7] STEM Teaching Tools (n.d.), http://stemteachingtools.org/tools accessed on July 7, 2021

STANDARDS BREAKDOWN

From Molecules to Organisms: Structures and Processes
LS-2-1
LS-2-2
LS-2-3
LS-2-4
LS-2-5

Students who demonstrate understanding can:

MS-LS2-1. **Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.** [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 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 provide evidence for phenomena.	**LS2.A: Interdependent Relationships in Ecosystems** • Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. • Growth of organisms and population increases are limited by access to resources.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Connections to other DCIs in this grade-band:
MS.ESS3.A ; **MS.ESS3.C**

Articulation of DCIs across grade-bands:
3.LS2.C ; **3.LS4.D** ; **5.LS2.A** ; **HS.LS2.A** ; **HS.LS4.C** ; **HS.LS4.D** ; **HS.ESS3.A**

Common Core State Standards Connections:
ELA/Literacy -

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-1)

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). (MS-LS2-1)

Grade	NGSS Discipline
MS	**Life Science 2.1**
LS2-1	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* Yellowstone National Forest and the reintroduction of the wolves. Look for how the wolves have changed the forest ecosystem. For examples: beaver population, willow stands, a. resources:

i. [article with a video attached]
ii. [This article talks about wolves and has links to other related sources as well.]

Classroom Assessment Items

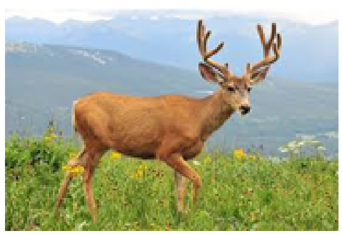
When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.

Deer population

Here are some snippets from this assessment.

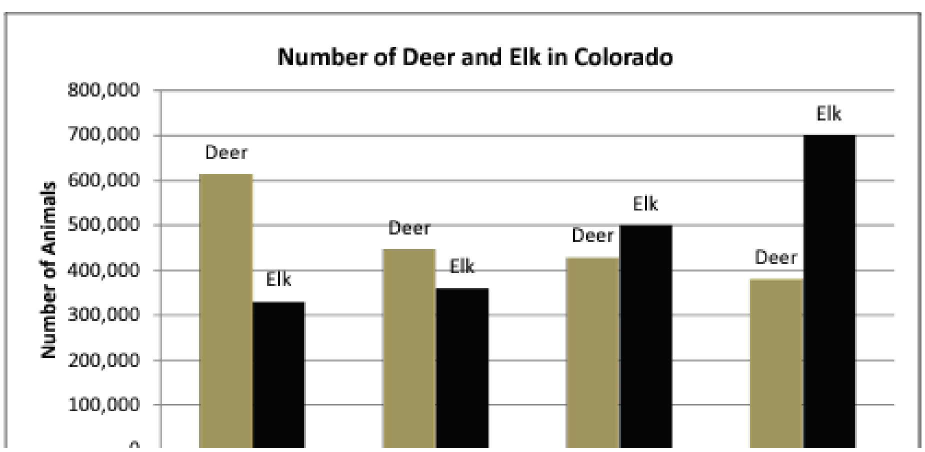
The deer and elk population from Colorado has had big changes over the years. People want to know why the changes are happening. Use these charts and graphs.

Scientists investigated other animals in Colorado to see if their populations showed similar patterns.
Deer and elk occupy similar niches in the same ecosystem. Scientists gathered data to compare the numbers of each type of animal across many years and made the graph below.


Deer (male)


Elk (male)

Figure 1: Comparison of Number of Deer and Elk in Colorado from 2005 to 2013



Grasses

Scientists investigated what deer eat and found:

- Deer can **only** eat a native grass called Sagebrush. Sagebrush has always grown in Colorado.
- Elk can eat Sagebrush **and** Cheatgrass. Cheatgrass is an invasive species.

Sagebrush

Cheatgrass

Scientist measured the amount of two types of grasses and made the following chart.

Figure 2: Amounts of Two Types of Grasses in Colorado

Type of Grasses	Year 2005 (square miles)	Year 2008 (square miles)	Year 2010 (square miles)	Year 2013 (square miles)
Cheatgrass	41,000	52,000	61,000	66,000
Sagebrush	185,000	140,000	110,000	100,000

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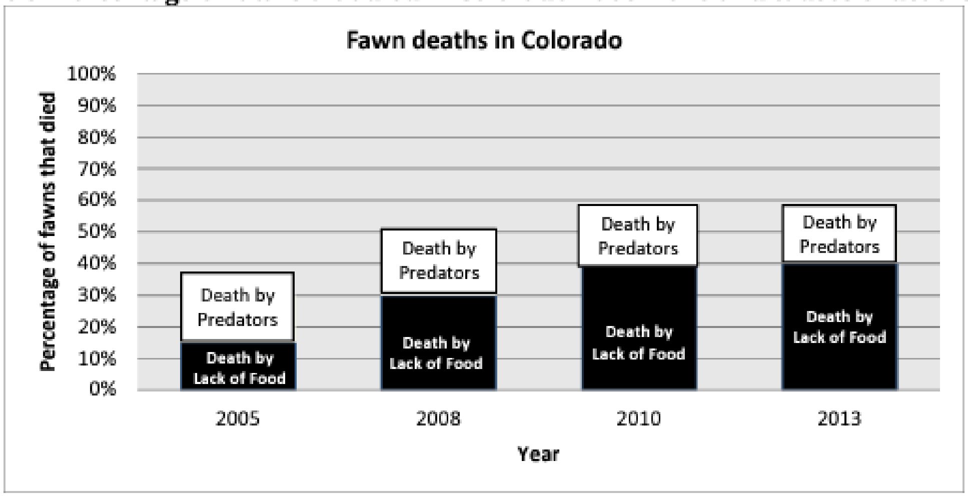
Cheatgrass	41,000	52,000	61,000	66,000
Sagebrush	185,000	140,000	110,000	100,000

In the second row in **the table on page 3**, add a description and interpretation of the patterns that you see in the data. Use evidence to support your ideas.

Fawn deaths

The scientists also studied data specifically on baby deer (fawns) to see if they showed any patterns that could help them understand changes in the whole population of deer.

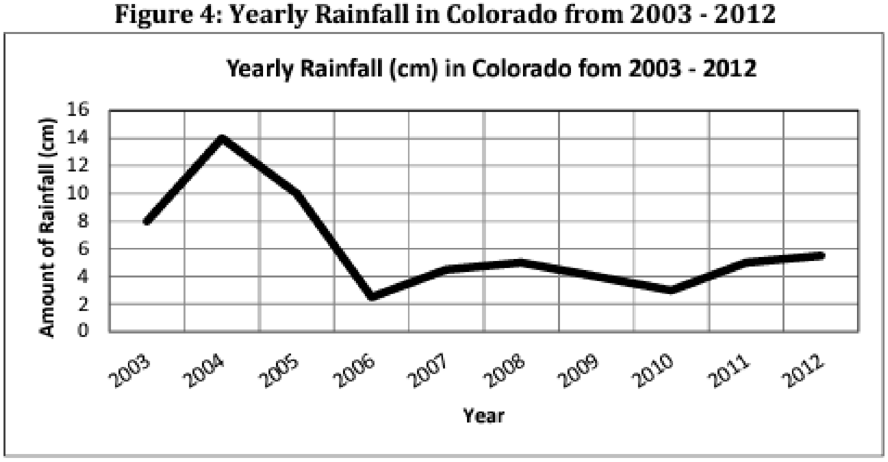
Figure 3: Percentage of fawns that died in Colorado 2005-2013 and causes of deaths.



Rainfall

They also collected data on environmental that might affect the deer, including the amount of rainfall each year.

Figure 4: Yearly Rainfall in Colorado from 2003 - 2012



In the last two rows **in the table on page 3**, add a description and interpretation of the patterns that you see in both graphs. Use evidence to support your ideas.

4. Once you have filled in the whole table on page 3, analyze the patterns to help you decide why the number of deer in Colorado was changing, based on these graphs.
   - Write a **claim** for the most likely cause or causes for the change in the number of deer.
   - Support your claim with patterns in the data **and** what you know about ecosystems.

5. Sometimes patterns in data look like they are showing what *caused* the change you are investigating, but are really just *correlated* to the change.
What additional data would you want to see to help you decide if your answer to question 4 really is a cause, not a correlation? Explain how the data would help you.

Universal Supports	Targeted Supports
• **Layer 1** - Students will need to compare and contrast the different populations before and after the reintroduction of the wolves into Yellowstone National Park. Have before and after reintroduction pictures of the park to show students to help make this comparison. Compare the population sizes with the resources availability.	• **Layer 2 -** Some students will need to be provided additional help on what resources are needed for each organism to grow and thrive. Have students come up with lists of needed resources for survival.

Common Misconceptions

- Plants are dependent on humans.
- Plants cannot defend themselves against herbivores.
- Varying the population size of a species may not affect an ecosystem because some organisms are not important.
- Ecosystems are not a functioning whole but simply a collection of organisms.
- Ecosystems change little over time.
- Species coexist in ecosystems because of their compatible needs and behaviors; they need to get along

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

These questions are for sense making circles. Use these questions to help guide a class discussion that brings student's own thoughts, ideas and culture into the science classroom.

Validate and Affirm:
- What have you noticed about the effect of rain on the desert landscape?
- Name some living and nonliving things in your environment.
- What are some things that you need in order to survive? Not necessarily happily.
- What knowledge and experiences have you had that might help us as a class explain how resource availability affects an organism or a population of organisms?

Build and Bridge:
- What questions do we need to answer to test your ideas about how resource availability affects an organism or a population of organisms?
- Why does this phenomenon matter to you, to your community or others to scientists?

Students who demonstrate understanding can:

MS-LS2-2. **Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.** [Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions 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 phenomena.	**LS2.A: Interdependent Relationships in Ecosystems** • Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.	**Patterns** • Patterns can be used to identify cause and effect relationships.

Connections to other DCIs in this grade-band:
MS.LS1.B

Articulation of DCIs across grade-bands:
1.LS1.B ; **HS.LS2.A** ; **HS.LS2.B** ; **HS.LS2.D**

Common Core State Standards Connections:
ELA/Literacy -

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-2)
WHST.6-8.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS2-2)
WHST.6-8.9	Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-2)
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. *(MS-LS2-2)*
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. *(MS-LS2-2)*

Mathematics -

6.SP.B.5	Summarize numerical data sets in relation to their context. *(MS-LS2-2)*

Grade	*NGSS Discipline*
MS	**Life Science 2.2**
LS2-2	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* 1. Frogs will ride on water buffalo. a. this is an article with embedded videos that talk about this strange relationship. This is a national geographic article. It explains why scientists think the frogs ride on the water buffalos. 2. A tree killing beetle is destroying an entire forest. a. links: i. This is a link to a data nugget lesson that talks about the tree killing beetle. ii. This is an article that talks about how small beetles are destroying forests throughout the world. 3. Fungi make ants kill themselves. a. Attack Of The Killer Fungi

b. **Description:** The cordyceps fungi has a fascinating life cycle. Spores from the fungi are ingested by an insect (like an ant). The fungi takes over the insect causing it to climb to a high branch and hold tight with its mandibles. A fruiting body then emerges from the head of the insect and spreads more spores that infect more insects. Different species of cordyceps infect different species of insects. This phenomenon can be used to introduce the diverse and unique life cycles found in organisms.

Classroom Assessment Items

When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.

Birds, bees, and cherry trees (ID# 141-03-Y01)
Use a model to describe the interactions between birds, bees, and cherry trees.

Birds, bees, and cherry trees (ID# 141-03-Y01)

Juan observed birds, bees, and cherry trees each spring for five years. He created a model showing how the birds, bees, and cherry trees interact.

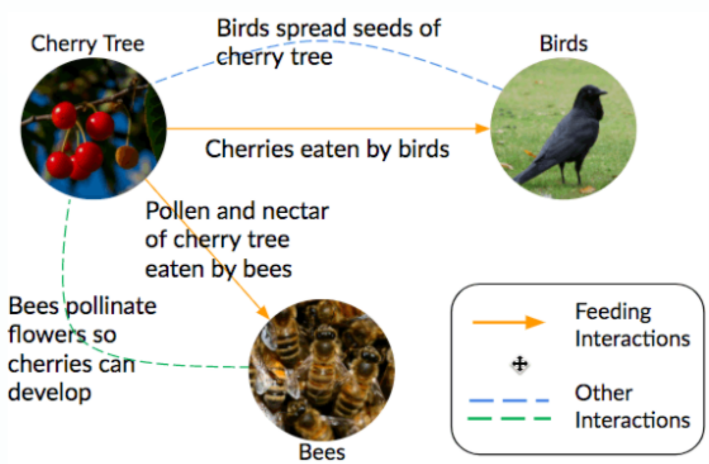
Juan observed that the number of birds, bees, and cherries on the cherry trees did not change much each spring. Juan thinks that the birds, bees, and cherry trees interact in mutually beneficial ways. He thinks that because of these interactions the number of birds, bees, and cherries do not change much.

Question #1

Use the model to describe if the interactions observed were mutually beneficial.

Include how the interactions could cause the number of, birds, bees, and cherries to not change much each spring.

Type answer here



All images are public domain.

Universal Supports	Targeted Supports
• Layer 1 - Students will need an example of specific interactions in a variety of ecosystems. In the desert there is a coyote and a rabbit. In the ocean there is the shark and its prey or sharks and its helper fish. Students can create lists of animals that help each other in the desert. Animals that are competing for the same food in the desert. Have students look at	• Layer 2 - Some students may require specific explanations of different ecosystems. How they need for the interaction is either helpful or harmful or both. Some students will need the definitions for the different kinds of

symbiosis. The 3 types are commensalism, parasitism , and mutualism.

Type of Symbiosis	Organism 1	Organism 2
Mutualism	🙂	🙂
Commensalism	🙂	😐
Parasitism	🙂	🙁

relationships with specific examples of each.

Common Misconceptions

- Predator and prey populations are similar in size.
- The relative sizes of predator and prey populations have no bearing on the size of the other.
- Carnivores have more energy or power than herbivores do.
- Carnivores are big or ferocious, or both. Herbivores are small and passive.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

These questions are for sense making circles. Use these questions to help guide a class discussion that brings student's own thoughts, ideas and culture into the science classroom.

Validate and Affirm:

- Name some living and nonliving things in your environment.
- How do you interact with other organisms?
- How and what other organisms do you need to survive?
- How do organisms interact with each other in the ecosystem?
- What knowledge and experiences have you had that might help us as a class explain the interdependence of these organisms?

Build and Bridge:

- What questions do we need to answer to test your ideas about the interdependence of these organisms?
- Why does this phenomenon matter to you, to your community or others to scientists?

Students who demonstrate understanding can:

MS-LS2-3. **Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.** [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [*Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe phenomena.	**LS2.B: Cycle of Matter and Energy Transfer in Ecosystems** • Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a natural system. - - - - - - - - - - - - - - - - *Connections to Nature of Science* **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Connections to other DCIs in this grade-band:
MS.PS1.B

Articulation of DCIs across grade-bands:
5.LS2.A ; **5.LS2.B** ; **HS.PS3.B** ; **HS.LS1.C** ; **HS.LS2.B** ; **HS.ESS2.A**

Common Core State Standards Connections:
ELA/Literacy -
SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-LS2-3)*
Mathematics -
6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *(MS-LS2-3)*

Grade	*NGSS Discipline*
MS	**Life Science 2.3**
LS2-3	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* Identify a phenomenon that illustrates the DCI and can be approached in such a way as to incorporate appropriate SEPs and CCCs. 1. According to this Daily Mail article David Latimer has had a sealed ecosphere for over fifty years that he has only watered once. 2. Plan ahead. Have students create a bottle biosphere early in the year. Then in a few months discuss why it works. a. resources: i. https://www2.nau.edu/lrm22/lessons/bottle_biology/ - this explains very well why it is very difficult to keep a sealed system working. And how to create 1 using 2 liter bottles.

Classroom Assessment Items

When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.

Does leaving grass clippings on the lawn help, harm or make no difference on the health of the lawn?

Observations of Customers' Shared Lawn			
		Lawn 1 (Cut Grass Left on Lawn)	Lawn 2 (Cut Grass Removed)
Average length of grass when lawn is cut every two weeks		10.2 cm	6.1 cm
Average number of decomposers observed every two weeks	Mushrooms	32	2
	Slugs	10	0
	Snails	7	0
	Worms	8	6

Using the charts explain which lawn is healthier. Why is your answer correct?
This web site does ask more questions about this and asks for more details. This is the basic idea.

Mouse in a jar
The following assessment is found on the Next Generation Science standard assessment page.
Mouse in a jar (ID #138-02-s05)

Sara saw a mouse in her mint plant pot. She captured the mouse by placing a jar over the pot and sealed the jar. Sara observed that the mouse was perfectly fine even after an hour. This surprised Sara because she knows organisms have to take in and release substances for survival. She knows mint plants are good at performing photosynthesis and wondered if the plant in the jar helped the mouse.

To investigate how the mouse survived, she did the following experiment:

1. Over 5 minutes, Sara measured the levels of oxygen (O_2) in the sealed jar with the mouse and mint plant. She found that the oxygen (O_2) levels in the jar's air stayed around the same the whole time.
2. She then measured the levels of oxygen (O_2) in a sealed jar with just the mouse.

3. She saw the oxygen (O_2) levels in the jar's air drop to a point that might be dangerous for the mouse.
4. She stopped her experiment and opened the jar.

Question #1

Use the draw tool to show how the mouse survived when a mint plant is present even though no new oxygen (O_2) could have entered the jar.

Based on your model, describe why the mouse survived when the mint plant is present even though no new oxygen (O_2) could have entered the jar.

Universal Supports	Targeted Supports
• Layer 1 - Students will need to model the different cycles of matter in relationship to ecosystems. Students will need to model how the energy transfers from 1 organism to another. Does the energy increase or decrease? Have students create their own food chains and food webs. Making sure that students understand that the food web and food chains are actually showing the energy flow and not what eats what. Draw the water cycle with its different forms of water to gas and ice.	• Layer 2 - Some students will need further practice in identifying living and nonliving parts of an ecosystem.

Common Misconceptions

- Food webs are interpreted as simple food chains.
- Organisms higher in a food web eat everything that is lower in the food web.
- There are more herbivores than carnivores because people keep and breed herbivores.

- Food chains involve predators and prey, but not producers.
- Decomposers release some energy that is cycled back to plants.
- predators can single handedly kill prey many times their own weight.
- Some students have difficulty in identifying the sources of energy for plants and also for animals
- Students tend to confuse energy and other concepts such as food, force, and temperature. As a result, students may not appreciate the uniqueness and importance of energy conversion processes like respiration and photosynthesis
- Middle-school students seem to know that some kind of cyclical process takes place in ecosystems. Some students see only chains of events and pay little attention to the matter involved in processes such as plant growth or animals eating plants.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

These questions are for sense making circles. Use these questions to help guide a class discussion that brings student's own thoughts, ideas and culture into the science classroom.

Validate and Affirm:
- What are some cycles in nature?
- How do you get energy to do your daily activities?
- How do other organisms get energy to do their daily activities?
- How do organisms transfer energy from 1 to another?
- What knowledge and experiences have you had that might help us as a class explain how organisms collect energy to survive?

Build and Bridge:
- What questions do we need to answer to test your ideas about how organisms collect energy to survive?
- Why does this phenomenon matter to you, to your community or others to scientists?

Students who demonstrate understanding can:

MS-LS2-4. **Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.** [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on K–5 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 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. - - - - - - - - - - - - - - - - *Connections to Nature of Science* **Scientific Knowledge is Based on Empirical Evidence** • Science disciplines share common rules of obtaining and evaluating empirical evidence.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.	**Stability and Change** • Small changes in one part of a system might cause large changes in another part.

Connections to other DCIs in this grade-band:
MS.LS4.C ; **MS.LS4.D** ; **MS.ESS2.A** ; **MS.ESS3.A** ; **MS.ESS3.C**

Articulation of DCIs across grade-bands:
3.LS2.C ; **3.LS4.D** ; **HS.LS2.C** ; **HS.LS4.C** ; **HS.LS4.D** ; **HS.ESS2.E** ; **HS.ESS3.B** ; **HS.ESS3.C**

Common Core State Standards Connections:
ELA/Literacy -

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-4)
RI.8.8	Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS2-4)
WHST.6-8.1	Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4)
WHST.6-8.9	Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-4)

Grade	*NGSS Discipline*
MS	**Life Science 2.4**
LS2-4	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* 1. A year without summer in Europe. It was so cold that almost the entire month of May was below freezing on the European continent. a. A quick article about what happened when the sun did not come out in 1816 b. a little longer article about the impacts. 2. Extension from LS2 - 1 yellowstone national forest and the reintroduction of the wolves. Look for how the wolves have changed the forest ecosystem. a. resources: i. article with a video attached ii. This article talks about wolves and has links to other related sources as well.

Classroom Assessment Items

When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.

[Why has the monarch butterfly population changed over time?]
MONARCH BUTTERFLY REAL WORLD DATA ANALYSIS ASSIGNMENT (A)
Goal: Use data to support a claim explaining why the monarch butterfly population has been decreasing.
1.1: Monarch Butterfly Population Size
Data: Estimated monarch butterfly population size in millions of butterflies for each year
NOTE: This past winter's population of 57 million is 80% below the long-term average of 300 million.

NOTE: This past winter's population of 57 million is 80% below the long-term average of 300 million.

'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14
631	910	289	278	449	142	468	377	556	110	296	334	231	253	96	201	145	60	34	57

Describe the pattern:

1.3: Area of Conserved Oyamel Forest (there is more forest, but it's degraded/partially deforested)
Data: Area of Oyamel Forest not affected by logging within a 420 km2

region over 45 years

Data: Area of Oyamel Forest not affected by logging within a 420 km^2 region over 45 years

1971	1979	1984	1991	1999	2007	2014
274 km^2	251 km^2	220 km^2	179 km^2	153 km^2	139 km^2	123 km^2

Describe the pattern:

2. Support an argument with evidence in the form of a graph: Claim-Evidence-Reasoning
Directions: Use the claim, evidence, reasoning format to help answer this question:
What has caused the monarch butterfly population to decrease by 90% over the past 20 years?
Claim: Record a simple statement that answers the question and is based upon evidence.
____
____
Evidence: Create a graph that supports your claim. Include a 1-2 sentence caption describing the patterns visible in the graph. Do NOT talk about why this is happening or what it means yet.

____
Reasoning: Explain how your evidence supports your claim. Why is this happening? Be sure to use relevant scientific vocabulary and explain this within the context of resources within ecosystems.
Potential vocabulary to use: population, resource, food, shelter, competition (or competing), ecosystem damage

Universal Supports	Targeted Supports
• **Layer 1** - Students will need to identify different physical or biological components an an ecosyst. Then identify how each component will cause a change in the ecosystem (example look at the finches on Galapagos Island before and after the drought) Students can look at why the population of the white pepper moths decreased in England around the 1900's. and then what happened to the white peppered moths after the cleanup effort.	• **Layer 2 -** some students will need help to analyze the empirical evidence. Some students will need help understanding that sometimes this can happen quickly and other times this will happen slowly.

Common Misconceptions

- Traits are developed by individuals in response to the needs of the individual.
- Ecosystems change little over time.
- Species coexist in ecosystems because of their compatible needs and behaviors; they need to get along.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

These questions are for sense making circles. Use these questions to help guide a class discussion that brings student's own thoughts, ideas and culture into the science classroom.

Validate and Affirm:
- Have you ever experienced a change in your environment?
- What knowledge and experiences have you had that might help us as a class explain how ecosystems would vary over time?
- What things could change an environment?

Build and Bridge:
- What questions do we need to answer to test your ideas about how ecosystems would vary over time?
- Why does this phenomenon matter to you, to your community or others to scientists?

Students who demonstrate understanding can:

MS-LS2-5. **Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*** [Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 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).

- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.

Disciplinary Core Ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.

LS4.D: Biodiversity and Humans

- 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. *(secondary)*

ETS1.B: Developing Possible Solutions

- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. *(secondary)*

Crosscutting Concepts

Stability and Change

- Small changes in one part of a system might cause large changes in another part.

- -

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.

- -

Connections to Nature of Science

Science Addresses Questions About the Natural and Material World

- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

Connections to other DCIs in this grade-band:
MS.ESS3.C

Articulation of DCIs across grade-bands:
HS.LS2.A ; **HS.LS2.C** ; **HS.LS4.D** ; **HS.ESS3.A** ; **HS.ESS3.C** ; **HS.ESS3.D**

Common Core State Standards Connections:

ELA/Literacy -

RST.6-8.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (MS-LS2-5)

RI.8.8 Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS2-5)

Mathematics -

MP.4 Model with mathematics. *(MS-LS2-5)*

6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems. *(MS-LS2-5)*

Grade	*NGSS Discipline*
MS	**Life Science 2.5**
LS2-5	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* 1. Yellowstone National Forest and the reintroduction of the wolves. Look for how the wolves have changed the forest ecosystem. a. resources: i. article with a video attached ii. This article talks about wolves and has links to other related sources as well. **2.** The Salmon Canon

a. **Description:** Dams provide hydroelectric power and recreation to much of the Pacific Northwest. However these dams block the normal migration of salmon upstream to spawn. Whoosh Systems has created a "salmon cannon" that may the problem of salmon migration. Salmon are moved up a vacuum tube and launched into the water above the dam.
b. **Web Resources:** Meet the Salmon Cannon - Geek Wire, Whooshh Innovations

Classroom Assessment Items

When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.

research an ecosystem. Describe the ways that ecosystem maintains itself.

Explore
In a whole-group brainstorm, make a list of all ecosystems students can think of: forest, desert, grasslands, mountain, aquatic (and the many sub-ecosystems). Leave space between each ecosystem so that students can sign up to investigate that ecosystem.
Let students sign up for the system they want to investigate, with no more than three students in each group. Students should record their ecosystems and group members in their notebooks.
Next, students need to work with their group members to do the following:
1. Brainstorm and research all the ways in which their ecosystem maintains its health. Students should look at the rigor, organization, and resilience of their system as well as the ecosystem services.
2. Make charts in their notebooks in preparation for their solutions. Students should chart their own ecosystem, identifying strengths, weaknesses, solutions, and so on (see example chart).
3. Students fill in their charts as they research solutions. Remind them to use the academic language for this activity.
4. Students discuss and then rank their solutions, with "1" being the most important solution to maintain the ecosystem services.
5. Students then transfer their notebook work to a whiteboard and discuss their plans to share orally with the full class.

Doing Good Science in Middle School 179
Activity 8: Saving the World—One Ecosystem at a Time

Example: Coral Reef Ecosystem

Solution for Maintaining Health	Merits	Constraints (scientific, economic, and social considerations)	Ranking and Reasoning (lowest number = most important to do first)
Spectrographic imager	Takes pictures of coral from airplane for data comparison; can assess quickly	Expensive	
Predator-prey monitoring	Balance needed for health of ecosystem	Difficult to control and introduce species	
Coastal zone management	Control amount of development and industrial run-off	Cost of regulating	
SCUBA divers and snorkelers	Ecosystem service: cultural	Need to control and educate about coral reef care when diving. Hard to regulate diver activities.	

Explain
Student groups present their ecosystems and whiteboards, one at a time, to the rest of the class. The teacher invites other students to ask questions about the group's rankings. Be sure to apply the academic language in context as students explain their solutions.
Elaborate
Each group takes their top-ranked idea from their chart and draws a "to scale" diagram depicting their idea.
Evaluate
Students should write their explanation of the process they went through to rank-order their solutions.

Universal Supports

- **Layer 1 -** students need to explain why biodiversity is important in an ecosystem. How trees and plants can prevent soil erosion. Students can do a simple water purification using sand, gravel and charcoal. Identify and create solutions for water problems in NM.

Targeted Supports

- **Layer 2 -** Some students will need help to understand the concept of biodiversity. The interconnectedness of all things. How 1 thing in an ecosystem can affect another thing in an ecosystem.

Common Misconceptions

- In biodiversity, not all species are important and some can be sacrificed
- Large numbers of a particular species means the ecosystem is healthy
- Large empty spaces are wastelands
- Humans do not need to be concerned with biodiversity
- Environmental damage is irreversible

- Biodiversity is only important at the species level
- Plants are dependent on humans
- Species have always gone extinct so we do not need to worry
- Plants get their food from soil
- The top of the food chain has the most energy because energy accumulates moving up the chain

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

These questions are for sense making circles. Use these questions to help guide a class discussion that brings student's own thoughts, ideas and culture into the science classroom.

Validate and Affirm:
- What are some natural resources that you rely on or enjoy?
- What are some problems that we know of in our environment?
- What are some environmental problems that have occured in the world?
- What are some possible solutions to maintain biodiversity and ecosystem services?
- What are some ways that water can be purified?
- What knowledge and experiences have you had that might help us as a class to come up with possible solutions to problems maintaining clean water and biodiversity?

Build and Bridge:
- What questions do we need to answer to test your ideas about discovering the validity of our solutions to the pure water and biodiversity problems?
- Why does this phenomenon matter to you, to your community or others to scientists?

Section 3: Resources

Science is not just a body of knowledge that reflects current understanding of the world; it is also a set of practices used to establish, extend, and refine that knowledge. [8] Our core science instruction must also allow for students to develop their science and engineering practices over time in addition to disciplinary core ideas. We know that children enter kindergarten with a surprisingly complex way of thinking about the world.[9] We know that students need sustained opportunities to work with and develop the underlying ideas and to appreciate those ideas' interconnections over a period of years rather than weeks or months.[2] We know that in order for students to develop a sustained attraction to science and for them to appreciate the many ways in which it is pertinent to their daily lives, classroom learning experiences in science need to connect with their own interests and experiences.[1] To this end, the National Research Council lays out a three-dimensional framework that is foundational to the development of the *Next Generation Science Standards (NGSS)*.

Dimension 1 describes the scientific and engineering practices (SEP). Dimension 2 describes the crosscutting concepts (CCC). Dimension 3 describes the core ideas (DCI) in the science disciplines and the relationships among science, engineering, and technology. All three of these dimensions must be interwoven in curriculum, instruction, and assessment.[1]

Engaging in the Practices of Science

Students provided sustained opportunities to engage in the practices of science and engineering better understand how knowledge develops and provides them an appreciation of the diverse strategies used to investigate, model, and explain the world.[1] The practices for K-12 science classrooms are:

1. Asking questions (science) and defining problems (engineering)
    a. Science asks:
        i. What exists and what happens?
        ii. Why does it happen?
        iii. How does one know?
    b. Engineering asks:
        i. What can be done to address a particular human need or want?
        ii. How can the need be better specified?
        iii. What tools or technologies are available, or could be developed, for addressing this need?
    c. Both ask:
        i. How does one communicate about phenomena, evidence, explanations, and design solutions?
2. Developing and using models
    a. Mental models: functional, used for thinking, making predictions, and making sense of experiences.
    b. Conceptual models: allow scientists and engineers to better visualize and understand phenomena and problems.

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[8] National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

[9] National Research Council. (2007). *Taking Science to School: Learning and Teaching Science in Grades K-8.* Committee on Science Learning, Kindergarten through Eighth Grade. R.A. Duschl, H.A. Schweingruber, and A.W. Shouse (Eds.). Board of Science Education, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

   c. Are used to represent current understanding of a system (or parts of a system) under study, to aid in the development of questions or explanations, and to communicate ideas to others.
3. Planning and carrying out investigations
   a. Used to systematically describe the world and to develop and test theories and explanations of how the world works.
4. Analyzing and interpreting data
   a. Once collected, data are presented in a form that can reveal any patterns and relationships and that allows results to be communicated to others.
5. Using mathematics and computational thinking
   a. Enables the numerical representation of variables, the symbolic representation of relationships between physical entities, and the prediction of outcomes.
6. Constructing explanations (science) and designing solutions (engineering)
   a. Explanations are accounts that link scientific theory with specific observations or phenomena.
   b. Engineering solutions must include specifying constraints, developing a design plan, producing and testing models/prototypes, selecting among alternative design features to optimize achievement, and refining design ideas based on prototype performance.
7. Engaging in argument from evidence
   a. Scientists and engineers use reasoning and argumentation to make their case concerning new theories, proposed explanations, novel solutions, and/or fresh interpretations of old data.
8. Obtaining, evaluating, and communicating information
   a. Being literate in science and engineering requires the ability to read and understand their literature. Science and engineering are ways of knowing that are represented and communicated by words, diagrams, charts, graphs, images, symbols, and mathematics.

STEM teaching tools develop briefs to assist STEM teachers with issues that arise in the teaching of STEM. Here are some briefs that address scientific practices. All of these can be found at www.stemteachingtools.org/tools

Why focus on science and engineering practices – and not "inquiry?" Why is "the scientific method" mistaken? - STEM teaching tool #32

For decades science education has engaged students in a version of science inquiry that reduces the investigation of the natural world to a fixed, linear set of steps—sometimes devoid of a deep focus on learning and applying science concepts. Rigid representations of a single "scientific method" do not accurately reflect the complex thinking or work of scientists. The new vision calls for engaging students in multifaceted science and engineering practices in more complex, relevant, and authentic ways as they conduct investigations.

Practices should not stand alone: how to sequence practices in a cascade to support student investigations – STEM teaching tool #3

Science and engineering practices should strongly shape instruction—and be integrated with disciplinary core ideas and cross-cutting concepts. Some people might treat the practices as "stand alone" activities to engage students, but research shows that it is more effective to think about designing instruction as a cascade of practices. Practices should be sequenced and intertwined in different ways to support students in unfolding investigations.

What is meant by engaging youth in scientific modeling? - STEM teaching tool #8

A model is a representation of an idea or phenomenon that otherwise may be difficult to understand, depict, or directly observe. Models are integral to the practice of science and are used across many disciplines in a variety of ways. Scientists develop, test, refine, and use models in their research and to communicate their findings. Helping students develop and test models supports their learning and helps them understand important aspects of how science and engineering work.

Beyond a written C-E-R: supporting classroom argumentative talk about investigations – STEM teaching tool #17

Argumentation, a central scientific practice, relies on the coordination of claims, evidence, and reasoning (C-E-R). C-E-R scaffolds can help students compose a written argument for an investigation. However, there are additional important dimensions to argumentation beyond individually written claims. Classroom discussions that require students to make evidence-based claims and collectively build understanding also reflect argumentation. Several types of discussions can be used and can help build a supportive classroom culture.

Why should students learn to plan and carry out investigations in science and engineering? - STEM teaching tool #19

The NRC Framework for K-12 Science Education specifies eight science and engineering practices to be incorporated into science education from kindergarten through twelfth grade. One of these is planning and carrying out investigations. Although many existing instructional models and curricula involve engaging students in planned investigations, this tool will help you think about ways you can promote student agency by having them plan and conduct science investigations.

How can assessments be designed to engage students in the range of science and engineering practices? - STEM teaching tool #26

The new vision for K-12 science education calls for engaging students in three-dimensional science learning. This approach requires us to figure out new ways to assess student learning across these multiple dimensions—including the eight science and engineering practices. But there aren't many assessment tasks that require students to apply their understanding of core ideas using practices. In this tool, we describe how to use "task formats" to guide the development of such items. The formats can also spark ideas for designing classroom instruction.

Integrating science practices into assessment tasks – STEM teaching tool #30

This detailed and flexible tool suggests activity formats to help teachers create three-dimensional assessments based on real-world science and engineering practices. In response to this felt need being expressed among educators, researchers at the Research + Practice Collaboratory have developed a series of "task format" tables, which suggest different possible templates for student activities that integrate real-world science and engineering practices with disciplinary core ideas. This tool also combines two of the Research + Practice Collaboratory's major focuses: formative assessment and engaging learners in STEM practices. This tool offers between four and eight possible task formats for each of the science and engineering practices listed in the Next Generation Science Standards. It can be a great way for educators to brainstorm new activities or to adapt their existing lesson plans to this new three-dimensional vision.

Engaging students in computational design during science investigations – STEM teaching tool #56

Inquiry in science has become increasingly computational over the past several decades. The broad availability of computational devices, sensor networks, visualizations, networking infrastructure, and programming have revolutionized the way science and engineering investigations are carried out. Computational thinking practices enable unique modes of scientific inquiry that allow scientists to create models and simulations to generate data, and to understand and predict complex phenomena. K-12 science classrooms are natural contexts in which students can engage in computational thinking practices during their investigations.

Designing productive uncertainty into investigations to support meaningful engagement in science practices – STEM teaching tool #60

We want students to engage from the earliest ages in science and engineering practices with sincere curiosity and purpose. Science investigations can be viewed as "working through uncertainty." However, 3D instructional materials often try to support engagement in science practices by making them very explicit and scaffolding the process to make it easy to accomplish—arguably, too easy. An alternative approach that emphasizes productive uncertainty focuses on how uncertainty might be strategically built into learning environments so that students establish a need for the practices and experience them as meaningful ways of developing understanding.

Crosscutting concepts

A Framework for K-12 Education identifies seven concepts that bridge disciplinary boundaries. These concepts provide students with an organizational framework for connecting knowledge from the various disciplines into a coherent and scientifically based view of the world.[1] These crosscutting concepts are:

1. Patterns – guide organization and classification, prompt questions about relationships and the factors that influence them.
2. Cause and effect: mechanisms and explanations – a major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across contexts and used to predict and explain events in new contexts.
3. Scale, proportion, and quantity – in considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
4. Systems and system models – Defining systems under study provides tools for understanding and testing ideas that are applicable throughout science and engineering.
5. Energy and matter: flows, cycles, and conservation – Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. Structure and function – The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
7. Stability and change – conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

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Prompts for integrating crosscutting concepts into assessment and instruction – STEM teaching tool #41

This set of prompts is intended to help teachers elicit student understanding of crosscutting concepts in the context of investigating phenomena or solving problems. These prompts should be used as part of a multi-component extended task. These prompts were developed using the Framework for K-12 Science Education and Appendix G of the Next Generation Science Standards, along with relevant learning sciences research.

The planning and implementation of instruction in your classroom should allow your students multiple and sustained opportunities to learn disciplinary core ideas through the science and engineering practices, as well as using appropriate crosscutting concepts as lenses to understand the disciplinary core idea and its relationship to other core ideas.

Planning Guidance for Culturally and Linguistically Responsive Instruction

"Equity in science education requires that all students are provided with equitable opportunities to learn science and become engaged in science and engineering practices; with access to quality space, equipment, and teachers to support and motivate that learning and engagement; and adequate time spent on science. In addition, the issue of connecting to students' interests and experiences is particularly important for broadening participation in science[1]"

In order to ensure our students from marginalized cultures and languages view themselves as confident and competent learners and doers of science within and outside of the classroom, educators must intentionally plan ways to counteract the negative or missing images and representations that exist in our curricular resources. The guiding questions below support the design of lessons that validate, affirm, build, and bridge home and school culture for learners of science:

> **Validate/Affirm:** How can you design your classroom to intentionally and purposefully legitimize the home culture and languages of students and reverse the negative stereotypes regarding the science abilities of students of marginalized cultures and languages?
>
> **Build/Bridge:** How can you create connections between the cultural and linguistic behaviors of your students' home culture and language and the culture and language of school science to support students in creating identities as capable scientists that can use science within school and society?

STEM Teaching tools highlight ways of working on specific issues that arise during STEM teaching. Here are some tools that have been created to guide STEM instruction around the concept of culturally and linguistically responsive instruction. All of these can be found at www.stemteachingtools.org/tools

How can we promote equity in science education? - STEM teaching tool #15

Equity should be prioritized as a central component in all educational improvement efforts. All students can and should learn complex science. However, achieving equity and social justice in science education is an ongoing challenge. Students from non-dominant communities often face "opportunity gaps" in their educational experience. Inclusive approaches to science instruction can reposition youth as meaningful participants in science learning and recognize their science-related assets and those of their communities.

Building an equitable learning community in your science classroom – STEM Teaching Tool #54

Equitable classroom communities foster trusting and caring relationships. They make cultural norms explicit in order to reduce the risk of social injuries associated with learning together. Teachers are responsible for disrupting problematic practices and developing science classroom communities that welcome all students into safe, extended science learning opportunities. However, this is tricky work. This tool describes a range of classroom activities designed to cultivate communities that open up opportunities for all students to learn.

How can you advance equity and justice through science teaching? - STEM teaching tool #71

Inequities are built into the systems of science education such that "students of color, students who speak first languages other than English, and students from low-income communities… have had limited access to high-quality, meaningful opportunities to learn science." Intersecting equity projects can guide the teaching and learning of science towards social justice. Science educators who engage in these projects help advance Indigenous self-determination (details) and racial justice by confronting the consequences of legacies of injustice and promoting liberatory approaches to education.

Focusing science and engineering learning on justice-centered phenomena across PK-12 – STEM Teaching tool #67

In the Framework vision for science education, students engage in active investigations to make sense of natural phenomena and analyze and build solutions to problems. Basing these investigations on justice-centered phenomena can be a powerful and rightful way to support science and engineering learning. Justice-centered investigations can open up important opportunities for students to engage in projects that support equity for communities and to see how the application of science and engineering are fundamentally entwined with political and ethical questions, dimensions, and decisions.

Teaching STEM in ways that respect and build upon indigenous peoples' rights – STEM teaching tool #10

Indigenous ways of knowing are sometimes thought to be in opposition to and detrimental to the learning of Western Science or STEM. Consequently, indigenous ways of knowing are rarely engaged to support learning. If STEM learning is to be meaningful and transformative for Indigenous youth, respecting Indigenous peoples' rights and related critical issues, including Indigenous STEM, settler-colonialism, and decolonization, must be understood and explicitly addressed in Indigenous youths' informal and formal STEM learning experiences.

How can formative assessment support culturally responsive argumentation in a classroom community? - STEM teaching tool #25

Argumentation has long been seen as an important practice in science and thus in science education. Formative assessment can be used to help students value the contributions and perspectives of others as they engage in argumentation to make sense of natural phenomena. Educators can use these strategies to help foster argumentation that is culturally responsive, meaning it draws from and respects students' cultural resources, backgrounds, and personal experiences. Culturally responsive formative assessment happens within a community of learners where the teacher has cultivated explicit norms for increasing student-centered discourse, making decisions for their own purposes through democratic processes, and using clear guidelines for maintaining mutual respect.

Engaging English learners in science and engineering practices – STEM teaching tool #27

Routinely engaging all students in the practices of science and engineering is a crucial fixture of the new vision for K-12 science education. The practices can be seen as a barrier to participation for English Learners (ELs), or they can be viewed as an opportunity to provide rich instruction that builds science-related competencies and identities. Certain elements of the practices and related instructional approaches can be beneficial for students learning science while also learning the language of instruction.

How can I promote equitable sensemaking by setting expectations for multiple perspectives? - STEM teaching tool #47

In a phenomena-focused, 3D approach to science learning, students use science practices to consider each other's ideas based on available interpretations and evidence. To promote deep and equitable learning, plan purposefully to ensure that the various perspectives that students bring to making sense of phenomena are solicited, clarified, and considered. It is important to support students as they develop a shared understanding of the different perspectives in the group.