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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

What: 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
    - o 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?
    - o 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?
    - o 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
    - o 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.

<u>How:</u> 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

Students who demonstrate understanding can:

HS-LS2-1. **Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.*]

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

Using Mathematics and Computational Thinking
Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Use mathematical and/or computational representations of phenomena or design solutions to support explanations.

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

Crosscutting Concepts

Scale, Proportion, and Quantity

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

Connections to other DCIs in this grade-band: N/A

Articulation of DCIs across grade-bands:
MS.LS2.A ; **MS.LS2.C**; **MS.ESS3.A** ; **MS.ESS3.C**

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-LS2-1)*
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. *(HS-LS2-1)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-LS2-1)
MP.4	Model with mathematics. *(HS-LS2-1)*
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-1)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-LS2-1)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-1)

Grade	*NGSS Discipline*
HS	**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

Drought spurs fish kill at Eagle Nest Lake

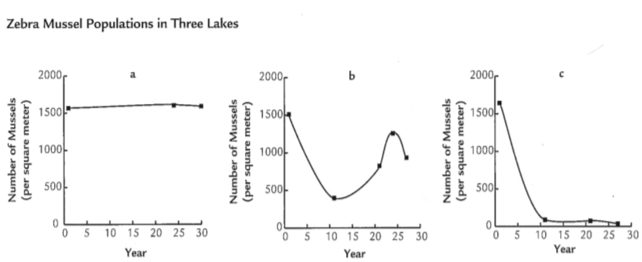
A 10-year cycle of fish kill has resurfaced along the shores of Eagle Nest Lake on June 23, 2013, according to New Mexico Game and Fish officials. Whitesucker fish wander to the shoreline and starve the algae of sunlight. As a result of the lack of sunlight, algae are not able to perform photosynthesis. This results in reduced oxygen levels. Whitesucker fish are dying due to warm temperatures and low lake levels.

Resources:
[Drought spurs fish kill at Eagle Nest Lake]
[Magothy Monitoring Story]

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.

Shown below are graphs of the zebra mussels population in 3 lakes near Lake Mikoladjskie.



Analyze three sets of graphical data and provide explanations about the push and pull of the environment.

- Describe the population trend in each graph.
- How does each population change over time?
- How would these population changes affect the carrying capacity of the lake?

Universal Supports	Targeted Supports
• Have students describe, analyze, and summarize important features and parts of graphs, charts, and histograms. • Use graphs, charts, and histograms to help develop and support student understanding of carrying capacity • Work in small and large groups to develop reasons why a population will reach carrying capacity • In small groups, have students analyze data sets and develop conclusions about what factors caused the organisms to reach their carrying capacity • Working in a small group, students will make a timeline or chain of actions for the direct causes, indirect causes and contributing factors for the fish kill. • Use graphic organizers to allow the students to **wonder** and ask **questions** about what they saw in the fish kill phenomenon.	• In small groups, provide students with an exemplar analysis of a graph, chart, and/or histogram and provide students with blank examples and allow them to share the analysis of the graph, charts, and/or histogram • Provide students with examples of living and non-living resources that limit a population and have them use the examples to analyze data sets • Complete a guided simulation to model to show the effect of population changes on carrying capacity

Common Misconceptions

- Organisms higher in a food web eat everything that is lower in the food web.
- Populations exist in states of either constant growth or decline.
- Competition between organisms always involves direct, aggressive interaction (i.e., physical encounters for resources).
- Organisms of the same species do not compete with each other for resources.
- Different kinds of organisms (species)do not compete for resources.Plants do not compete for resources, space or light; animals do not compete for resources, shelter, or water.
- All populations exist in an unchanging steady state unless disturbed. Organisms can have only one role in an ecosystem.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

- Students identify and describe their community, socio-cultural demographics, availability of resources and support; and identify how people in their community have access to the resources (support and aids).
- Knowing the availability and access of resources in their community as a model, students will be able to connect them to the different factors that affect carrying capacities of ecosystems at different scales. Some linguistic aspects that need to be addressed are:
    - Population demographics vs available resources

	○ Changes of population over time vs carrying capacity of community in terms of resources ● Students will gather historical data of their community and identify various changes that affect the community's ecosystems and natural resources. ● At ecosystem level, linguistic emphasis will be understanding the data on numbers and types of organisms as well as boundaries, resources, and climate.

Students who demonstrate understanding can:

HS-LS2-2. **Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] *[Assessment Boundary: Assessment is limited to provided data.]*

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
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena or design solutions to support and revise explanations. - - - - - - - - - - ***Connections to Nature of Science*** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.	**LS2.A: Interdependent Relationships in Ecosystems** • Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.	**Scale, Proportion, and Quantity** • Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

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

Articulation of DCIs across grade-bands:
MS.LS2.A ; **MS.LS2.C** ; **MS.ESS3.C**

Common Core State Standards Connections:
ELA/Literacy -
RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-LS2-2)*
WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. *(HS-LS2-2)*
Mathematics -
MP.2 Reason abstractly and quantitatively. (HS-LS2-2)
MP.4 Model with mathematics. *(HS-LS2-2)*
HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-2)
HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. *(HS-LS2-2)*
HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-2)

HS	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

Coyote attacks have increased over the years. In the Albuquerque area, coyotes play a key role in the natural ecosystem. Coyotes are not able to distinguish between wild prey and unsupervised pets. While coyotes are common in the area, some are aggressive. Unaggressive coyotes typically freeze and stare at people. Aggressive coyotes will approach people or pets with their teeth showing and lunge or nip at the person or pet.

Warning About Coyote Attacks

- Allow the students to wonder and ask questions about what they saw in the video.
- Sample and anticipated questions:
  - Students will ask questions about the cause of the increase in the amount of coyote attacks.
  - Students will develop models to demonstrate initial thinking about changes in ecosystem causing coyote attacks

Resources:
Coyotes in Albuquerque
Coyote Attack Videos
Cause & Effect Graphic Organizer - The Wonder of Science

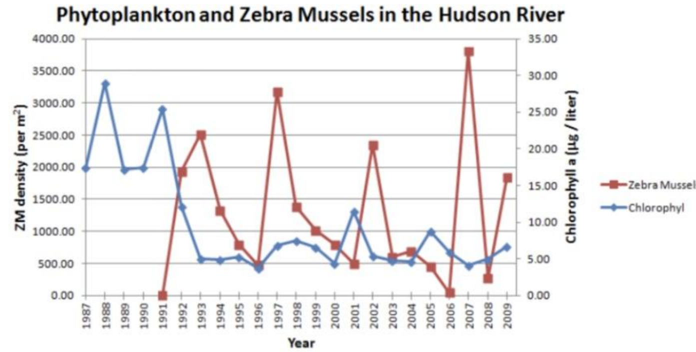
Classroom Assessment Items

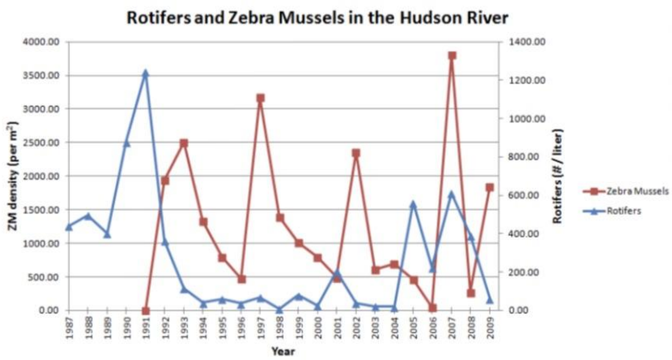
When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.

Who Needs Mussels?

Video Clip- "Silent Invaders" *Stop at 1 min 33 seconds and allow students to "Wonder" and Ask Questions about what they saw. How will these changes impact the stability and diversity of the ecosystem?

Stimulus





These data were collected as part of a long-term study of the Hudson River ecosystem by researchers at the Cary Institute of Ecosystem Studies, started in 1991 and continuing today.
https://www.caryinstitute.org/sites/default/files/public/downloads/lesson-plans/effects_of_zm_on_the_hr_-_graphs_provided_ws.pdf

Prompt

- How do changes in populations of organisms impact the biodiversity of a freshwater ecosystem?
- What impact do invasive species have on the quantity of various organisms, like rotifers and phytoplankton?
- What proportional relationships can be observed from using graphical comparisons?

Resources:

- Zebra Mussel Fact Sheet
- Student Assessment

HS-LS2-2 Assessment - Who Needs Mussels? Edited (NY)

Universal Supports	Targeted Supports
• Open forum/Q&A will be used to address misconceptions. • Focus of discussion will revolve around the	• Students will be in pairs. They will utilize the KWL chart and discuss the pros and cons of various types of ecological interactions and

causes of the increase in the amount of coyote attacks. ● Using a model to explain initial thinking about coyotes and interactions between them and other components of the ecosystem.	how they affect diversity.

Common Misconceptions

- Populations exist in states of either constant growth or decline.
- Competition between organisms always involves direct, aggressive interaction.
- Exploitative competition (e.g., getting to the resource before other organisms) is not competition.
- Organisms of the same species do not compete for resources.
- Different kinds of organisms (species) do not compete for resources.
- Plants do not compete for resources, space or light; animals do not compete for resources, shelter, or water.
- Plants and animals do not compete (with each other) for space or water.
- If a population in a food web is disturbed, there will be little or no effect on populations that are not within the linear sequence in the food web (e.g., no effect on populations below it in the food web, such as if a predator is removed, there will be no effect on prey).
- Organisms higher in a food web eat everything that is lower in the food web.
- If the size of one population in a food web is altered, all other populations in the web will be altered in the same way.
- A change in the size of a prey population has no effect on its predator population.
- Changes in a population in a food web do not affect the populations of any other organism in the food web.
- The top predator in a food web will never be significantly affected by changes in the populations of organisms below it in the food web.
- Varying the population size of species will only affect the others that are directly connected through a food chain.
- Organisms can have only one role in an ecosystem.
- Populations exist in constant states that neither grow nor decline.
- Diversity is the variation of traits in a population.
- Variation is the number and distribution of species in a community

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

- Students describe the biodiversity of their local community and identify factors affecting biodiversity and population levels, which will include the following linguistic emphasis:

  i. ***Abiotic*** (physical) and ***Biotic*** (biological) dynamics of the ecosystem.
  ii. The response of an ecosystem to a change in populations (***sustainable community***)
  iii. Ecosystems can exist in the same location on a variety of scales (***microecosystem vs macroecosystem***). Use of Prompt: What is your concept of the ecosystem as a member of the community?
  iv. Interaction of population significantly changes ecosystems (***mutualism, competition, commensalism, parasitism, predation***, etc). The pros and cons of competition?
- Population diversity in America
- Land border and homeland security policies
- Students will look at Census in NM and US data to understand the population trends.

	• With the population trends in NM and US, students will understand how these affect the distribution of resources, relationships, social and environmental stability, and sustainability of resources.

Students who demonstrate understanding can:

HS-LS2-3. **Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.** [Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.] [*Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.*]

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 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. - - - - - - - - - - - - - - - - ***Connections to Nature of Science*** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** • Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.	**Energy and Matter** • Energy drives the cycling of matter within and between systems.

Connections to other DCIs in this grade-band:
HS.PS1.B ; **HS.PS3.B** ; **HS.PS3.D** ; **HS.ESS2.A**

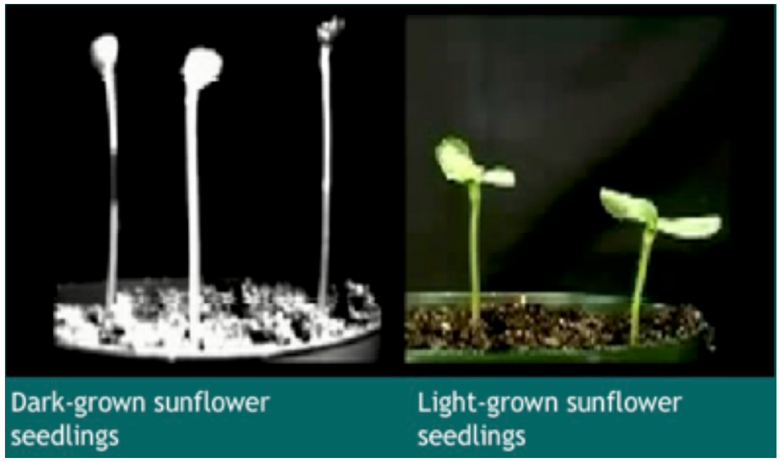
Articulation of DCIs across grade-bands:
MS.PS1.B ; **MS.PS3.D** ; **MS.LS1.C** ; **MS.LS2.B**

Common Core State Standards Connections:
ELA/Literacy -

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS2-3)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS2-3)

HS	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. **Phenomenon #1:**



When starting a garden, seeds are often germinated indoors before being transplanted to the outside garden when the temperature warms. Picking the right conditions for getting seeds to germinate and grow properly is critical to starting a healthy garden.

Resource:
[Plants in Motion Light vs. Darkness]

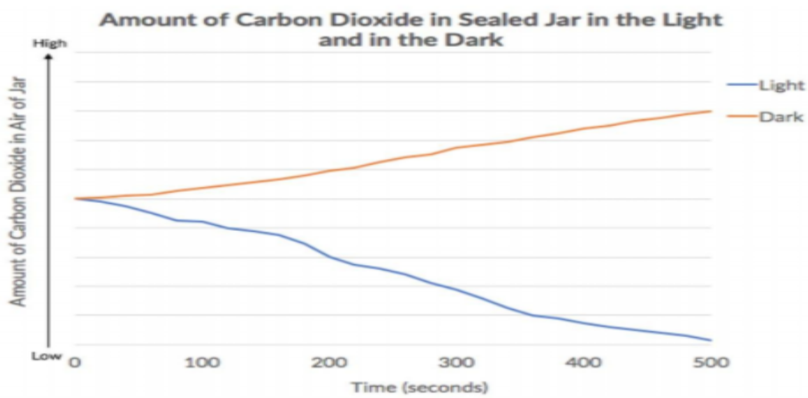
Phenomenon #2

Ancient organisms were typically simple unicellular organisms without a true nucleus or specialized organelles. Today, more modern organisms with membrane-bound nuclei and specialized subcellular structures are capable of many more processes than the simple, prehistoric ones. Part of the reason is because eukaryotic cells, which have a nucleus and organelles, are able to do aerobic cellular respiration. That is, they use oxygen to harvest energy from their food. Prokaryotes, which are simpler and have no nucleus, are smaller and less complex. They also do not complete aerobic respiration, but rather perform a shorter energy-harvesting process called anaerobic respiration. Throughout this unit, you will examine how the two different processes generate different amounts of energy, resulting in different levels of complexity in their life functions and processes.

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.

- Susan is wondering what happens to the carbon dioxide ($CO2$) levels of a plant when it does or does not have light. She sets up an experiment to test this.
  Susan's experiment:
  - Step 1: Susan places a plant inside a jar with soil and enough water for growth.
  - Step 2: She seals the jar to prevent anything from entering or leaving.
  - Step 3: She connects sensors that can measure carbon dioxide (CO2) levels inside the jar.
  - Step 4: She places the jar under a bright light to collect CO2 data for 500 seconds. She sees the CO2 levels decreasing.
  - Step 5: She then opens the jar to allow the CO2 levels in the jar to return to normal.
  - Step 6: Then, she seals the jar and places it in a box that is completely dark to collect CO2 data for 500 seconds. She sees the CO2 levels increasing.
- **Results**: Susan makes a graph using data from Step 4 (jar in bright light) and Step 6 (jar in the dark)



- Develop a model for Susan that describes why the amount of CO2 in the jar increased in the dark and decreased in bright light. Describe how your model shows why the amount of CO2 in the sealed jar increased in the dark and decreased in bright light.

Universal Supports	Targeted Supports
• With direct instruction, students will trace how energy from photosynthesis and respiration drives the cycling of matter and flow of energy under aerobic or anaerobic conditions within an ecosystem. • Use graphic organizers to compare and contrast photosynthesis and respiration and how matter and energy are cycled through the processes. • Use pictures and graphs to help develop and support their understanding of the concept of energy transfer and utilization in photosynthesis and respiration.	• In small groups, students will analyze, describe and summarize important features of the process of photosynthesis and respiration. • Using examples, students will construct and revise an explanation on how energy drives the cycling of matter within and between systems. • Provide partially complete graphic organizers that compare and contrast photosynthesis and respiration and how matter and energy are cycled through the processes. • Use diagrams, texts, and videos to demonstrate how matter and energy are cycled through the processes.

Common Misconceptions

- Carbon atoms (or carbon dioxide molecules) are an energy source for plants.
- Sugar (glucose) provides energy directly for cell functions (no ATP is necessary).
- Cells never require oxygen to undergo respiration.
- Plants and animals use gases to produce energy,not carbohydrate molecules (glucose).
- Respiration is necessary to eliminate carbon dioxide, not to produce energy.
- Respiration occurs in organs and tissues, not in cells.
- Respiration cannot occur without oxygen (or carbon dioxide) present.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

Students will construct an explanation on:

- how native Americans follow traditional agricultural and land-use practices that govern carbon cycling on tribal lands (i.e, no-till farming, moving domesticated animals seasonally in accordance with forage availability, raising crops and livestock native to ancestral landscape, managing forests, etc.)
- how resource extraction on tribal lands results in substantial ecosystem degradation;
- increasing renewable energy development on tribal lands but limited by federal regulations, tribal land tenure, lack of energy transmission infrastructure on reservations, and economic challenges;
- Contemporary socio-economic challenges that continue to impact Indigenous carbon management decision-making.
- the importance placed on youth education by indigenous communities to create opportunities for future generations to sustain and pass on traditional knowledge.
- Students will look for scientific data and peer-reviewed publications as evidence pertaining to carbon stocks and fluxes, carbon management and policy on native lands and use reasoning to connect evidence, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to construct their explanation.

Students who demonstrate understanding can:

HS-LS2-4. **Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.** [Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.] [*Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.*]

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
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena or design solutions to support claims.	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** • Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.	**Energy and Matter** • Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.

Connections to other DCIs in this grade-band:
HS.PS3.B ; **HS.PS3.D**

Articulation of DCIs across grade-bands:
MS.PS3.D ; **MS.LS1.C** ; **MS.LS2.B**

Common Core State Standards Connections:
Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-LS2-4)
MP.4	Model with mathematics. *(HS-LS2-4)*
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-4)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-LS2-4)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-4)

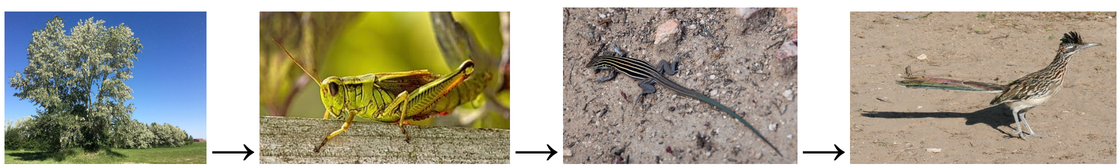
HS	Life Science 2.4
LS2-4	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* **Fish Farming with Vegetables** **Description:** Aquaponics is the combination of aquaculture (i.e. fish farming) with hydroponics (i.e. growing plants in water). Matter cycles in the system and is driven by energy flow from light. Waste from the fish is used as fertilizer for the plants which in turn feeds the fish. Excess plants and fish can be harvested as food for humans. **Web Resources:** How to DIY Aquaponics, Aquaponics - Wikipedia Video Resource: Backyard Aquaponics Diy System To Farm Fish With Vegetables

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.

In New Mexico, researchers have found large quantities of toxins in the Rio Grande bosque ecosystem. You have been tasked to find a solution to the problem of toxins. Use content knowledge of food chains, biomagnification, and mathematical relationships to explain your design solution to state lawmakers.

Figure 1



Cottonwood → Cricket → New Mexico whiptail → Roadrunner

Figure 2

	Energy present (kilograms calories)
Cottonwood	240
Cricket	24
New Mexico Whiptail	2.4
Roadrunner	.24

- List the organisms in this NewMexico food chain and describe what happens to the energy as you go higher up the food chain. Use mathematical representations to support this phenomena.
- Describe what happens to the energy between each of the trophic levels in this food chain. What do you think causes this change in energy at each level?
- Each trophic level supports a given amount of organisms, why do you think this occurs? Explain your claim using mathematical representations and data from Figure 2.
- Each organism uses a given amount of energy to live, explain how this energy and the cycling of matter is used and how it is important for the individual organism. In your explanation, describe one of the following cycles affected by pollution: carbon, oxygen, hydrogen.

Citation:

- Hosted by The Wonder of Science. [HS-LS2-4 Assessment - Biomass & Trophic Levels (NY)]

Universal Supports | Targeted Supports

● Provide students with food webs and transfer the organisms to an ecological pyramid ● Use graphic organizers to allow students will obtain, evaluate and communicate information about energy and matter within the ecological pyramid ● Create the a classwide ecological pyramid on chart paper to address any misconceptions and add any corrections to misconceptions throughout the lesson ● Use images, texts, and manipulatives to show how energy and matter are cycled through an ecosystem ● Provide students variety of ways to engage in discourse (pairs/whole group) and institute protocols for engaging in partner and whole group discourse	● Provide sentence stems/starters to support developing written arguments ● Provide extension opportunities for students or additional readings to go deeper in learning, for those students with high interests. ● Provide partially filled visuals and graphic organizers to trace the pathway of energy and compare their observations with a partner

Common Misconceptions

- Organisms and other things can “use up” energy.
- Plants take in food from the outside environment, and/or plants get their food from the soil via roots.
- Organisms higher in a food web eat everything that is lower in the food web.
- The top of the food chain has the most energy because it accumulates up the food chain.
- Populations higher on a food web increase in number because they deplete those lower in the food web.
- There are more herbivores because people keep and breed them.
- Decomposers release some energy that is cycled back to plants.
- The number of producers is high to satisfy consumers.Varying the population size of species will only affect the others that are directly connected through a food chain.
- A model is always a three-dimensional object.
- Therefore,pictures, diagrams, graphs, written descriptions, and abstract mathematical or conceptual models are not models.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

- Students will be able to state sources of energy in ecosystems, show a path of energy through a short energy food chain, and describe at least 3 types of energy that are gained and lost by plants and/ or animals. This activity is centered on the bosque and river ecosystems of the Southwestern US.
- The students both understand the types of energy in ecosystems, and also adaptations and interrelationships of organisms in their local bosque ecosystem. ***Bosque*** is the Spanish word for “forest” or “woods” but it is generally used in New Mexico to refer to the cottonwood forest along rivers in the region.
- Most students, by the time they reach upper elementary and middle school, can tell you that plants do something unique called photosynthesis. But in order to fully put that word into the context of the energy needs of an entire ecosystem, it takes some focused vocabulary and tracing of that energy in different parts of the ecosystem.

	• Students will use the balanced chemical equation of the process of photosynthesis to show cycling of matter and conservation of energy.

Students who demonstrate understanding can:

HS-LS2-5. **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.*]

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 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show how relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or components of a system.	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** • Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. **PS3.D: Energy in Chemical Processes** • The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. *(secondary)*	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Connections to other DCIs in this grade-band:
HS.PS1.B ; **HS.ESS2.D**

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

Common Core State Standards Connections: N/A

HS — Life Science 2.5

Sample Phenomena

LS2-5

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.

Ecosystem In Bottle Only Watered Once In 50 Years

In 1960, David Latimer planted a terrarium by placing a quarter pint of water and compost in the ten gallon bottle. He then lowered in spiderworts seeding with a wire, sealed it, and placed it in a corner that received a lot of sun. Photosynthesis is occurring in the ecosystem despite the plants not being watered since 1972. Photosynthesis puts moisture and oxygen in the air through the plants. The moisture then starts to build and begins to rain back down on the plants. Leaves will also fall and rot which produces carbon dioxide that the plants need for nutrition. More than a half century has passed and David's case study has become a self-sustaining sealed ecosystem.

Resources:

- https://biologicperformance.com/sealed-bottle-terrarium-garden-watered-once-53-years/
- Ecosystem in the Bottle Only Watered Once in 50 years
- Thriving Bottle Garden Hasn't Been Watered in Over 40 Years

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.

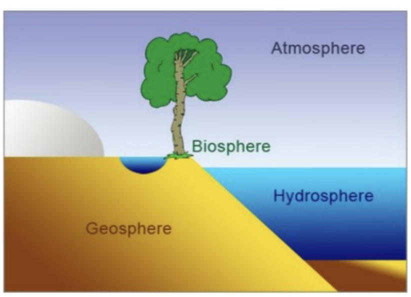
Cycling of Carbon in Ecosystems

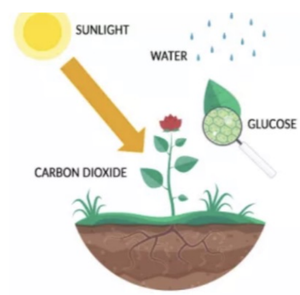
Read the following articles on How plants use CO_2

- The strange, controversial way plants trap CO2
- Amazon's trees removed nearly a third less carbon in last decade – study
- Rising carbon dioxide is causing plants to have fewer pores, releasing less water to the atmosphere
- What is Ocean Acidification? (video on ocean acidification)
- https://www.youtube.com/watch?v=zaXBVYr9Ij0 (video on fossil fuel formation)

According to the evidence presented in the last article, increased carbon dioxide levels in the biosphere have led to decreased density and size of plant stomata. If this trend continues in plants across the globe, develop a model that shows what might occur in:

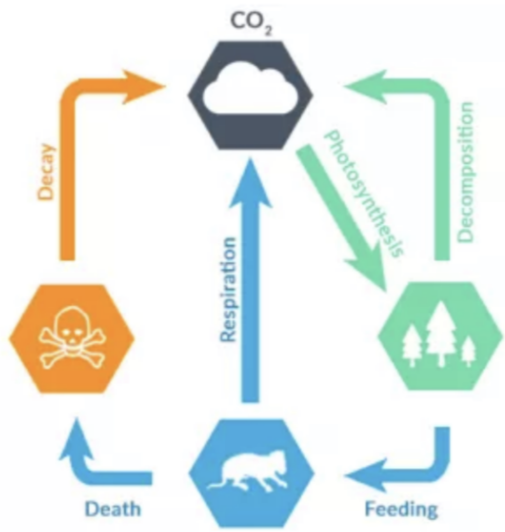
1. Identify and describe the inputs and outputs of photosynthesis
2. Identify and describe the inputs and outputs of cellular respiration
3. Describe the relevant components of the biosphere, atmosphere, hydrosphere, and geosphere
4. The relative exchange of carbon (through carbon-containing compounds) between organisms and the environment
5. The role of storing carbon in organisms (in the form of carbon-containing compounds)
6. Describe the contribution of photosynthesis and cellular respiration to the exchange of carbon within and among the biosphere, atmosphere, hydrosphere, and geosphere in your model. Be sure to make a distinction between the model's simulation and the actual cycling of carbon via photosynthesis and respiration.





Your model can take the form of a skit, a poster, a mathematical representation, a short story or any other approved literary form.

The answer.......
NASA | Earth Science Week: Keeping Up With Carbon Carbon Cycle



Universal Supports	Targeted Supports

• Provide students with videos, text, and diagrams on the inputs and outputs of photosynthesis and cellular respiration.
• In small groups/in pairs, they express what they have learned about the cycling of matter with emphasis on the flow of energy in photosynthesis and cellular respiration. They will also utilize the visuals to develop a model in which they identify and describe the relevant components, including:
  ○ The inputs and outputs of photosynthesis;
  ○ The inputs and outputs of cellular respiration; and
  ○ The biosphere, atmosphere, hydrosphere, and geosphere.
• They will also utilize graphic organizers to trace the pathway of energy and compare their observations in pairs/small groups.
• Talk, Read, Talk, Write (partners)
  ○ Talk (Provide students with a model and respond to model about
	• Provide partially filled models to demonstrate the cycling of matter and energy through photosynthesis and cellular respiration
	• Monitor the students to provide individualized interventions
	• Provide sentence stems/starters for talk, read, talk, write
	• Provide extension opportunities for students or additional readings to go deeper in learning, for those students with high interests.

photosynthesis and cellular respiration)
  - Read (Text should be academic, have students annotate text)
  - Talk (Provide open ended questions for students to discuss; provide targeted vocabulary for discussion)
  - Write (Have students develop a model to demonstrate understanding)

Common Misconceptions

- A model is always a three-dimensional object. Therefore,pictures, diagrams, graphs, written descriptions, and abstract mathematical or conceptual models are not models.
- Plants take in food from the outside environment, and/or plants get their food from the soil via roots.
- Energy can be created or destroyed - it can "disappear" or come from nowhere. Specifically, students need to always be asked where the energy is coming from.
- Carbon dioxide is a source of energy for plants.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

- Using the Chihuahuan and Sonoran desert as a sample ecosystem, students will develop a model on how plants adapt to the harsh environmental and climatic conditions in their photosynthetic and cellular respiration activities.
- Students will have a deep understanding of the geology, topography and climatology of the desert ecosystem in New Mexico. (Small group online research will be the main activity)

Students who demonstrate understanding can:

HS-LS2-6. **Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]

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 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. - - - - - - - - - - ***Connections to Nature of Science*** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

Connections to other DCIs in this grade-band:
HS.ESS2.E

Articulation of DCIs across grade-bands:
MS.LS2.A ; MS.LS2.C ; MS.ESS2.E ; MS.ESS3.C

Common Core State Standards Connections:
ELA/Literacy -

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-LS2-6)
RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS2-6)
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-LS2-6)*
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-6)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-LS2-6)
HSS-ID.A.1 Represent data with plots on the real number line. *(HS-LS2-6)*
HSS-IC.A.1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population. *(HS-LS2-6)*
HSS-IC.B.6 Evaluate reports based on data. (HS-LS2-6)

HS	Life Science 2.6
LS2-6	**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.* **Rio Grande Bosque Restoration, New Mexico** The Rio Grande Bosque runs through the Albuquerque metropolitan area. Native willows, majestic cottonwood, and the New Mexico olive populations are in jeopardy. Invasive species (Russian olive and Salt Cedar) have taken

resources away from native New Mexico plants in the Rio Grande Bosque. They form dense thickets that consume large quantities of shallow groundwater, alter wildlife habitat, and create a wildfire hazard in the bosque.
https://www.ciudadswcd.org/projects/bosque-restoration

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.

Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in new problems and change in the ecosystem.

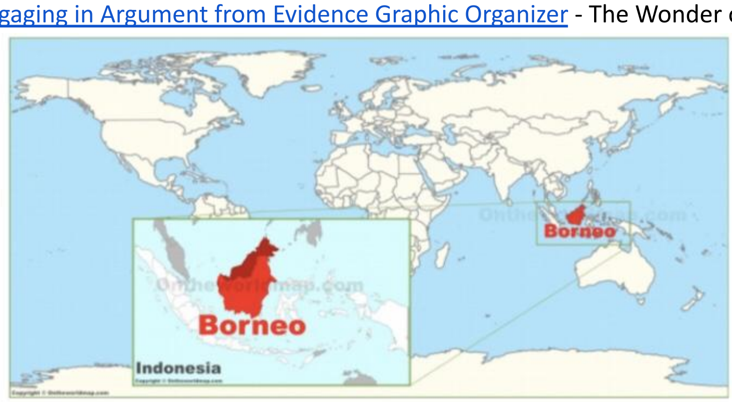
Students will complete a graphic organizer with the following questions:

Question:		**Claim:**
Evidence:	**Evidence:**	**Evidence:**
Reasoning:		

1. What abiotic factor(s) have people changed and what is the impact on the biotic factors in the ecosystem?
2. Construct an explanation for how the introduction of the invasive species had a change on the ecosystem and how that change caused instability in the different populations of organisms.
3. How has daily life contributed to this change and how is it affected?

***Be sure to construct an argument for which factors stabilize or destabilize the balance of the ecosystem.**

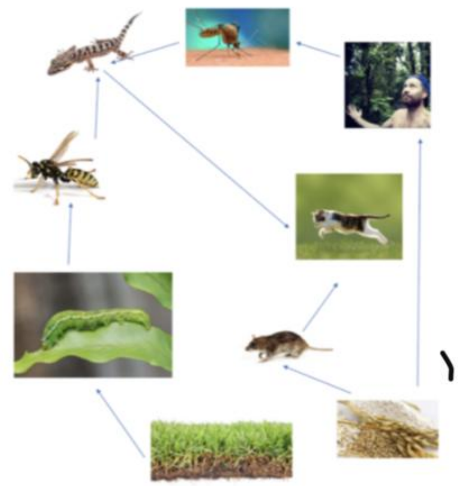
Engaging in Argument from Evidence Graphic Organizer - The Wonder of Science



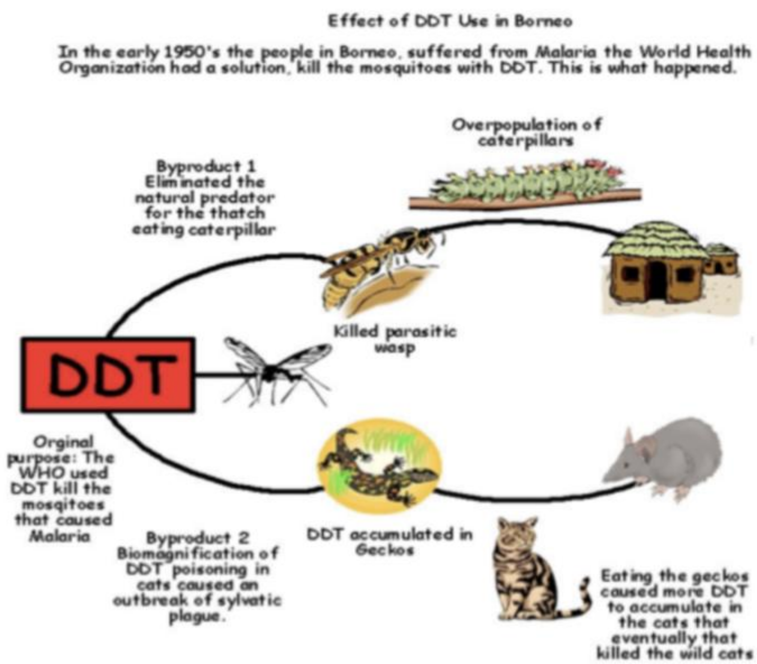
Around 1950 on Borneo, a subtropical island in southeast Asia, there had been a large outbreak of malaria (disease) that had been associated with mosquitos. Large numbers of people began to suffer uncontrollable chills and hallucinations from high fever, massive vomiting, diarrhea, and death. To eradicate the mosquitoes the World Health Organization (WHO) came to Borneo and spread DDT to kill the mosquitoes. The percentage of mosquitoes carrying the malaria-causing parasite fell from 35.6% to 1.6% during a 2-year period in Borneo in the 1950's (NIH).

But then something weird happened...

● Thatch roofed houses begin to collapse, killing people in their sleep.
● Rat populations go wild, spreading sylvatic plague and typhus, which are both diseases that affect humans.
● The Air Force straps parachutes to cats, and drops them from planes into the jungles of Borneo. Numerous doctors, biologists and ecologists have been working on the problem to find a solution to the sicknesses the Borneans have been experiencing.



Borneo Food Web 1950



http://actionoutdoors.org/educational-resources/coastal-birds/biomagnification-and-ddt-classroom-activity

Experts in many fields wanted to answer the following question:

- What was introduced into the environment in Borneo that led to fluctuations in the population sizes of organisms resulting in the collapsing of homes and new diseases introduced to the human population of Borneo?

Biologists suggested that the use of DDT to eradicate mosquitoes led to a collapse in the thatch roof houses in Borneo and an increase in diseases in humans.

They believed this occurred because the introduction of DDT into the jungles of Borneo during the 1950's eradicated the mosquitoes which helped get rid of malaria but at the same time decreased the population of wasps and increased the population of caterpillars who feed on the thatch on roofs. While DDT did not negatively affect the geckos, they ate the mosquitos who contained DDT. So this negatively affected the cat population when they ate the geckos. A change in the rat population affected the population of humans in the area.

Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in new problems and change in the ecosystem.

Fill in the chart utilizing the information on the Phenomenon and Stimulus sections.

Question:		Claim:
Evidence:	Evidence:	Evidence:
Reasoning:		

- Describe the strengths and weaknesses of the given claim in accurately explaining a particular response of biodiversity to a changing condition:
- What additional evidence can be used to assess the validity and reliability of the given evidence and its ability to support the:
- Construct an explanation for the initial change in the ecosystem and how that change caused instability in the different populations of organisms.
- What evidence supports the actions taken by the Air Force to drop cats from the sky into the jungles of Borneo?
- Explain what fluctuations in conditions occurred in the population of rats when the population of cats decreased? Explain how humans were negatively affected by these changes.

Engaging in Argument from Evidence Graphic Organizer - The Wonder of Science

Citation:
The Short Performance Assessment (SPA) and the Assessment Rubric adapted from the Stanford NGSS Assessment Project http://snapgse.stanford.edu/

HS-LS2-6 Assessment - Operation Cat Drop Edited (NY)

Universal Supports	Targeted Supports
● Providing students with a high-quality, coherent direct instruction on the factors that affect biodiversity; the relationships between species and the physical environment in an ecosystem; and the changes in the numbers of species and organisms in an ecosystem. ● They will have access to books, videos, etc and what materials, scaffolds and supports they need to learn (i.e., visuals, exemplars, graphic organizers, rubrics, etc.). ● In small groups/in pairs, they will utilize graphic organizers to compare and contrast biotic and abiotic components of the ecosystem and how they affect biodiversity. ● They will go back to working on the project bulletins and they will complete a graphic organizer with the following questions: ○ What abiotic factor(s) have people changed and what is the impact on the biotic factors in the ecosystem? ○ What is the evidence/data for your conclusion? ○ How has daily life contributed to this change and how is it affected? ○ What are possible solutions?	● Students who are unable to complete the graphic organizer will be given "choice boxes" or word banks of answers to help narrow down options to put into each box of the organizer. ● If necessary, the teacher may provide a modular review of abiotic and biotic factors with students in Layer 2. Ie, demonstrate a rock, a stick, and a gas versus an ant, a picture of a hippo, and a tree, to let students sort these into abiotic and biotic categories.

Common Misconceptions

- Species coexist in an ecological system because of their compatible needs and behaviors; they need to get along.
- Ecosystems are not a functioning whole,but simply a collection of organisms.
- Communities change little over time.
- The number of producers is high to satisfy consumers (i.e., producers and food organisms exist because the organisms above them in the food web need food).
- Humans can easily and permanently change any ecosystem to suit their needs.
- Ecological disturbances always cause permanent and irreversible change in ecosystems.
- Organisms inhabit certain habitats and ecosystems by preference rather than to fill a niche.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

- Linguistic emphasis will be on "**Habitat Change**". Students will be asked to predict what will happen to an animal population if its habitat changes. It can be used to elicit student ideas about adaptation; specifically whether individuals intentionally change their physical characteristics or behaviors in response to an environmental change.
- Students learn about ecosystems and relationships by observing their local environment.

	- Students explore how various organisms satisfy their needs within their environments and the kinds of relationships that exist between organisms within an environment. - Have students explain to their families why it's so important to understand various relationships that exist between organisms within an environment. Ask them to brainstorm things they as a family can do to help - (To encourage students to follow through, you might require them to bring in their brainstormed list signed by all family members participating in the activity.)

Students who demonstrate understanding can:

HS-LS2-7. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

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 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. **LS4.D: Biodiversity and Humans** • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary)* • 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. *(secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)* **ETS1.B: Developing Possible Solutions** • When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. *(secondary)*	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

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

Articulation of DCIs across grade-bands:
MS.LS2.C ; **MS.ESS3.C** ; **MS.ESS3.D**

Common Core State Standards Connections:

ELA/Literacy -

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. *(HS-LS2-7)*

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-LS2-7)*

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-7)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7)

Mathematics -

MP.2 Reason abstractly and quantitatively. *(HS-LS2-7)*

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *(HS-LS2-7)*

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. *(HS-LS2-7)*

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-LS2-7)*

HS	Life Science 2.7
LS2-7	Sample Phenomena

Same as HS-LS2-7-NM

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.

Phenomena #1 - Salt Cedar

- **Description**: To introduce this standard, students can explore salt cedar as an invasive species and its impact on the regions of the New Mexico ecosystem. In this introductory phase of instruction, student's can be introduced to the problems presented by salt cedar through the PBS video "Salt Cedar Invasion" (linked below). The focus is to have students **construct explanations (SEP)** on the problem presented by salt cedar in New Mexico and how **stability and change (CCC)** are impacted through this invasive species in regions of New Mexico ecosystems.
- **Resources**:
  - Webisode - Salt Cedar Invasion NM video
  - Stability & Change graphic organizer

Phenomena #2 - Carbon Underground Storage

- **Description:** As atmospheric carbon dioxide continues to increase to historic levels (NASA, 2021), the need for solutions to mitigate the effects of greenhouse gases is necessary. Presented as a possible solution, underground carbon storage is a carbon capture method currently under consideration (Tsuji et al., 2021). Various organizations within New Mexico are leading the forefront of refining and implementing this technology. To engage students in this standard, have students read current articles, such as "New Mexico Tech seeks funding to study carbon storage near San Juan generation station" (linked below). As students read the article, ask students to consider the pros and cons of carbon storage in New Mexico. Each student would share their pros and cons list with the class (**construct explanations -SEP)** and each student's response would be categorized by the class in relation to if it would increase or decrease the **stability and change (CCC)** of the New Mexico and global ecosystem.
- **Resources:**
  - "New Mexico Tech seeks funding to study carbon storage near San Juan generation station" news article
- **Citation**:
  - NASA. (2021). *Global Climate Change*. Retrieved from https://climate.nasa.gov/vital-signs/carbon-dioxide/.
  - Tsuji, T. et al. (2021). Geological storage of CO_2–N_2–O_2 mixtures produced by membrane-based direct air capture (DAC), *Greenhouse Gases: Science and Technology*. DOI: 10.1002/ghg.2099.

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.

New Mexico Biodiversity Task

- To begin the project, teachers show students the following introductory video and discuss with students (until 2:35). Why Should Humans Care About Biodiversity Loss?

- How can we preserve biodiversity? You are presenting to a local town board on how to best preserve the stability of the New Mexico environment. As mentioned in the video, human impact on the environment can have negative consequences and affect the biodiversity of the ecosystem. Over the next few days, your problem (task) is to design, evaluate and refine a solution for reducing the impacts of human activities on the stability of the New Mexico environment and biodiversity.

- Choose one of the following human activities (circle your choice): overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, or climate change. Use reputable websites such as: DEC, NOVA, National Geographic, NOAA, AGI (American Geoscience Institute), etc to research your human activity and its impact.
- Answer the following questions and then create a poster with the information:
  - What is a negative effect on the ecosystem and biodiversity of your chosen human activity?
  - Why is broad biodiversity important for humans?
  - Design a solution to reduce the negative effects of this human activity on the stability of the environment and biodiversity.
  - Explain how your solution decreases the negative effects of human activity on the stability of the environment and biodiversity.
  - Describe and quantify the criteria (amount of reduction of impacts and human activities to be reduced) and constraints (for example cost, human needs, and environmental impacts) of the human activity. State the tradeoffs in your proposed solution.
  - Evaluate your proposed solution of human activity. Rate your solution 1-5 (5 being the best) for each of the following criteria: cost, safety, reliability, and impact on overall environmental stability. Justify why you chose your number.
  - Now that you've gathered some data, what (if anything) would you refine (change) about your initial solution. Address how this revised solution addresses the tradeoff involved with human needs and the impact of the loss of biodiversity.
- Part 2: Students will display their posters around the classroom.
  - Have students evaluate 2-3 groups to design solution posters and provide written feedback based on the rubric.

Student Self-Evaluation:		
	Score (1-5)	**Justification**
Cost		
Safety		
Reliability		
Impact on Overall Environment		

Peer to Peer Evaluation:		
Question	**Yes/Partially/No**	**Explain**
Human impact identified		
Solution to the human impact identified		
Explanation of the improvement to environmental stability and biodiversity		
Description and quantification of the criteria and constraints for the solution of the problem		
Consideration of tradeoffs of the solution		

Citation - Modified from:

- The Short Performance Assessment (SPA) and the Assessment Rubric adapted from the Stanford NGSS Assessment Project [Stanford NGSS Assessment Project |]

Universal Supports	Targeted Supports
• Students design a solution that involves reducing the negative effects of human activities on the environment and biodiversity, and that relies on scientific knowledge of the factors affecting changes and stability in biodiversity. • Student choice regarding a project in their area of interest within their local community is critical. Students should describe the ways the proposed solution decreases the negative effects of human activity on the environment and biodiversity.	• Intervention strategies should be applied for students who are uncomfortable with the engineering design process, have trouble selecting a local phenomenon. • Research and presentation strategies may need to be scaffolded. ○ For example, only give students one step of the project at a time - first, take thirty minutes to gather research and draw conclusions. Then time to draft a hypothesis, then time to make variables… do these on separate slides or separate sheets of paper so students are not overwhelmed with the full task all at once.

Common Misconceptions

- Disciplinary Core Ideas (DCI's)
    - Students may have misconceptions or gaps in learning on Ecosystems & Biodiversity related to the following concepts:
        - Humans do not have a negative impact on aspects of the environment or Earth.
        - Biodiversity is not necessary to maintain the health of an ecosystem.
        - Small changes in ecosystems can can not have large impacts
        - Negative impacts on Earth's ecosystems can not be reversed or mitigated
        - All ecosystems are impacted similarly by disruptive events
        - A change in one region of Earth will not impact other regions

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

- Ensure all material presented is derived from current and accurate scientific resources.
- Acknowledge the difference in perspectives on the role of humans and their impact on our environment.
- Use current and accurate data to support scientific evidence regarding the events under investigation.
- Allow all students the opportunity to share perspectives and diverse issues in their community related to this topic.
- Provide student choice on the problem they would like to design a solution for, based on their local community.
- Allow students to represent ideas in the language and format of their choice. Technology, such as Google Translate can be used to support translation of various languages utilized.

HS.Interdependent Relationships in Ecosystems

HS.Interdependent Relationships in Ecosystems

PERFORMANCE EXPECTATIONS

Students who demonstrate understanding can:

HS-LS2-7 NM. **Using a local issue in your solution design, describe and analyze the advantages and disadvantages of human activities that support the local population such as reclamation projects, building dams, and habitat restoration.***

The performance expectations above were 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 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. **LS4.D: Biodiversity and Humans** • 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. (secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.) **ETS1.B: Developing Possible Solutions** • When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (secondary)	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

Connections to other DCIs in this grade-band: HS.ESS2.D ; HS.ESS2.E ; HS.ESS3.A ; HS.ESS3.C

Articulation of DCIs across grade-bands: MS.LS2.C; MS.ESS3.C; MS.ESS3.D

Common Core State Standards Connections:

ELA/Literacy –

RST.9-10.8	Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
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Mathematics –

MP.2	Reason abstractly and quantitatively.
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

*The performance expectation marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS	Life Science
	Sample Phenomena

LS2-7 NM	***Same as HS-LS2-7***
	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.
	Phenomena #1 - Salt Cedar
	• **Description**: To introduce this standard, students can explore salt cedar as an invasive species and its impact on the regions of the New Mexico ecosystem. In this introductory phase of instruction, student's can be introduced to the problems presented by salt cedar through the PBS video "Salt Cedar Invasion" (linked below). The focus is to have students **construct explanations (SEP)** on the problem presented by salt cedar in New Mexico and how **stability and change (CCC)** are impacted through this invasive species in regions of New Mexico ecosystems.
	• **Resources**:
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	  ○ Stability & Change graphic organizer

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- **Resources:**
  - "New Mexico Tech seeks funding to study carbon storage near San Juan generation station" news article
- **Citation**:
  - NASA. (2021). *Global Climate Change*. Retrieved from https://climate.nasa.gov/vital-signs/carbon-dioxide/.
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- Choose one of the following human activities (circle your choice): overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, or climate change. Use reputable websites such as: DEC, NOVA, National Geographic, NOAA, AGI (American Geoscience Institute), etc to research your human activity and its impact.
- Answer the following questions and then create a poster with the information:
  - What is a negative effect on the ecosystem and biodiversity of your chosen human activity?
  - Why is broad biodiversity important for humans?
  - Design a solution to reduce the negative effects of this human activity on the stability of the environment and biodiversity.
  - Explain how your solution decreases the negative effects of human activity on the stability of the environment and biodiversity.

    - Describe and quantify the criteria (amount of reduction of impacts and human activities to be reduced) and constraints (for example cost, human needs, and environmental impacts) of the human activity. State the tradeoffs in your proposed solution.
    - Evaluate your proposed solution of human activity. Rate your solution 1-5 (5 being the best) for each of the following criteria: cost, safety, reliability, and impact on overall environmental stability. Justify why you chose your number.
    - Now that you've gathered some data, what (if anything) would you refine (change) about your initial solution. Address how this revised solution addresses the tradeoff involved with human needs and the impact of the loss of biodiversity.
- Part 2: Students will display their posters around the classroom.
    - Have students evaluate 2-3 groups to design solution posters and provide written feedback based on the rubric.

Student Self-Evaluation:		
	Score (1-5)	**Justification**
Cost		
Safety		
Reliability		
Impact on Overall Environment		

Peer to Peer Evaluation:		
Question	**Yes/Partially/No**	**Explain**
Human impact identified		
Solution to the human impact identified		
Explanation of the improvement to environmental stability and biodiversity		
Description and quantification of the criteria and constraints for the solution of the problem		
Consideration of tradeoffs of the solution		

Citation - Modified from:

The Short Performance Assessment (SPA) and the Assessment Rubric adapted from the Stanford NGSS Assessment Project http://snapgse.stanford.edu/

 HS-LS3-3 Assessment - Polynesian Butterflies

Universal Supports	Targeted Supports
• Students design a solution that involves reducing the negative effects of human activities on the environment and biodiversity, and that relies on scientific knowledge of the factors affecting changes and stability in biodiversity. • Student choice regarding a project in their area of interest within their local community is critical. Students should describe the ways the proposed solution decreases the negative effects of human activity on the environment and biodiversity.	• Intervention strategies should be applied for students who are uncomfortable with the engineering design process, have trouble selecting a local phenomenon. • Research and presentation strategies may need to be scaffolded. ○ For example, only give students one step of the project at a time - first, take thirty minutes to gather research and draw conclusions. Then time to draft a hypothesis, then time to make variables… do these on separate slides or separate sheets of paper so students are not overwhelmed with the full task all at once.

Common Misconceptions

- Disciplinary Core Ideas (DCI's)
  - Students may have misconceptions or gaps in learning on Ecosystems & Biodiversity related to the following concepts:
    - Humans do not have a negative impact on aspects of the environment or Earth.
    - Biodiversity is not necessary to maintain the health of an ecosystem.
    - Small changes in ecosystems can can not have large impacts
    - Negative impacts on Earth's ecosystems can not be reversed or mitigated
    - All ecosystems are impacted similarly by disruptive events
    - A change in one region of Earth will not impact other regions

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

- Ensure all material presented is derived from current and accurate scientific resources.
- Acknowledge the difference in perspectives on the role of humans and their impact on our environment.
- Use current and accurate data to support scientific evidence regarding the events under investigation.
- Allow all students the opportunity to share perspectives and diverse issues in their community related to this topic.

	• Provide student choice on the problem they would like to design a solution for, based on their local community. • Allow students to represent ideas in the language and format of their choice. Technology, such as Google Translate can be used to support translation of various languages utilized.

Students who demonstrate understanding can:

HS-LS2-8. **Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.** [Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]

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 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the evidence behind currently accepted explanations to determine the merits of arguments. - - - - - - - - - - ***Connections to Nature of Science*** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.	**LS2.D: Social Interactions and Group Behavior** • Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band: N/A

Articulation of DCIs across grade-bands: ***MS.LS1.B***

Common Core State Standards Connections:
ELA/Literacy -

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. *(HS-LS2-8)*

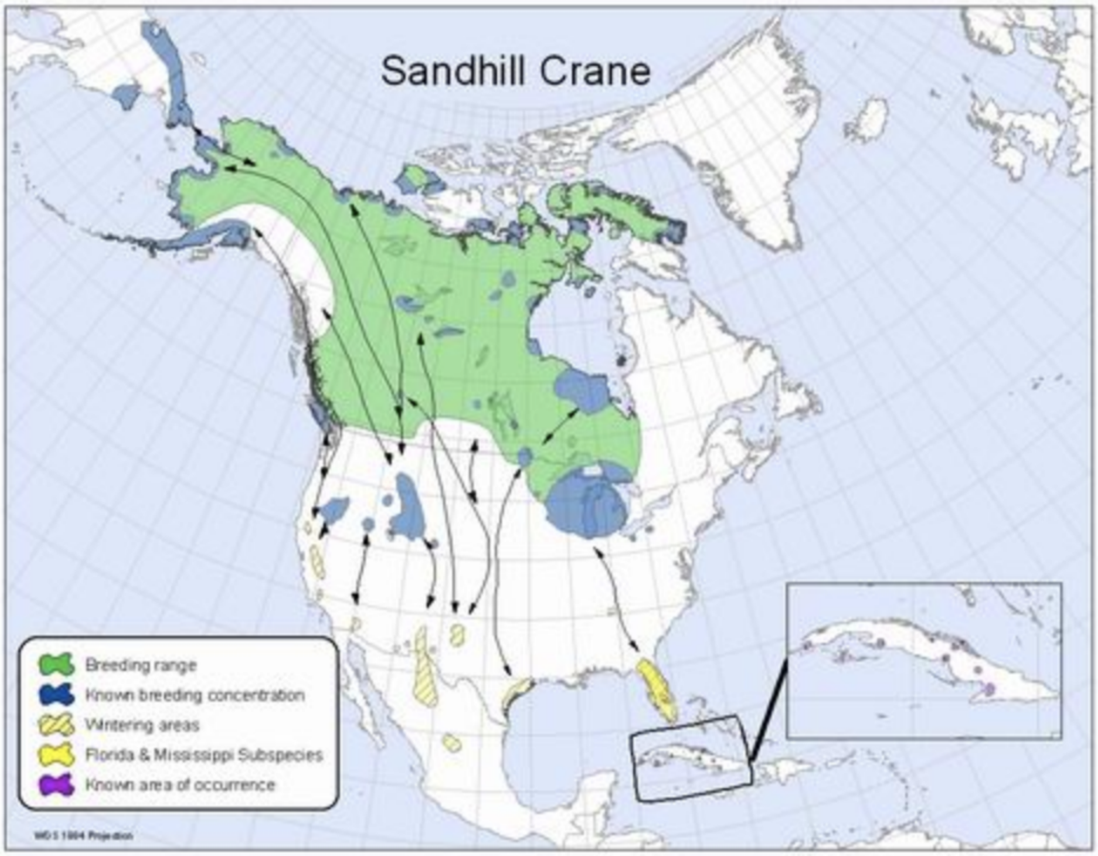
RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS2-8)

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-LS2-8)*

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-8)

HS	Life Science 2.8
	Sample Phenomena
LS2-8	*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.* **Phenomena #1 - NM Bird Migration** • **Description**: Bosque del Apache National Wildlife Refuge, located in San Antonio, NM is a migration path for over 400 species of birds. During each season, specific species can be observed in this section of the Rio Grande river, which is managed to recreate wetland conditions to support wildlife. The sandhill crane migration is considered to be one of the world's last mass annual migration events and exhibits group behaviors to increase reproduction rates. In pairs, ask students to analyze a sandhill crane migration map (example below) and document evidence (**engaging in argument from evidence -SEP**) for how and where the sandhill crane migrates. Based on evidence gathered from the migration map, students will then

consider causes for the observed migration patterns and possible effects of changing climate on the migration patterns (**cause and effect - CCC**). Student ideas should be shared with the class and used to launch future lessons related to the standard.



- **Resources**:
  - [Bosque del Apache website]
  - "The Migration - New Mexico True" video
  - "The Great Migration: Sandhill Cranes in Nebraska" video
  - Bosque del Apache Bird Migration in New Mexico Resource
  - Cause & Effect Graphic Organizer - The Wonder of Science
  - Engaging in Argument from Evidence Graphic Organizer - The Wonder of Science
- **Citations**:
  - Sandhill Crane map retrieved from: http://kynaturalinquirer.blogspot.com/2013/02/sandhill-crane-migration.html

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.

A Bee's Purpose

From spring through fall, a bee’s main task is turning plant nectar into honey. The honey is stored and eaten over the winter, so it is vital for the colony’s survival. Because honey is an energy-rich food source, hives are targets for break-ins from animals, like bears, skunks, and humans that want to steal the honey. The increase in these chronic disturbances cause bees to fight off other organisms that try to steal honey.

Bees Work Together When Threatened:

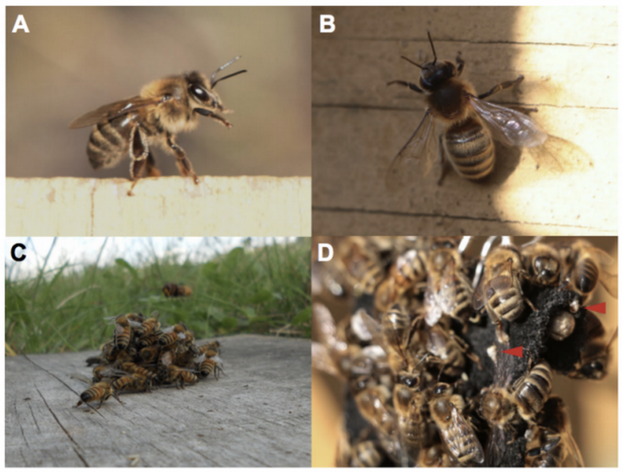
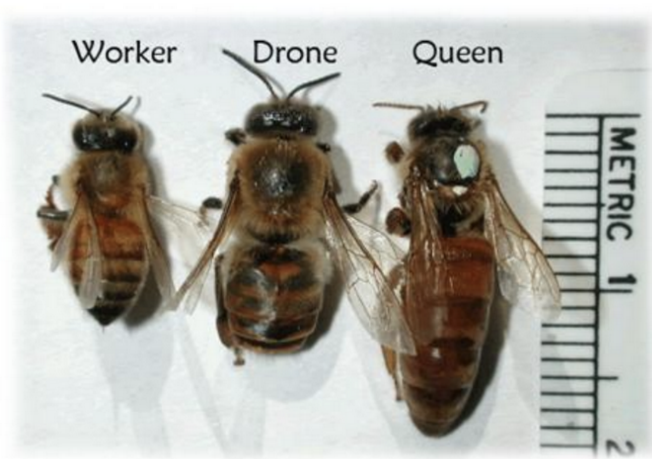


Fig. 1. Behavioural responses of honeybees to different threats. (A) Guard in the characteristic stance, forelegs off the ground and antennae pointing forward. (B) Alerted bee ready to fly off toward the intruder. (C) Honeybees engulfing a hornet in a 'hot bee ball'. A second hornet (*Vespa crabro*) is visible in the background. (D) Guards recruit nestmates to sting large intruders (here the leather flag used as decoy during a field assay). Sting autotomy is evidenced by the stingers (red arrowheads) remaining embedded in the leather. Photos are courtesy of David Vogel, Centre de Recherche sur la Cognition Animale (CRCA) (A,B,D), and David Baracchi, CRCA (C).

Bee Roles

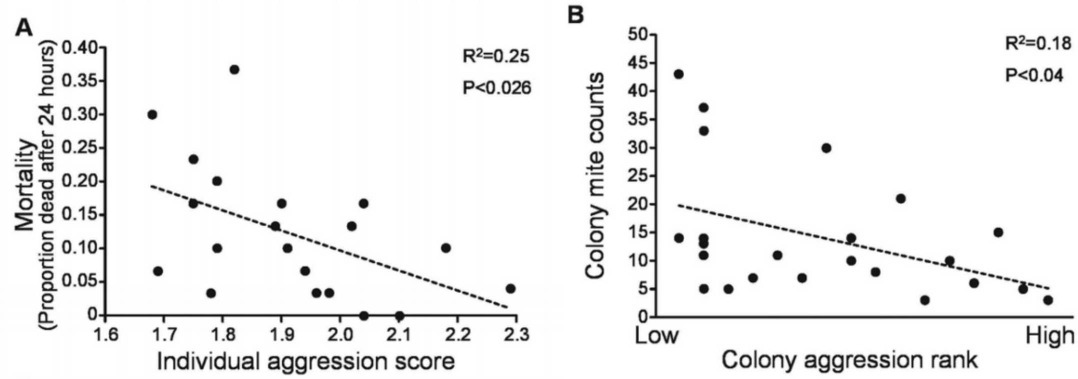
- Worker: a female bee that is not capable of reproducing; feeds the rest of the hive; collects nectar and makes wax
- Drone/Soldier: a male honey bee (without a stinger) whose primary role is to mate with the queen
- Queen: produces chemical scent that regulates the unity of the colony; lays many eggs



Beekeepers are wondering if they should stimulate their colonies by increasing the number of disturbances to become more aggressive. Perhaps a more aggressive hive would produce more honey. As an animal behavior specialist the beekeepers have asked you to collect research to determine if there is a cause/effect relationship between aggression, honey production and colony survival.

A group of researchers conducted investigations to determine the effects that aggressive behavior have on colony success.

https://www.nature.com/articles/srep15572.pdf
The second group investigated the effects of aggression in bees on their immune system resilience.



Aggressive bees are able to resist a harmful pesticide better, decreasing death.

Aggressive colonies have fewer mites found on individual bees. Mites are a harmful parasite.

- A scientist makes the claim that more aggressive bee colonies increase survival rate. Identify a specific piece of evidence that supports this statement for individual bees and colonies of bees.
- Identify potential additional evidence (in the form of data, information, or other appropriate forms) that was not provided but supports the claim that group behavior benefits the survival of the species.
- How can group behavior aggressiveness increase the chances of survival for individuals?(need a reading passage for this?)
- Explain how the chronic disturbance to the colony caused changes in the bee behavior over time.
- Identify the evidence that would be used to explain how specific bee behavior can increase the chances for individuals and a species to survive and reproduce.
- Write a claim for whether or not the beekeepers should train their hives to become more or less aggressive based on the graphs above. Provide evidence to support your claim. Support your claim with scientific reasoning.

Citation:

- The Short Performance Assessment (SPA) and the Assessment Rubric adapted from the Stanford NGSS Assessment Project http://snapgse.stanford.edu/

- Hosted by The Wonder of Science. HS-LS2-8 Assessment - Defending the Hive to Survive Edited (NY)

Universal Supports	Targeted Supports
• Students should evaluate the given evidence for the degree to which it supports a **causal**	• Small group instruction to target individual student misconceptions

claim that group behavior can have a survival advantage for some species, including how the evidence allows for distinguishing between **causal and correlational relationships**, and how it supports **cause and effect relationships** between various kinds of group behavior and individual survival rates (for example, the relationship between moving in a group and individual survival rates, compared to the survival rate of individuals of the same species moving alone or outside of the group). ● Students identify group behavior can increase the chances for an individual and a species to survive and reproduce. ● Students should identify additional evidence (in the form of data, information, or other appropriate forms) that was not provided but is relevant to the explanation and to **evaluating the given evidence**, and which includes evidence for **causal relationships** between specific group behaviors (e.g., flocking, schooling, herding, cooperative hunting, migrating, swarming) and individual survival and reproduction rates.	● Provide partially filled graphic organizers to allow students to develop their claims ● Provide sentence stems/starters to support developing written arguments

Common Misconceptions

- Students may have misconceptions or gaps in learning on **Ecosystems & Biodiversity** related to the following concepts:
  - Group behavior does not support survival and reproduction in some populations.
  - Group behavior has not evolved over time to support survival of a species

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

- Acknowledge the difference in perspectives on the role of humans and their impact on our environment.
- Provide diverse grouping opportunities to support student learning from multiple perspectives.
- Ask students to share examples of group behavior they have observed in the language of their choice. Technology, such as Google Translate can be used to support translation of various languages utilized.
- Allow student choice to investigate the topic of group behavior of their interest.
- Provide examples of various formats and strategies to engage in argument from evidence on their topic.
- Mini-lesson on how to write a claim, or the CER format, may be needed by some students.
- Allow students to represent ideas in the language and format of their choice. Technology, such as Google Translate can be used to support translation of various languages utilized.

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.

[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.

   b. Conceptual models: allow scientists and engineers to better visualize and understand phenomena and problems.
   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.

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

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.