Building on the Past; Preparing for the Future

1990s

1990s-2009

Phase I

Phase II

1/2010 - 7/2011

7/2011 – March 2013
Read It For Yourself

“Don’t believe everything you read on the Internet just because there’s a picture with a quote next to it.”

—Abraham Lincoln
What’s Different about the Next Generation Science Standards?
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. The NGSS and Common Core State Standards (English Language Arts and Mathematics) are Aligned.
The NGSS are written as Performance Expectations.

NGSS will require contextual application of the three dimensions by students.
MATH

M1. Make sense of problems & persevere in solving them
M2. Reason abstractly & quantitatively
M3. Construct viable argument & critique reasoning of others
M4. Model with mathematics
M5. Use appropriate tools strategically
M6. Attend to precision
M7. Look for & make use of structure
M8. Look for & express regularity in repeated reasoning

SCIENCE

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

ELA

E1. Demonstrate independence
E2. Build strong content knowledge
E3. Respond to the varying demands of audience, talk, purpose, & discipline
E4. Comprehend as well as critique
E5. Value evidence
E6. Use technology & digital media strategically & capably
E7. Come to understand other perspectives & cultures
E8. Obtain, evaluate & communicate information

Source: Working Draft v2, 12-06-11 by Tina Cheuk, ell.stanford.edu
Inquiry Standards

a. Students will explore the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.

b. Students will use standard safety practices for all classroom laboratory and field investigations.

c. Students will have the computation and estimation skills necessary for analyzing data and following scientific explanations.

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

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

f. Students will communicate scientific ideas and activities clearly.

g. Students will question scientific claims and arguments effectively.

Content Standards

a. Distinguish between atoms and molecules.

b. Describe the difference between pure substances (elements and compounds) and mixtures.

c. Describe the movement of particles in solids, liquids, gases, and plasmas states.

d. Distinguish between physical and chemical properties of matter as physical (i.e., density, melting point, boiling point) or chemical (i.e., reactivity, combustibility).

e. Distinguish between changes in matter as physical (i.e., physical change) or chemical (development of a gas, formation of precipitate, and change in color).

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

g. Identify and demonstrate the Law of Conservation of Matter.
Standards Comparison:
Structure and Properties of Matter

Current State Middle School Science Standard

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g. **Identify and demonstrate** the Law of Conservation of Matter.
Standards Comparison: Structure and Properties of Matter

NGSS Middle School Sample

a. Develop molecular-level models of a variety of substances, comparing those with simple molecules to those with extended structures.
b. Design a solution that solves a practical problem by using characteristic chemical and physical properties of pure substances.*
c. Develop a molecular level model that depicts and predicts why either temperature change and/or change of state can occur when adding or removing thermal energy from a pure substance.
d. Develop molecular models of reactants and products to support the explanation that atoms, and therefore mass, are conserved in a chemical reaction.
e. Analyze and interpret the properties of products and reactants to determine if a chemical reaction has occurred.
f. Gather and communicate information that people's needs and desires for new materials drive chemistry forward, and that synthetic materials come from natural resources and impact society.*
g. Design, construct, and test a device that either releases or absorbs thermal energy by chemical processes.*
Standards Comparison: Structure and Properties of Matter

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a. **Develop molecular-level models** of a variety of substances, comparing those with simple molecules to those with extended structures.

b. **Design a solution that solves a practical problem** by using characteristic chemical and physical properties of pure substances.*

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d. **Develop molecular models** of reactants and products to support the explanation that atoms, and therefore mass, are conserved in a chemical reaction.

e. **Analyze and interpret** the properties of products and reactants to determine if a chemical reaction has occurred.

f. **Gather and communicate information** that people's needs and desires for new materials drive chemistry forward, and that synthetic materials come from natural resources and impact society.*

g. **Design, construct, and test a device** that either releases or absorbs thermal energy by chemical processes.*
PS1 Matter and Its Interactions

Students who demonstrate understanding can:

K-PS1-a. Design and conduct an investigation of different kinds of materials to describe their observable properties and classify the materials based on the patterns observed. [Clarification Statement: Observations are qualitative only and can include relative length, weight, color, texture, and hardness. Patterns include the similar properties that different materials share.]

K-PS1-b. Design and conduct investigations to test the idea that some materials can be a solid or liquid depending on temperature. [Assessment Boundary: Only a qualitative description of temperature should be used such as hot, cool, and warm.]

K-PS1-c. Ask questions, based on observations, to classify different objects by their use and to identify whether they occur naturally or are human-made.* [Clarification Statement: Patterns include the similar characteristics of objects that determine whether they occur naturally or are human-made.]

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
- Asking Questions and Defining Problems
  - Ask questions based on observations of the natural and/or designed world. (K-PS1-c)
- Planning and Carrying Out Investigations
  - With guidance, design and conduct investigations in collaboration with peers. (K-PS1-a),(K-PS1-b)
  - Make direct or indirect observations and/or measurements to collect data which can be used to make comparisons. (K-PS1-a),(K-PS1-b)

Disciplinary Core Ideas
  - Different kinds of matter exist (e.g., wood, metal, water) and many of them can be either solid or liquid, depending on temperature. (K-PS1-a),(K-PS1-b)
  - Matter can be described and classified by its observable properties (e.g., visual, aural, textural, by its uses, and by whether it occurs naturally or is manufactured). (K-PS1-a),(K-PS1-c)

Crosscutting Concepts
- Patterns
  - Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. (K-PS1-a),(K-PS1-c)
- Cause and Effect
  - Events have causes that generate observable patterns. (K-PS1-b)
  - Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS1-b)

Connections to Engineering, Technology, and Applications of Science
- Influence of Engineering, Technology, and Science on Society and the Natural World
  - People depend on various technologies in their lives; human life would be very different without technology. (K-PS1-c)
  - Every human-made product is designed by applying some knowledge of the natural world and is built by using materials derived from the natural world, even when the materials are not thermo-natural—for example, spoons made from refined metals. (K-PS1-c)
Connections to the Nature of Science

Knowledge is based on empirical evidence.

Scientific knowledge is based on evidence from observations and experiments. (K-PS1-a), (K-PS1-b), (K-PS1-c)

Common Core State Standards Connections:

- Literacy:
  1. With prompting and support, ask and answer questions about key details in a text. (K-PS1-c)
  8. With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question. (K-PS1-c)
  3. Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (K-PS1-c)

- Mathematics:
  6. Construct viable arguments and critique the reasoning of others. (K-PS1-b)

  1. Directly compare two objects with a measurable attribute in common, to see which has "more of" or "less of" the attribute, and describe the difference. (K-PS1-a), (K-PS1-b)

Connections to Engineering, Technology, and Applications of Science

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

- People depend on various technologies in their daily lives; human life would be very different without technology. (K-PS1-c)
- Every human-made product is designed by applying some knowledge of the natural world; the product is built by using materials derived from the natural world, even when the materials are not themselves natural—for example, spoons made from refined metals. (K-PS1-c)
Goal: To distribute and receive feedback from interested stakeholders; and continue the transparent development process to enable states to prepare for consideration of NGSS

- The standards opened for review at 3:00 p.m. EST on January 8, 2013.
- The review period will end on January 29, 2013.
- The standards and the survey can be accessed at www.nextgenscience.org
- Final Release – March of 2013
Feedback Data from the May 2012 NGSS Public Draft
General Feedback on the May Draft, September Draft, and CCR Review

• Overall, very positive.
General Strengths of the Drafts

- Pedagogical Vision
- Architecture, including integration of the three dimensions
- Rigor required by the NGSS at all grades
- Web presentation and interactivity
- NGSS are well structured and clear about expectations
  - Clarification statements and assessment boundaries support additional clarity
- Intentional connections to other NGSS and math and ELA CCSS
Students who demonstrate understanding can:

- **HS-LS4.a.** Produce scientific writing that communicates how multiple lines of evidence, such as similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development, contribute to the strength of science theories related to natural selection and biological evolution. [Clarification Statement: Emphasis is on identifying historically reliable sources of scientific evidence contributing to the strength of the theories of natural selection and biological evolution (e.g., DNA sequencing, embryology, anatomy) and evaluating how multiple lines of evidence contribute to an understanding of evolution.] [Assessment Boundary: The assessment should provide evidence of students' abilities to evaluate the strength of the evidence.]

- **HS-LS4.b.** Use a model to support the explanation that the process of natural selection is the result of four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. [Clarification Statement: Emphasis is on the interrelationship of the four factors that result in natural selection. Mathematical models and simulations of changes in distribution of traits in a population at different times may be used.] [Assessment Boundary: Assessment should provide evidence of students' abilities to explain natural selection in terms of the number of organisms, behaviors, morphology, or physiology factors having a direct effect on survival and reproduction as well as ability to compete for limited resources. Mathematical models may be used to communicate the explanation.]

- **HS-LS4.c.** Apply concepts of statistics and probability to support explanations for how organisms with an advantageous heritable trait tend to increase in proportion to organisms that lack this trait. [Clarification Statement: Emphasis is on mathematically analyzing changes in the numerical distribution of heritable traits in a population.] [Assessment Boundary: The assessment should provide evidence of students' abilities to analyze shifts in numerical distribution of traits as evidence to support explanations. Analysis is limited to basic statistical and graphical analysis, not gene frequency calculations.]
Students who demonstrate understanding can:

ESS2-a. Use Earth system models to support explanations of how Earth’s internal and surface processes operate concurrently at different spatial and temporal scales to form landscapes and sea floor features. [Clarification Statement: The appearance of the land (e.g., mountains, basins, valleys, plateaus, platforms) and sea floor features (e.g., trenches, ridges, fracture zones, seamounts, abyssal plains, continental slopes) are a result of both constructive forces (e.g., volcanism, tectonic uplift, orogeny) and destructive mechanisms (e.g., stream processes, coastal wave action, mass wasting, weathering, erosion, shoreline progressions).] [Assessment Boundary: Details of the formation of major geographic features of Earth’s surface are not assessed.]

ESS2-b. Construct an evidence-based argument about how a natural or human-caused change to one part of an Earth system can create feedback that causes changes in that system or other systems.* [Clarification Statement: Modern civilization depends on major technological systems and these are critical aspects of decisions about technology usage. Local real world examples could include how removing ground vegetation causes an increase in water runoff and soil erosion; building reservoirs increases groundwater recharge; installing a coastal rock jetty changes currents and resulting beach erosion patterns; removing wetlands causes a decrease in local humidity that further reduces the wetland extent; diminishing glacial ice reduces the amount of sunlight reflected from Earth’s surface, which increases surface temperatures and further reduces the amount of ice.]

ESS2-c. Apply scientific reasoning to show how empirical evidence from Earth observations and laboratory experiments have been used to develop the current model of Earth’s interior.* [Clarification Statement: Examples of evidence may include results from drill cores (rock composition with depth), gravity (density with depth), Earth’s magnetic field, seismic waves (elastic properties with depth), and laboratory experiments on Earth materials (composition, density, and elastic properties with pressure).]
General Areas for Improvement

- Clarity of Some Language
- Integration of Critical Areas in Some Standards
  - Mathematics, engineering, crosscutting concepts
- Scope of Required Content
- Confusion about the role of standards versus curriculum
- Concern about the consistency of organization of the standards versus Framework in terms of coding and arrangement
- Concern about the amount of support that will be needed for implementation of the standards
  - Professional Development, materials, administrator support and understanding, future assessments
Changes since May

- 95% of the Performance Expectations have been rewritten based on feedback, with more specific and consistent language used.
- A review focused on college- and career-readiness resulted in the removal of some content.
- Some content shifted grade levels in elementary.
- Engineering has been better integrated into the traditional science disciplines.
- More math expectations have been added to the performance expectations.
- “Nature of science” concepts have been highlighted throughout the document.
- The Science and Engineering Practices matrix has been revised to provide more clarity.
Appendices have been added to support the NGSS and in response to feedback
- Appendix A – Conceptual Shifts
- Appendix B – Responses to May Public Feedback
- Appendix C – College and Career Readiness
- Appendix D – All Standards, All Students
- Appendix E – Disciplinary Core Idea Progressions in the NGSS
- Appendix F – Science and Engineering Practices in the NGSS
- Appendix G – Crosscutting Concepts in the NGSS
- Appendix H – Nature of Science
- Appendix I – Engineering Design, Technology, and the Applications of Science in the NGSS
- Appendix J – Model Course Mapping in Middle and High School
- Appendix K – Connections to Common Core State Standards in Mathematics
3. Interdependent Relationships in Ecosystems: Environmental Impacts on Organisms

Students who demonstrate understanding can:

3-LS4-d. Analyze and interpret data about changes in the environment of different areas and describe how the changes may affect the organisms that live in the areas. [Clarification Statement: Environmental changes should include changes to landforms, distribution of water, temperature, or availability of resources. The system is a particular area, its components, and how they interact.] [Assessment Boundary: Data may be provided for students.]

3-LS4-e. Use evidence about organisms in their natural habitats to design an artificial habitat in which the organisms can survive well. [Clarification Statement: Evidence to include needs and characteristics of the organisms. The organisms and their habitat make up a system in which the parts depend on each other.]

3-LS4-a. Analyze and interpret data from fossils to describe the types of organisms that lived long ago and the environments in which they lived and compare them with organisms and environments today. [Clarification Statement: Students can observe fossils, images of fossils, and/or other data.]

3-LS2-a. Use multiple sources to generate and communicate information about the size, stability, and specialization of groups animals may form, and how different types of groups may help the members survive in their natural habitats. [Clarification Statement: Systems are groups of animals. [Assessment Boundary: Knowledge of specific groups of animals is not required.]

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**
- Analyzing and Interpreting Data
  - Analyzing data in 3-5 builds on K-2 and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations.
  - Display data in tables and graphs, using digital tools when feasible, to reveal patterns that indicate relationships. (3-LS4-d, 3-LS4-a)
  - Use data to evaluate claims about cause and effect. (3-LS4-d)
- 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.
  - Use evidence (e.g., measurements, observations, patterns) to construct a scientific explanation or design a solution to a problem. (3-LS4-e)
- Obtaining, Evaluating, and Communicating Information
  - Obtaining, evaluating, and communicating information in 3-5 builds on K-2 and progresses to evaluating the merit and accuracy of ideas and methods.
  - Compare and/or combine across complex texts and/or other reliable media to acquire appropriate scientific and/or technical information. (3-LS2-a)
  - Use multiple sources to generate and communicate scientific and/or technical information orally and/or in written formats, including various forms of media, and may include tables.

**Disciplinary Core Ideas**

- **LS2.C: Ecosystem Dynamics, Functioning, and Resilience**
  - When the environment changes in ways that affect a place’s physical characteristics, temperature, or availability of resources, some organisms survive and reproduce; others move to new locations, yet others move into the transformed environment, and some die. (3-LS4-d)
  - **LS2.D: Social Interactions and Group Behavior**
    - Groups comprise collections of equal individuals, hierarchies with dominant members, small families, groups of single or mixed gender, or groups composed of individuals similar in age. Some groups are stable over long periods of time; others are fluid with members moving in and out. Some groups assign specialized tasks to each member in others, all members perform the same or a similar range of functions. (3-LS4-a)

- **LS4.A: Evidence of Common Ancestry and Diversity**
  - Some kinds of plants and animals that once lived on Earth (e.g., dinosaurs) are no longer found anywhere, although others now living (e.g., lizards) resemble them in some ways. (Moved from K-2). (3-LS4-a)
  - Fossils provide evidence about the types of organisms (both visible and microscopic) that lived long ago and also about the nature of their environments. Fossils can be compared with one another and to living organisms according to their similarities and differences. (3-LS4-a)

- **LS4.C: Adaptation**
  - Changes in an organism’s habitat are sometimes beneficial to it (e.g., new food sources, changes in water temperature). (3-LS4-a)

**Crosscutting Concepts**

- **Systems and System Models**
  - A system can be described in terms of its components and their interactions. (3-LS4-d, 3-LS4-e)
  - **Stability and Change**
    - Some systems appear stable, but over long periods of time will eventually change. (3-LS4-a, 3-LS4-b)

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

- **Interdependence of Science, Engineering, and Technology**
  - Knowledge of relevant scientific concepts and research findings is important in engineering. (3-LS4-e)
Supplementary Documents and Materials Available at nextgenscience.org
- Why Standards Matter?
- How to Read the NGSS
- How to Complete the NGSS Survey
- Glossary of Terms

Additional Aspects of the NGSS Public Release II
- More flexibility of viewing of the standards has been provided with two official arrangements of the performance expectations: by topics and by DCI.
- Additional flexibility was added to the website views of standards, allowing users to turn off pop up” description boxes.
- The public feedback survey has been completed revised
Appendices for the NGSS
## Earth Space Science Progression

### INCREASING SOPHISTICATION OF STUDENT THINKING

<table>
<thead>
<tr>
<th></th>
<th>K-2</th>
<th>3-5</th>
<th>6-8</th>
<th>9-12</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Universe</strong></td>
<td><strong>Stars range greatly in size and distance from Earth and this can explain their relative brightness</strong></td>
<td><strong>The Big Bang describes the origin of the universe; the Earth is part of one galaxy among many</strong></td>
<td></td>
<td><strong>a) Light spectra are used to describe characteristics of stars;</strong></td>
</tr>
<tr>
<td><strong>B. Sun and the system</strong></td>
<td><strong>Patterns of movement of the sun, moon and stars as seen from Earth can be observed, described and predicted</strong></td>
<td><strong>The Earth’s orbit and rotation, and the orbit of the moon around the Earth cause observed patterns of movement of celestial objects as seen from Earth</strong></td>
<td><strong>The solar system can be modeled to predict tides, eclipses and the apparent motion of planets seen in the sky from Earth. The Earth’s tilt cause seasons</strong></td>
<td><strong>b) The sun will burn out over a life span of about 10 billion years;</strong></td>
</tr>
<tr>
<td><strong>C. History of Earth</strong></td>
<td><strong>Some events on Earth occur in cycles while some are discrete events, any of which can occur over varying time scales</strong></td>
<td><strong>Earth has changed over time; the history of local landscapes can be inferred. Certain features can be used to order events that have occurred in a landscape</strong></td>
<td><strong>Rock strata and the fossil record can be used as evidence to organize the relative occurrence of major historical events in Earth’s history</strong></td>
<td><strong>c) Stars and galaxies are abundant in the universe;</strong></td>
</tr>
<tr>
<td><strong>D. Materials and resources</strong></td>
<td><strong>The materials and resources found in association with landforms provide homes for plants and animals</strong></td>
<td><strong>Four major Earth systems interact to affect materials and processes on Earth’s surface</strong></td>
<td><strong>Energy flows and matter cycles within and among Earth’s systems, including the sun and Earth’s interior as primary energy sources; Plate tectonics is one result of these processes</strong></td>
<td><strong>d) The development of technologies has provided the observable astronomical data that are the empirical evidence of the Big Bang theory</strong></td>
</tr>
<tr>
<td><strong>E. Tectonics</strong></td>
<td><strong>Wind and water carry natural materials that influence landforms and what can live in a location</strong></td>
<td><strong>Earth’s physical features occur in patterns, as do earthquakes and volcanoes; Maps can be used to locate features and predict location of those events</strong></td>
<td><strong>Plate tectonics is the unifying theory that explains movements of rocks at Earth’s surface and geological history; Maps are used to display evidence of plate movement</strong></td>
<td><strong>Radioactive decay and residual heat of formation within Earth’s interior contribute thermal convection in the mantle</strong></td>
</tr>
</tbody>
</table>
In the 6-8 grade band, students can classify relationships as causal or correlational and understand that correlation does not necessarily imply causation. Cause and effect relationships may be used to predict phenomena in natural and designed systems. Students understand that some phenomena have more than one cause, and some cause and effect relationships may only be described using probability.

Examples from Life Science include using empirical evidence to support an argument for how characteristic animal behaviors affect the probability of successful reproduction (MS-LS1-e). Examples from Physical Science includes developing a molecular model that predicts why either temperature change and/or change of state can occur when adding or removing thermal energy from a pure substance (MS-PS1-c). Examples from Earth and Space Science include collecting data and generating evidence to show how changes in weather conditions result from the motions and interactions of air masses (MS-ESS2-i).

Performance Expectations using Cause and Effect in 6-8: MS-PS1-c, MS-PS2-c, MS-PS2-e, MS-LS1-e, MS-LS1-f, MS-LS1-g, MS-LS1-h, MS-LS1-i, MS-LS2-a, MS-LS3-a, LS4-b, MS-LS4-b, MS-LS4-f, MS-LS4-j, MS-LS1-l, MS-ESS2-i, MS-ESS2-m, MS-ESS2-p, MS-ESS3-b, MS-ESS3-e, MS-ESS3-f.]
Practice 1 Asking Questions and Defining Problems

Students at any grade level should be able to ask questions of each other about the texts they read, the features of the phenomena they observe, and the conclusions they draw from their models or scientific investigations. For engineering, they should ask questions to define the problem to be solved and to elicit ideas that lead to the constraints and specifications for its solution. (NRC Framework 2012, p. 56)

Scientific questions arise in a variety of ways. They can be driven by curiosity about the world, inspired by the predictions of a model or theory, or they can be stimulated by the need to solve a problem. What distinguishes scientific questions from other types of questions is that they can be answered by appealing to evidence, including evidence that has been gathered by others, or that might be gathered by planning and conducting an investigation.

While science begins with questions, engineering begins with defining a problem to solve. However, engineering may also involve asking questions to define a problem, such as: What is the need or desire that underlies the problem? What are the criteria for a successful solution? Other questions arise when generating ideas, or testing possible solutions, such as: What are the possible trade-offs? What evidence do we need to determine which solution is best?

Whether engaged in science or engineering, the ability to ask good questions and clearly define problems is essential for everyone. The following progression of Practice 1 competencies summarizes what students should be able to do by the end of each grade band.

<table>
<thead>
<tr>
<th>Grades K-2</th>
<th>Grades 3-5</th>
<th>Grades 6-8</th>
<th>Grades 9-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking questions and defining problems in grades K–2 builds on prior experiences and progresses to simple descriptive questions that can be tested.</td>
<td>Asking questions and defining problems in grades 3–5 builds from grades K–2 experiences and progresses to specifying qualitative relationships. - Identify scientific (testable) and non-scientific (non-</td>
<td>Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to formulating and refining empirically testable models to explain phenomena or solve problems. - Ask questions that arise from careful observation of phenomena, models, or design solutions using models and simulations</td>
<td>Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design solutions using models and simulations</td>
</tr>
</tbody>
</table>
Nature of Science

Overview
One goal of science education is to help students understand the nature of scientific knowledge. This matrix presents eight major themes and grade level understandings about the nature of science. Four themes extend the scientific and engineering practices and four themes extend the crosscutting concepts. These eight themes are presented in the left column. The matrix describes learning outcomes for the themes at grade bands for K-2, 3-5, middle school, and high school. Appropriate learning outcomes are expressed in selected performance expectations and presented in the foundation boxes throughout the standards.

<table>
<thead>
<tr>
<th>Understanding about the Nature of Science</th>
<th>Categories</th>
<th>K-2</th>
<th>3-5</th>
<th>Middle School</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific Investigations Use a Variety of Methods</td>
<td></td>
<td>Science investigations begin with a question.</td>
<td>Science methods are determined by questions.</td>
<td>Science investigations use a variety of methods and tools to make measurements and observations.</td>
<td>Science investigations use diverse methods and do not always use the same set of procedures to obtain data.</td>
</tr>
<tr>
<td>Scientific Knowledge is Based on Empirical Evidence</td>
<td></td>
<td>Scientists look for patterns and order when making observations about the world.</td>
<td>Science findings are based on recognizing patterns.</td>
<td>Science knowledge is based upon logical and conceptual connections between evidence and explanations.</td>
<td>Science knowledge is based on empirical evidence.</td>
</tr>
<tr>
<td>Scientific Knowledge is Open to Revision in Light of New Evidence</td>
<td></td>
<td>Science knowledge can change when new information is found.</td>
<td>Scientific explanations can change based on new evidence.</td>
<td>Scientific explanations subject to revision and improvement is light of new evidence.</td>
<td>Scientific explanations can be probabilistic.</td>
</tr>
<tr>
<td>Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena</td>
<td></td>
<td>Science uses drawings, sketches, and models as a way to communicate ideas.</td>
<td>Science theories are based on a body of evidence and many tests.</td>
<td>Theories are explanations for observable phenomena.</td>
<td>Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.</td>
</tr>
</tbody>
</table>

The discourse practices of science are organized around disciplinary domains that share exemplars for making decisions regarding the values, instruments, methods, models, and evidence to adopt and use. Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.
Engineering in the NGSS

Engineering Performance Expectations

The following chart shows all performance expectations that require engineering design practices, disciplinary core ideas, or the crosscutting concepts of engineering, technology, and society. Engineering performance expectations are designated with an asterisk (*). This chart allows readers to quickly identify the performance expectations in each grade/grade-band. Following the chart are the actual performance expectations in the NGSS architecture.

Engineering in Kindergarten through Fifth Grade

<table>
<thead>
<tr>
<th>Grade / Grade-Level</th>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Idea</th>
<th>Cross-Cutting Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K-ESS3-d.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1-PS4-d.</td>
<td>1-PS4-e.</td>
<td>1-PS4-e.</td>
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<tr>
<td></td>
<td>1-PS4-e.</td>
<td></td>
<td>1-LS1-b.</td>
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<td>1-LS1-b.</td>
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<td>1-ESS1-b.</td>
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<tr>
<td></td>
<td>1-ESS1-b.</td>
<td></td>
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</tr>
</tbody>
</table>
I. Introduction

II. Course Maps
   A. Conceptual Progressions Model (6-8) and (9-12) (Course Map Model 1)
      1. Process and Assumptions: Where did this course map come from?
      2. Refining Course Map 1
Connections to CCSS Mathematics

4.E Energy

As part of this work, teachers should give students opportunities to use the four operations with whole numbers to solve problems:

4.OA.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. Science example: The class has 144 rubber bands with which to make rubber-band cars. If each car uses 6 rubber bands, how many cars can be made? If there are 28 students, at most how many rubber bands can each car have (if every car has the same number of rubber bands)?

Alignment notes: Grade 4 students are expected to fluently add and subtract multi-digit whole numbers; multiply a number of up to four digits by a one-digit whole number; multiply two two-digit numbers; and find whole-number quotients and remainders with up to four-digit dividends and one-digit divisors.
The second draft of the NGSS is ready for your review before January 29

Review the standards and provide feedback.
The second draft of the Next Generation Science Standards will be available for feedback from January 8, 2013 through January 29, 2013. We fully encourage all interested parties to review the draft as individuals or in groups and provide feedback to the Lead States and writers. In this draft, the standards are coded by Disciplinary Core Ideas (DCI) from the NRC’s Framework for K-12 Science Education, and are available in two different arrangements: by DCI and by topic.

NGSS Structure
NGSS Second Draft Front Matter
How to Give Feedback on the NGSS / PDF version
Glossary of Terms
Appendices to the Second Draft:
A. Conceptual Shifts
B. Responses to May Public Feedback
C. College and Career Readiness
D. All Standards, All Students

Search DCI Arrangements
Search Topic Arrangements

Survey by DCI Arrangement / PDF version
Survey by Topics Arrangement / PDF version

Click here for a PDF of the DCI Arrangement of the standards, click here for a PDF of the Topical Arrangement of the standards, or use the search buttons above to explore interactive versions of the standards.

The NGSS will be completed in March of 2013. Since the May draft release, the Lead States and the writers evaluated the tens of thousands of comments collected during the May 2012 review period and worked on revising the standards. The goal of this public release is to share revisions based on the first public review and the college and career
You can also search for topical arrangements of standards.

**Download a PDF** of all performance expectations grouped by DCI, or select criteria below to search for individual DCI groupings. You can Ctrl+click (cmd+click on Macs) to select or de-select multiple criteria. Note that adding criteria from both categories narrows your results.

### Grades

<table>
<thead>
<tr>
<th>Grades</th>
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<td>K</td>
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<td>3-5</td>
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<td>4</td>
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<tr>
<td>5</td>
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<tr>
<td>Middle School (6-8)</td>
</tr>
</tbody>
</table>

### Disciplinary Core Idea

- Earth and Space Sciences
  - ESS1A: The Universe and its Stars
  - ESS1B: Earth and the Solar System
  - ESS1C: The History of Planet Earth
  - ESS2A: Earth Materials and Systems
  - ESS2B: Plate Tectonics and Large-Scale Systems
  - ESS2C: The Role of Water in Earth’s Surface Processes
  - ESS2D: Weather and Climate
  - ESS2E: Biogeology
## Performance Expectations by DCI

Click on a topic to view associated performance expectations.

### Elementary

<table>
<thead>
<tr>
<th>K-5 Storylines: K</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>K.PS1 Matter and Its Interactions</td>
<td>2.LS2 Ecosystems: Interactions, Energy, 4.PS3 Energy and Dynamics</td>
<td>4.PS4 Waves and Their Applications in Technologies for Information Transfer</td>
<td></td>
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</tr>
<tr>
<td>K.LS1 From molecules to organisms: Structures and processes</td>
<td>2.ESS2 Earth's Systems</td>
<td>4.ESS1 Earth's Place in the Universe</td>
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<tr>
<td>K.ESS2 Earth's Systems</td>
<td>3.PS2 Motion and Stability: Forces and Interactions</td>
<td>4.ESS2 Earth's Systems</td>
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<td></td>
</tr>
<tr>
<td>K.ESS3 Earth and Human Activity</td>
<td>3.LS1 From Molecules to Organisms: Structures and Processes</td>
<td>4.ESS3 Earth and Human Activity</td>
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</tr>
<tr>
<td>1.PS4 Waves and Their Applications in Technologies for Information Transfer</td>
<td>3.LS2 Ecosystems: Interactions, Energy, and Dynamics</td>
<td>5.PS1 Matter and Its Interactions</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1.LS1 From Molecules to Organisms: Structure and Processes</td>
<td>3.LS3 Heredity: Inheritance and Variation of Traits</td>
<td>5.PS2 Motion and Stability: Forces and Interactions</td>
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<tr>
<td>1.ESS1 Earth's Place in the Universe</td>
<td>3.LS4 Biological Evolution: Unity and Diversity</td>
<td>5.PS3 Energy</td>
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### Middle School

<table>
<thead>
<tr>
<th>PS: Physical Sciences</th>
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<tbody>
<tr>
<td>MS.PS1 Matter and Its Interactions</td>
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<tr>
<td>MS.PS2 Motion and Stability: Forces and Interactions</td>
</tr>
<tr>
<td>MS.PS3 Energy</td>
</tr>
<tr>
<td>MS.PS4 Waves and Their Applications in Technologies for Information Transfer</td>
</tr>
</tbody>
</table>

### High School

| HS.PS1 Matter and Its Interactions |
| HS.PS2 Motion and Stability: Forces and Interactions |
| HS.PS3 Energy |
| HS.PS4 Waves and Their Applications in Technologies for Information Transfer |
Students who demonstrate understanding can:

S1-a. Design and conduct an investigation of different kinds of materials to describe their observable properties and classify the materials based on the patterns observed. [Clarification Statement: Observations are qualitative only and could include relative length, weight, color, texture, and hardness. Patterns include the similar properties that different materials share.]

S1-b. Design and conduct investigations to test the idea that some materials can be a solid or liquid depending on temperature. [Assessment Boundary: Only a qualitative description of temperature should be used such as hot, cool, and warm.]

S1-c. Ask questions, based on observations, to classify different objects by their use and to identify whether they occur naturally or are human-made. [Clarification Statement: Patterns include the similar characteristics of objects that determine whether they occur naturally or are human-made.]

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**

- **Clarifying Questions and Defining Problems**
  - Asking questions and defining problems in grades K–2 uses prior experiences and progresses to simple, descriptive questions that can be tested.
  - Asking questions based on observations of the natural and/or designed world. (K-PS1-c)

- **Planning and Carrying Out Investigations**
  - Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on experiences and progresses to simple investigations, based on fair tests, which provide data support explanations or design solutions.
  - With guidance, design and conduct investigations in collaboration with peers. (K-PS1-a), (K-PS1-b)
  - Make direct or indirect observations and/or measurements to collect data which can be used to make comparisons. (K-PS1-a), (K-PS1-b)

- **Connections to the Nature of Science**
  - Science Knowledge is based on empirical evidence
  - Scientists look for patterns and order when making observations about the world. (K-PS1-a), (K-PS1-b), (K-PS1-c)

**Disciplinary Core Ideas**

- **PS1.A: Structure and Properties of Matter**

  - Different kinds of matter exist (e.g., wood, metal, water) and many of them can be either solid or liquid, depending on temperature. (K-PS1-a), (K-PS1-b)
  - Matter can be described and classified by its observable properties (e.g., visual, aural, textual), by its uses, and by whether it occurs naturally or is manufactured. (K-PS1-a), (K-PS1-c)

**Crosscutting Concepts**

- **Patterns**
  - Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. (K-PS1-a), (K-PS1-c)

- **Cause and Effect**
  - Events have causes that generate observable patterns. (K-PS1-b)
  - Simple tests can be designed to gather evidence to support or refute student ideas about cause. (K-PS1-b)

- **Connections to Engineering, Technology, and Applications of Science**

  - Influence of Engineering, Technology, and Science on Society and the Natural World
    - People depend on various technologies in their lives; human life would be very different without technology. (K-PS1-c)
    - Every human-made product is designed by applying some knowledge of the natural world and is built by using materials derived from the natural world, even when the materials are not themselves natural—for example, spoons made from refined metals. (K-PS1-c)
**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, design and conduct investigations in collaboration with peers.
- Make direct or indirect observations and/or measurements to collect data which can be used to make comparisons.

**PS1-a.**

**Design and conduct investigations to test the idea** that some materials can be a solid or liquid depending on temperature. [Assessment Boundary: Only a qualitative description of temperature should be used such as hot, cool, and warm.]

**PS1-b.**

Ask questions, based on observations, to classify different objects by their use and to identify whether they occur naturally or are human-made.* [Clarification Statement: Patterns include the similar characteristics of objects that determine whether they occur naturally or are human-made.]

---

**Science and Engineering Practices**

- **Asking Questions and Defining Problems**
  - Asking questions and defining problems in grades K–2 is on prior experiences and progresses to simple investigative questions that can be tested.
  - Ask questions based on observations of the natural and/or designed world. (K–PS1-c)
  - 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, design and conduct investigations in collaboration with peers. (K–PS1-a), (K–PS1-b)
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Dear Optimist, Pessimist, and Realist,

While you guys were busy arguing about the glass of water, I drank it!

Sincerely,
The Opportunist
Contact Information

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spruitt@achieve.org

www.nextgenscience.org