A phenomenon is any object or event that can be experienced and that can be observed and/or measured either directly by one’s senses or by use of technological devices.

According to A Framework for K–12 Science Education and the Next Generation Science Standards (NGSS), teachers should expose students to phenomena and guide them to engage in science and engineering practices to explain those phenomena. By carefully selecting phenomena to share with students, teachers can guide them toward the scientific understanding of the world as described by the elements of the disciplinary core ideas (DCIs) in the Framework and NGSS.

But some phenomena are much more effective than others at helping all students learn, so it is essential to consider many factors when selecting phenomena. The criteria below are meant as a guide in evaluating the usefulness of phenomena for classroom instruction.

Before beginning, identify the DCI element you wish to target with the phenomena, and then ask the following questions.

1. The phenomenon …
   - addresses the entire DCI element (Continue to next step.)
   - addresses only part of the DCI element (Continue to next step only if the phenomenon addresses the parts of the DCI element you wish to address.)
   - does not address any part of the DCI element (End of evaluation. Do not use this phenomenon. Seek a different phenomenon.)

2. The phenomenon is observable to students, either through firsthand experiences or through someone else’s experiences (such as a recording or set of measurements).
   - Yes (Continue to next step.)
   - No (End of evaluation. Do not use this phenomenon. Seek a different phenomenon.)

3. The phenomenon is likely comprehensible to students. For example:
   - The relationship to the DCI element is clear and easy to comprehend.
   - Any experimental procedure, calculations, and measurements are unlikely to detract from the learning experience.
   -Additional ideas and reasoning skills needed by students are appropriate (given students' grade level and prior experiences).
   - Yes (Continue to next step.)
   - No (End of evaluation. Do not use this phenomenon. Seek a different phenomenon.)

4. The phenomenon is suitably attention-getting, relevant, thought-provoking, and requiring of explanation that all students are likely to be motivated to engage in learning the targeted DCI.
   - Yes (Continue to next step.)
   - No (End of evaluation. Do not use this phenomenon. Seek a different phenomenon.)

5. Use of the phenomenon is efficient in that the benefits justify any financial costs and time devoted to using the phenomenon with students.
   - Yes (Evaluation completed—the phenomenon is promising.)
   - No (End of evaluation. Do not use this phenomenon. Seek a different phenomenon.)

* Based in part on the Project 2061 Curriculum Analysis Procedure 7-11-17
5. Matter and Energy in Organisms and Ecosystems

Students who demonstrate understanding can:

5-PS3-1. Use models to describe that energy in animals’ food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.  
[Clarification Statement: Examples of models could include diagrams, and flow charts.]

5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water.  
[Clarification Statement: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.]

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.  
[Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth. ] [Assessment Boundary: Assessment does not include molecular explanations.]

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

Science and Engineering Practices

Developing and Using Models
Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.
• Use models to describe phenomena. (5-PS3-1)
• Develop a model to describe phenomena. (5-LS2-1)

Engaging in Argument from Evidence
Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).
• Support an argument with evidence, data, or a model. (5-LS1-1)

Science Models, Laws, Mechanisms, and Theories

Explain Natural Phenomena
• Science explanations describe the mechanisms for natural events. (5-LS2-1)

Disciplinary Core Ideas

PS3.D: Energy in Chemical Processes and Everyday Life
• The energy released [from food] was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (5-PS3-1)

• Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. (secondary to 5-PS3-1)
• Plants acquire their material for growth chiefly from air and water. (5-LS1-1)

LS2.A: Interdependent Relationships in Ecosystems
• The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as “decomposers.” Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. (5-LS2-1)

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
• Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. (5-LS2-1)

Crosscutting Concepts

Systems and System Models
• A system can be described in terms of its components and their interactions. (5-LS2-1)

Energy and Matter
• Matter is transported into, out of, and within systems. (5-LS1-1)
• Energy can be transferred in various ways and between objects. (5-PS3-1)

Connections to Nature of Science

Connections to other DCIs in fifth grade: 5.ESS2.A (5-LS2-1); 5.PS1.A (5-LS1-1); 5.PS2.B (5-PS3-1)

Articulation of DCIs across grade-bands: K.LS1.C (5-LS1-1); 5-PS3-1; 2.PS1.A (5-LS2-1); 2.LS2.A (5-PS3-1); 2.LS4.D (5-LS2-1); 4.PS3.A (5-PS3-1); 4.PS3.B (5-PS3-1); 4.PS3.D (5-PS3-1); 4.ESS2.E (5-LS2-1); MS.PS3.D (5-PS3-1); MS.PS4.B (5-PS3-1); MS.LS1.C (5-PS3-1); MS.LS2.A (5-PS3-1); MS.LS2.B (5-PS3-1)

Common Core State Standards Connections:

ELA/Literacy –
R1.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (5-LS1-1)
R1.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (5-PS3-1); (5-LS2-1)
R1.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (5-LS1-1)
W.1.5 Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (5-LS1-1)
SL.3.5 Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes. (5-PS3-1); (5-LS2-1)

Mathematics –
MP.2 Reason abstractly and quantitatively. (5-LS2-1)
MP.4 Model with mathematics. (5-LS2-1)
S.MD.A.1 Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems. (5-LS2-1)

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

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April 2013
NGSS Release 29
Qualities of a good anchor phenomenon for a coherent sequence of science lessons

Instructional sequences are more coherent when students investigate compelling natural phenomena (in science) or work on meaningful design problems (in engineering) by engaging in the science and engineering practices. We refer to these phenomena and design problems here as ‘anchors.’ What makes for a good phenomenon to anchor an investigation?

- A good anchor builds upon everyday or family experiences: who students are, what they do, where they came from. It is important that it is compelling to students from non-dominant communities (e.g., English language learners, students from cultural groups underrepresented in STEM, etc.).

- A good anchor will require students to develop understanding of and apply multiple performance expectations while also engaging in related acts of mathematics, reading, writing, and communication.

- A good anchor is too complex for students to explain or design a solution for after a single lesson.
  - The explanation is just beyond the reach of what students can figure out without instruction.
  - Searching online will not yield a quick answer for students to copy.

- A good anchor is observable to students. “Observable” can be with the aid of scientific procedures (e.g., in the lab) or technological devices to see things at very large and very small scales (telescopes, microscopes), video presentations, demonstrations, or surface patterns in data.

- A good anchor can be a case (pine beetle infestation, building a solution to a problem), something that is puzzling (why isn’t rainwater salty?), or a wonderment (how did the solar system form?).

- A good anchor has relevant data, images, and text to engage students in the range of ideas students need to understand. It should allow them to use a broad sequence of science and engineering practices to learn science through first-hand or second-hand investigations.

- A good anchor has an audience or stakeholder community that cares about the findings or products.
Using Phenomena in NGSS-Designed Lessons and Units

**What are phenomena in science and engineering?**
- 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 are phenomena such a big deal?**
- Despite their centrality in science and engineering, phenomena have traditionally been a missing piece in science education, which too often has focused on teaching general knowledge that students can have difficulty applying to real world contexts.
- 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 the “this” is. In contrast, students might not understand the importance of learning science ideas that teachers and curriculum designers know are important but that are unconnected from phenomena.
- 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. For example, instead of simply learning about the topics of photosynthesis and mitosis, students are engaged in building evidence-based explanatory ideas that help them figure out how a tree grows.
- Explaining phenomena and designing solutions to problems allow students to build general science ideas 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. Focusing investigations on compelling phenomena can help sustain students’ science learning.

**How are phenomena related to the NGSS and three-dimensional learning?**
- The Next Generation Science Standards (NGSS) focus on helping students use science to make sense of phenomena in the natural and designed world, and use engineering to solve problems.
- 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 Disciplinary Core Ideas (DCIs) and Crosscutting Concepts (CCCs) through use of the Science and Engineering Practices (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 do we use phenomena to drive teaching and learning?**

- The point of using phenomena to drive instruction is 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. Using the phenomenon of tree growth, a middle school teacher might want middle school students to develop and apply DCIs about photosynthesis and mitosis; alternately, a 3rd grade teacher might want students to learn and apply DCIs about life cycles. In each case, 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 motivate 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 also should prepare to support student engagement in different ways. While starting with one phenomenon in the 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. For example, when teaching toward Kindergarten DCI PS3.B about how sunlight warms the surface of the Earth, a teacher could notice that students don’t have experience with hot sand and instead engage the group in observations of hot concrete. When necessary, teachers can engage the class in a shared experience with a relevant phenomenon (e.g., by watching a video).

- Not all phenomena need to be used for the same amount of instructional time. Teachers could use an anchoring phenomenon or two 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.

**What makes phenomena effective for use in instruction?**

- The most powerful phenomena from an educational perspective 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. The phenomenon needs to be useful for teachers to help students build the target pieces of the DCIs, SEPs, and CCCs. For example, engaging in discussions about redshifts of light from galaxies is unlikely to be helpful in moving 5th grade students to a grade-appropriate
understanding of DCI ESS1.A, which, at the 5th grade level, focuses on the relationship between star brightness and distance from Earth.

- The process of developing an explanation for a phenomenon should advance students’ understandings. 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 (although it might be useful for assessment).

- Students should be able to make sense of anchoring or investigative phenomenon, but not immediately, and not without investigating it using sequences of the science and engineering practices. With instruction and guidance, students should be able to figure out, step by step, how and why the phenomenon works.

- *An effective phenomenon does not always have 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. It takes careful teacher facilitation to help students become dissatisfied with what they can explain, helping them discover that they really can’t explain it beyond a simple statement such as “smells travel through the air” or a vocabulary word, such as “water appears on cold cans of soda because it condenses.”

### Prior Thinking About Phenomena

<table>
<thead>
<tr>
<th>If it’s something fun, flashy, or involves hands-on activities, it must be engaging.</th>
<th>Authentic engagement does not have to be fun or flashy; instead, engagement is determined more by how the students generate compelling lines of inquiry that create real opportunities for learning.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anything students are interested in would make a good “engaging phenomenon”</td>
<td>Students need to be able to engage deeply with the material in order to generate an explanation of the phenomenon using target DCIs, CCCs, and SEPs.</td>
</tr>
<tr>
<td>Explanations (e.g., “electromagnetic radiation can damage cells”) are examples of phenomena</td>
<td>Phenomena (e.g., a sunburn, vision loss) are specific examples of something in the world that is happening—an event or a specific example of a general process. Phenomena are <em>NOT</em> the explanations or scientific terminology behind what is happening. They are what can be experienced or documented.</td>
</tr>
<tr>
<td>Phenomena are just for the initial hook</td>
<td>Phenomena can drive the lesson, learning, and reflection/monitoring throughout. Using phenomena in these ways leads to deeper learning.</td>
</tr>
<tr>
<td>Phenomena are good to bring in after students develop the science ideas so they can apply what they learned</td>
<td>Teaching science ideas in general (e.g., teaching about the process of photosynthesis) may work for some students, but often leads to decontextualized knowledge that students are unable to apply when relevant. Anchoring the development of general science ideas in investigations of phenomena helps students build more usable and generative knowledge.</td>
</tr>
<tr>
<td>Engaging phenomena need to be questions</td>
<td>Phenomena are observable occurrences. Students need to <em>use the occurrence to help generate the science questions or design problems</em> that drive learning.</td>
</tr>
<tr>
<td>Student engagement is a nice optional feature of instruction, but is not required</td>
<td>Engagement is a crucial access and equity issue. Students who do not have access to the material in a way that makes sense and is relevant to them are disadvantaged. Selecting phenomena that students find interesting, relevant, and consequential helps support their engagement. A good phenomenon builds on everyday or family experiences: who students are, what they do, where they came from.</td>
</tr>
</tbody>
</table>

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