# Demystifying the NGSS



# Marshmallow Challenge Build the Tallest Freestanding Structure



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



20 sticks of spaghetti



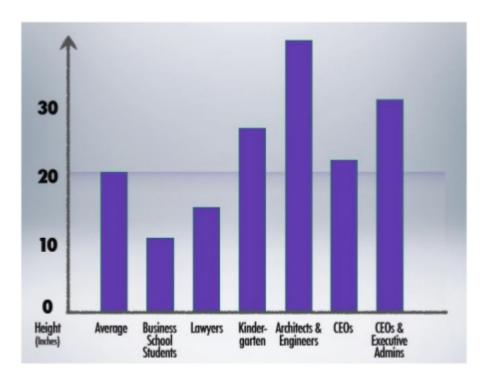
one yard tape

one yard string



one marshmallow





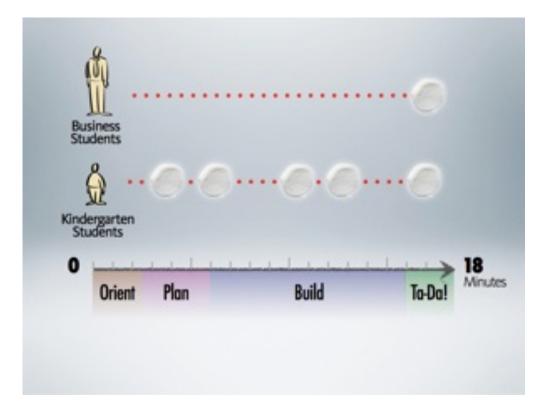
# Magic happens at *intersections* – where different mindsets, approaches, and skills collide

Source: Tom Wujec, The Marshmallow Challenge, TED April 2010 http://www.ted.com/talks/tom\_wujec\_build\_a\_tower.html

@ Copyright 2014 Innosight LLC



50





### **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



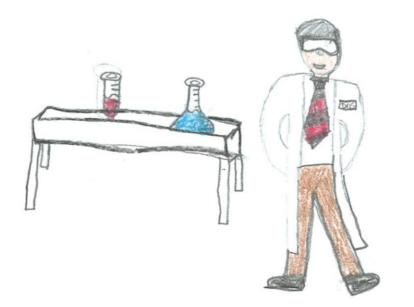


### Facts, facts, facts

Problems with teaching science this way...

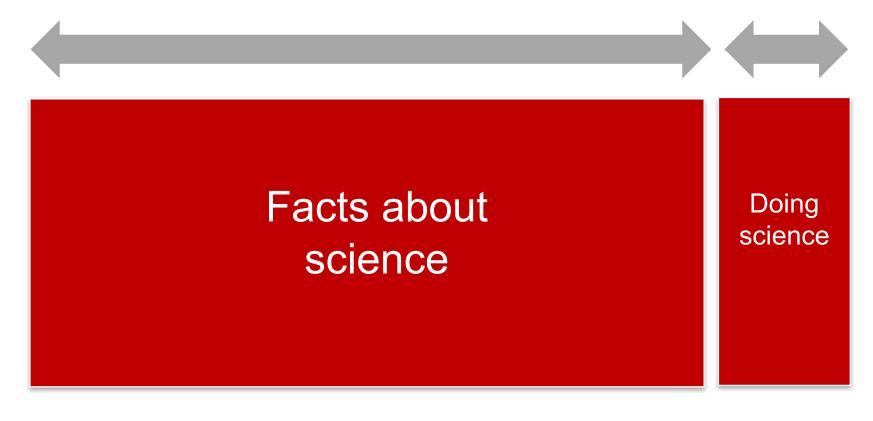
### » Students don't relate to science or scientists





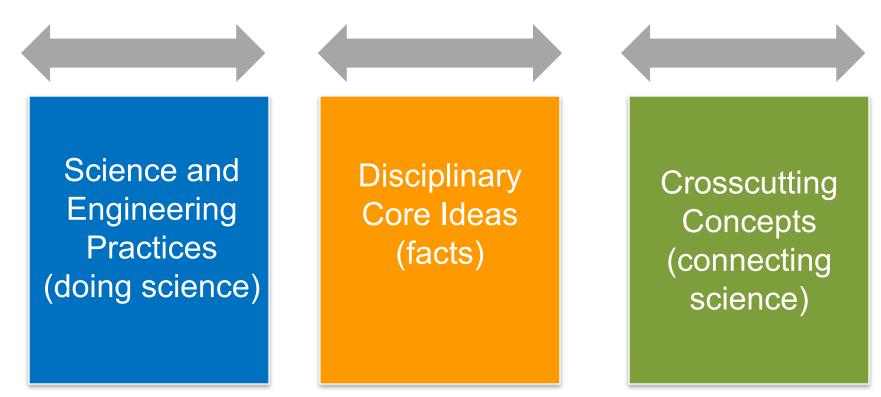


### Science Standards in Oregon





## Next Generation Science Standards (NGSS)



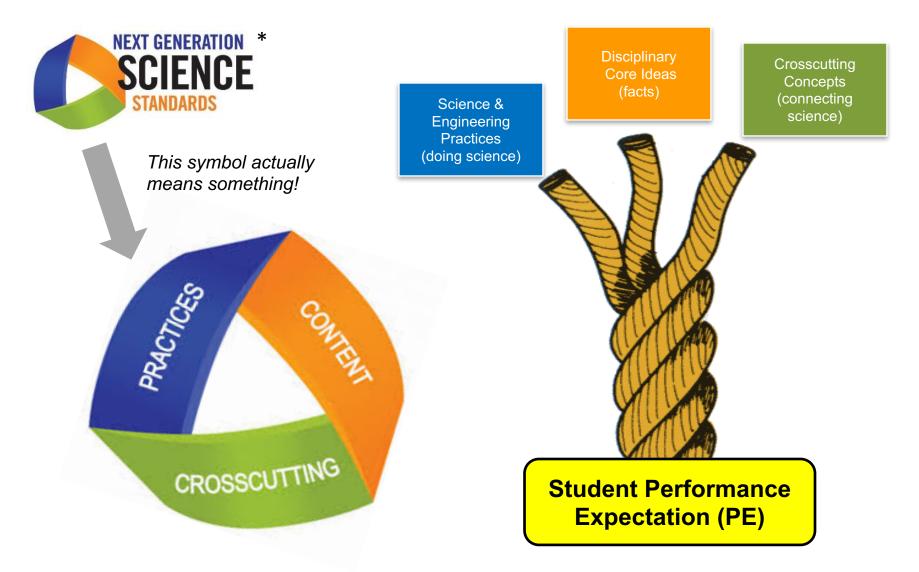


\* NEXT GENERATION SCIENCE STANDARDS

is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.



# The 3 Dimensions of the NGSS



Adapted from NSTA



a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next eneration Science Standards was involved in the production of, and does not endorse, this product.



### Math

& digital media

strategically &

M5: Use appropriate

tools strategically

capably

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 E6: Use in repeated technology reasoning

**Science** M4. Models with mathematics **S2:** Develop & use models **S5:** Use mathematics & computational thinking

E2: Build a strong base of knowledge through content rich texts E5: Read, write, and speak grounded in evidence

M3 & E4: Construct viable arguments and critique reasoning of others

> **S7:** Engage in argument from evidence

S1: Ask questions and define

problems

S3: Plan & carry out investigations

S4: Analyze & interpret data

**S6:** Construct explanations & design solutions

S8: Obtain. evaluate. & communicate information E3: Obtain, synthesize, and report findings clearly and effectively in response to task and purpose

E1: Demonstrate independence in reading complex texts, and writing and speaking about them E7: Come to understand other perspectives and cultures through reading, listening, and collaborations

**ELA** 

http://ell.stanford.edu/sites/default/files/VennDiagram\_practices\_v11 %208-30-13%20color.pdf



### 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

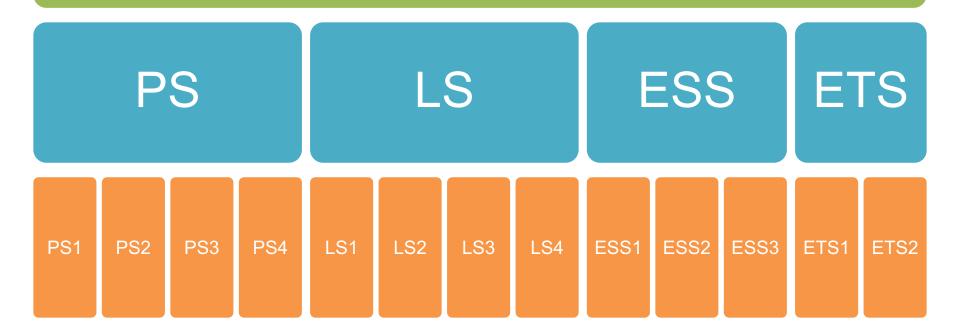
Earth and Space Sciences

Engineering, Technology, and Applications of Science

### Disciplines



# SCIENCE!



# Disciplinary Core Ideas DCIs



# **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)**

Physical Sciences (PS)	Life Sciences (LS)
PS1: Matter and Its Interactions	LS1: From Molecules to Organisms: Structures and Processes
PS2: Motion and Stability: Forces and Interactions	LS2: Ecosystems: Interactions, Energy, and
PS3: Energy	Dynamics
PS4: Waves and Their Applications in Technologies for Information Transfer	LS3: Heredity: Inheritance and Variation of Traits
	LS4: Biological Evolution: Unity and Diversity
Earth & Space Sciences (ESS)	Engineering & Technology (ETS)
ESS1: Earth's Place in the Universe	ETS1: Engineering Design
ESS2: Earth's Systems	ETS2: Links Among Engineering, Technology, Science, and Society
ESS3: Earth and Human Activity	



# SCIENCE!



### **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**

### SCIENTIFIC AND ENGINEERING PRACTICES

### Identify the main scientific and engineering practice needed to do the <u>underlined directions</u>.

Practice	Station 1		Station 2	Station 3	Station 4 EGG	Station 5	Station 6		Station 7
	SOILS A	SOILS B	FLOWER	ICE MELTS	EGG EARTH	YEAST	CRICKETS A	CRICKETS B	DIVER
Asking questions and defining problems									
Developing and using models									
Planning and carrying out investigations									
Analyzing and interpreting data									
Using mathematics and computational thinking									
Constructing explanations and designing solutions									
Engaging in argument from evidence									
Obtaining, evaluating, and communicating information									2012

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

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



Station #	CCC	Notes
	Patterns	
	Cause and effect	
	Scale, proportion, and quantity	
	Systems and system models	
	Energy and matter	
	Structure and function	
	Stability and change	



### **CCC Station Key**

#### 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 400,00 years



# Looking for Evidence of 3D Learning





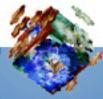
### Build a Boat











# 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.E ineering Design	3-5.Engineering Design			
Stude whe deverse that understanding and 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.				
<ul> <li>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.</li> <li>3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify</li> </ul>				
aspects of a model or prototy	De that can be improved. loped using the following elements from the NRC document A Framework for the NRC document.	nr K•12 Science Education:		
Science and Engineering Practices				
-	Disciplinary Core Ideas	Crosscutting Concepts		
<ul> <li>Asking Questions and Defining Problems</li> <li>Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.</li> <li>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)</li> <li>Planning and Carrying Out Investigations</li> <li>Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.</li> <li>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)</li> <li>Constructing Explanations and Designing Solutions</li> <li>Constructing explanations that specify variables that describe and prodice phenomena and in designing multiple solutions to design problems.</li> <li>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)</li> </ul>	<ul> <li>ETS1.A: Defining and Delimiting Engineering Problems</li> <li>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 proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)</li> <li>ETS1.B: Developing Possible Solutions</li> <li>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)</li> <li>At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)</li> <li>Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)</li> <li>ETS1.C: Optimizing the Design Solution</li> <li>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)</li> </ul>	<ul> <li>Influence of Science, Engineering, and Technology on Society and the Natural World</li> <li>People's needs and wants change over time, as do their demands for new and improved technologies. (3- 5-ETS1-1)</li> <li>Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)</li> </ul>		
Connections to 3-5-ETS1.A: Defining and Delimiting Engineering Fourth Grade: 4-PS3-4	Provens include:			
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.ETS1.A (3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3); K-2.ETS1.B (3-5-ETS1-2); K-2.ETS1.C (3-5-ETS1-2),(3-5-ETS1-3); MS.ETS1.A (3-5-ETS1-1); MS.ETS1.B (3-5-ETS1-2),(3-5-ETS1-2),(3-5-ETS1-3); MS.ETS1.C (3-5-ETS1-2),(3-5-ETS1-3); Common Core State Standards Connections:				
RI.5.7 Draw on information from multiple print or digital s ETS1-2)	t the text says explicitly and when drawing inferences from the text. (3-5-E sources, demonstrating the ability to locate an answer to a question quickly the topic in order to write or speak about the subject knowledgeably. (3-5-E	or to solve a problem efficiently. (3-5-		

constraints on mater	ng can: gn problem reflecting a mais, time, or cost. are multiple possible so nts of the problem. air tests in which vari r prototype that can	a need or a want that includes specified olutions to a problem based on how we les are controlled and failure points ar improved. wing elements from the NRC document A Framework f	Il each is likely to meet the re considered to identify
Science and Engineering Practi		Disciplinary Core Ideas	Crosscuttir Concepts
<ul> <li>As ng Questions and Defining Problems</li> <li>As ng questions and defining problems in 3–5 build of K-2 experiences and progresses to specifyin quartative relationships.</li> <li>Define a simple design problem that can be solving development or an object, tool, process, or includes several criteria for success and constramaterials, time, or cost. (3-5-ETS1-1)</li> <li>Planning and Carrying Out Investigations</li> <li>Planning and Carrying Out Investigations</li> <li>Planning and carrying out investigations to answer or test solutions to problems in 3–5 builds on K-2 e and progresses to include investigations that contro and provide evidence to support explanations or desolutions.</li> <li>Plan and conduct an investigation collaboratively produce data to serve as the basis for evidence, tests in which variables are controlled and the matrials considered. (3-5-ETS1-3)</li> <li>Constructing Explanations and Designing Solutions in on K-2 experiences and progresses to the use of evidence, test and predict phenomena and in designing multiple solutions to a p based on how well they meet the criteria and cor of the design problem. (3-5-ETS1-2)</li> <li>Connections to 3-5-ETS1-A: Defining and Delimitime</li> </ul>	and resord determined determined for insise Di basis of how or how well is basis of how or how well is basis of how or how well is experiences il variables sign t variables sign t variables sign t variables sign t variables sign t variables sign t variables solutions is a ideas can lea Tests are oft which sugge improved. (3 <b>ETS1.C: Optim</b> Different solut them best so constraints. (1)	<b>tizing the Design Solution</b> utions need to be tested in order to determine which of olves the problem, given the criteria and the (3-5-ETS1-3)	Influence of Scient 2, Engineering, and Technology on Society and the People's needs and wants change over time, as do their demands for new and improved technologies. (3- 5-5751-1) • Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)
Fourth Grade: 4-PS3-4	y chymeening rhouenis include:		
Connections to 3-5-ETS1.8: 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.ETS1.A (3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3); K-2.ETS1.B (3-5-ETS1-2); K-2.ETS1.C (3-5-ETS1-2),(3-5-ETS1-3); MS.ETS1.A (3-5-ETS1-1); MS.ETS1.B (3-5-ETS1-2),(3-5-ETS1-2),(3-5-ETS1-3); MS.ETS1.C (3-5-ETS1-2),(3-5-ETS1-3); MS.ETS1.C (3-5-ETS1-3); MS.E			
Common Core State Standards Connections:			
RI.5.7 Draw on information from multiple pr ETS1-2)	rint or digital sources, demonstra	licitly and when drawing inferences from the text. (3-5-E ating the ability to locate an answer to a question quickly o write or speak about the subject knowledgeably. (3-5-E	or to solve a problem efficiently. (3-5-



# **Reading the Standards**



#### 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.

3ased on the Ianuary 2013 Draft of NGSS

#### Title and Code

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

#### 3-PS2 Motion and Stability: Forces and Interactions

3-PS2-a. Carry out investigations of the motion of objects to predict the effect of forces on an object in terms of balanced forces that do not change motion and unbalanced forces that change motion. one variable at a time: number, size, or direction of forces. The size and direction of fo that pulls objects down. 3-PS2-b. Investigate the motion of objects to determine when a consistent pattern can be observed and used to predict future motions in the system. [Chriftation Statement: An example of motion with a re-3-PS2-c Investigate the effect of electric and magnetic forces between objects not in contact with each other and use the observations to describe their relationships. [Clarification Statement: An example of an electric fr 3-PS2-d. Apply scientific knowledge to design and refine solutions to a problem by using the properties of magnets and the forces between them rstand that the results of investigations about non Science and Engineering Practices Crosscutting Concep ing Questions and Defining Problems 52.A: Forces and Motion use and Effect g questions and defining problems in grades 3–5 built grades K–2 experiences and progresses to specifying Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces Cause and effect relationships are routinely identified, tested, and used to acting on it, but they add to give zero net force on the object explain change, (3-PS2-a),(3-PS2-c) one that can be inve ated and Forces that do not sum to zero can cause changes in the object bility and Change peed or direction of motion. (Boundary nships. (3-PS2-b ,(3-PS2-a),(3 es. (3-PS2-b) nd Carrying Out Inves asured: when that past motion exhibits a requi nd carrying out investigations to answer or test solutions to problems in 3–5 builds on K attern, future motion can be predicted from it. (Boundary ections to Fina ineerina, Techn rector, quartery, such as magnitude, velocity, momentum, and rector, quartery, are not introduced at this level, but the concept and Apple ins need both size and direction to be descrit ign and conduct invest neering and Technology ools and instruments (e.g., rulers, 52.B: Types of Interactions fair tests in which variables are contr and the n each other (friction, elastic r of trials considered. (3-PS2-a) bservations and/or measurements, collect, riate data, and identify patterns that provid and pulls) (3-PS2-b) ppropriate data, and identity pathemotion or test avidence for an explanation of a phenominon or test design solution. (3-952-b) (3-952-a),(3-922-c) and Designing Solution onal forces between a pair of in scientific exploration to gather et require that the objects be in contact-for example and help answ pull at a distance. The sizes of the forces in each natural world. Engineering design Inspired grant of plant at a distance. The states of the forces in a statution degrad on the properties of the objects and their fastances apart and, for forces between two magnets, on their instances apart and, for forces between two magnets, on their instration relative to each other, (3-PS2-(0,3-PS2-4) C: Stability and Instability in Physical Systems about the natural orld can often lead to new and A system can change as it moves in one direction (e.g., a ball rolling down a hill), shift back and forth (e.g., a swinging ed technologies, which are n solve design ned through the os (3.052.d) rces on and within the system change Connections to Nature of Science oves can help explain a system's patterns of change. (3/PS2-a A system can appear to be unchanging when process o on at opposite but equal rates. (3 ency in Natural Sy Science assumes consistent natural systems. (3-P52-b) (3-P52-b AAL EVUIDATAR1.3.5 Use text features and sensitive of comprehend information
R1.3.0 Butbased of the year, read and comprehend information
0.4952-0(1952-0)
W.3.7 Conduct Bept research projects of collaborative discussions of
conduct Application of the text of text 3-PS2-d) al texts of the high end of the grades 2-3 text ding history/social s : a topic. (3-PS2-b pne-gn-gne, in gro ).(3-PS2-c) (3-PS2-b) (3-PS2-a) (3-PS2-c) research projects used by the project of the projec n grade 3 topi Make sense of pro and persev Place sense of problems and persevere to striving them. (J+Ax-c) Construct values arguments and crimical the providence of the strict (J+Ax-c) Look for and make use of structure. (J+Ax-c) Measure and restimate Ingunophysiums and mayakes of objects (sing standard up step word problems involving masses or volumes that are plenein the same up roblem. (J+Ax-2).(J+Ax-z) MP.3 MP.7 3.MD.2 units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. (3-PS2-b).(3-PS2-a)

#### **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.

#### **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

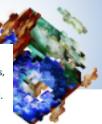
These connections are drawn from the disciplinary core ideas for engineering, technology, and applications of science in the *Framework*.

#### **Connections to Nature of Science**

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



Vational Science Teachers Association



### What Is Assessed

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

### **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

#### MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

[Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.]

Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.

- 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:				
Science and Engineering Practices Developing and Using Models Modeling in A-B bulks on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe phenomena (MS-LS2-3) Engaging in Argument from Evidence Engaging in argument from Evidence in 6-8 bulks on K-5 experiences and progresses to constructing a convincing argument. That supports or refutes dams for either explanation or solutions about the natural and designed work(s). • Evelope incode and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a ahenomenon or a solution to a problem, (MS-LS2-4) • Evaluate commeting design criteria. (MS-LS2-5) • • • • • • • • • • • • • • • • • • •	Disciplinary Core Ideas     ISJ.B: Cycle of Matter and Energy Transfer in     Ecosystem     Todo webs are models that demonstrate how matter     and energy is transferred between producers,     consumers, and decomposers as the three groups     interact within an ecosystem. Transfers of matter into     and out of the physical environment occur at every     level. Decomposers recycle nutrents from dead plant     or nimal matter back to the soil in terrestrial     environments or to the water in aquatic environments.     The atoms that make up the organisms in an     ecosystem are cycled repeatedly between the luing     and nonliving parts of the ecosystem. (MS-LS2-3)     IS2.2: Ecosystem Ornamics, Functioning, and     Resilience     Ecosystems are dynamic in nature: their dwaracteristics     an vary over time. Disruptions to any bhysical or     biological opponent of an ecosystem is     biodiversity describes the variety of species found in     Earth's terrestrial and coeanic ecosystems. The     completeness or integrity of an ecosystem's     biodiversity is often used as a measure of its health.     (MS-LS2-5)     IS4.D: Biodiversity can influence humans'     resources, such as food, renergy, and medicines, as     well as ecosystem and recycling.     (secondary to MS-LS2-5)     IS1.B: Developing Possible Solutions     with respect to how well they meet the criteria and     constraints of a problem. (secondary to MS-LS2-5)	Crosscutting Concepts Energy and Matter In the transfer of energy can be tracked as energy frow 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), (MS-LS2-5) Connections to Engineering, Technology, and Applications of Science Influence Science, Brand the Natural World Technology on Society and the Natural World Technology on Society and engineering, the second s		
4),(MS-LS2-5)	IS-LS2-3); MS.LS4.C (MS-LS2-4); MS.LS4.D (MS-LS2-4); MS			
The State of th				
Common Core State Standards Connections: ELA/Literary, – RST.6-8.1 Cite specific textual evidence to support an RST.6-8.8 Distinguish among facts, reasoned judamen RI.8.8 Distinguish among facts, reasoned judamen RI.5.8.1 Write arguments to support claims with clea WHST.6-8.1 Write arguments to support claims with clea WHST.6-8.9 Draw evidence from literary or informationa	lysis of science and technical texts. (MS-LS2-4) t based on research findings, and speculation in a text. (MS-LS ic claims in a text, assessing whether the reasoning is sound a	and the evidence is relevant and sufficient to support the		
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) 1.9 evailables 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 carpits and tables, and relate these to the equation. (MS-LS2-3)				

#### Title

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



### What Is Assessed

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

#### MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

- MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]
- 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 posystem 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 Framework for K-12 Science Education:

#### **Clarification Statement**

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

#### Engineering Connection (\*)

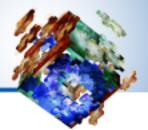
An asterisk indicates that a performance expectation integrates traditional science content with engineering through a practice or core idea.

#### **Assessment Boundary**

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

#### Performance Expectations

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



### **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

#### Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe phenomena. (MS-

 Develop a model to describe phenomena. (N LS2-3)

Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. Analyze and interpret data to provide evidence

 Analyze and interpret data to provide evider for phenomena. (MS-LS2-1)
 Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

 Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. (MS-LS2-2)
 Engaging in Argument from Evidence

Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS2-4)
- 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 Evidence • Science disciplines share common rules of

 Science disciplines share common rules of obtaining and evaluating empirical evidence. (MS-LS2-4)

#### Disciplinary Core Ideas LS2.A: Interdependent Relationships in Ecosystems

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving
- factors. (MS-LS2-1)
   In any ecosystem, organisms and populations with similar requirements for food, water, oxygen or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1)
- Growth of organisms and population increases are limited by access to resources. (MS-LS2-1)
   Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial
- populations of organisms, may become so interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. (MS-LS2-2)

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems

 Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem.

Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The

atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)

#### LS2 C: Fossystem pynamics, 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-I 52-4)
- (MS-LSZ-4) Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a
- measure of its health. (MS-LS2-5) LS4.D: Biodiversity and Humans
- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary to MS-LS2-5)
- ETS1.B: Developing Possible Solutions • There are systematic processes for evaluating
- solutions with respect to how well they meet the criteria and constraints of a problem. (secondary to MS-LS2-5)

#### Crosscutting Concepts

- Patterns • Patterns can be used to identify cause and efference relationships. (MS-LS2-2) Cause and Effect
- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)
- 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),(MS-LS2-5)

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

- Influence of Science, Engineering, and Technology on Society and the Natural World
- The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-LS2-5)

#### Connections to Nature of Science

- Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (NO LOC 9)
- 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)

#### Science 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 in people's lives

#### **Crosscutting Concepts**

Ideas, such as patterns and cause and effect, that 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 concepts sections of the foundation 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

<b>0</b> "				
	s to other DCIs in this grade-band: $M_{\rm e}$   $\Omega_{\rm e}$   $\Omega_{$			
	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-LS2-4); MS.ESS3.A (MS-LS2-1),(MS-LS2-4); MS-LS2-4); MS-			
	3.C (MS-LS2-1),(MS-LS2-4),(MS-LS2-5) of DCIs across grade-bands:			
	S-LS2-2); 3.LS2.C (MS-LS2-1),(MS-LS2-4); 3.LS4.D (MS-LS2-1),(MS-LS2-4); 5.LS2.A (MS-LS2-1),(MS-LS2-3); 5.LS2.B (MS-LS2-3); HS.PS3.B (MS-LS2-3);			
1.LS1.B (MS-LS2-2); 3.LS2.C (MS-LS2-1),(MS-LS2-4); 3.LS4.D (MS-LS2-1),(MS-LS2-4); 5.LS2.A (MS-LS2-3); 1.LS2.B (MS-LS2-3); HS.LS2.B (MS-LS2-3); HS.LS2.B (MS-LS2-3); HS.LS2.B (MS-LS2-3); HS.LS2.D (MS-				
	MS-LS2-3); HS.LS2-4); HS.LS4-D (MS-LS2-1), (MS-LS2-3); HS.LS2-5); HS.ESS2.A (MS-LS2-3); HS.ESS2.E (MS-LS2-4); HS.ESS3.A (MS-LS2-1), (MS-LS2-2), (MS-LS2-4); HS.ESS3.A (MS-LS2-1), (MS-LS2-4); HS.ESS3.A (MS-LS2-4); HS.ESS3.A (MS-LS2-4); (MS-LS2-4); (MS-LS2-4); HS.ESS3.A (MS-LS2-4); (MS-LS2-4)			
	3.B (MS-LS2-4); HS.ESS3.C (MS-LS2-4),(MS-LS2-5); HS.ESS3.D (MS-LS2-5)			
	The State Standards Connections:			
ELA/Literac				
RST.6-	Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-1),(MS-LS2-2),(MS-LS2-4)			
8.1				
RST.6-	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,			
8.7	model, graph, or table). (MS-LS2-1)			
RST.6-	Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (MS-LS2-5)			
8.8				
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			
MUNTO	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-	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of			
8.2	relevant content. (MS-LS2-2)			
WHST.6-	Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-2),(MS-LS2-4)			
8.9				
SL.8.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues,			
	building on others' ideas and expressing their own clearly. (MS-LS2-2)			
SL.8.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen			
	details; use appropriate eye contact, adequate volume, and clear pronunciation. (MS-LS2-2)			
SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-LS2-3)			
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 quantity, thought of as the independent variable. Analyze the relationship between the dependent			
6 0 D D C	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)			

#### MS-LS2 Ecosystems: Interactions, Energy, and Dynamics Students who demonstrate understanding can MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.] 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: **Disciplinary Core Ideas** Science and Engineering Practices Crosscutting Concept **Developing and Using Models** LS2.B: Cycle of Matter and Energy Transfer in **Energy and Matter** ing in 6-8 builds on K-5 experiences and progresses The transfer of energy can be tracked as energy Ecosystems flows through a natural system. (MS-LS2-3) to developing, using, and revising models to describe, test, and predict more abstract phenomena and design Food webs are models that demonstrate how matter and energy is transferred between producers, systems. consumers, and decomposers as the three groups Stability and Change · Small changes in one part of a system might cause Develop a model to describe phenomena. (MS-LS2-3) interact within an ecosystem. Transfers of matter into large changes in another part. (MS-LS2-4), (MS-LS2-5) and out of the physical environment occur at every Engaging in Argument from Evidence level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing environments or to the water in aquatic environments. The atoms that make up the organisms in an Connections to Engineering, Technology, argument that supports or refutes claims for either and Applications of Science Influence of Science, Engineering, and explanations or solutions about the natural and designed ecosystem are cycled repeatedly between the living world(s). and nonliving parts of the ecosystem. (MS-LS2-3) · Construct an oral and written argument supported by rechnology on Society and the Natural World empirical evidence and scientific reasoning to support The use of technologies and any limitations on their LS2.C: Ecosystem Dynamics, Functioning, and or refute an explanation or a model for a phenomenon Resilience use are driven by individual or societal needs, or a solution to a problem. (MS-LS2-4) Ecosystems are dynamic in nature: their characteristics desires, and values; by the findings of scientific Evaluate competing design solutions based on jointly can vary over time. Disruptions to any physical or research; and by differences in such factors as biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4) d-and agreed-upon design criteria. climate, natural resources, and economic conditions. MS-I S2-5) Thus technology use varies from region to region Biodiversity describes the variety of species found in and over time. MS-LS2-5) Earth's terrestrial and oceanic ecosystems. The onnections to Nature of Science completeness or integrity of an ecosystem's Connections to Nature of Science Scientific Knowledge Assumes an Order and Consistency in Natural Systems Scientific I owledge is Based on Empirical ity is often used as a measure of its h MS-I \$2-5) Evidence Science disciplines share common rules of obtaining Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and and evaluating empirical evidence. (MS-LS2-4) LS4.D: Biodiversity and Humans Charges in biodiversity can influence humans' resources, such as food, energy, and medicines, as observation. (MS-LS2-3) well as ecosystem services that humans rely on-for example, water purification and recyclin (secondary to MS-LS2-5) Science Addresses Questions About the Natural and Material World ETS1.B: Developing Possible Soluti Scientific knowledge can describe the consequences There are systematic processes for evaluating solutions of actions but does not necessarily prescribe the decisions that society takes. (MS-LS2-5) ith respect to how well they meet the criteria and onstraints of a problem. (secondary to MS-LS2-5) Connections to other DCIs in this grade-band: MS.PS1.B (MS-LS2-3); MS.LS4/C (MS-LS2-4); MS.LS4.D (MS-LS2-4); MS.ESS2.A (MS-LS2-3), (MS-LS2 4), MS-LS2-5) 4), MS-152-5] Michaelina across grade-lands: 3.152.C (MS-152-4); 3.154.D (MS-152-4); 3.152.A (MS-152-3); 5.152.B (MS-152-8); HS.P53.B (MS-152-3); HS.CS1.C (MS-152-3); MS-152-5); HS.152.B (MS-152-3); HS.152.C (MS-152-4); MS-152-C (MS-152-4); S.153.D (MS-152-5); HS.153.C (MS-152-3); HS.153.C (MS-152-4); MS-152-2); HS.153.C (MS-152-4); MS-153.C (MS-152-4); HS.153.C (MS-152-3); HS.153.C (MS-152-3); HS.153.C (MS-152-3); HS.153.C (MS-152-3); HS.153.C (MS-152-3); HS.153.C (MS-152-3); HS.153.C (MS-152-4); MS-153.C (MS-152-4); HS.153.C ( HS.ESS3.A (MS-LS2-5); HS.ESS3.B (MS-LS2-4); HS.ESS3.C (MS-LS2-4),(NS-LS2-5); HS.ESS3.D (MS-LS2-5) Common Core State Standards Connections ELA/Literacy -RST.6-8.1 te specific textual evidence to support analysis of science and technical texts. (MS-LS2-4) Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (MS-LS2-5) Trate and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the RST.6-8.8 RI.8.8 evidence is relevant and sufficient to support the claims, (MS-LS-4),(MS-LS2-5) WHST.6-8.1 Write arguments to support claims with clear reasons and relevant/evidence. MS-LS2; WHST.6-8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-4) SL8.5 Integrate/multimedia and visual displays into present/tions to clurify information, sprengthen claims and evidence, and add interest. (MS-LS2-3) Mathematics Model with methematics. (MS-LS2-5) Use ratio and rate reasoning to solve real-world and mathematical problems (MS-LS2-5) MP.4 6.RP.A.3 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 valiable, 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. (M94.52-3)

#### **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 potential connection rather than a required prerequisite connection.

