Maryland State Department of Education
Preparing World-Class Students

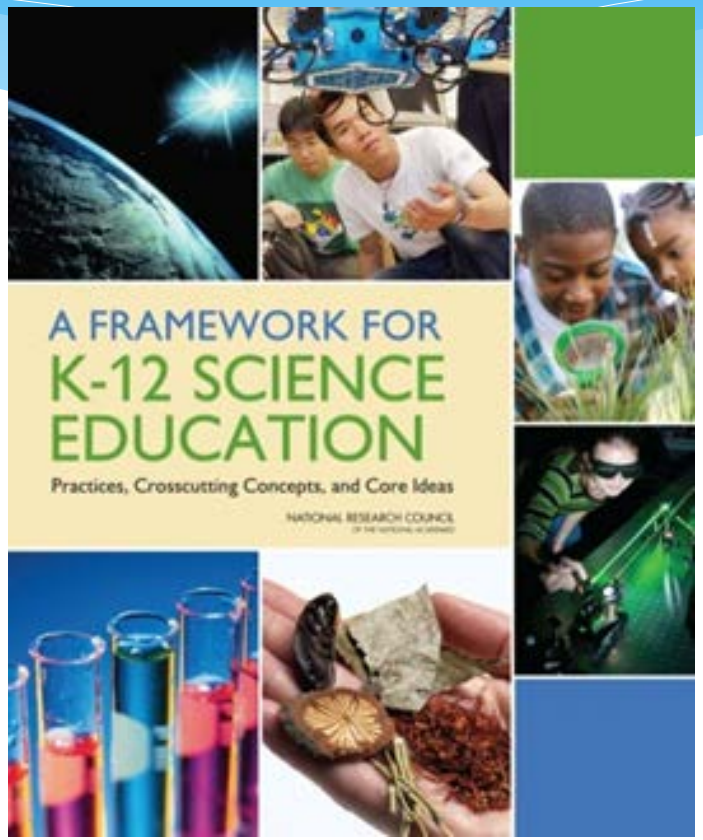
NGSS 101

Next Generation Science Standards Adoption & Implementation

Next Generation Science Standards
For States, By States

To what extent have you interacted with this document?

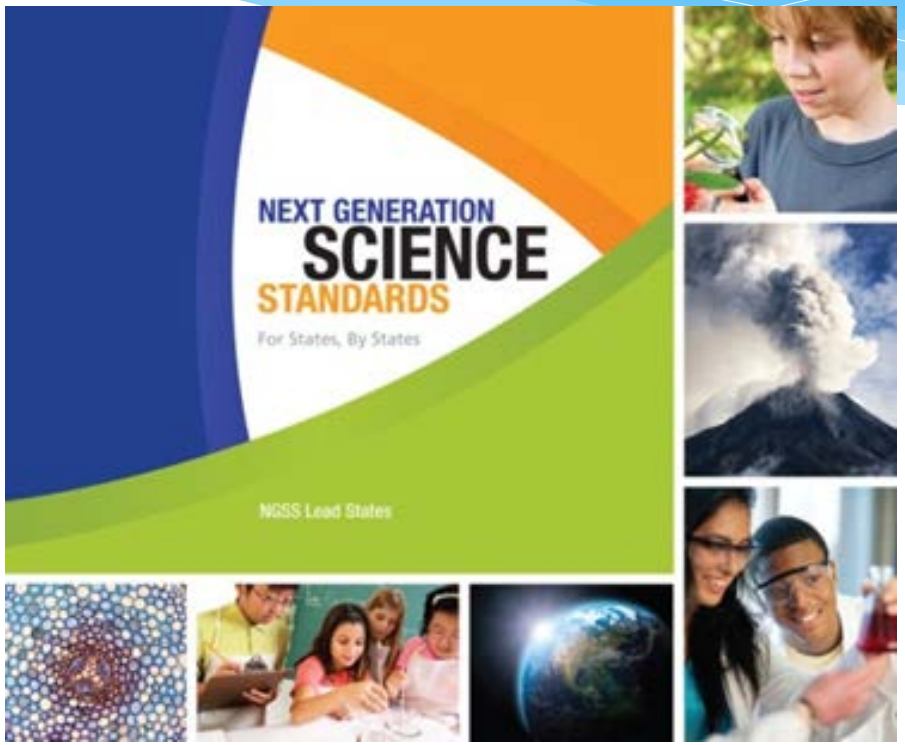
A. I've read it thoroughly.
B. I've skimmed it for general information.
C. It's on my bookshelf.
D. Huh?



http://www.nap.edu/catalog.php?record_id=13165

How about this one?

A. I've read it thoroughly.
B. I've skimmed it for general information.
C. It's on my bookshelf.
D. No clue



Or this one?

A. I've read it thoroughly.
B. I've skimmed it for general information.
C. It's on my bookshelf.
D. It's the first time I've seen it.

http://www.nap.edu/catalog.php?record_id=18409

Why, What, Who, When & Where

- Explain the reasons for building new science standards.
- Describe the process and timeline for constructing the Framework and the NGSS.
- Describe the structure of a standard within NGSS.
- Discuss the implications of the "shifts" in NGSS for teaching and learning.
- Examine instructional strategies that reflect the intent of NGSS.

NEXT GENERATION SCIENCE STANDARDS
For States, By States

Why were the NGSS developed?

Goal

*For **all** students to:*

- Have appreciation for the beauty and wonder of science
- Have sufficient knowledge of science and engineering to engage in public discussions
- Be careful consumers of scientific information relevant to their daily lives
- Continue to learn about science outside school
- Have the skills to enter careers of their choice, including (but not limited to) science, engineering and technology.

Data to Inform Action

The National Assessment of Educational Progress (NAEP)

* **NAEP** is the largest nationally representative and continuing assessment of what America's students know and can do in various subject areas.

http://nationsreportcard.gov/testyourself.aspx

NAEP
NATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS

2009 NAEP Science Results

Grade 4

34%

of students perform at or above Proficient

Grade 8

30%

of students perform at or above Proficient

Grade 12

21%

of students perform at or above Proficient

National Assessment of Educational Progress (NAEP), 2009 Science Assessment, p. 8

Program for International Student Assessment

- **PISA** is an international assessment that measures 15-year-old students' **reading, mathematics,** and **science literacy.**
- PISA also includes measures of general or **cross-curricular competencies,** such as **problem solving.**
- PISA emphasizes **functional skills** that students have acquired as they near the end of compulsory schooling.

http://pisa-sq.acer.edu.au/showQuestion.php?testId=2300&questionId=1

OECD PISA

2009 PISA Science Results Grade 10

29%

of students scored at or above level 4—the level at which students can complete higher order tasks.

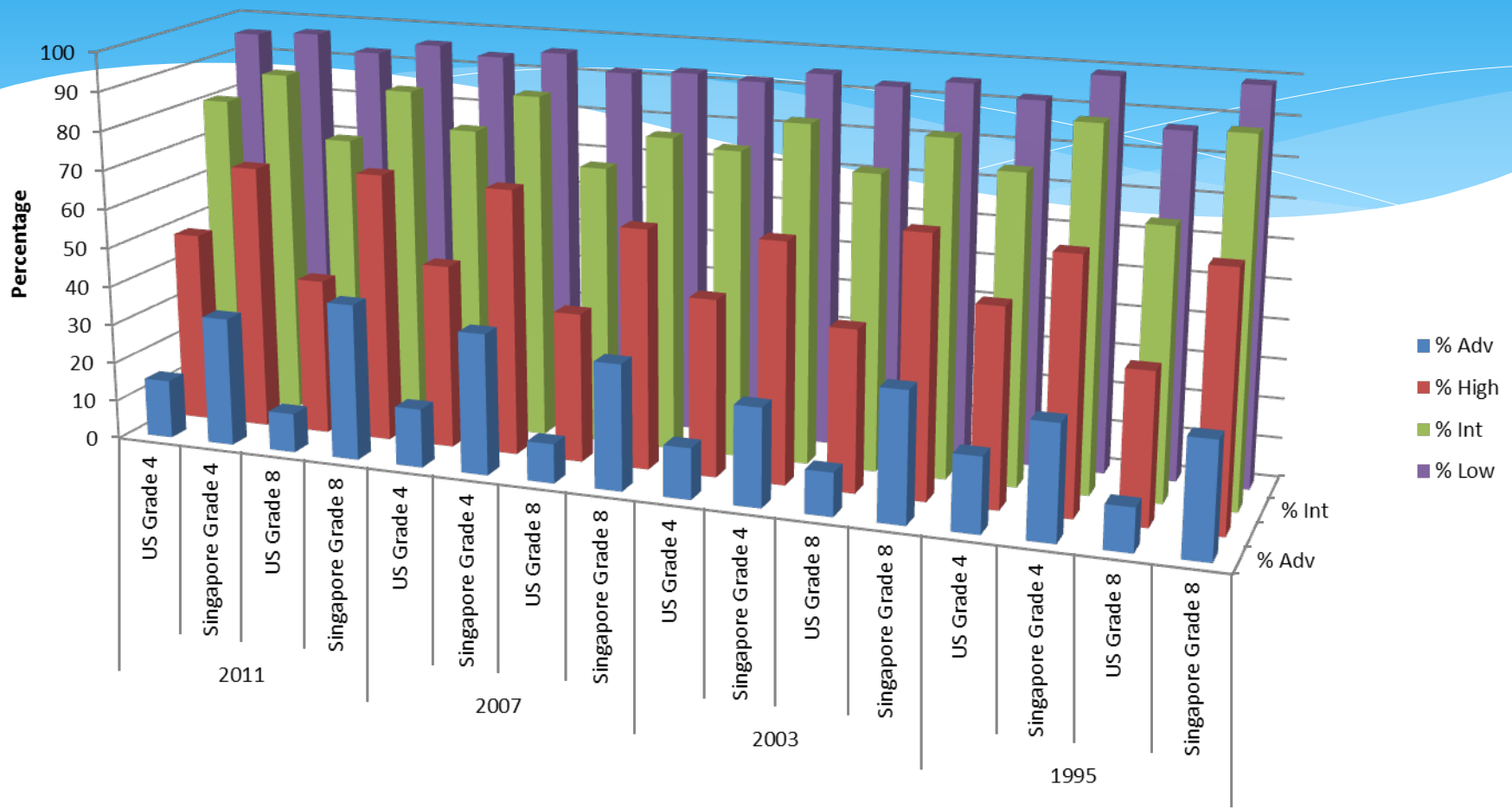
Highlights from PISA 2009, p. 26

Trends in International Mathematics and Science Study

TIMSS provides reliable and timely data on the **mathematics** and **science** achievement of U.S. students compared to that of students in other countries.

TIMSS 2015

TIMSS Performance: US v. Singapore



TIMSS 2011 Science, p. 88-89, p. 116-117

TIMSS Performance

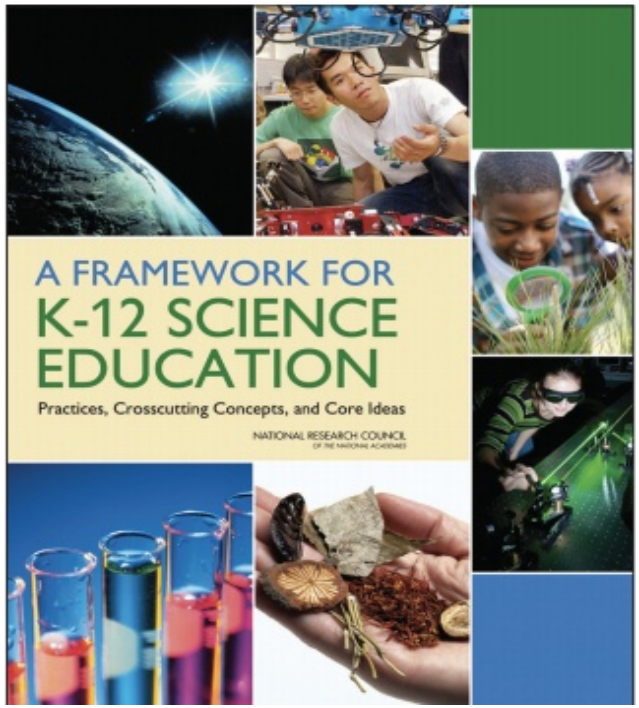
United States v Singapore Benchmark Achievement

Grade 4	% Advanced		% High		% Intermediate		% Low	
	US**	Singapore*	US	Singapore	US	Singapore	US	Singapore
2011	15	33	49	68	81	89	96	97
2007	15	36	47	68	78	88	94	96
2003	13	25	45	61	78	86	94	95
1995	19	14	50	42	78	71	92	89
Grade 8	**% Advanced**		**% High**		**% Intermediate**		**% Low**	
	US***	Singapore*	US	Singapore	US	Singapore	US	Singapore
2011	10	40	40	69	73	87	93	96
2007	10	32	38	61	71	80	92	93
2003	11	33	41	66	75	85	93	95
1999	12	29	37	60	67	84	87	95
1995	11	29	38	64	68	91	87	99

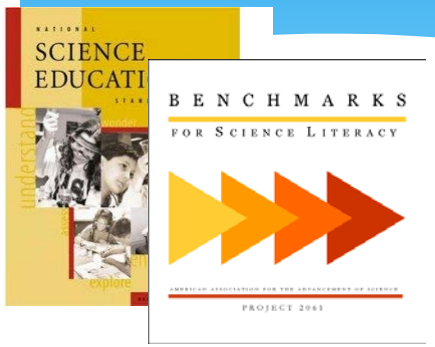
* Rank = 1; ** Rank = 5; ***Rank = 9

TIMSS 2011 Science, p. 88-89, p. 116-117

Where do you start when developing new standards?

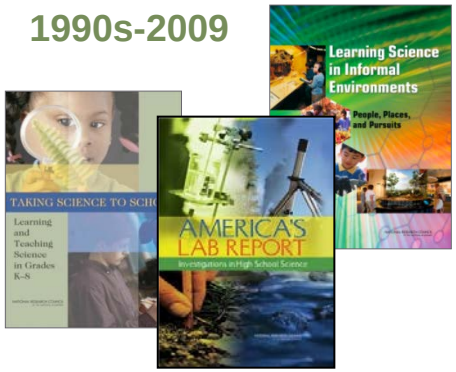


Building on the Past; Preparing for the Future

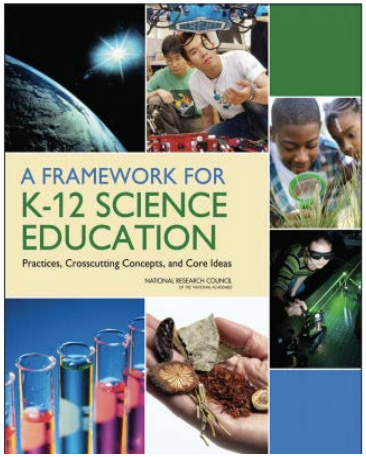


1990s

1990s-2009



Phase I



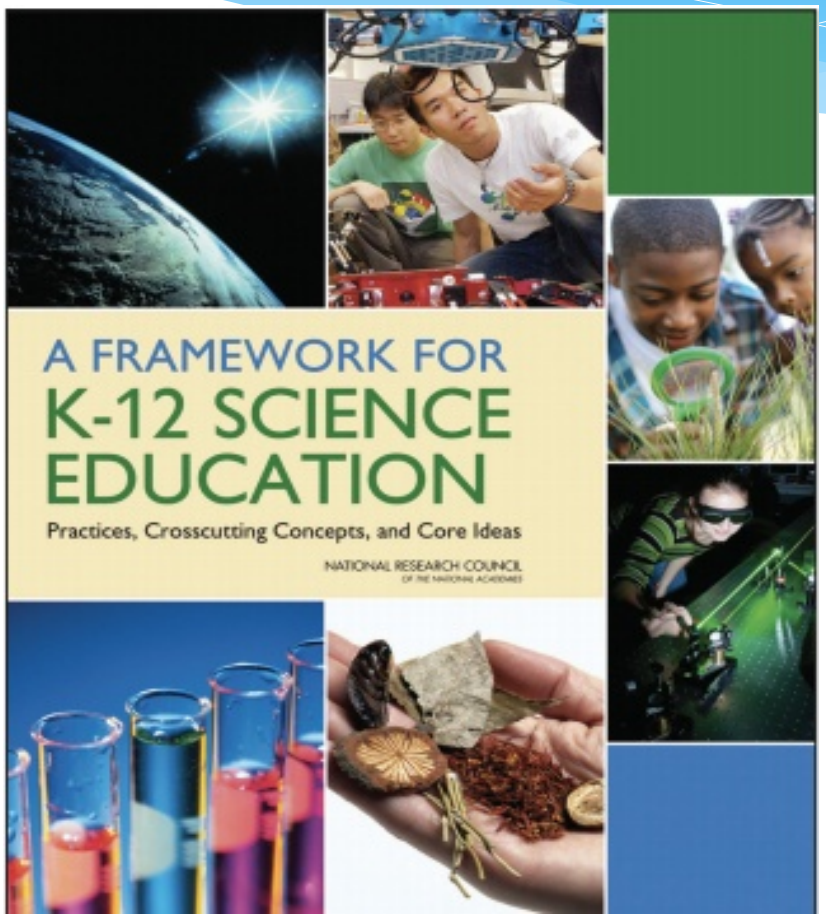
1/2010 - 7/2011

Phase II

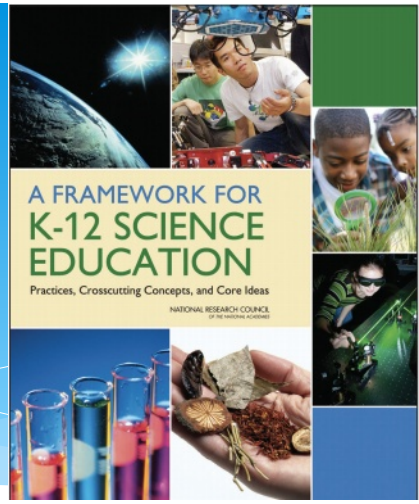
NEXT GENERATION SCIENCE STANDARDS
For States, By States

7/2011 – April 9, 2013

A New Vision of Science Learning that Leads to a New Vision of Teaching



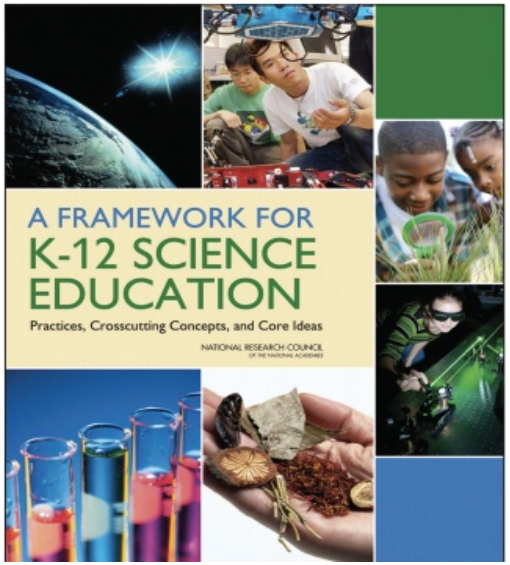
Vision for Science Education



"The framework is designed to help realize a vision for education in the sciences and engineering in which **(all) students**, over **multiple years** of school, **actively engage** in science and engineering **practices** and apply **crosscutting concepts** to deepen their understanding of the **core ideas** in these fields."

A Framework for K-12 Science Education pp. 8-9

The framework is built on the notion of learning as a developmental progression.



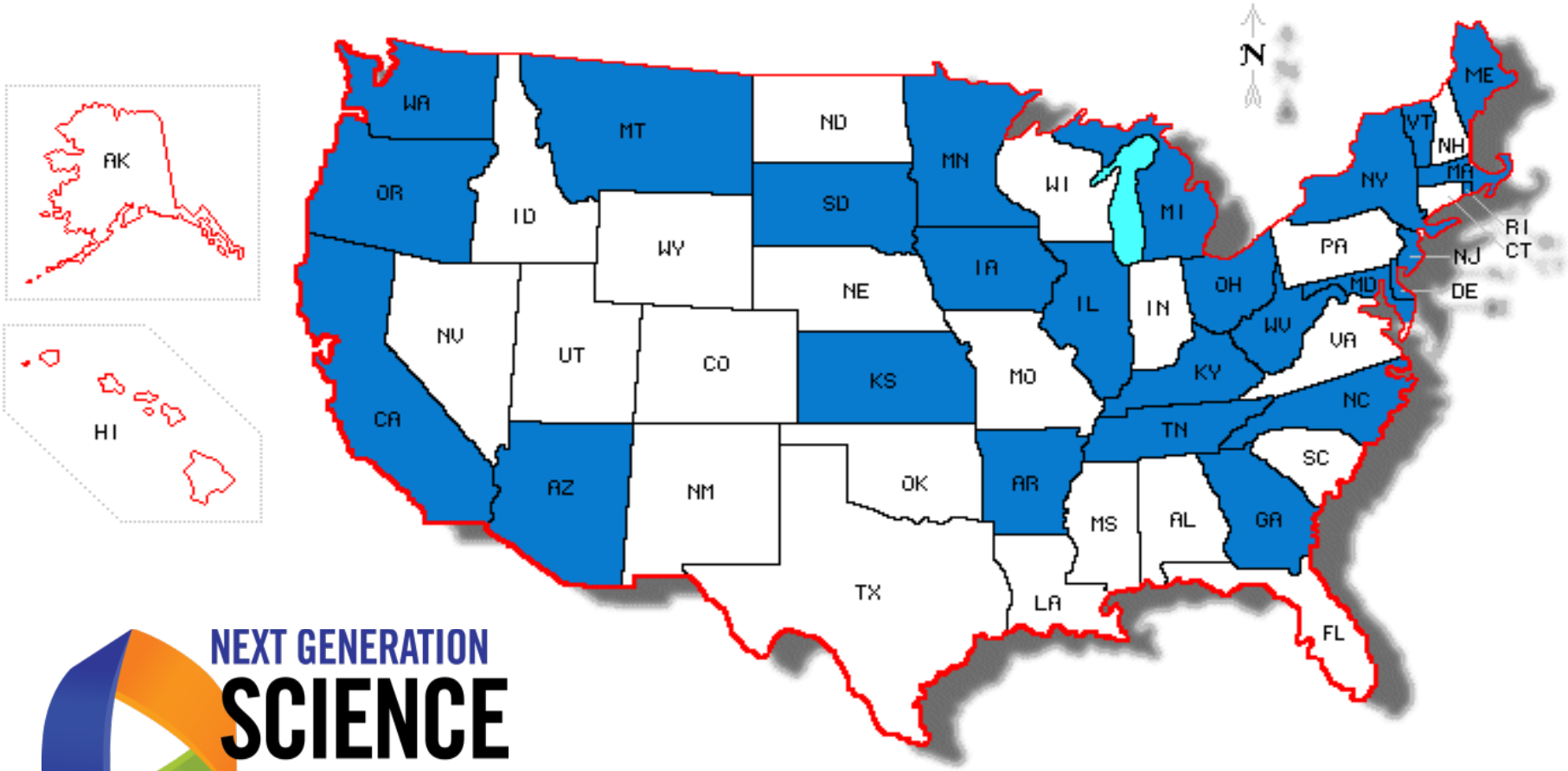
It is designed to help children continually build on and revise their knowledge and abilities, starting from their curiosity about what they see around them and their initial conceptions about how the world works.

Framework, p.11

Who developed the NGSS?

NEXT GENERATION
SCIENCE
STANDARDS
For States, By States

NGSS Lead States



NEXT GENERATION SCIENCE STANDARDS
For States, By States

http://www.nextgenscience.org/maryland

What does a standard look like in the NGSS?

NEXT GENERATION SCIENCE STANDARDS

For States, By States

K.Forces and Interactions: Pushes and Pulls

K.Forces and Interactions: Pushes and Pulls

Students who demonstrate understanding can:

K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. [Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.] [Assessment Boundary: Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.]

K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.* [Clarification Statement: ... a solution could include having a marble or other object move a certain distance, follow a particular path, and ... other objects such as a ramp to increase the speed of the object and a structure that would cause an object ... Assessment does not include friction as a mechanism for change in speed.]

The performance expectations above ... *Framework for K-12 Science Education*:

YIKES!!

Science and Engineering Practices

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.

- With guidance, plan and conduct an investigation in collaboration with peers. (K-PS2-1)

Analyzing and Interpreting Data
Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations.

- Analyze data from tests of an object or tool to determine if it works as intended. (K-PS2-2)

Connections to Nature of Science

Scientific Investigations Use a Variety of Methods

- Scientists use different ways to study the world. (K-PS2-1)

Disciplinary Core Ideas

... (K-PS2-2)

... or direction (K-PS2-2)

... on one another and can ...

... between Energy and Forces
... makes things speed up or slow down more than others. *(secondary to K-PS2-1)*

ETS1.A: Defining Engineering Problems

- A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. *(secondary to K-PS2-2)*

Crosscutting Concepts

Cause and Effect

- Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS2-1),(K-PS2-2)

Connections to other DCIs in kindergarten: **K.ETS1.A** (K-PS2-2); **K.ETS1.B** (K-PS2-2)

Articulation of DCIs across grade-levels: **2.ETS1.B** (K-PS2-2); **3.PS2.A** (K-PS2-1),(K-PS2-2); **3.PS2.B** (K-PS2-1); **4.PS3.A** (K-PS2-1); **4.ETS1.A** (K-PS2-2)

Common Core State Standards Connections:

ELA/Literacy –

RI.K.1 With prompting and support, ask and answer questions about key details in a text. *(K-PS2-2)*
W.K.7 Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them). (K-PS2-1)
SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood. *(K-PS2-2)*

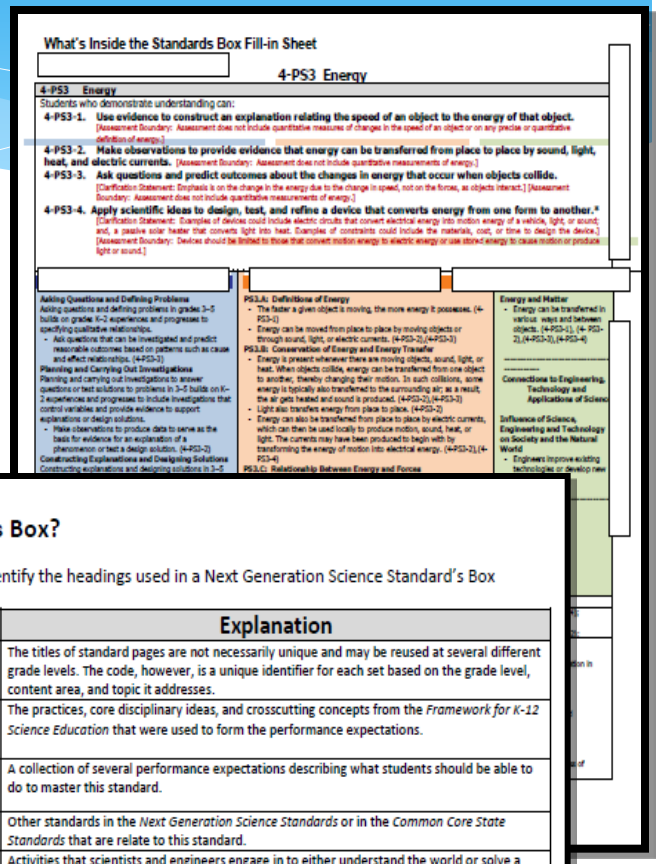
Mathematics –

MP.2 Reason abstractly and quantitatively. *(K-PS2-1)*
K.MD.A.1 Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. *(K-PS2-1)*
K.MD.A.2 Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. (K-PS2-1)

What's Inside the Standards Box?

Exploring the Standards Box

- **Read the explanation for each heading**
- **Write a heading in the box that best explains each section of the Standards Box.**


What's Inside the Standards Box Fill-in Sheet

4-PS3 Energy

4-PS3 Energy

Students who demonstrate understanding can:

4-PS3-1. **Use evidence to construct an explanation relating the speed of an object to the energy of that object.** [Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.]

4-PS3-2. **Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.** [Assessment Boundary: Assessment does not include quantitative measurements of energy.]

4-PS3-3. **Ask questions and predict outcomes about the changes in energy that occur when objects collide.** [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [Assessment Boundary: Assessment does not include quantitative measurements of energy.]

4-PS3-4. **Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*** [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.]

Asking Questions and Defining Problems
Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.
- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3)

Planning and Carrying Out Investigations
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.
- Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (4-PS3-2)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 3–5

PS3.A: Definitions of Energy
- The faster a given object is moving, the more energy it possesses. (4-PS3-1)
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)

PS3.B: Conservation of Energy and Energy Transfer
- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3)
- Light also transfers energy from place to place. (4-PS3-2)
- Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2),(4-PS3-4)

PS3.C: Relationship Between Energy and Forces

Energy and Matter
- Energy can be transferred in various ways and between objects. (4-PS3-1), (4- PS3-2),(4-PS3-3),(4-PS3-4)

Connections to Engineering, Technology and Applications of Science

Influence of Science, Engineering and Technology on Society and the Natural World
- Engineers improve existing technologies or develop new

What's Inside the Standards Box?

Use the explanation provided to help identify the headings used in a Next Generation Science Standard's Box

Headings	Explanation
Standard 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.
Foundation Box	The practices, core disciplinary ideas, and crosscutting concepts from the *Framework for K-12 Science Education* that were used to form the performance expectations.
What is Assessed	A collection of several performance expectations describing what students should be able to do to master this standard.
Connection Box	Other standards in the *Next Generation Science Standards* or in the *Common Core State Standards* that are relate to this standard.
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*, which are not specific to any one discipline but cut across them all.

Title and Performance Expectations

4-PS3
Energy

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.

What is Assessed
A set of performance expectations describing what students should know and be able to do to master this standard

4-PS3 Energy
Students who demonstrate understanding can:
4-PS3-1. **Use evidence to construct an explanation relating the speed of an object to the energy of that object.** [Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.]
4-PS3-2. **Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.** [Assessment Boundary: Assessment does not include quantitative measurements of energy.]
4-PS3-3. **Ask questions and predict outcomes about the changes in energy that occur when objects collide.** [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [Assessment Boundary: Assessment does not include quantitative measurements of energy.]
4-PS3-4. **Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*** [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.]

A Closer Look at a Performance Expectation

K-LS1 From Molecules to Organisms: Structures and Processes

K-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive.

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations. • Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. (K-LS1-1) ---------- ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** • Scientists look for patterns and order when making observations about the world. (K-LS1-1)	**LS1.C: Organization for Matter and Energy Flow in Organisms** • All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow. (K-LS1-1)	**Patterns** • Patterns in the natural and human designed world can be observed and used as evidence. (K-LS1-1)

Note: Performance expectations combine practices, core ideas, and crosscutting concepts into a single statement of ***what is to be assessed***.

They are not instructional strategies or objectives for a lesson.

Foundation Box

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. ▪ Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3) **Planning and Carrying Out Investigations** 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. ▪ Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (4-PS3-2) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. ▪ Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1) ▪ Apply scientific ideas to solve design problems. (4-PS3-4)	**PS3.A: Definitions of Energy** ▪ The faster a given object is moving, the more energy it possesses. (4-PS3-1) ▪ Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3) **PS3.B: Conservation of Energy and Energy Transfer** ▪ Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2),(4-PS3-3) ▪ Light also transfers energy from place to place. (4-PS3-2) ▪ Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2),(4-PS3-4) **PS3.C: Relationship Between Energy and Forces** ▪ When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3) **PS3.D: Energy in Chemical Processes and Everyday Life** ▪ The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4) **ETS1.A: Defining 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 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. *(secondary to 4-PS3-4)*	**Energy and Matter** ▪ Energy can be transferred in various ways and between objects. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4) ---------- ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering and Technology on Society and the Natural World** ▪ Engineers improve existing technologies or develop new ones. (4-PS3-4) ---------- ***Connections to Nature of Science*** **Science is a Human Endeavor** ▪ Most scientists and engineers work in teams. (4-PS3-4) ▪ Science affects everyday life. (4-PS3-4)

Scientific & 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*, which are not specific to any one discipline but cut across them all.

The Connection Box

Connection Box

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

Connections to other DCIs in fourth grade: N/A
Articulation of DCIs across grade-levels: **K.PS2.B** (4-PS3-3); **K.ETS1.A** (4-PS3-4); **2.ETS1.B** (4-PS3-4); **3.PS2.A** (4-PS3-3); **5.PS3.D** (4-PS3-4); **5.LS1.C** (4-PS3-4); **MS.PS2.A** (4-PS3-3); **MS.PS2.B** (4-PS3-2); **MS.PS3.A** (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4); **MS.PS3.B** (4-PS3-2),(4-PS3-3),(4-PS3-4); **MS.PS3.C** (4-PS3-3); **MS.PS4.B** (4-PS3-2); **MS.ETS1.B** (4-PS3-4); **MS.ETS1.C** (4-PS3-4)
Common Core State Standards Connections: *ELA/Literacy –* **RI.4.1** Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-PS3-1) **RI.4.3** Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. (4-PS3-1) **RI.4.9** Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. *(4-PS3-1)* **W.4.2** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1) **W.4.7** Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2),(4-PS3-3),(4-PS3-4) **W.4.8** Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4) **W.4.9** Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-PS3-1) *Mathematics –* **4.OA.A.3** Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding. *(4-PS3-4)*

Inside the NGSS Box

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.

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 the *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

3-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

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. [Clarification Statement: An example is pushing on one side of a box can make it start sliding and pushing on a box from both sides, with equal forces, will not produce any motion at all.] [Assessment Boundary: Limit testing to one variable at a time: number, size, or direction of forces. The size and direction of forces should be qualitative. Gravity is only to be addressed as a force 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. [Clarification Statement: An example of motion with a predictable pattern is a child swinging in a swing. In this example, the student could observe the swing moving at different relative rates depending on where it is in the arc of the swing.]

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 force could be the force on hair from an electrically charged balloon; an example of a magnetic force could be the force between two magnets. Cause and effect relationships include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.] [Assessment Boundary: Limited to forces produced by objects that can be manipulated by students.]

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.* [Clarification Statement: Example problems include constructing a latch to keep a door shut, or creating a device to keep two moving objects from touching each other. Students should understand that the results of investigations about non-contact forces inform design solutions.]

Science and Engineering Practices

Asking Questions and Defining Problems
Asking questions and defining problems in grades 3–5 builds from grades K–2 experiences and progresses to specifying qualitative relationships.
- Formulate questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (3-PS2-b),(3-PS2-a),(3-PS2-c)

Planning and Carrying Out Investigations
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.
- Design and conduct investigations collaboratively, using fair tests in which variables are controlled and the number of trials considered. (3-PS2-a)
- Make observations and/or measurements, collect appropriate data, and identify patterns that provide evidence for an explanation of a phenomenon or test a design solution. (3-PS2-b),(3-PS2-a),(3-PS2-c)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 3–5 builds on prior experiences in K–2 and progresses to the use of evidence in constructing multiple explanations and designing multiple solutions.
- Apply scientific knowledge to solve design problems. (3-PS2-d)

Connections to Nature of Science

Scientific Investigations Use a Variety of Methods
- Science investigations use a variety of tools and techniques. (3-PS2-b),(3-PS2-a),(3-PS2-c)
- There is not one scientific method. (3-PS2-b),(3-PS2-a),(3-PS2-c)

Disciplinary Core Ideas

PS2.A: Forces and Motion
- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (3-PS2-a)
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-b)

PS2.B: Types of Interactions
- Objects in contact exert forces on each other (friction, elastic pushes and pulls). (3-PS2-b)
- Electric, magnetic, and gravitational forces between a pair of objects do not require that the objects be in contact—for example, magnets push or pull at a distance. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. (3-PS2-c),(3-PS2-d)

PS2.C: Stability and Instability in Physical Systems
- 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 pendulum), or go through cyclical patterns (e.g., day and night). (3-PS2-b)
- Examining how the forces on and within the system change as it moves can help explain a system's patterns of change. (3-PS2-a)
- A system can appear to be unchanging when processes within the system are going on at opposite but equal rates. (3-PS2-a)

Crosscutting Concepts

Cause and Effect
- Cause and effect relationships are routinely identified, tested, and used to explain change. (3-PS2-a),(3-PS2-c)

Stability and Change
- Change is measured in terms of differences over time and may occur at different rates. (3-PS2-b)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
- Tools and instruments (e.g., rulers, balances, thermometers, graduated cylinders, telescopes, microscopes) are used in scientific exploration to gather data and help answer questions about the natural world. Engineering design can develop and improve such technologies. (3-PS2-d)
- Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. (3-PS2-d)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science assumes consistent patterns in natural systems. (3-PS2-b)

Connections to other DCIs in this grade-level: will be added in future version.

Articulation of DCIs across grade-levels: will be added in future version.

Common Core State Standards Connections:

ELA/Literacy –

RI.3.5 Use text features and search tools (e.g., key words, sidebars, hyperlinks) to locate information relevant to a given topic efficiently. (3-PS2-d)

RI.3.10 By the end of the year, read and comprehend informational texts, including history/social studies, science, and technical texts, at the high end of the grades 2–3 text. (3-PS2-b),(3-PS2-a),(3-PS2-c)

W.3.7 Conduct short research projects that build knowledge about a topic. (3-PS2-b),(3-PS2-a),(3-PS2-c)

SL.3.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 3 topics and texts, building on others' ideas and expressing their own clearly. (3-PS2-b),(3-PS2-a),(3-PS2-c)

Mathematics –

MP.1 Make sense of problems and persevere in solving them. (3-PS2-d)

MP.3 Construct viable arguments and critique the reasoning of others. (3-PS2-a)

MP.7 Look for and make use of structure. (3-PS2-b)

3.MD.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. *(3-PS2-b),(3-PS2-a)*

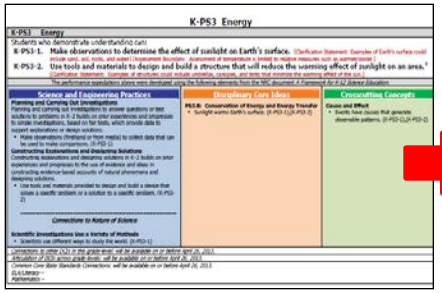
Based on the January 2013 Draft of NGSS

How is content articulated in the NGSS?

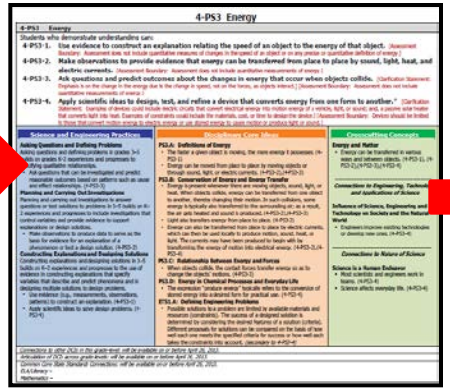
NEXT GENERATION
SCIENCE
STANDARDS
For States, By States

Review and discuss the progression of energy standards with a partner or your team.

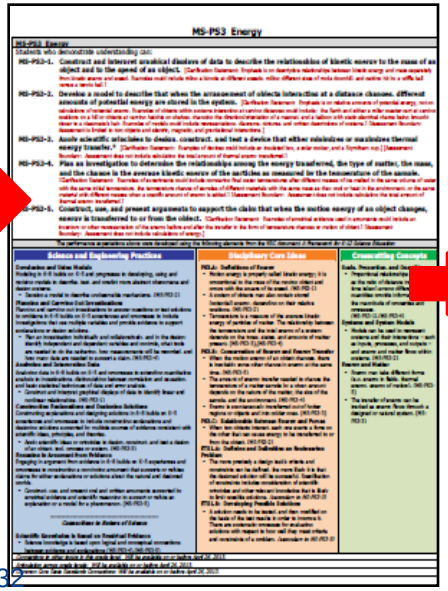
Kindergarten



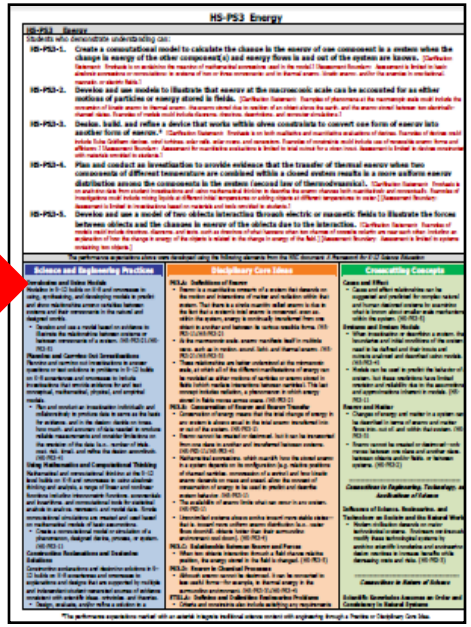
Grade 4



Middle School



High School



Partner/Group Review and Discussion

NEXT GENERATION SCIENCE STANDARDS

Questions to explore with a partner or team

- How do the standards for Energy build coherently K-HS?
- How does the cognitive rigor progress K-HS?
- What are the opportunities for integration with CCSS and STEM?

Core Idea: Energy			
Coherence *How do the Core Ideas progress K-12*	Cognitive Rigor	Integration with CCSS Math and Literacy	Integration with STEM
Evidence:	Evidence:	Evidence:	Evidence:
What are the implications of NGSS for planning and teaching in your school?			

Discuss and Record your observations:

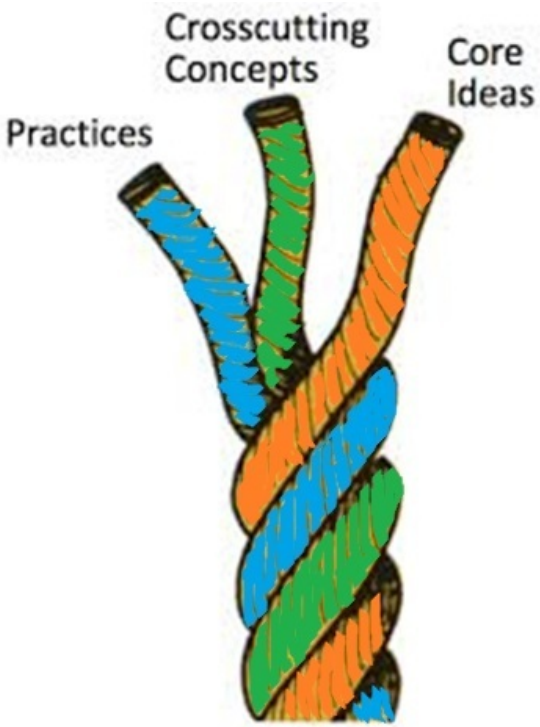
- **How do the standards build coherently K-HS?**
- **How do core ideas progress K-12.**
- **How does the cognitive rigor progress K-HS?**
- **What are the opportunities for integration with ELA, Math, and STEM?**

What are the three dimensions of learning in the NGSS?

NEXT GENERATION SCIENCE STANDARDS

For States, By States

Three Dimensions Intertwined



- **The NGSS are written as Performance Expectations**
- **NGSS will require contextual application of the three dimensions by students.**

http://www.nextgenscience.org/2ls2-ecosystems-interactions-energy-dynamics

NEXT GENERATION SCIENCE STANDARDS
For States, By States

Dimension 1
Science and Engineering Practices

- Behaviors that scientists engage in as they investigate, build models, analyze data and communicate information
- "Practices" rather than "skills" since knowledge and skills are required that are specific to each practice.
- Engineering involves solving a problem through design.
- Engineering practices make STEM relevant to students.

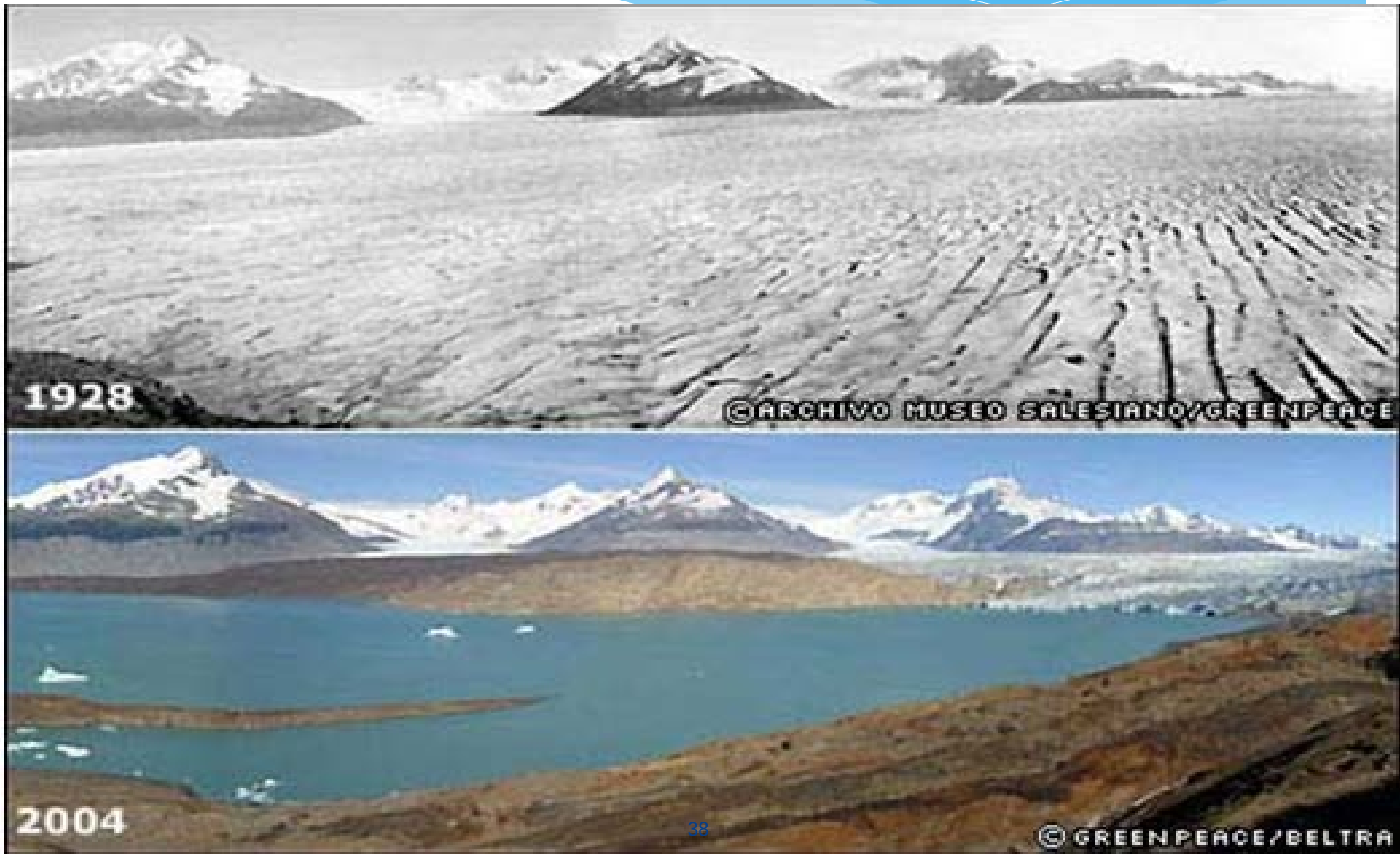
Framework, pp. 41-82

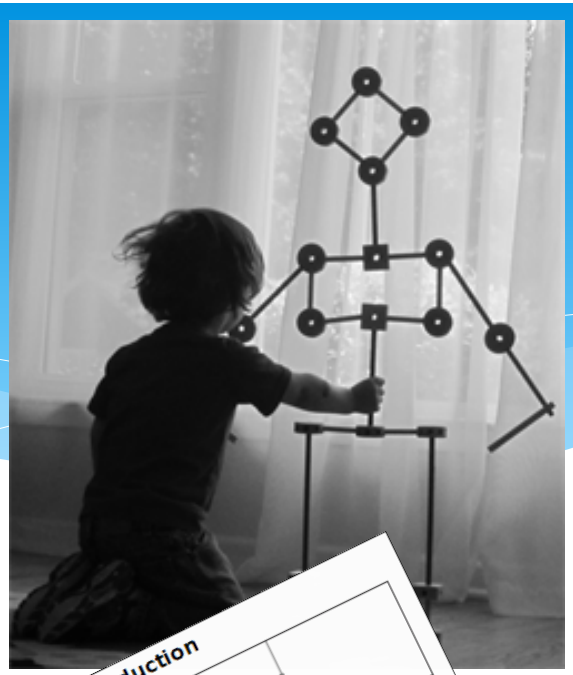
Why are there seasons?

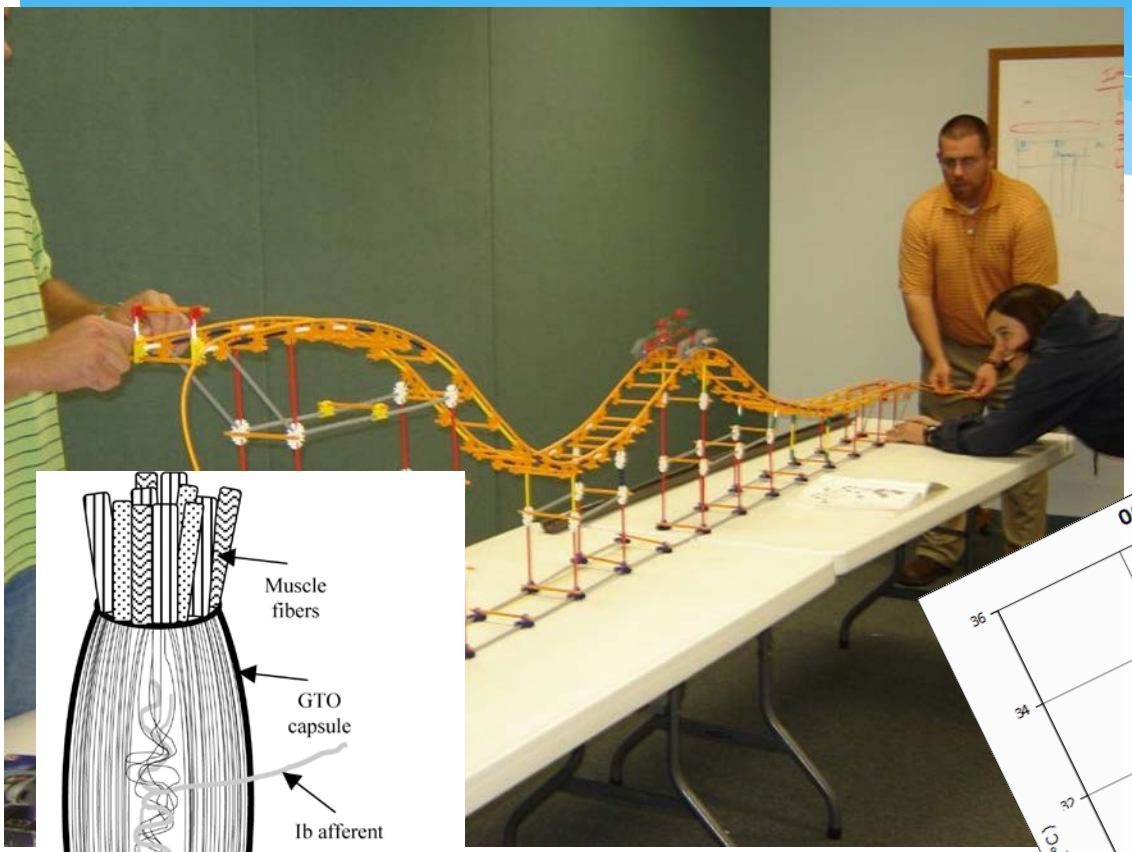
Why did the structure collapse?

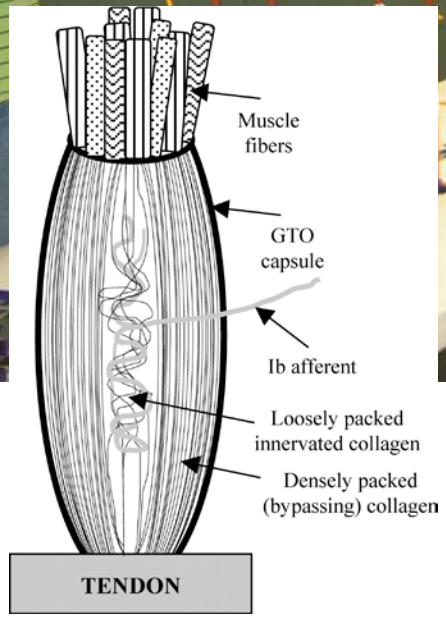
How is electric power generated?

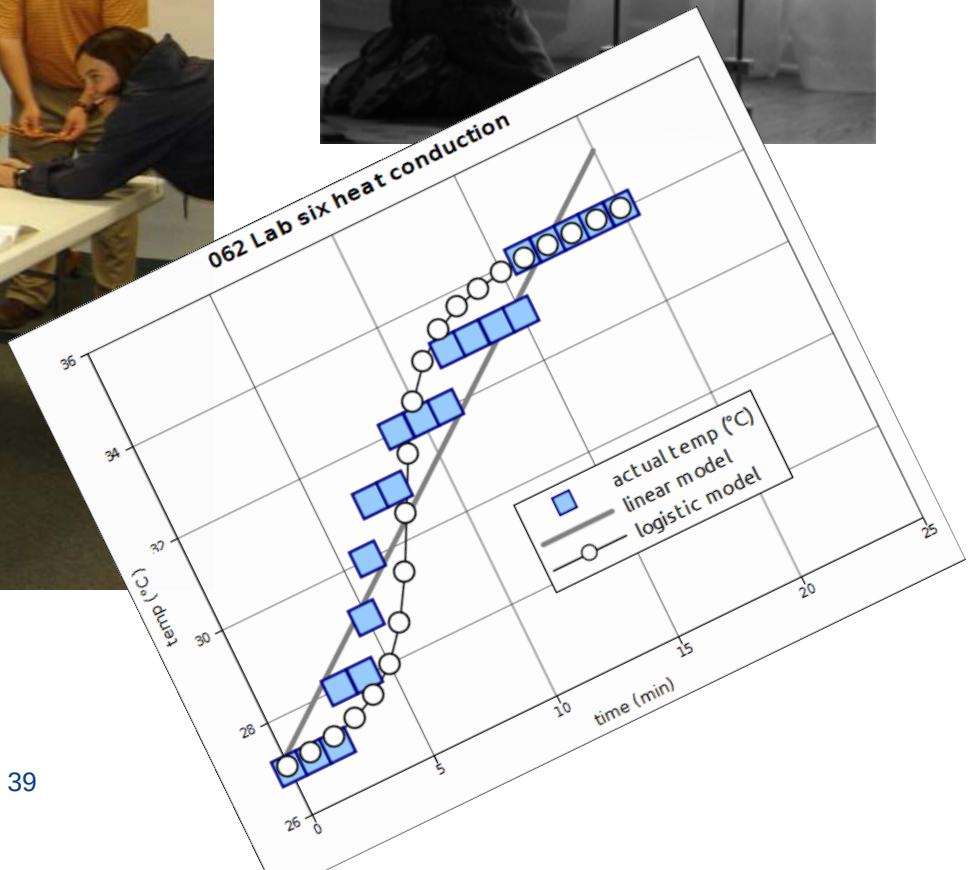
What do plants need to survive?

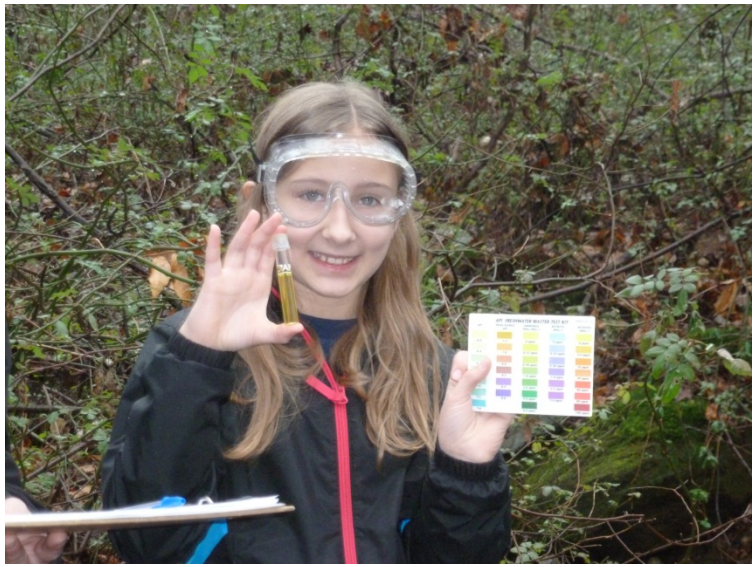

1928
©ARCHIVO MUSEO SALESIANO/GREENPEACE
2004
© GREENPEACE/BELTRA

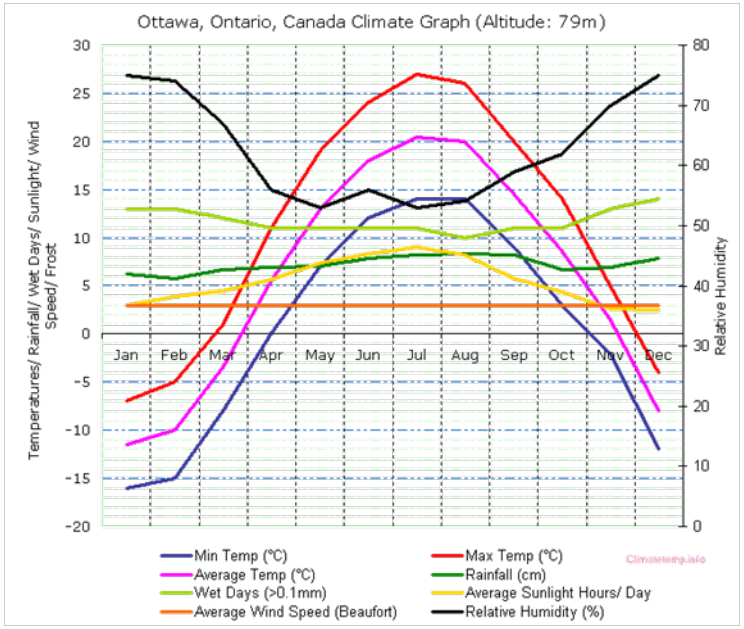


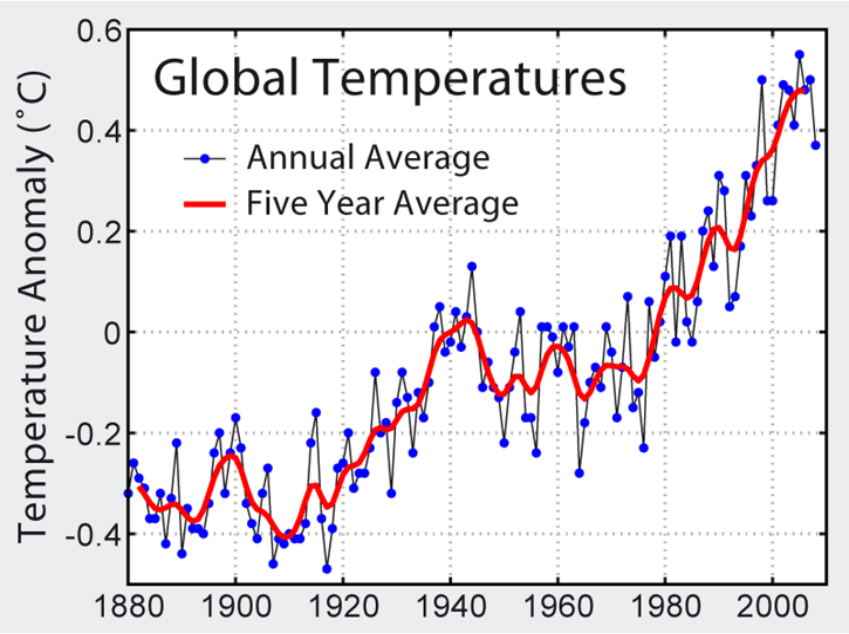


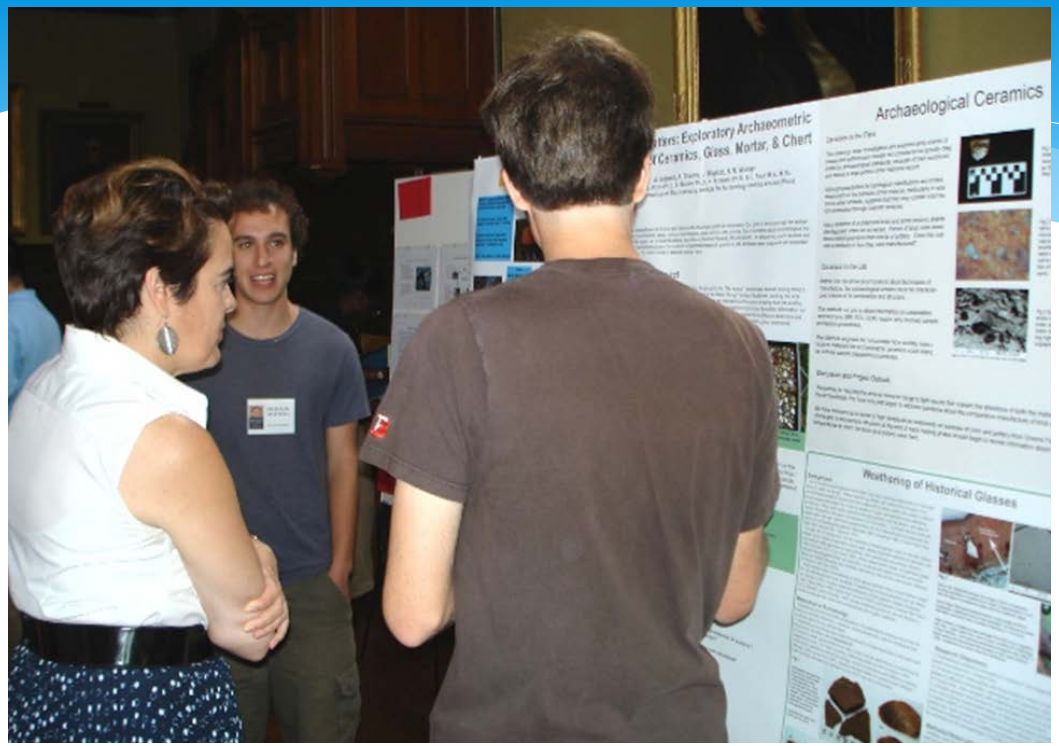

Muscle fibers
GTO capsule
Ib afferent
Loosely packed innervated collagen
Densely packed (bypassing) collagen
TENDON


062 Lab six heat conduction
actual temp (°C)
linear model
logistic model
temp (°C)
time (min)
26
28
30
32
34
36
0
5
10
15
20
25



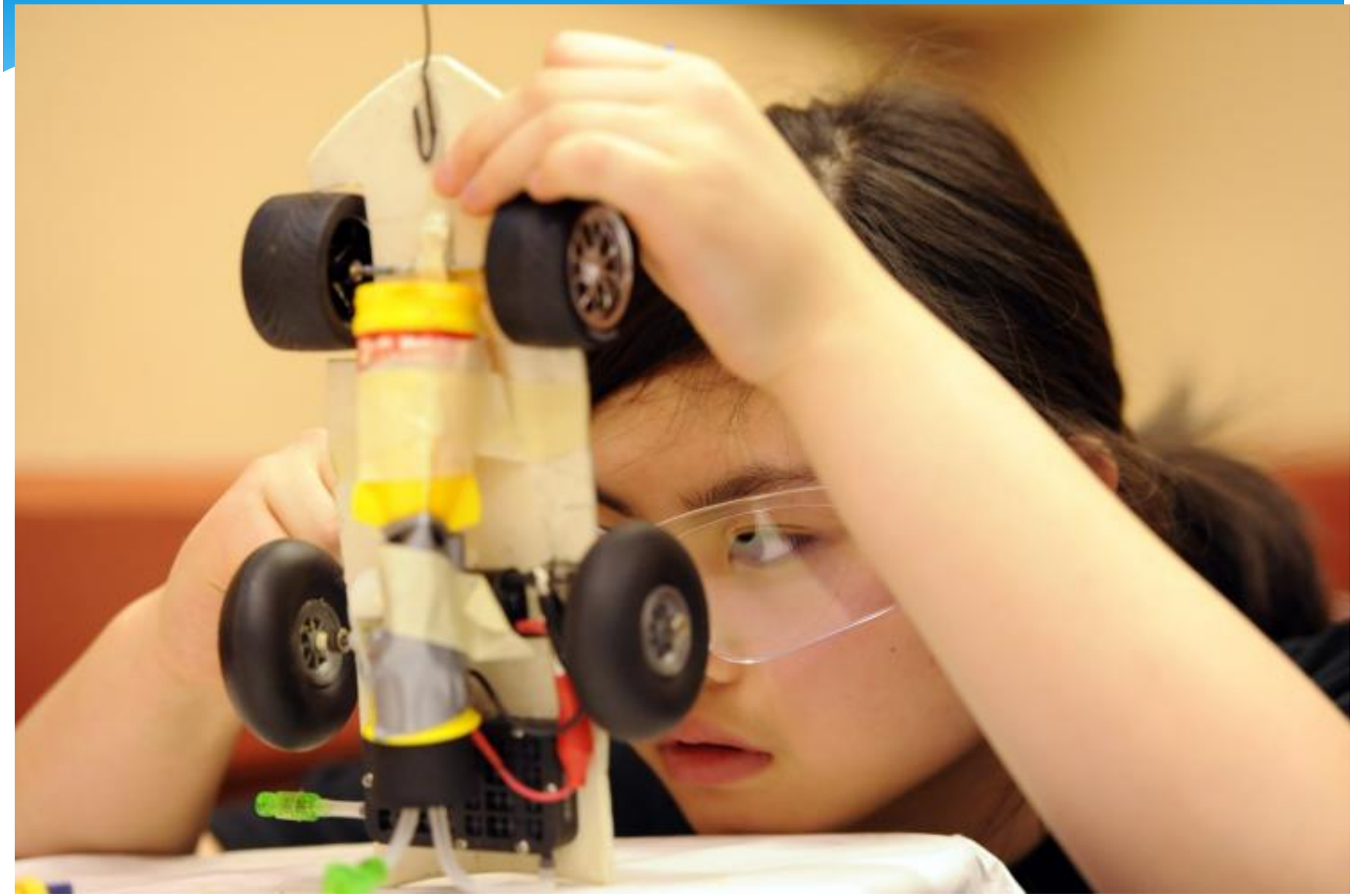

Ottawa, Ontario, Canada Climate Graph (Altitude: 79m)
Temperatures/ Rainfall/ Wet Days/ Sunlight/ Wind Speed/ Frost
Relative Humidity
30
25
20
15
10
5
0
-5
-10
-15
-20
80
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Min Temp (°C)
Max Temp (°C)
Average Temp (°C)
Rainfall (cm)
Wet Days (>0.1mm)
Average Sunlight Hours/ Day
Average Wind Speed (Beaufort)
Relative Humidity (%)


Global Temperatures
Annual Average
Five Year Average
Temperature Anomaly (°C)
0.6
0.4
0.2
0
-0.2
-0.4
1880
1900
1920
1940
1960
1980
2000


Archaeological Ceramics
Weathering of Historical Glasses

EARTHQUAKE RESISTANT
BAMBOO HOUSE

HEAT & COLOR
HYPOTHESIS
DARKER COLORS WILL ABSORB MORE HEAT THAN LIGHTER COLORS
CONCLUSION
Provided Photo



Dimension 2
Crosscutting Concepts

* Have application across all domains of science
* Provide an organizational schema for interrelating knowledge from various science fields

* Include:

  (1) Patterns, similarity, and diversity;

  (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

Dimension 3
Disciplinary Core Ideas

* Focus K–12 science curriculum, instruction and assessments on the most important aspects of science
  * Broad importance or key organizing principle
  * Key tool for understanding complex ideas
  * Connected to personal or societal concerns
  * Teachable and learnable at multiple grades

Disciplinary Core Ideas

Physical Science

PS1: Matter & Interactions

PS2: Motion & Stability: Forces and Interactions

PS3: Energy

PS4: Waves and Their Applications in Technologies for Information Transfer

Life Science

LS1: From Molecules to Organisms

LS2: Ecosystems: Interaction, Energy & Dynamics

LS3: Heredity: Inheritance and Variation of Traits

LS4: Biological Evolution: Unity & Diversity

Earth & Space Science

ESS1: Earth's Place in the Universe

ESS2: Earth's Systems

ESS3: Earth & Human Activity

Engineering Design

ETS1: Engineering Design

Influence of Science, Engineering, and Technology on Society and the Natural World

Current State Science Standard Sample

Inquiry Standards

Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities utilizing safe laboratory procedures.

Students will use the ideas of system, model, change, and scale in exploring scientific and technological matters.

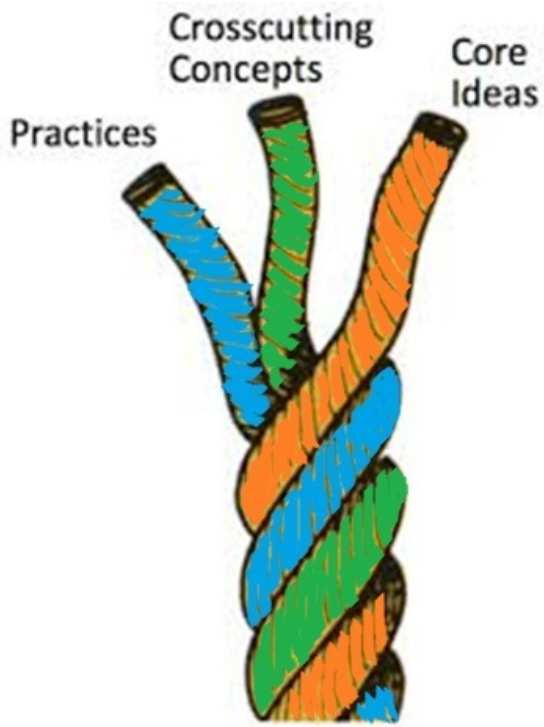
Content Standards

Distinguish between atoms and molecules.

Recognize that there are more than 100 elements and some have similar properties as shown on the Periodic Table of Elements.

Identify and demonstrate the Law of Conservation of Matter.

Three Dimensions Intertwined

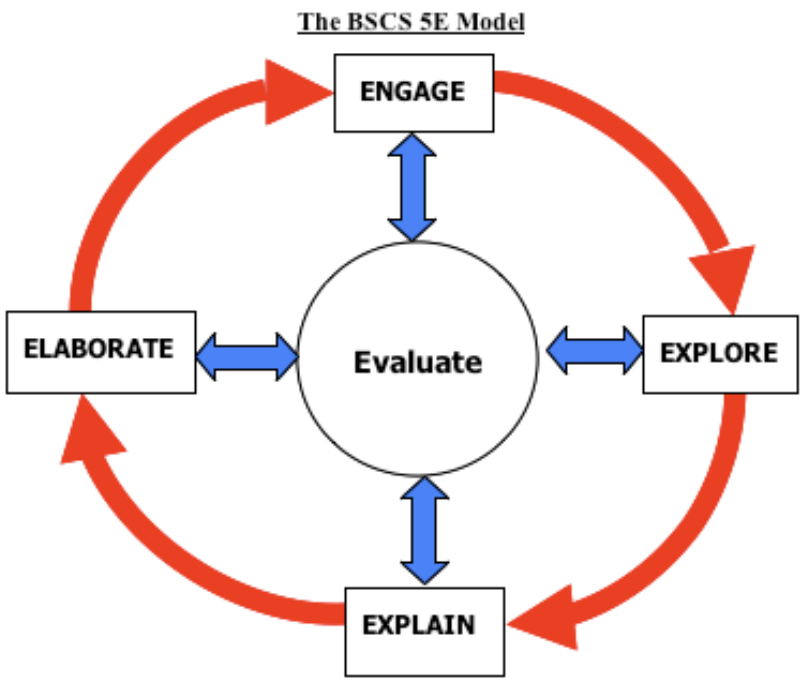


- The NGSS are written as Performance Expectations
- NGSS will require contextual application of the three dimensions by students.

NEXT GENERATION SCIENCE STANDARDS
For States, By States

The 5E Instructional Model

* Appropriate for lessons or units
* Activates prior knowledge
* Student-centered
* Multiple opportunities to explore
* Connects to real world scenarios
* Assessment opportunities in each E



Elementary School

* **Engage:** Students are given an example of a plant or animal and tell where it lives.
* **Explore:** teams of two students visit the school yard to answer: "How many different plants and animals can you observe?"
* **Explain:** student present their findings from the trip
* **Elaborate:** students are asked to collect pictures of three different organisms, display the pictures and describe their habitats
* **Evaluate:** Students are given pictures of plants and animals in different habitats; describe the plants and animals and describe how their actions are like scientists.

Performance Expectation?

5E	Practices	DCIs	Crosscutting
Engage			
Explore			
Explain			
Elaborate			
Evaluate			

Elementary School

* **Engage:** Students are given an example of a plant or animal and tell where it lives.
* **Explore:** teams of two students visit the school yard to answer: "How many different plants and animals can you observe?"

http://www.nextgenscience.org/2-ls4-1-biological-evolution-unity-and-diversity

* **Explain:** student present their findings from the trip
* **Elaborate:** students are asked to collect pictures of three different organisms, display the pictures and describe their habitats
* **Evaluate:** Students are given pictures of plants and animals in different habitats; describe the plants and animals and describe how their actions are like scientists.

Three dimensions (ES)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. ▪ Make observations (firsthand or from media) to collect data which can be used to make comparisons. (2-LS4-1) ---------- *Connections to Nature of Science* **Scientific Knowledge is Based on Empirical Evidence** ▪ Scientists look for patterns and order when making observations about the world. (2-LS4-1)	**LS4.D: Biodiversity and Humans** ▪ There are many different kinds of living things in any area, and they exist in different places on land and in water. (2-LS4-1)	

Middle School

* **Engage:** describe characteristics of two fossil brachiopods to see if changes occurred; supply evidence to support claim
* **Explore:** measure and graph characteristics of two populations; propose explanations for variations
* **Explain:** present explanations and evidence
* **Elaborate:** Students review images of embryological development for similarities; research the similarities of related organisms and how they evolved
* **Evaluate:** students answer questions about variation in a population of cheetahs and describe how variation results in some individuals surviving and reproducing

High School

* **Engage**: view images of the "arms" of organisms, and attempt to identify their habitat; discuss adaptations.
* **Explore**: review slides of the Galapagos Islands and examine data on beak depth and tarsal length in finches. How could variation in beak depth help or harm finches?
* **Explain:** read and discuss Darwin's description of natural selection.
* **Elaborate:** examine morphological features of apes and humans. Students build models to compare DNA codes for proteins to determine relatedness of organisms.
* **Explain:** describe findings and predict relationships to ancestor
* **Evaluate:** use graphical evidence for natural selection to construct an explanation for adaptation of populations

What shifts are necessary for teaching and learning in the NGSS?

NEXT GENERATION SCIENCE STANDARDS

For States, By States

Conceptual Shifts in the NGSS

1. K-12 science education should reflect the interconnected nature of science as it is practiced and experienced in the real world.
2. The Next Generation Science Standards are student performance expectations – **NOT** curriculum.
3. The science concepts build coherently from K-12.
4. The NGSS focus on deeper understanding of content as well as application of content.
5. Science and Engineering are integrated in the NGSS from K–12.
6. NGSS content is focused on preparing students for college, careers, and citizenship.
7. The NGSS and Common Core State Standards (English Language Arts and Mathematics) are **Aligned.**

NEXT GENERATION SCIENCE STANDARDS
For States, By States

Maryland and the NGSS: Where are We Going?

Maryland State Department of Education
Preparing World-Class Students

Next Generation Science Standards
For States, By States

62

Maryland Next Generation Science Standards Implementation and Planning Document

PHASE 1 Spring 2013-2014	PHASE 2 2014-2015	PHASE 3 2015-2016	PHASE 4 2016-2017	PHASE 5 2017-2018
Exploration, Awareness, and Statewide Capacity Building	Classroom Transitions, Shifts, and Practices	Leveraging Materials, Resources, and Expertise	Statewide Application, Assessment, and Coordination	Full PreK-12 Implementation

ONGOING STATEWIDE COORDINATION AND COLLABORATION TO SUPPORT TEACHERS, SUPERVISORS, ADMINISTRATORS

Communication: MSDE, State Science Leadership Team, LEA Science Supervisors				
Develop common messages	General Outreach on Shifts	Ongoing Consistent messaging		
Statewide Capacity/Network Building: MSDE Programs; State Science Leadership Team; LEA Science Supervisors				
Identify existing expertise and gaps	Develop NGSS Support Networks	Ongoing Support of Leadership Network		
Professional Learning: MSDE Programs, State Science Leadership Team, LEA Science Supervisors, Teachers, Administrators, Informal Educators				
Identify professional learning needs: teachers, administrators, and informal educators – LEA Progress Updates	Professional Learning designed for all Stakeholders: Regular Updates at Maryland BOE meetings; Briefings, and IHE	Professional Learning: Implementation for teachers and administrators at all levels at CCRC : Sessions – NGSS 101; EQuIP NGSS Rubric; Assessment; DL	Professional Learning: Implementation for Informal Educators and ongoing adaptation of Professional Learning	
Instructional Practices/Shifts: MSDE, State Science Leadership Team, LEA Science Supervisors, Teachers, Administrators, Informal Educators				
Focus on the Framework to inform development of PreK – 12 Scope and Sequence which incorporates the Science and Engineering Practices	Continue to focus on equity (all students) and integrating the Science and Engineering Practices and Cross Cutting Concepts	Focus on the Integration of the 3 Dimensions (S and E Practices, Cross Cutting Concepts, and Disciplinary Core Ideas)	Instructional Shifts in place Statewide; development of Formative Assessments for use at varied levels	Assessments developed: beginning with classroom assessment and moving to monitoring (large-scale) assessment.
Instructional Materials and Curriculum: MSDE Programs, State Science Leadership Team, LEA Science Supervisors, Teachers				
Evaluate existing material using the EQuIP NGSS Rubric	Adapt existing materials and ongoing exploration of e-innovations	Evaluate newly developed material using the on an ongoing basis		
Assessment: MSDE Programs, LEAs , LEA Science Supervisor, Administrators, Teachers				
Align existing State assessments with NGSS (to the extent feasible)	Focus on developing classroom formative assessment systems	Participate in multi-state assessment consortium with NGSS adopted states		
Data: MSDE, LEAs , Administrators, Teachers				
Determine metrics to be tracked (e.g. course taking, student achievement) to inform instruction	Develop data collection plan for formative & summative assessments	Track and report science related data		
Policy Shifts: MBOE, MSDE, Legislature				
Identify policy changes needed to implement NGSS (e.g. Teacher Certification, Teacher Evaluation, assessments)	Consideration of Alternate Pathways, Early College Admission Program, Approved CTE or Other	Piloting Assessments		

Phase I: Spring 2013-2014

Exploration

Awareness

State capacity-building

* Teachers
* LEA Science Supervisors
* State Science Leadership Team
* MSDE staff

Phase 2: 2014-2015

Classroom transitions, K-12

* Map scope and sequence
* Incorporate Engineering Practices

Shifts in instruction

* Integrate the three Dimensions
* Focus on teaching through the Science and Engineering Practices
* Incorporate formative assessment tasks
* Continue to evaluate instructional resources using the EQuIP rubric

Identify possible policy changes to implement NGSS

Phase 3: 2015-2016

Classroom transitions, K-12

* Refine scope and sequence
* Articulate Performance Expectations among grades and courses
* Refine formative assessment tasks
* Continue to evaluate, incorporate and refine instructional resources using the EQuIP rubric

Provide professional learning opportunities for teachers and administrators

Phase 4: 2016-2017

Ongoing support of leadership network

- Professional learning
- Assessment development
  - Multistate consortium with NGSS states
  - State-level assessment system
- Data collection: courses, student achievement

Policy changes

- Course credit requirements
- Teacher evaluation

Phase 5: 2017-2018

Full PreK-12 implementation

* Scope and sequence appropriate for all LEAs
* High school credit requirements in place
* Assessment system in place
* Instructional resources and strategies aligned with NGSS
* Professional learning for pre-service and new teachers
* Data reporting, storage and retrieval system in place

Outcomes

- Explained the reasons for building new science standards.
- Described the process and timeline for constructing the Framework and the NGSS.
- Described the structure of a standard within NGSS.
- Discussed the implications of the “shifts” in NGSS for teaching and learning.
- Examined instructional strategies that reflect the intent of NGSS.

Exit Slip

* Write a message that describe the implications of the NGSS for teaching and learning in YOUR classroom.
  * Tweet
  * Message
  * Facebook

Resources

A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012)

http://www.nap.edu/catalog.php?record_id=13165#

Developing Assessments for the Next Generation Science Standards

http://www.nap.edu/download.php?record_id=18409

NSTA

http://ngss.nsta.org/access-standards/

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Next Generation Science Standards
www.nextgenscience.org

National Academy of Sciences
http://sites.nationalacademies.org/dbasse/bose/framework_k12_science/index.htm