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New Mexico STEM Ready! Science Standards Implementation Guide

Overview

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

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

The standards

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

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

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

The connections box identifies connections to other disciplinary core ideas at this grade level that are relevant to the standard, identifies the articulation of disciplinary core ideas across grade levels, and identifies connections to

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

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.

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.

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

- 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?

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

Sample Phenomena

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

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

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

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

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

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

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

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

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

Classroom Assessment Items

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

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

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

- Measuring the three-dimensional science learning called for in the framework and the NGSS requires assessment tasks that examine students' performance of scientific and engineering practices in the context of crosscutting concepts and disciplinary core ideas. To adequately cover the three dimensions, assessment tasks will generally need to contain multiple components. It may be useful to focus on individual practices, core ideas, or crosscutting concepts in the various components of an assessment

[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.

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 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,

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

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

Common Misconceptions

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

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

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

Multi Layered System of Supports (MLSS)

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

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

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

Culturally and Linguistically Responsive Instruction

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

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

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

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

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

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

STANDARDS BREAKDOWN

From Molecules to Organisms: Structures and Processes
LS-1-1
LS-1-2
LS-1-3
LS-1-4
LS-1-5
LS-1-6
LS-1-7
LS-1-8

Students who demonstrate understanding can:

MS-LS1-1. **Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.** [Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.]

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
Planning and Carrying Out Investigations Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. • Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.	**LS1.A: Structure and Function** • All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).	**Scale, Proportion, and Quantity** • Phenomena that can be observed at one scale may not be observable at another scale. - ***Connections to Engineering,Technology and Applications of Science*** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.

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

Articulation of DCIs across grade-bands:
HS.LS1.A

Common Core State Standards Connections:

ELA/Literacy -

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-LS1-1)

Mathematics -

6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *(MS-LS1-1)*

Grade	*NGSS Discipline*
MS	**Life Science 1.1**
LS1-1	**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.

Phenomenon: A salamander develops from a single cell
Use this nat-geo resource that show a salamander growing from a single-cell:
https://www.youtube.com/watch?v=SEejivHRIbE
Have students record what they notice and wonder.

Other Possible Phenomenon:

- -Living organisms that are too small to be seen with the naked eye
- Materials that may contain varying characteristics related to life
- The relationship between the development of the cell theory and the germ theory as presented in a model of disease outbreak or infection
- A simulation that provides an opportunity for students to expose cells to a variety of environmental stimuli and observe the response of the cells
- A simulation that allows students to manipulate the input of materials to a cell and observe the subsequent outputs and cell activity
- Cell representations that can be sorted into individual unicellular organisms and specialized members of a multicellular organism

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.

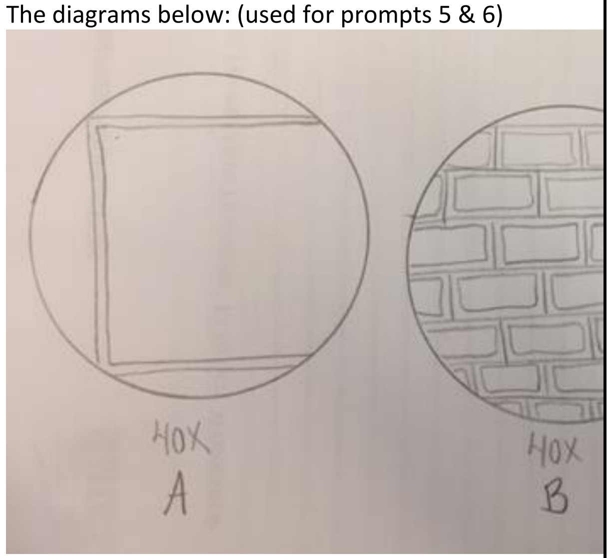
Performance Assessment
Phenomenon
Do not share this info with students ahead of time Students observe a beaker containing sewer lice. (Sewer Lice are raisins in a beaker of carbonated clear soda. You can add food color to make the liquid look brownish.)

Stimulus

Pictures of the following equipment: (used for prompt 2)

- Microscope
- Slides
- Scalpel
- Magnifying glass
- Fish food
- Hot plate
- Ruler
- Thermometer
- Probe
- Flux capacitor

The diagrams below: (used for prompts 5 & 6)



Prompt
Are sewer lice living organisms? 1. State your claim as to whether or not the sewer lice are living organisms. 2. Plan an investigation using the pictured equipment that would allow you to collect evidence to support your claim. You do not have to use all the equipment pictured in your plan. You do not have to conduct this investigation; simply plan it. 3. What evidence do you expect to collect from this investigation that would provide you the reasoning to either support or deny your claim? Be specific. 4. Explain why a student would require the use of a microscope to support their claim that something is alive. 5. Student A peels the "skin" off the sewer lice and places it under a microscope. Choose the image (a, b OR c) that best matches the scale, proportion and quantity of what would be observed under the microscope. 6. Explain why the other two choices are not an accurate representation. Remember to use the words scale and proportion in your response.

Universal Supports	Targeted Supports
• **Layer 1:** Compare and contrast single celled organisms, plants, and animals. Discuss the qualifications of being alive. Discuss cell theory.	• **Layer 2:** Small groups to support that single celled organisms, such as bacteria, are alive. What makes something living? Some students will need to understand the range of differences that cells can have in the same organism. For instance red blood cells, nerve cells and muscle cells.

Common Misconceptions

- Vocabulary differences between cells, atoms, molecules, particles. i.e. living things are made of cells and non-living things are made of atoms
- All cells look the same
- Cells are generated out of nowhere as opposed to divided
- Everything on this planet has a “life force”
- All living organisms are made up of many cells
- -Cells are too small to be alive.
- -Only animals are made of cells.
- *resource for misconceptions: https://www.youtube.com/watch?v=tfDfLXnW2N0

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

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

Validate and Affirm:
- What are you made up of?
- Think of your experiences. What are things you have come in contact with that are living and nonliving?

Build and Bridge:
- What knowledge and experiences have you had that might help us as a class explain how to determine if something is living or nonliving?
- What questions do we need to answer to test your ideas about if something is living or nonliving?
- Why does this phenomenon matter to you, to your community or others to scientists?

Students who demonstrate understanding can:

MS-LS1-2. **Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function.** [Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.] [*Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.*]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena.	**LS1.A: Structure and Function** • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.	**Structure and Function** • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

Connections to other DCIs in this grade-band:
MS.LS3.A

Articulation of DCIs across grade-bands:
4.LS1.A** ; **HS.LS1.A

Common Core State Standards Connections:

ELA/Literacy -

SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-LS1-2)*

Mathematics -

6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *(MS-LS1-2)*

Grade	*NGSS Discipline*
MS	**Life Science 1.2**
LS1-2	**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.* Phenomenon: t-cells move through the body and destroy cancer cells. Demonstrate how t-cells move through the body destroying cancer cells. Example: https://thewonderofscience.com/phenomenon/2018/7/9/killer-t-cell-the-cancer-assassin Phenomenon: Peppers and other vegetables change color when they are ready to harvest. Show a time-lapsed video or grow a pepper in class. Ex: https://www.youtube.com/watch?v=hOuOeoLrH7Q Other possible phenomenon: ● -Visualizations of different types of cells to identify their components ● -Models of cells that illustrate the scope and scale of various components ● -Simulations that explore relationships among cellular components ● -Structures and functions of plant and animal cells

- -The contributions of cell components to a particular function of the cell (e.g., cellular respiration, photosynthesis, endocytosis)
- -Visualizations of specialized cells used to identify their function based on their internal structure and components

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.

Example of creating a model of a cell in relationship to a city.
https://www.gpisd.org/cms/lib/TX01001872/Centricity/Domain/15103/Cell%20Analogy%20Project.doc

Name____ Date___________________

Cell Analogy Project
Introduction:

Each individual cell operates much like a city, a business, a home, or a school does. Each organelle in the cell does a job that allows the whole cell to function properly. There are many different jobs that have to be done in order for a city business, school, etc. to run smoothly. There must be a waste management system that deals with trash. Could you imagine what a city, home, or business would be like if there wasn't anyone picking up the trash? In this project, you are going to compare the organelles in a cell to the functions of other objects that are needed to run a city, home, business, or school. You and your partners will design a project where you will need to research the organelles to deepen your understanding, plan what the pieces to your project will look like, and then build/design all the parts of your city, home, etc. that correspond to the organelles in a cell.

Organelle List: *Chloroplast, Nucleus, Lysosome, Vacuole, Endoplasmic Reticulum, Golgi apparatus, Cell Membrane, Cell wall, Cytoplasm, Mitochondria, chromosomes, ribosomes.*

Instructions:

- Ø **Step 1: Research the functions of the organelles that are found within the cell.**
- Ø **Step 2: Plan your city/home/business:**
    - o **Decide what Parts of you will need for the cell type you chose.**

Cell Organelle	**Organelle Function**	**Similar to a ____ because it ________.**

Instructions Continued:

- **Step 3: Choose whether you want to do a plant cell or animal cell**
- **Step 4: Build your city:**
  - **Decide what Parts of a city you will need for the cell type you chose**
  - **On a poster board provided, draw, design, cut-out your city parts and organize them on the poster like a real city or business would be organized.**
  - **Label each part of the city and underneath it in parentheses label the organelle it represents. Ex. City Hall (nucleus), Principal's Office (nucleus).**
- **Step 5: In the left corner of your poster draw an actual cell.**

OR

The Pool Has Ruined the Grass

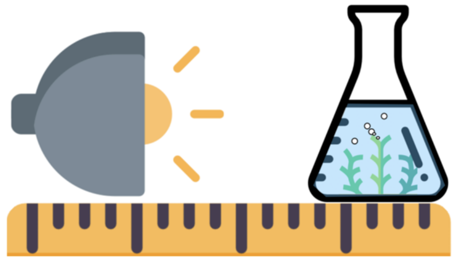
The following post was added to a bulletin board by user Voidless2. You will use your knowledge of cell parts to create a model of what may be happening in the grass.

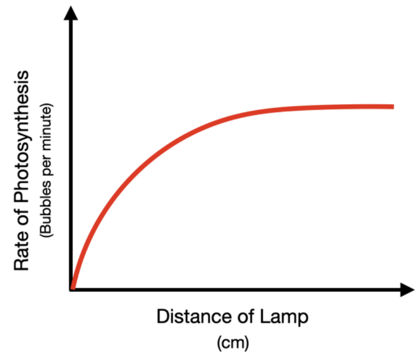
1. What interesting patterns do you observe in the phenomenon
2. What might be causing this change?

Research

You do some research and find the following two investigations related to plants that may be helpful as you develop your model. In the first investigation a lamp was placed at varying distances from an aquatic plant. The bubbles were used to measure the rate of photosynthesis.

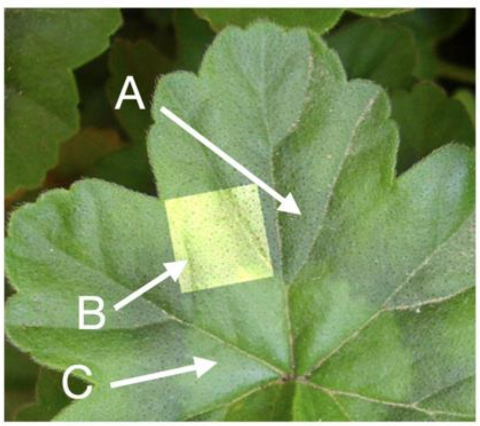
Investigation 1: Photosynthesis Rate





In the second investigation a geranium leaf was covered with paper. After two weeks measurements were made of both the color of the leaf and the presence of starch (sugar) in the leaf.

Investigation 2: Covered Leaf

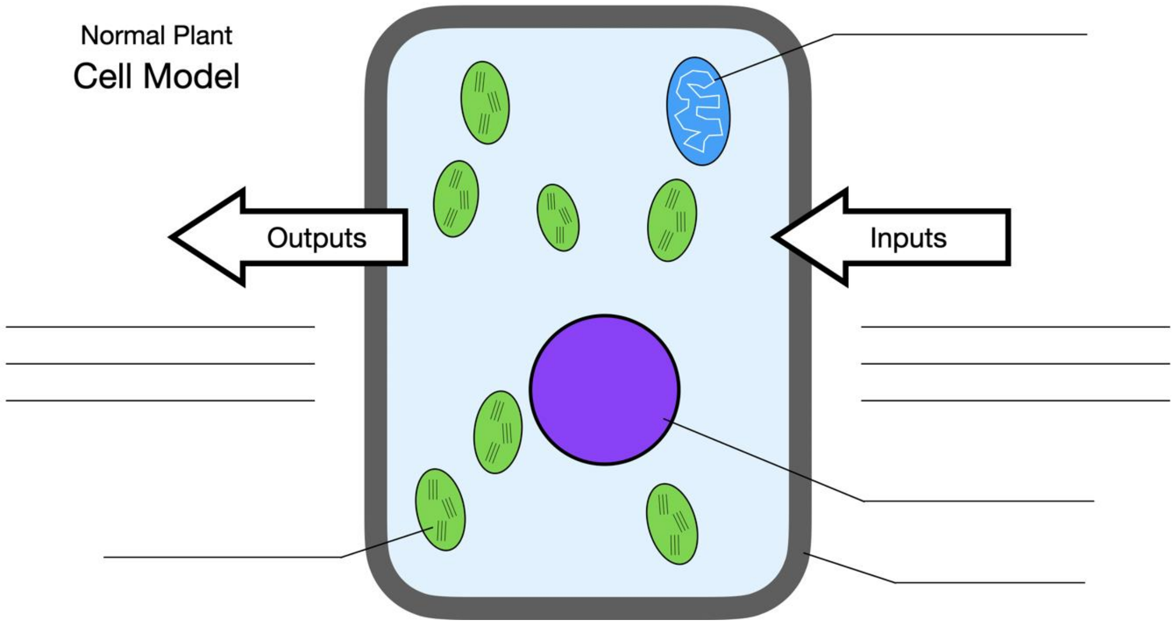


Location	Color	Starch
A	Dark green	Present
B	Yellow	Absent
C	Medium green	Present

Modeling

3. Identify the following parts in a normally functioning plant cell on the model below.
   - mitochondria, nucleus, cell wall, chloroplast

3. Identify normal plant cell needs (inputs) and products (outputs) on the cell model below.



Use the model below to show a causal mechanism for the "***pool ruined the grass***" phenomenon. Describe your mechanism using evidence from the research on page two.

Universal Supports	Targeted Supports
• **Layer 1:** Identifying parts of a cell and their functions. How do these parts work together to function as a whole unit?	• **Layer 2:** Small groups to support students in the development of a cell model to describe the function

Common Misconceptions

- Living things grow because cells get larger
- The parts of the cell float in empty space inside the cell
- -Each component of a cell functions independently.
- All components of the cell are the same size
- Each component of the cell functions separately
- Chemical reactions do not happen in living things

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

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

Validate and Affirm:

- What does each part of the cell organelles remind you of in your world? Example mitochondria is like the power plant that gives us electricity.
- What knowledge and experiences have you had that might help us as a class explain the structure and function of cells?

Build and Bridge:

- What questions do we need to answer to test your ideas about what each structure of a cell does?
- Why does this phenomenon matter to you, to your community or others to scientists?

Students who demonstrate understanding can:

MS-LS1-3. **Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.** [Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.] [*Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.*]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.	**LS1.A: Structure and Function** • In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.	**Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. - - - - - - - - - - - - - - - - ***Connections to Nature of Science*** **Science is a Human Endeavor** • Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

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

Articulation of DCIs across grade-bands:
HS.LS1.A

Common Core State Standards Connections:
ELA/Literacy -

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-3)

RI.6.8 Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. (MS-LS1-3)

WHST.6-8.1 Write arguments focused on discipline content. (MS-LS1-3)

Mathematics -

6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the

Grade	*NGSS Discipline*
MS	**Life Science 1.3**
	Sample Phenomena
LS1-3	*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: Skin will regenerate when it is injured. Demonstrate how the human body heals itself. Find a video that looks at the macro and micro. Example: https://www.youtube.com/watch?v=TLVwELDMDWs Phenomenon: Some people perceive numbers and words as colors: Synesthesia Introduce the idea of synesthesia in either text or video format. Have students conjecture about why we as humans perceive the world around us differently. Example: https://thewonderofscience.com/phenomenon/2018/7/9/synesthesia

Everyone sees colors “differently”
https://www.youtube.com/watch?v=evQsOFQju08&t=1s

Other Possible Phenomenon:

- -Cells that are organized to form tissues
- -Tissues that are organized to form organs
- -Organs that work together in a system
- -Organ systems that work together to perform necessary functions for survival and growth of an organism
- -Structural tissues vs. chemically functional tissues
- -Extracellular matrices associated with tissues

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.

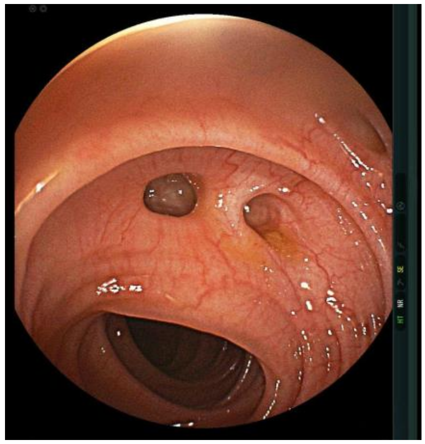
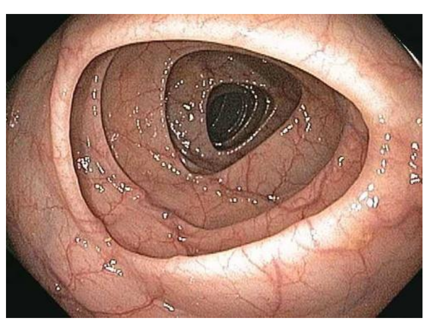
This is a link taken from OpenSciEd’s unit 7.3 on metabolic reactions. This assessment can be modified to fit a more general unit on human body interactions.

https://docs.google.com/document/d/1ptrgu0N5MveGHp2NTY9lqtblQdDcg59A2JIg1f1W2c4/edit

Part 3: Argue from Evidence What’s Causing M’Kenna’s Symptoms

Now that you have gathered more evidence about the structures of the digestive system and their functions, revisit the Gastrointestinal Conditions table below and determine which of the conditions best explains what is causing M’Kenna’s symptoms. Using all of what you’ve figured out in this unit, construct an argument from evidence that you’ve collected that shares a conclusion about which condition you believe is causing M’Kenna’s symptoms and the evidence you have that supports that conclusion.

Gastrointestinal Condition	**Image of Intestinal Lining**	**Symptoms**	**Cause(s)**

Diverticular disease is the general name for a common condition that causes small bulges or sacs to form in the wall of the large intestine. Although these sacs can form anywhere in the colon, they are most common in the part of the large intestine closest to the rectum.	 MAC 06 Large Intestine	Painful abdominal cramps Nausea and vomiting Fever Chills Abdominal tenderness Constipation Diarrhea	**Diverticula**, which can range from pea-sized to much larger, are formed by increased pressure on weakened spots of the intestinal walls by gas, waste, or liquid. Diverticula can form while straining during a bowel movement, such as with constipation.
If a person has **celiac disease** and eats foods with gluten, their immune system responds by damaging the small intestine. Gluten is a protein found in wheat, rye, and barley.	 Naspghan Endoscopic Video Library Small Intestine	Diarrhea Bloating Gas Fatigue Weight loss Iron-Deficiency Anemia Constipation Depression	**Celiac disease** is an immune disease in which people can't eat gluten because it will damage their small intestine. It affects both males and females. People with this condition have flattened "villi," which are tiny finger-like structures, on their small intestine. Villi can only be seen with a high magnification microscope.
Irritable bowel syndrome (**IBS**) is a common disorder that affects the large intestine. Signs and symptoms include cramping, abdominal pain, bloating, gas, and diarrhea or		Abdominal pain and cramping Diarrhea Constipation Alternating constipation and diarrhea Gas and bloating Food intolerance	**IBS** is thought to result from a combination of **abnormal gastrointestinal** tract movements, increased awareness of bodily functions, and a disruption in the communication between the brain and

constipation, or both. **IBS** is a chronic condition that needs to be managed long term.	Dr. Alexander Mantas & mantasmd.com Large Intestine	Fatigue	the gastrointestinal tract. More research is still being done to better understand the causes of IBS.
Colitis is a chronic digestive disease characterized by inflammation of the inner lining of the colon. Infection and loss of blood supply in the colon can occur. Colitis affects only the large intestine and only the inside lining.	 Rocky Mountain Gastroenterology & Rocky Mountain Endoscopy Center Large Intestine	Not feeling hungry Weight loss Fatigue Dehydration Joint pain Canker sores Eye pain Anemia Skin sores Diarrhea Rectal bleeding Abdominal cramps Frequent and immediate need to empty the bowels	**Colitis** is an inflammatory bowel disease that causes long-lasting inflammation and ulcers or sores in the digestive tract. One type of **colitis** affects the innermost lining of the large intestine and rectum. Symptoms usually develop over time, rather than suddenly.
Crohn's disease is a chronic inflammation of the digestive tract, primarily the small intestine. This chronic disease means sometimes people feel well and sometimes people do not notice symptoms at all.	 Diagnosis and Management of Crohn's Disease, 84, No 12 Small intestine	Persistent diarrhea Rectal bleeding Urgent need to move bowels Abdominal cramps and pain Fever Loss of appetite Weight loss Fatigue Night sweats	**Crohn's disease** is an inflammatory bowel disease. No one knows exactly what causes Crohn's. It may be caused by a malfunctioning immune system, genetics, or environmental factors.

Claim. The condition that is most likely causing M'Kenna's symptoms is: ______________________________.

2. **Write an argument to support your claim.** Use your work from Parts 1 and 2 in lesson 7 and use at least 4 pieces of evidence from the unit so far that support your claim that M'Kenna has the disease you chose and not the other diseases you examined. List each piece of evidence and answer the questions below.

Evidence #1:

How is Evidence #1 connected to M'Kenna and her disease?

How does Evidence #1 help you rule out other diseases in the table?

Evidence #2:

How is Evidence #2 connected to M'Kenna and her disease?

How does Evidence #2 help you rule out other diseases in the table?

Evidence #3:

How is Evidence #3 connected to M’Kenna and her disease?

How does Evidence #3 help you rule out other diseases in the table?

Evidence #4:

How is Evidence #4 connected to M’Kenna and her disease?

How does Evidence #4 help you rule out other diseases in the table?

Universal Supports	Targeted Supports
• **Layer 1:** Include hierarchy of cells, tissues, organs, organ systems, and organism to clarify that not all cells do the same job. (Ex. blood cells vs muscular cells). Organ systems support other organ systems to allow the organism to fully function.	• **Layer 2:** Small groups to understand the different functions of different cells.

Common Misconceptions

- Each organ system functions independently
- That cells cannot be grouped together to form larger tissues
- All cells are the same size
- -Cells function independently in multicellular organisms.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

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

Validate and Affirm

- What does your body do for you?
- What are some of the different parts of your body and what is the job of each part?
- What knowledge and experiences have you had that might help us as a class explain how our bodies' interacting subsystems work together to keep you alive?

Build and Bridge:
- What questions do we need to answer to test your ideas about how our bodies' interacting subsystems work together to keep you alive?
- Why does this phenomenon matter to you, to your community or others to scientists?

Students who demonstrate understanding can:

MS-LS1-4. **Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.** [Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	**LS1.B: Growth and Development of Organisms** • Animals engage in characteristic behaviors that increase the odds of reproduction. • Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Connections to other DCIs in this grade-band:
MS.LS2.A

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

Common Core State Standards Connections:

ELA/Literacy -

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-4)
RI.6.8	Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. (MS-LS1-4)
WHST.6-8.1	Write arguments focused on discipline content. (MS-LS1-4)

Mathematics -

6.SP.A.2	Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape. *(MS-LS1-4)*
6.SP.B.4	Summarize numerical data sets in relation to their context. *(MS-LS1-4)*

Grade	*NGSS Discipline*
MS	**Life Science 1.4**
LS1-4	**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.* Phenomenon: The bee orchid flower looks like a bee butt! Introduce species like the bee orchid. Look for text or media examples of how the bee orchid actually pollinates itself by mimicking the shape of a bee. Example: https://www.youtube.com/watch?v=GV0oLYLgSJs. Tie in cause and effect. If the orchid looks like a bee, then the bee will be attracted to it because... Phenomenon: Mother penguins can find their chick in crowds due to their unique calls. Find text or media about penguins finding their own individual chicks in flocks of thousands due to their unique calls. Example: https://www.youtube.com/watch?v=ECxwzOmlDAU Other Possible Phenomenon:

- -Courtship behaviors involved in attracting a mate
- -Behaviors that provide offspring with shelter, food, and protection from predation
- -Teaching survival skills to offspring
- -Flower characteristics that attract birds, bats, and insects for pollination
- -Adaptations that facilitate seed dispersal by gravity, wind, water, or animals
- -Adaptations that enable seeds to sprout in different environments
- -Transporting pollen between flowers
- -Transporting seeds to new locations (e.g., carrying seeds, eating fruit, and eliminating seeds)
- -Cultivating environments conducive to plant growth

Classroom Assessment Items

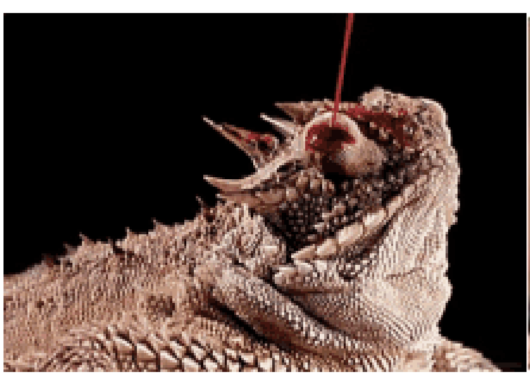
When available, you should use your locally selected or created high quality instructional materials. However, the following are example assessment items you can use if you don't have local instructional materials available.

Research Question: What affects an organism's probability of successful reproduction?

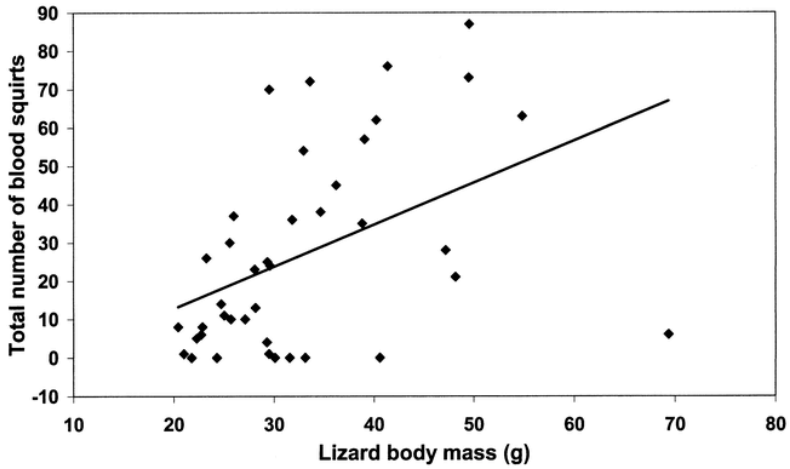
Task: You will be participating in a debate to engage in an argument to evaluate the evidence below. In your debate you must discuss the evidence in terms of:

- Validity
- Reliability
- Relevance

A graphic organizer has been included for you to fill out as you prepare for your debate. Fill out the research question and evidence section as you read the information below.



A lizard covered in horns and spines might not sound appetizing to us, but to many other animals, it's a tasty treat! Horned lizards, also known as horny toads because of their toad-like round body and blunt snout, live in deserts and semi-arid regions from southern Canada to Guatemala.



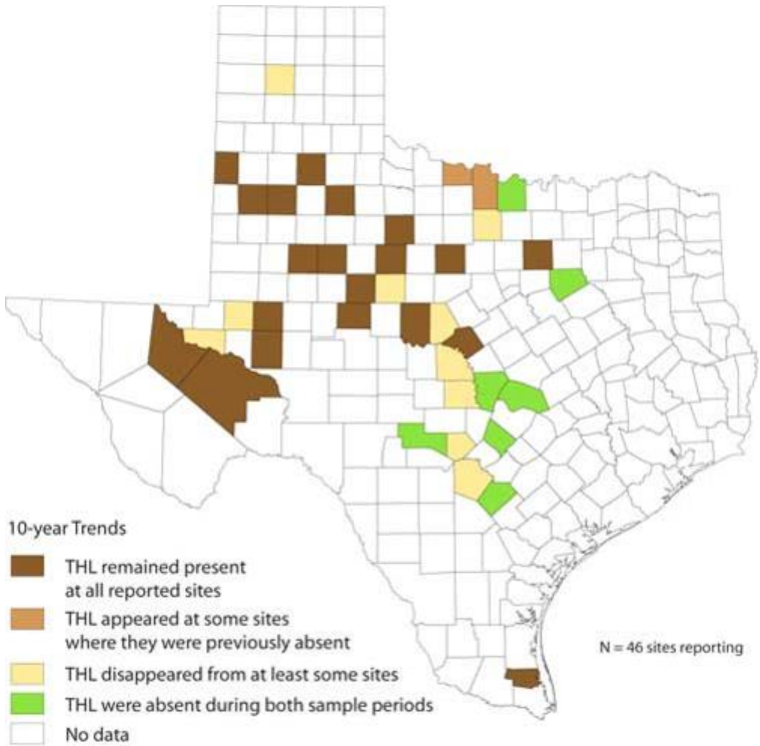
To fend off predators including hawks, snakes, wolves, and coyotes, horned lizards use several lines of defense. First, their bodies are covered in spiny armor. Some species can even inflate into what looks a bit like a spiny balloon. That doesn't sound tasty! But some species, including the Texas horned lizard, coast horned lizard, and regal horned lizard, excel in using an even stranger defense strategy: shooting blood from their eyes.

How? It constricts muscles near its eyes to reduce blood flow out of its head, which builds up blood pressure. Talk about hot-headed! The rapidly increasing blood pressure in the thin-walled sinuses within the lizard's eye sockets eventually breaks the sinus walls. When these walls break, blood shoots out of the eye in jet-like squirts that can travel up to four or five feet! The lizard can repeat this process several times in a row. Think your seasonal allergies are bad? At least your sinus pressure doesn't do this!

Evidence suggests that, by shifting its eye muscles, the lizard can even control the direction of the squirt, helping to aim at its target. Not only that, but scientists think that a chemical in its blood is noxious to canids (such as dogs, coyotes, and wolves). It's no wonder that startled predators often give up on making the lizard lunch and run the other way.

Believe it or not, the lizard is thought to use a similar blood pressure-building strategy to remove dirt and other unwanted material from its eyes.

In recent years, horned lizard populations have been on the decline due to habitat destruction, eradication of ants (their main food source), and the pet trade.



This species is vulnerable to environmental changes, especially the loss of harvester ants which comprise up to 69% of their diet. However, the abundance of harvester ants has decreased drastically as a result of introduced fire ants, which are thought to out compete native harvester ants for food and space. The widespread use of insecticides and habitat destruction have also contributed to declines.

Tree shrew, (order Scandentia), any of 17 Southeast Asian species of small mammals resembling squirrels and "true" shrews. Tree shrews, however, are neither rodents nor insectivores and differ from them to the extent that they constitute their own mammalian order. They have large eyes, conspicuous ears, and, like insectivores, a long muzzle. Tree shrews have slender bodies, long, slender limbs, and sharp, curved claws. Depending on the species, the tail is slightly shorter or much longer than the body. Tree shrews have acute senses of hearing and smell, along with good vision.

The tropics are full of pitcher plants, but only Nepenthes lowii is full of poo. Yes, shrew poo. Instead of capturing insects, like most pitcher plants, this species evolved to capture the excrement of tree-dwelling mammals and birds, like the mountain treeshrew.

To appreciate the full evolutionary majesty of this plant-o-potty, let's have a look at the pitcher's shape. Most pitcher plants have lids that curve down over the opening, further trapping insects and other critters. But instead of acting as a trap, the lids on Nepenthes lowii act as a mammal minibar, secreting a white, sugary substance. As the tree shrews enjoy a tasty snack, they can conveniently perch on the wide, funnel-like opening, which sluices all of their poo right into the pitcher. (Apparently, the shrews even scent-mark their favorite plants by rubbing their sex organs all over the lid.)

But why, exactly would evolution have pushed this particular pitcher plant to be such an exceptional excrement accumulator? Nepenthes lowii is only found on a handful of isolated mountain peaks in Borneo, where soils are nutrient-poor and insects are scarce. Scientists recently discovered that Nepenthes lowii derive between 57 and 100 percent of their nitrogen from the pitcher-caught shrew poo.

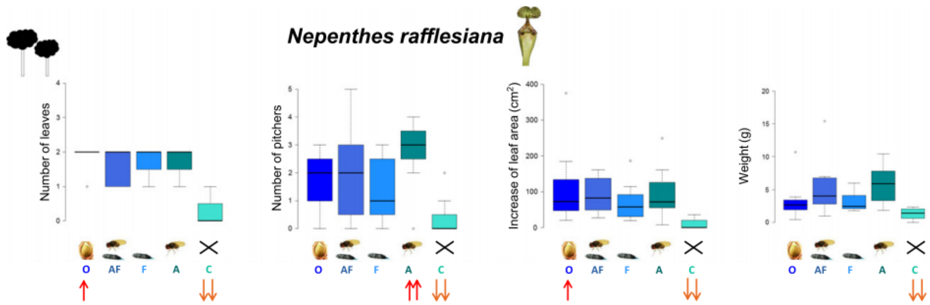


Fig. 1. Influence of feeding treatments on the four tested growth parameters (number of newly developed leaves and pitchers, increase of the leaf area and weight of the newly developed plant parts). In the first row, results of the field experiment (tree symbol) and in the second row, the results of the glasshouse experiment (house symbol) for *Nepenthes hemsleyana* are shown. In the third row, the results of the field experiment for *Nepenthes rafflesiana* are shown. Significant positive (↑) or negative (↓) differences of treatments from random distributions (Monte Carlo tests) are shown below each boxplot: significance level: ↑, ↓: $P < 0.05$; ↑↑, ↓↓: $P < 0.01$. Abbreviations: O = pitcher with natural capture rate that was left open; AF = plants fed with arthropods + faeces; F = fed with faeces; A = fed with arthropods; C = unfed control. [Colour figure can be viewed at wileyonlinelibrary.com]

Directions: Answer questions 1 + 2 below in the Engaging in Argument from Evidence graphic organizer.

Questions:

1). Based on all the evidence you have seen, make a claim to support a given explanation of the phenomenon.

2) Identify the given evidence that supports the claim.

3.) Evaluate the evidence and identify the strengths and weaknesses of the evidence used to support the claim.

4) Provide an alternative interpretation of the evidence and state why the evidence supports your claim, as opposed to any other claims.

This task was sourced from The Wonder of Science

Universal Supports	Targeted Supports
• **Layer 1:** Characteristics of plants and animals that support the survival and reproduction of the organism. Identify ways organisms protect their young. Identify ways animals attract mates and how plants transfer pollen or seeds.	• **Layer 2:** Small groups to identify which characteristics are most beneficial to the survival and reproduction of the organism.

Common Misconceptions

- Animal behaviours have no influence on plants and vice versa
- That animals and plants have always been the same and do not respond to changes in their environment.
- Some plants and animals are just luckier than others, or every living thing has a purpose

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

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

Validate and Affirm

- How do animals you know of behave?
- How have you seen specific plants adjust to changes in their environment? like desert grasses, or mosses
- What are some ways that plants reproduce?
- What knowledge and experiences have you had that might help us as a class explain behaviors increasing the probability of survival?

Build and Bridge:

- What questions do we need to answer to test your ideas about an organism's behaviors increasing the probability of reproduction
- Why does this phenomenon matter to you, to your community or others to scientists?

Students who demonstrate understanding can:

MS-LS1-5. **Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.** [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.] [*Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.*]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS1.B: Growth and Development of Organisms** • Genetic factors as well as local conditions affect the growth of the adult plant.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Connections to other DCIs in this grade-band:
MS.LS2.A

Articulation of DCIs across grade-bands:
3.LS1.B ; **3.LS3.A** ; **HS.LS2.A**

Common Core State Standards Connections:
ELA/Literacy -

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-5)
RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. *(MS-LS1-5)*
WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. *(MS-LS1-5)*
WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS1-5)

Mathematics -

6.SP.A.2 Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape. *(MS-LS1-5)*
6.SP.B.4 Summarize numerical data sets in relation to their context. *(MS-LS1-5)*

Grade	*NGSS Discipline*
MS	**Life Science 1.5**
LS1-5	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* Phenomenon: Arctic animals' fur changes color in winter. Introduce the idea via text or media of the fur on animals changing color in the arctic as winter approaches. Phenomenon: Plants that are exposed to more sunlight grow taller. Grow vegetables or plants in the classroom or show a virtual experiment where plants exposed to more nutrients, i.e. sunlight, water, fertilizer develop at different rates. Work with cause and effect language. If we give a plant more water, then we will observe…

Other Possible Phenomenon:

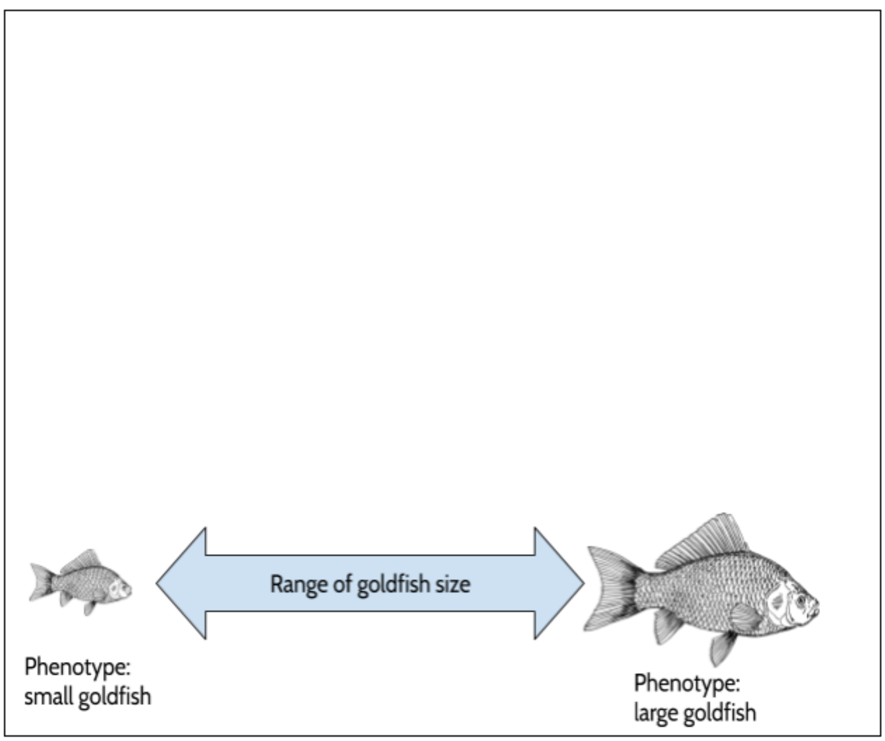
- -Light
- -Water
- -Soil nutrients
- -Space for nesting
- -Genetic makeup
- -Fertilizer application on crops
- -Drought leading to a food shortage
- -Unintended impacts of pesticide application
- -Change in annual temperature
- -Impact of disease on organisms

Classroom Assessment Items

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

Source: OpenSciEd

Goldfish growth depends on many environmental factors including clean, warm water, oxygen in the water, food, and space. Scientists found only a few genes that might account for some differences in how big a goldfish can grow. In excellent environmental conditions, any goldfish can grow to be very large. Explain the relative influence of genetics and the environment on the range of sizes that a goldfish could be.



Universal Supports	Targeted Supports
• **Layer 1:** Identify methods that affect the growth of an organism, comparing genetic factors vs environmental factors. List the environmental factors that affect the growth of an organism.	• **Layer 2:** Small groups to determine if the growth of an organism is due to a genetic factor or an environmental factor.

Common Misconceptions

- Genetics will always control the growth of organisms, regardless of environmental conditions.
- Plant growth is not controlled by genetics.
- Only animals inherit genes from their parents.
- That animals and plants have always been the same and do not respond to changes in their environment

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

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

Validate and Affirm

- What do plants look like where you live?
- Why do some plants grow larger than other plants?
- Why can the same species of plant be different sizes?
- Why can some organisms of the same kind be larger?
- How do animals keep their offspring alive?
- What knowledge and experiences have you had that might help us as a class explain how the environment affects the growth of an organism.
- What knowledge and experiences have you had that might help us as a class explain how genetic factors affect the growth of an organism.

Build and Bridge:

- What questions do we need to answer to test your ideas about how the environment influences the growth of an organism?
- What questions do we need to answer to test your ideas about how genetic factors affect the growth of an organism?
- Why does this phenomenon matter to you, to your community or others to scientists?

Students who demonstrate understanding can:

MS-LS1-6. **Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.** [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [*Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.*]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. - ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical connections between evidence and explanations.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. **PS3.D: Energy in Chemical Processes and Everyday Life** • The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. *(secondary)*	**Energy and Matter** • Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

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

Articulation of DCIs across grade-bands:
5.PS3.D ; **5.LS1.C** ; **5.LS2.A** ; **5.LS2.B** ; **HS.PS1.B** ; **HS.LS1.C** ; **HS.LS2.B** ; **HS.ESS2.D**

Common Core State Standards Connections:
ELA/Literacy -

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-6)
RST.6-8.2	Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. *(MS-LS1-6)*
WHST.6-8.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS1-6)
WHST.6-8.9	Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS1-6)

Mathematics -

6.EE.C.9	Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *(MS-LS1-6)*

Grade	*NGSS Discipline*
MS	**Life Science 1.6**
LS1-6	**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.* Phenomenon: Sunflower plants track the sun with their young flowers until they reach maturity. Observe sunflowers tracking the sun either in real time or virtually.

Phenomenon: Phytoplankton blooms crop up in earth's oceans.
Show various images of phytoplankton blooms from space. Students will wonder how these blooms are created.
Example: https://www.youtube.com/watch?v=BsAUmTPcc7c
https://www.youtube.com/watch?v=J3uxyOSs2FU
https://www.youtube.com/watch?v=JloWlDA6ccM

Other possible Phenomenon:

- -Photosynthetic microorganisms
- -Photosynthetic organisms using carbon dioxide and water to make sugar and oxygen
- -Photosynthetic organisms releasing oxygen
- -Animals depending on the oxygen released by photosynthetic organisms for respiration
- -Animals returning carbon dioxide to the atmosphere
- -Photosynthetic organisms capturing energy from sunlight
- -Photosynthetic organisms using captured energy to make sugars
- -Photosynthetic organisms using, storing, or modifying the sugars
- -Some animals eating photosynthetic organisms for their stored energy
- -Some animals eating other animals, thus indirectly getting the energy stored by photosynthetic organisms

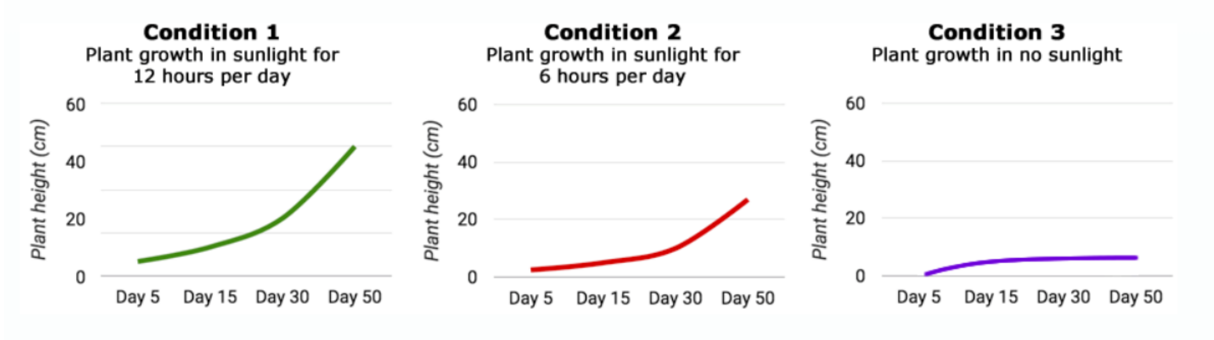
Classroom Assessment Items

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

Tomato plants in sunlight (ID #081.04-p01)

Jane wanted to grow healthy tomato plants so that she could donate the tomatoes to her local community center.

She planted tomato plants in three different places around her house. All plants were planted in the same soil and received the same amount of water and carbon dioxide. But, the plants had different conditions for sunlight. Jane wanted to know how sunlight affects the growth (height) of the plants. She collected data for 50 days and graphed how much each plant grew in each condition.



- In **Condition 1**: Plant received sunlight for 12 hours each day.
- In **Condition 2**: Plant received sunlight for 6 hours each day.
- In **Condition 3**: Plant received no sunlight each day.

Use the graphs to describe how sunlight affected the growth (height) of Jane's tomato plants. Give examples of how much the plants grew in each condition. Include what you know about the role of sunlight in plant growth.

Universal Supports	Targeted Supports
• **Layer 1:** Using plants, algae, or microorganisms to explain how photosynthesis allows these organisms to create their own food (source of energy). Animals consume photosynthetic organisms to acquire energy. Students can make matter and energy cycles (such as a food chain or food web) to show how matter and energy move throughout an ecosystem.	• **Layer 2:** Some students may need to further discuss that all energy comes from the sun and matter is never actually destroyed.

Common Misconceptions

- The energy from the sun turns directly into leaves and plant parts and other matter
- Plants get their food from their environment instead of making it themselves
- The vocabulary difference between matter and energy
- Plants get energy from the soil
- Plants take in all substances they need from their roots

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

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

Validate and Affirm

- What type of plants do you eat to get energy from?
- How do plants get energy?
- How do animals get their energy?
- What happens to oxygen throughout the ecosystem?
- What happens to water throughout the ecosystem?
- What knowledge and experiences have you had that might help us as a class explain how energy is taken from the sun and then transferred to other organisms?

Build and Bridge:

- What questions do we need to answer to test your ideas about how energy is taken from the sun and then transferred to other organisms?
- Why does this phenomenon matter to you, to your community or others to scientists?

Students who demonstrate understanding can:

MS-LS1-7. **Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.** [Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.] [*Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or 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 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe unobservable mechanisms.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. **PS3.D: Energy in Chemical Processes and Everyday Life** • Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. *(secondary)*	**Energy and Matter** • Matter is conserved because atoms are conserved in physical and chemical processes.

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

Articulation of DCIs across grade-bands:
5.PS3.D ; **5.LS1.C** ; **5.LS2.B** ; **HS.PS1.B** ; **HS.LS1.C** ; **HS.LS2.B**

Common Core State Standards Connections:
ELA/Literacy -
SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-LS1-7)*

Grade	*NGSS Discipline*
MS	**Life Science 1.7**
LS1-7	**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: Maple trees produce sap that we put on pancakes! https://youtu.be/NuY5n61TVtE?list=PLSLDxqPb5NQlbsfjcUJF-n1qYaPUZlbAY https://www.openscied.org/instructional-materials/7-4-matter-cycling-photosynthesis/ Other Possible Phenomenon: ● -Chemical equations ● -A model illustrating how energy is released for cellular work ● -The role of oxygen in cellular respiration

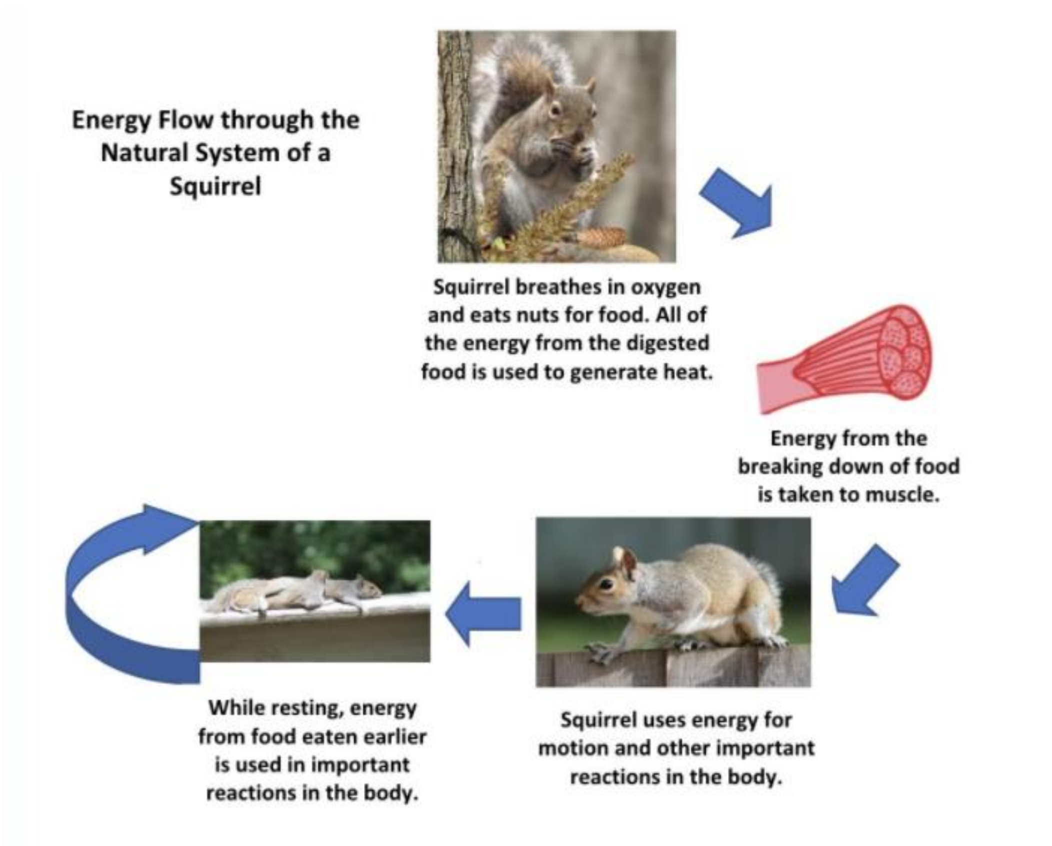
- -A model illustrating the breakdown of carbon-containing molecules during cellular respiration and the construction of new molecules in organisms from the component parts
- -Products of digestion of specific polymers
- -Use of products of digestion to produce polymers

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.

Jaden's squirrel model (ID #091-03-r01)

Jaden has a science project on how energy flows through the natural systems of living beings. Jaden knows that plants use the sun's energy to live and grow. He wonders how energy flows through a natural system of an animal who eats these plants. To investigate this, Jaden decided to make a model of the animal in his neighborhood, **the squirrel**. Jaden's model is shown below:



Take a snapshot of Jaden's model and circle all the parts of Jaden's model that need improvement. You can circle images and text, if necessary.

Use the text box to detail the improvements you would make to the part or parts of Jaden's model you circled.

Universal Supports	Targeted Supports
• **Layer 1:** Develop an animation or comic strip to model how the molecules of food are rearranged in an organism through chemical reactions forming new molecules. Cellular respiration in both animals and plants. Cellular respiration is the releasing of energy and allows for organisms to grow and function. Matter is conserved and never destroyed.	• **Layer 2:** Small groups to show how plants also perform cellular respiration.

Common Misconceptions

- Energy is created through cellular respiration instead of released
- Vocabulary differences between respiration and breathing
- Cellular respiration is different in plants and animals
- Plants also "breathe"
- Respiration in plants only happens at night since photosynthesis happens during the day
- Living things function without chemical reactions
- Food is only a source of energy, not matter for growth

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

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

Validate and Affirm

- What are some things that give you energy?
- What happens to the food you eat once it enters your body?
- What does your body do when you start to exercise or play sports? Emphasize the rate of breathing when you exercise verses when you are resting.
- What knowledge and experiences have you had that might help us as a class explain how food is rearranged to support growth and release energy?

Build and Bridge:

- What questions do we need to answer to test your ideas about how food is rearranged to support growth and release energy
- Why does this phenomenon matter to you, to your community or others to scientists?

Students who demonstrate understanding can:

MS-LS1-8. **Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.** *[Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.]*

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
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 6-8 builds on K-5 experiences and progresses to evaluating the merit and validity of ideas and methods. • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.	**LS1.D: Information Processing** • Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural systems.

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

Articulation of DCIs across grade-bands:
4.LS1.D ; **HS.LS1.A**

Common Core State Standards Connections:
ELA/Literacy -
WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-LS1-8)

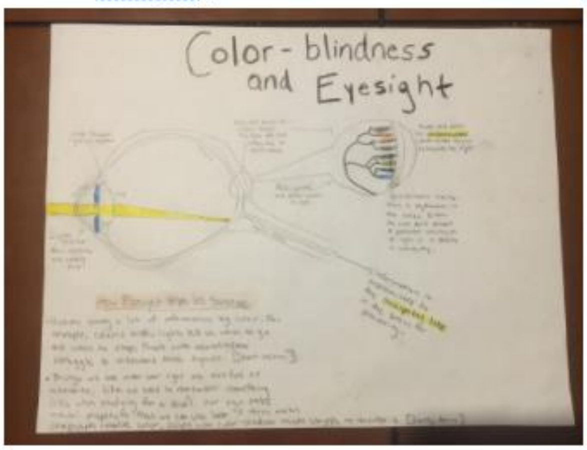
Grade	*NGSS Discipline*
MS	**Life Science 1.8**
LS1-8	**Sample Phenomena** *When available, you should use your locally selected or created high quality instructional materials. However, the following is an example phenomenon you can use if you don't have local instructional materials available.* Sample Phenomenon: Hockey goalies have quick movements that seem almost cat-like. Through practice, hockey goalies are able to store memories and use those memories during a game to improve their sensory receptor response to stimuli. Video: Sport Science- NHL Goaltender This phenomenon can be expanded for students to determine if they have the assets required to perform as professional athletes or how students could become elite athletes or redirect towards how animals may increase their chances of survival in the wild. **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.*

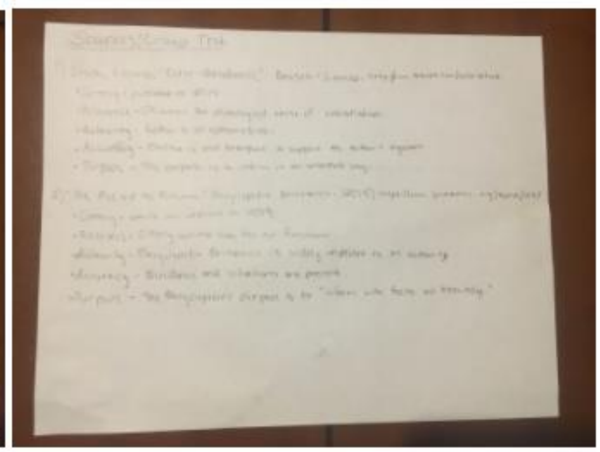
Directions: You will be assigned a disorder related to your senses. You are responsible for creating an informational poster that could be hung in the nurse's office about your disorder and the sense that the disorder affects.

Your poster must include the following:

- ❑ A <u>zoomed-out</u> drawing of how your sense organ operates in conjunction with the brain.
- ❑ A <u>zoomed-in</u> drawing of how the sensory receptors function in the organ.
- ❑ Labels on your drawing that show how that sense is supposed to function <u>AND</u> how it functions with your given disorder.
- ❑ A label that tells the type of sensory receptor present (thermo, chemo, etc.) and the area of the brain responsible for processing information from your sense organ.
- ❑ An explanation of how this sense helps a person survive, both in an immediate sense, as well as a longer-scale sense, and how this differs when a person has the disorder. (See example on poster about this.)
- ❑ The back of the poster must include an explanation of why <u>at least two</u> of the sources you used pass the CRAAP test.

See the exemplar poster below.





[Sensory Receptor]

Universal Supports	Targeted Supports
• **Layer 1:** Begin by displaying a source (text, media, visual, display, data, etc.) for all students to view, [Up In Your Head: Can Having Tourette Syndrome Make You a Superior Athlete?]. Teach students how to identify a resource that is credible with guidance of a checklist (see examples below). Have students work together in small groups to identify credible resources. Have students practice on their own to gather and synthesize information on sensory receptors.	• **Layer 2:** Small group instruction on explicit interventions for understanding how to gather and synthesize information from various sources assessing credibility and accuracy

Web Page Credibility Checklist

Use this checklist as a guideline to help you decide whether an online source is reliable.

7 or more points: This is probably a reliable source; consider using it.
4-6 points: This might be a good source; try to find out more about it before using it.
3 or less: This is probably not worth including in your sources.

URL: http://		
Circle the number in the column that is the best answer	Yes	No/Not Sure
POSITIVES		
I can identify a group or individual responsible for the content on this site.	1	0
This site is maintained by a person or organization that I know is credible outside of the Internet	1	0
This site has been updated in the past 3 to 6 months	1	0
This site has external links to other credible websites	1	0
I know of other credible websites that link to this website	1	0
This site has a .gov or .edu suffix	1	0
This site provides a phone number or mailing address that I could use for contacting the person or organization for more information	1	0
I have verified the information on this site using reliable offline resources	1	0
The main purpose of this site is to provide facts (not opinions)	1	0
subtotal:		
NEGATIVES		
This site is clearly biased toward a specific opinion or point of view	-1	0
This site contains many misspellings and/or broken links	-1	0
The main purpose of this site is to sell a product or service	-1	0
This site has no external links	-1	0
final total:		
Would you use this as a credible source? Why or why not?		

- Taken from page 11
- Website Credibility Checklist

Common Misconceptions

- There is only one type of sensory receptor.-
- There are five senses.
- Each type of sensory receptor sends a different kind of signal.
- Identifying resources that are credible and accurate.

Culturally and Linguistically Responsive Instruction

Guiding Questions and Connections

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

Validate and Affirm:

- What's your favorite memory?
- What's something you've done so much that you don't have to think about it anymore? (brushing teeth, using your phone, playing video games)

Build and Bridge:

- What knowledge and experiences have you had that might help us as a class explain how we store and use our memories?
- What questions do we need to answer to test your ideas about what's happening with your memories?
- Why does this phenomenon matter to you, to your community or others to scientists?

Section 3: Resources

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

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

Engaging in the Practices of Science

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Crosscutting concepts

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

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

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.