Demystifying the NGSS
Marshmallow Challenge
Build the Tallest Freestanding Structure

- Teams of Four People
- Eighteen Minutes
- Using the Following Ingredients

- 20 sticks of spaghetti + one yard tape + one yard string + one marshmallow
Magic happens at intersections – where different mindsets, approaches, and skills collide


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Overview

» Why are the standards changing?

» What do they look like?
Facts, facts, facts

Problems with teaching science this way...

» Students don’t build the skills needed for real science
Facts, facts, facts

Problems with teaching science this way...

» Students don’t relate to science or scientists
Science Standards in Oregon

Facts about science

Doing science
Next Generation Science Standards (NGSS)

Science and Engineering Practices (doing science)

Disciplinary Core Ideas (facts)

Crosscutting Concepts (connecting science)

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The 3 Dimensions of the NGSS

- Disciplinary Core Ideas (facts)
- Science & Engineering Practices (doing science)
- Crosscutting Concepts (connecting science)

This symbol actually means something!
M1: Make sense of problems and persevere in solving them
M2: Reason abstractly & quantitatively
M6: Attend to precision
M7: Look for & make use of structure
M8: Look for & make use of regularity in repeated reasoning

S1: Ask questions and define problems
S2: Develop & use models
S3: Plan & carry out investigations
S4: Analyze & interpret data
S5: Use mathematics & computational thinking
S6: Construct explanations & design solutions
S7: Engage in argument from evidence
S8: Obtain, evaluate, & communicate information

E1: Demonstrate independence in reading complex texts, and writing and speaking about them
E2: Build a strong base of knowledge through content rich texts
E3: Obtain, synthesize, and report findings clearly and effectively in response to task and purpose
E4: Construct viable arguments and critique reasoning of others
E5: Read, write, and speak grounded in evidence
E6: Use technology & digital media strategically & capably
E7: Come to understand other perspectives and cultures through reading, listening, and collaborations
E8: Obtain, evaluate, & communicate information

Disciplinary Core Ideas (DCIs)
No more “mile wide, inch deep”

“...the framework focuses on a limited number of core ideas... Reduction of the sheer sum of details to be mastered is intended to give time for students to engage in scientific investigations and argumentation and to achieve depth of understanding of the core ideas presented.”

“...our effort to identify a small number of core ideas may disappoint some scientists and educators who find little or nothing of their favorite science topics included in the framework.

...students will leave school better grounded in scientific knowledge and practices than when instruction ‘covers’ multiple disconnected pieces of information that are memorized and soon forgotten once the test is over.”
Learning as a progression

“[The framework] is built on the notion of learning as a developmental progression. It is designed to help children continually build on and revise their knowledge and abilities.”
SCIENCE!

- Physical Sciences
- Life Sciences
- Earth and Space Sciences
- Engineering, Technology, and Applications of Science

Disciplines
SCIENCE!

Disciplinary Core Ideas
DCIs

PS
PS1
PS2
PS3
PS4

LS
LS1
LS2
LS3
LS4

ESS
ESS1
ESS2
ESS3

ETS
ETS1
ETS2
Disciplinary Core Ideas (DCIs)

Core ideas should:

1. Have broad importance across multiple sciences or engineering disciplines or be a key organizing principle of a single discipline

2. Provide a key tool for understanding or investigating more complex ideas and solving problems.

3. Relate to the interests and life experiences of students or be connected to societal or personal concerns

4. Be teachable and learnable over multiple grades at increasing levels of depth and sophistication

## Disciplinary Core Ideas (DCIs)

<table>
<thead>
<tr>
<th>Physical Sciences (PS)</th>
<th>Life Sciences (LS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS1: Matter and Its Interactions</td>
<td>LS1: From Molecules to Organisms: Structures and Processes</td>
</tr>
<tr>
<td>PS2: Motion and Stability: Forces and Interactions</td>
<td>LS2: Ecosystems: Interactions, Energy, and Dynamics</td>
</tr>
<tr>
<td>PS3: Energy</td>
<td>LS3: Heredity: Inheritance and Variation of Traits</td>
</tr>
<tr>
<td>PS4: Waves and Their Applications in Technologies for Information Transfer</td>
<td>LS4: Biological Evolution: Unity and Diversity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Earth &amp; Space Sciences (ESS)</th>
<th>Engineering &amp; Technology (ETS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESS1: Earth’s Place in the Universe</td>
<td>ETS1: Engineering Design</td>
</tr>
<tr>
<td>ESS2: Earth’s Systems</td>
<td>ETS2: Links Among Engineering, Technology, Science, and Society</td>
</tr>
<tr>
<td>ESS3: Earth and Human Activity</td>
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</tr>
</tbody>
</table>
Component Ideas
Science and Engineering Practices (SEPs)

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
## Practices Circus

Identify the main scientific and engineering practice needed to do the **underlined directions**.

<table>
<thead>
<tr>
<th>Practice</th>
<th>Station 1</th>
<th>Station 2</th>
<th>Station 3</th>
<th>Station 4</th>
<th>Station 5</th>
<th>Station 6</th>
<th>Station 7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SOILS A</td>
<td>SOILS B</td>
<td>ICE MELTS</td>
<td>EGG</td>
<td>YEAST</td>
<td>CRICKETS A</td>
<td>CRICKETS B</td>
</tr>
<tr>
<td>Asking questions and defining problems</td>
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Adapted from an activity created by the Exploratorium's Institute for Inquiry. California Academy of Sciences, 2013
There are 7 Crosscutting Concepts (CCCs)

1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change
### “Speed Dating” Definitions

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patterns</td>
<td>The CCC of ____ highlights that structures or events are often consistent and repeated.</td>
</tr>
<tr>
<td>Cause and effect</td>
<td>The CCC of ____ investigates how things are connected by identifying the reasons behind an occurrence, and what that occurrence results in.</td>
</tr>
<tr>
<td>Scale, proportion, and quantity</td>
<td>Different measures of size and time affect a system’s structure, performance, and our ability to observe phenomena.</td>
</tr>
<tr>
<td>Systems and system models</td>
<td>The CCC of ____ helps us understand the world by describing how things connect and interact. We can use simple representations to explore these interactions.</td>
</tr>
<tr>
<td>Energy and matter</td>
<td>These things are neither created nor destroyed, but may flow into and out of a system and influence its functioning.</td>
</tr>
<tr>
<td>Structure and function</td>
<td>The way something is built and the parts that it has determine how it works.</td>
</tr>
<tr>
<td>Stability and change</td>
<td>Over time, a system might stay the same or become different, depending on a variety of factors.</td>
</tr>
<tr>
<td>Station #</td>
<td>CCC</td>
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<tr>
<td></td>
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</tbody>
</table>
INTRODUCTION TO THE NGSS

Patterns
- Moon phases
- Monthly precipitation, San Francisco, United States and Perth, Australia
- Fibonacci sequence

Cause and effect
- Rachel and Alex juice story
- Population changes of predator and prey species over time
- Diagram of a Rube Goldberg machine

Scale, proportion and quantity
- Solar system and football field
- Statistically, conclusions based on a large sample size are more reliable than conclusions based on small sample size
- 4 females participants for every 1 male participant

Systems and system models
- United States Government
- Human circulatory system
- Water cycle

Energy and matter
- Trophic levels in an ecosystem
- Fire images
- E=mc2

Structure and function
- Predator and prey skulls
- The Academy’s Sustainable Design
- Bridges around the world

Stability and change
- Rock cycle diagram
- Insect life cycles
- Temperature and CO2 from Antarctic ice cores over the past 400,000 years
Looking for Evidence of 3D Learning
Build a Boat
Build a Boat Part 1:

**Task:** You are a team of engineers assigned to design and build a boat that can carry a heavy load without sinking.

- What design do you propose?
- How do you justify your design?
Build a Boat Part 2: Looking for Evidence of the Three Dimensions

Did students have opportunities to engage in three-dimensional learning to explain phenomena or design solutions?
3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5. Engineering Design

Students who demonstrate understanding can:

3-5-ETS1-1. **Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.**

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

**Science and Engineering Practices**

*Ask questions and defining problems*

- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1)

*Planning and carrying out investigations*

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)

*Conducting explanations and designing solutions*

- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2)

**Disciplinary Core Ideas**

**ETS1.A: Defining and Delimiting Engineering Problems**

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different approaches for solutions can be assessed on the basis of how well each meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)

- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)

- Enhancing student knowledge acquired from previous engineering design problems can improve the design process. (3-5-ETS1-3)

**ETS1.C: Optimizing the Design Solution**

- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)

**Crosscutting Concepts**

- People’s needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1)

- Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)

Connections to 3-5-ETS1.A: Defining and Delimiting Engineering Problems include:

**Fourth Grade:** 4-PS3-4

Connections to 3-5-ETS1.B: Designing Solutions to Engineering Problems include:

**Fourth Grade:** 4-ESS3-2

Connections to 3-5-ETS1.C: Optimizing the Design Solution include:

**Fourth Grade:** 4-PS4-3

Articulation of DCIs across grade bands:

- **K-2.E.T.S1A** (3-5-ETS1-1), (3-5-ETS1-3)
- **2-ETS1B** (3-5-ETS1-2)
- **K-2.E.TS1C** (3-5-ETS1-2), (3-5-ETS1-3)
- **MS.E.TS1A** (3-5-ETS1-1), (3-5-ETS1-2), (3-5-ETS1-3)
- **MS.E.TS1B** (3-5-ETS1-2), (3-5-ETS1-3)
- **MS.E.TS1C** (3-5-ETS1-2), (3-5-ETS1-3)

Common Core State Standards Connections:

- **ELA/Literacy - RI.5.1** Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (3-5-ETS1-2)
- **RI.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. (3-5-ETS1-2)
- **RI.5.9** Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (3-5-ETS1-2)
Reading the Standards
Inside the NGSS Box

Title and Code
The titles of standard pages are not necessarily unique and may be reused at different grade levels. The code, however, is a unique identifier for each set based on the grade level, content area, and topic it addresses.

Performance Expectations
A statement that combines practices, core ideas, and crosscutting concepts together to describe how students can show what they have learned.

Clarification Statement
A statement that supplies examples or additional clarification to the performance expectation.

Assessment Boundary
A statement that provides guidance about the scope of the performance expectation at a particular grade level.

Engineering Connection (*)
An asterisk indicates an engineering connection in the practice, core idea, or crosscutting concept that supports the performance expectation.

Scientific and Engineering Practices
Activities that scientists and engineers engage in to either understand the world or solve a problem.

Disciplinary Core Ideas
Concepts in science and engineering that have broad importance within and across disciplines as well as relevance to people’s lives.

Crosscutting Concepts
Ideas, such as Patterns and Cause and Effect, which are not specific to any one discipline but cut across them all.

Connections to Engineering, Technology, and Applications of Science
These connections are drawn from the disciplinary core ideas for engineering, technology, and applications of science in the Framework.

Connections to Nature of Science
Connections are listed in either the practices or the crosscutting connections section of the foundation box.

What is Assessed
A collection of several performance expectations describing what students should be able to do to master this standard.

Foundation Box
The practices, core disciplinary ideas, and crosscutting concepts from A Framework for K–12 Science Education that were used to form the performance expectations.

Connection Box
Other standards in the Next Generation Science Standards or in the Common Core State Standards that are related to this standard.

Codes for Performance Expectations
Codes designate the relevant performance expectation for an item in the foundation box and connection box. In the connections to common core, italics indicate a potential connection rather than a required prerequisite connection.

NSTA (2013)
Inside the NGSS Box

What Is Assessed
A collection of several performance expectations describing what students should be able to do at the end of instruction

Science and Engineering Practices
Discipling and Using Models
MODELING IN 6-8 BUILD ON K-5 EXPERIENCES AND PROGRESS TO DEVELOPING, USING, AND REFINING MODELS TO DESCRIBE, TEST, AND PREDICT MORE ABSTRACT PHENOMENA AND DESIGN SYSTEMS.

- Develop a model to describe phenomena. (MS-LS2-3)
- Engaging in Argument from Evidence
ENGAGE IN ARGUMENT FROM EVIDENCE BASED ON EMPIRICAL EVIDENCE AND SCIENTIFIC REASONING TO SUPPORT OR REFUTE EXPLANATIONS OR MODELS FOR PHENOMENA AND DESIGN SYSTEMS.

- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or model for a phenomenon or a solution to a problem. (MS-LS2-4)
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-LS2-5)

Disciplinary Core Ideas
- Ecosystems Dynamics, Functioning, and Resilience
ECOSYSTEMS ARE DYNAMIC IN NATURE; THEIR CHARACTERISTICS CHANGE OVER TIME IN RESPONSE TO THE INTERACTIONS AMONG THEIR LIVING AND NONLIVING PARTS. (MS-LS2-2)

- Life systems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biotic component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)
- Biodiversity describes the variety of species found in Earth’s terrestrial and oceanic ecosystems. The complexity or integrity of an ecosystem’s biodiversity is often used as a measure of its health. (MS-LS2-5)

Crosscutting Concepts
- Systems, Systems Models, and System Boundaries
ECOSYSTEMS ARE COMPLEX NETWORKS OF INTERACTING PARTS. THE PARTS CAN BE LIVING OR NONLIVING, AND THE PARTS CAN BE PARTS OF AN ECOSYSTEM OR PARTS OF SOMETHING ELSE. (MS-LS2-3)

- Conserved Qualities
THE TRANSFER OF ENERGY CAN BE TRACKED IN ECOSYSTEMS, WHETHER BY ENERGY FLOWS THROUGH A NATURAL SYSTEM OR ENERGETIC OUTCOMES OF LABORATORY EXPERIMENTS. (MS-LS2-3)

- Patterns and Trends
LIFE SYSTEMS ARE DYNAMIC IN NATURE; THEIR CHARACTERISTICS CHANGE OVER TIME IN RESPONSE TO THE INTERACTIONS AMONG THEIR LIVING AND NONLIVING PARTS. (MS-LS2-2)

Connections to Nature of Science
- Scientific Knowledge Assumes an Order and Interpretation of Evidence
SCIENCE ASSUMES THAT OBJECTS AND EVENTS IN NATURAL SYSTEMS OCCUR IN CONSISTENT PATTERNS THAT ARE UNDERSANDABLE THROUGH MEASUREMENT AND OBSERVATION. (MS-LS2-5)

- Scientific Understanding: Applying Science in Decision Making
SCIENCE ADDRESSES QUESTIONS ABOUT THE NATURAL AND MATERIAL WORLD; SCIENTIFIC KNOWLEDGE CAN DESCRIBE THE CONSEQUENCES OF ACTIONS BUT DOES NOT NECESSARILY PRESCRIBE THE DECISIONS THAT SOCIETY TAKES. (MS-LS2-5)

Connections to Other Disciplines
- Mathematics
- Physical Science
- Earth and Environmental Science
- ELA/Literacy
- Visual and Performing Arts

Foundation Box
The practices, disciplinary core ideas, and crosscutting concepts from the Framework for K-12 Science Education that were used to form the performance expectations

Connection Box
Places elsewhere in NGSS or in the Common Core State Standards that have connections to the performance expectations on this page

Title
The title for a set of performance expectations is not necessarily unique and may be reused at several different grade levels.
Inside the NGSS Box

What Is Assessed
A collection of several performance expectations describing what students should be able to do at the end of instruction

<table>
<thead>
<tr>
<th>MS-LS2 Ecosystems: Interactions, Energy, and Dynamics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Performance Expectations</strong></td>
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</tr>
<tr>
<td><strong>Engineering Connection (*)</strong></td>
</tr>
<tr>
<td>An asterisk indicates that a performance expectation integrates traditional science content with engineering through a practice or core idea</td>
</tr>
<tr>
<td><strong>Assessment Boundary</strong></td>
</tr>
<tr>
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</tr>
</tbody>
</table>

| MS-LS2-1 | Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.] |
| MS-LS2-2 | Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. [Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.] |
| MS-LS2-3 | Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.] |
| MS-LS2-4 | Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.] |
| MS-LS2-5 | Evaluate competing design solutions for maintaining biodiversity and ecosystem services.* [Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.] |

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

Foundation Box

The science and engineering practices, disciplinary core ideas, and crosscutting concepts from the Framework for K–12 Science Education that were used to form the performance expectations.

Science and Engineering Practices
Activities that scientists and engineers engage in to either understand the world or solve a problem.

Disciplinary Core Ideas
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Connections to Nature of Science
Connections are listed in either the practices or the crosscutting concepts sections of the foundation box.
Inside the NGSS Box

Connection Box
Places elsewhere in the NGSS or in the Common Core State Standards that have connections to the performance expectations on this page

### Connections to other DCIs in this grade-band:
- MS.PS1.B (MS-LS2-3)
- MS.LS1.B (MS-LS2-2)
- MS.LS4.C (MS-LS2-4)
- MS.LS4.D (MS-LS2-4)
- MS.ESS2.A (MS-LS2-3)
- MS.ESS3.A (MS-LS2-1)
- MS.ESS3.C (MS-LS2-1)

### Articulation of DCIs across grade-bands:
- LS1.B (MS-LS2-2)
- LS2.C (MS-LS2-1)
- LS4.D (LS-LS2-1)
- LS4.A (MS-LS2-4)
- LS4.B (MS-LS2-1)
- LS4.C (MS-LS2-4)
- LS4.D (MS-LS2-1)
- LS5.A (MS-LS2-4)
- LS5.B (MS-LS2-1)
- LS5.C (MS-LS2-4)
- LS5.D (MS-LS2-1)
- LS5.E (MS-LS2-4)
- LS5.F (MS-LS2-1)
- HS.LS2.A (MS-LS2-3)
- HS.LS2.B (MS-LS2-3)
- HS.LS2.C (MS-LS2-3)
- HS.LS2.D (MS-LS2-3)
- HS.LS2.E (MS-LS2-3)
- HS.ESS2.A (MS-LS2-3)
- HS.ESS2.B (MS-LS2-3)
- HS.ESS2.C (MS-LS2-3)
- HS.ESS2.D (MS-LS2-3)
- HS.ESS2.E (MS-LS2-3)
- HS.ESS2.F (MS-LS2-3)
- HS.ESS3.A (MS-LS2-3)
- HS.ESS3.B (MS-LS2-3)
- HS.ESS3.C (MS-LS2-3)

### Common Core State Standards Connections:

#### ELA/Literacy -
- **RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-1), (MS-LS2-2), (MS-LS2-4)
- **RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS2-1)
- **RST.6-8.8** Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (MS-LS2-5)
- **RI.8.8** Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS2-4), (MS-LS2-5)
- **WHST.6-8.1** Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4)
- **WHST.6-8.2** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS2-2)
- **WHST.6-8.9** Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-4)

#### Mathematics -
- **MP.4** Model with mathematics. (MS-LS2-5)
- **6.RP.A.3** Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-LS2-5)
- **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 variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. (MS-LS2-3)
- **6.SP.B.5** Summarize numerical data sets in relation to their context. (MS-LS2-2)
Inside the NGSS Box

<table>
<thead>
<tr>
<th>MS-LS2</th>
<th>Ecosystems: Interactions, Energy, and Dynamics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students who demonstrate understanding can:</td>
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<tr>
<td>MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.</td>
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<tr>
<td>[Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.]</td>
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<tr>
<td>MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.</td>
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<tr>
<td>[Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]</td>
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<tr>
<td>MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*</td>
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<tr>
<td>[Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]</td>
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</tbody>
</table>

### Science and Engineering Practices

#### Developing Using Models
- Modeling in K-5 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design solutions.
- Develop a model to describe phenomena. (MS-LS2-3)
- Construct a simple model that captures the interactions of biotic and abiotic factors. (MS-LS2-4)
- Evaluate competing design solutions based on jointly developed and agreed-upon criteria. (MS-LS2-5)

#### Engaging in Argument from Evidence
- Engaging in argument from evidence in K-5 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanatory or solutions about the natural and designed world.
- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support a claim (MS-LS2-3).
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-LS2-5)

#### Connections to Nature of Science

**Scientific Knowledge is Based on Empirical Experiences**: Scientific knowledge is based on empirical experiences and progresses to constructing a convincing model.

**Explanations or Solutions to Problems**: Science disciplines share common rules of obtaining explanations or solutions to a problem. (MS-LS2-3)

**Construct an Oral and Written Argument Supported by Evidence**: Construct an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS2-4)

**Develop a Model to Describe Phenomena**: Develop a model to describe phenomena. (MS-LS2-3)

**Draw Conclusions about the Natural and Designed World**: Draw conclusions about the natural and designed world. (MS-LS2-5)

**Evaluating Empirical Evidence Supporting Arguments About Changes to Ecosystems**: Evaluate evidence that supports claims about the natural and designed world. (MS-LS2-5)

### Disciplinary Core Ideas

#### LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
- Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers in an ecosystem. (MS-LS2-3)
- Food chains are linear sequences of organisms through which energy flows in an ecosystem. (MS-LS2-4)

#### LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-3)
- Biodiversity is the variety of species found in Earth’s terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem’s biodiversity is often used as a measure of its health. (MS-LS2-4)

#### LS4.D: Biodiversity and Humans
- Changes in biodiversity can influence human requirements, such as food, energy, and materials, as well as ecosystem services that humans rely on—for example, waste management and recycling. (MS-LS2-3)

### Crosscutting Concepts

#### Energy and Matter
- The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3)

#### Stability and Change
- Small changes in one part of a system might cause large changes in another part. (MS-LS2-4)

### Connections to Engineering, Technology, and Applications of Science

- Science and engineering involves designing and building systems that meet specific needs and criteria. (MS-LS2-3)

### Scientific Questions and Answers About the Natural and Designed World
- Scientific knowledge can describe the consequences of actions but does not necessarily predict the decisions that society takes. (MS-LS2-3)

### Codes for Performance Expectations

Every performance expectation has a unique code, and items in the foundation box and connection box reference this code. In the connections to Common Core, italics indicate a prerequisite rather than a required prerequisite.