NGSS 101

Next Generation Science Standards
Adoption & Implementation
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.
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.asp
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
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
29% of students scored at or above level 4—the level at which students can complete higher order tasks.
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 Performance

United States v Singapore Benchmark Achievement

<table>
<thead>
<tr>
<th>Grade 4</th>
<th>% Advanced</th>
<th>% High</th>
<th>% Intermediate</th>
<th>% Low</th>
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<tbody>
<tr>
<td>2011</td>
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<td>33</td>
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<td>2003</td>
<td>13</td>
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<td>45</td>
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</tr>
<tr>
<td>1995</td>
<td>19</td>
<td>14</td>
<td>50</td>
<td>42</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grade 8</th>
<th>% Advanced</th>
<th>% High</th>
<th>% Intermediate</th>
<th>% Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>10</td>
<td>40</td>
<td>40</td>
<td>69</td>
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<td>2007</td>
<td>10</td>
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<td>2003</td>
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<tr>
<td>1999</td>
<td>12</td>
<td>29</td>
<td>37</td>
<td>60</td>
</tr>
<tr>
<td>1995</td>
<td>11</td>
<td>29</td>
<td>38</td>
<td>64</td>
</tr>
</tbody>
</table>

* 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

Phase I

1990s

1990s-2009

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
“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?
NGSS Lead States

http://www.nextgenscience.org/maryland
What does a standard look like in the NGSS?
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.

Use the explanation provided to help identify the headings used in a Next Generation Science Standards’ Box.

<table>
<thead>
<tr>
<th>Headings</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Title and Code</td>
<td>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 standard based on the grade level, content area, and topic it addresses.</td>
</tr>
<tr>
<td>Foundation Box</td>
<td>The practices, core disciplinary ideas, and crosscutting concepts from the framework for Pre-K–12 Science Education that were used to form the performance expectations.</td>
</tr>
<tr>
<td>What is Assessed</td>
<td>A collection of several performance expectations describing what students should be able to do to master this standard.</td>
</tr>
<tr>
<td>Connection Box</td>
<td>Other standards in the Next Generation Science Standards or in the Common Core State Standards that are related to this standard.</td>
</tr>
<tr>
<td>Science and Engineering Practices</td>
<td>Activities that scientists and engineers engage in to either understand the world or solve a problem.</td>
</tr>
<tr>
<td>Disciplinary Core Ideas</td>
<td>Concepts in science and engineering that have broad importance within and across disciplines as well as relevance in people’s lives.</td>
</tr>
<tr>
<td>Crosscutting Concepts</td>
<td>Ideas, such as Patterns and Cause and Effect, which are not specific to any one discipline but cut across them all.</td>
</tr>
</tbody>
</table>
Title and Performance Expectations

What is Assessed

A set of performance expectations describing what students should know and be able to do to master this 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.

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

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

### 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.
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+PS3-1); 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)

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

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
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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.
How is content articulated in the NGSS?
Review and discuss the progression of energy standards with a partner or your team.

Kindergarten  Grade 4  Middle School  High 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?

**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?

<table>
<thead>
<tr>
<th>Core Idea: Energy</th>
<th>Coherence</th>
<th>Cognitive Rigor</th>
<th>Integration with CCSS Math and Literacy</th>
<th>Integration with STEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>How do the Core Ideas progress K-12</td>
<td>Evidence:</td>
<td>Evidence:</td>
<td>Evidence:</td>
<td>Evidence:</td>
</tr>
</tbody>
</table>

What are the implications of NGSS for planning and teaching in your school?
What are the three dimensions of learning in the NGSS?
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
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?
Ottawa, Ontario, Canada Climate Graph (Altitude: 79m)

- Min Temp (°C)
- Average Temp (°C)
- Wet Days (>0.1mm)
- Rainfall (cm)
- Average Sunlight Hours/ Day
- Average Wind Speed (Beaufort)
- Relative Humidity (%)

Legend:
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
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.
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
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.
<table>
<thead>
<tr>
<th>5E</th>
<th>Practices</th>
<th>DCIs</th>
<th>Crosscutting</th>
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</thead>
<tbody>
<tr>
<td>Engage</td>
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**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.

http://www.nextgenscience.org/2-ls4-1-biological-evolution-unity-and-diversity
Three dimensions (ES)

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.
- Make observations (firsthand or from media) to collect data which can be used to make comparisons. (2-LS4-1)

Disciplinary Core Ideas
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)

Crosscutting Concepts
Scientific Knowledge is Based on Empirical Evidence
- Scientists look for patterns and order when making observations about the world. (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?
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.
Maryland and the NGSS: Where are We Going?
**Maryland Next Generation Science Standards Implementation and Planning Document**

### Ongoing Statewide Coordination and Collaboration to Support Teachers, Supervisors, Administrators

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Phase 4</th>
<th>Phase 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration, Awareness, and Statewide Capacity Building</td>
<td>Classroom Transitions, Shifts, and Practices</td>
<td>Leveraging Materials, Resources, and Expertise</td>
<td>Statewide Application, Assessment, and Coordination</td>
<td>Full PreK-12 Implementation</td>
</tr>
</tbody>
</table>

### 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


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/
Science Contacts

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Next Generation Science Standards
www.nextgenscience.org

National Academy of Sciences
http://sites.nationalacademies.org/dbasse/bose/framework_k12_s
  cience/index.htm