



Framework for K-12 Science Education:  
Practices, Crosscutting Concepts  
and Core Ideas

***The New National K-12 Science Standards:  
A 2-Step Process***

1. ***“Conceptual Framework for New Science Education Standards”***  
--- A National Academy of Science report by the NRC (National Research Council), came out *THIS MONTH!*
2. Actual standards will be written by *Achieve, Inc.* (finished late-2012???)

# National Research Council's *Conceptual Framework for New Science Education Standards*

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## Conceptual Framework for New Science Education Standards

On behalf of the National Research Council's (NRC) Committee on "A Conceptual Framework to Develop New Science Education Standards," I want to thank all of those who provided feedback on the draft framework which was available for public comment during the period from July 12 through August 2, 2010. Over 2,000 people responded to the on-line survey and hundreds more participated in discussion groups across the country. The committee has received a wide range of comments from a wide variety of perspectives; all of the feedback will be taken seriously by the committee as it finalizes its work.

The NRC committee has begun the process of summarizing and digesting the wide variety of suggestions expressed through the feedback and will be deciding on appropriate revisions to the framework as well as finishing writing the rest of its report. This process will take several months. Once the revisions are complete, the framework will undergo the traditional National Research Council confidential review by a diverse group of experts. After the committee revises its report in response to reviewers' comments, the framework report will be finalized and released to the public. We anticipate that the final version will not be publicly available until early 2011.

As you may know, the education nonprofit organization Achieve ([www.achieve.org](http://www.achieve.org)) will then work with a group of states to develop a set of standards for K-12 science education based on and guided by the final NRC committee framework report. Achieve's science work will be led by Stephen Pruitt who has recently joined the Achieve staff (and thus has resigned as a member of the NRC framework committee due to this appointment). Achieve has already begun planning and is currently developing a network of state partners. Further opportunities for public comment will be managed by Achieve as its work on the science education standards proceeds in 2011.

Thank you again for taking the time to review the committee's draft framework and for providing feedback. The input we received is invaluable to the committee as it moves forward with this important work.

**Question: What year did American schools first use any kind of standards?**

**Question: What year did American schools first use any kind of standards?**

**Answer: 1852**

→ **Horace Mann convinces Massachusetts to adopt the Prussian Education System**

→ **Started by Prussian King Frederick II in 1763 – made schooling compulsory for all children ages 5-13.**

## BRIEF HISTORY OF SCIENCE STANDARDS

- The Harvard Descriptive List of Physics Laboratories (1891)
- The Committee of Ten (1893)
- *A Nation at Risk* (National Commission on Excellence in Education, 1983)
- *Educating Americans for the 21<sup>st</sup> Century* (Commission on Precollege Education in Mathematics, Science, Technology of the National Science Board, 1983)
- PROJECT 2061 (1985)
- National Governors' Conference (1989)
- *Curriculum and Evaluation Standards for School Mathematics*(NCTM, 1989)
- *AMERICA 2000: An Education Strategy* (1991)
- *Benchmarks for Science Literacy* (AAAS, 1993)
- *GOALS 2000: Educate America Act* (1994)
- *National Science Education Standards* (1995)

# Major components of the Framework

- Vision of high quality science education
- Practices, crosscutting concepts, and disciplinary core ideas
- Guidance for standards developers
- Discussion of implementation issues
- Attendance to diversity and equity
- Suggestions for future research

# **NRC Conceptual Frameworks Committee**

## ***Science Content:***

**Helen Quinn**, Stanford, Chair (Physics)

**Wyatt Anderson**, University of Georgia (Biology)

**Tanya Atwater**, UCSB (Geophysics)

**Rodolfo Dirzo**, Stanford University (Bioecology)

**Phillip Griffiths**, Institute for Advanced Study (Mathematics)

**Dudley Herschbach**, Harvard University (Biology)

**Linda Katehi**, UC Davis (Engineering)

**John Mather**, NASA Goddard Space Flight Center (Astrophysics)

**Rebecca Richards-Kortum**, Rice University (Bioengineering)

## ***Education and Learning***

**Philip Bell**, University of Washington

**Thomas Corcoran**, Columbia University, Teachers College

**Tom Keller**, NRC

**Brett Moulding**, Utah Partnership for Effective Sci Teaching & Learning

**Jonathan Osborne**, Stanford

**James W. Pellegrino**, University of Illinois

**Stephen L. Pruitt**, Georgia Department of Education

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**Heidi Schweingruber**, NRC

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## Four Design Teams:

### ***Earth and Space Science:***

Michael Wysession, Washington University, St. Louis, MO (Team Lead)

Don Duggan-Haas, Museum of the Earth, Ithaca, NY

Scott Linneman, Western Washington University, Bellingham, WA

Eric Pyle, James Madison University, Harrisonburg, VA

Dennis Schatz, Pacific Science Center, Seattle, WA

### ***Life Science***

Rodger Bybee, BSCS, Colorado Springs, CO (Team Lead)

Bruce Fuchs, National Institutes of Health, Bethesda, MD

Kathy Comfort, WestEd, San Francisco, CA

Danine Ezell, Energy Project, San Diego, CA

### ***Physical Science***

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Shawn Stevens, University of Michigan, Ann Arbor, MI

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Arthur Eisenkraft, University of Massachusetts, Boston, MA

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### ***Engineering and Applied Science***

Cary Sneider, Portland State University, Portland, OR (Team Lead)

Rodney (Rod) L. Custer, Illinois State University, Normal, IL

Jacob (Jake) Foster, Mass. Dept Elementary & Secondary Ed, Malden, MA

Yvonne Spicer, Museum of Science, Boston, MA

Maurice Frazier, Chesapeake Public School System, Chesapeake, VA

# What is the Framework about?

- “The Framework is designed to help realize a vision for education in the natural 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.” (emphasis added)

# Framework Goals: By the end of Grade 12, students should be able to

- engage in public discussions on science-related issues,
- be critical consumers of scientific information related to their everyday lives,
- to continue to learn about science throughout their lives.
- to appreciate that science and the current scientific understanding of the world are the result of many hundreds of years of creative human endeavor

*(Chapter 1 page 3)*

## ***What's New??***

- Content that is shorter but deeper
- Fewer factoids; More process
- Greater integration among the sciences
- Greater integration with engineering and technology
- Greater integration of and focus on human-related content

# Three dimensions

- Scientific and engineering practices
- Crosscutting concepts
- Disciplinary core ideas

## Scientific and engineering practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology

## Scientific and engineering practices (cont')

6. Constructing explanations
7. Engaging in argument
8. Obtaining, evaluating, and communicating information

## Crosscutting concepts

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



## Recommendations for Standards Writers

- Recommendation 1: Standards should set rigorous learning goals that represent a common expectation for all students.
- Recommendation 2: Standards should be scientifically accurate yet also clear, concise, and comprehensible to science educators.
- Recommendation 3: Standards should be limited in number.
- Recommendation 4: Standards should emphasize all three dimensions articulated in the framework

## Recommendations *continued*

- Recommendation 5: Standards should include performance expectations that integrate the three dimensions. These expectations should require that students demonstrate knowledge-in-use and include criteria for identifying successful performance.
- Recommendation 6: Standards should incorporate boundary statements, including what does *not* need to be taught in order for students to achieve the standard.

## Recommendations *continued*

- Recommendation 7: Standards should be organized as sequences that support students' learning over multiple grades. They should take into account how students' command of the concepts, core ideas, and practices becomes more sophisticated over time with appropriate instructional experiences.

## Recommendations *continued*

- Recommendation 8: Whenever possible, the progressions in standards should be informed by existing research on learning and teaching.
  - In cases in which insufficient research is available to inform a progression, or in which there is a lack of consensus on the research findings, the progression should be developed on the basis of a reasoned argument about learning and teaching. The sequences described in the framework can be used as guidance.

## Recommendations *continued*

- Recommendation 9: The committee recommends that the diverse needs of students and of states be met by developing grade-band standards. For those states that prefer or require grade-by-grade standards, a suggested elaboration on grade-band standards could be provided.
- Recommendation 10: If grade-by-grade standards are written, these standards should provide a coherent progression within each grade band.

## Recommendations *continued*

- Recommendation 11: Any assumptions about the resources, time, and teacher expertise needed for students to achieve particular standards should be made explicit.
- Recommendation 12: The standards for the sciences and engineering should align coherently with those for other K-12 subjects. Alignment with the Common Core standards in mathematics and English/language arts is especially important.

## Recommendations *continued*

- Recommendation 13: In designing standards and performance expectations, issues related to diversity and equity need to be taken into account. In particular, performance expectations should provide students with multiple ways of demonstrating competence in science.

# Organizational Structure

- Core Idea (Ex. LS1)
  - Sub-ideas (Ex. LS1.A)
    - Grade-band endpoints (ex. By the end of grade 2)



# Life Sciences: Core Ideas

- LS1 - From Molecules to Organisms: Structures and Processes
- LS2 - Ecosystems: Interactions, Energy, and Dynamics
- LS3 - Heredity: Inheritance and Variation of Traits
- LS4 - Biological Evolution: Unity and Diversity

# Physical Sciences: Core Ideas

- PS1 - Matter and Its Interactions
- PS2 - Motion and Stability: Forces and Interactions
- PS3 - Energy
- PS4 - Waves and Their Applications in Technologies for Information Transfer

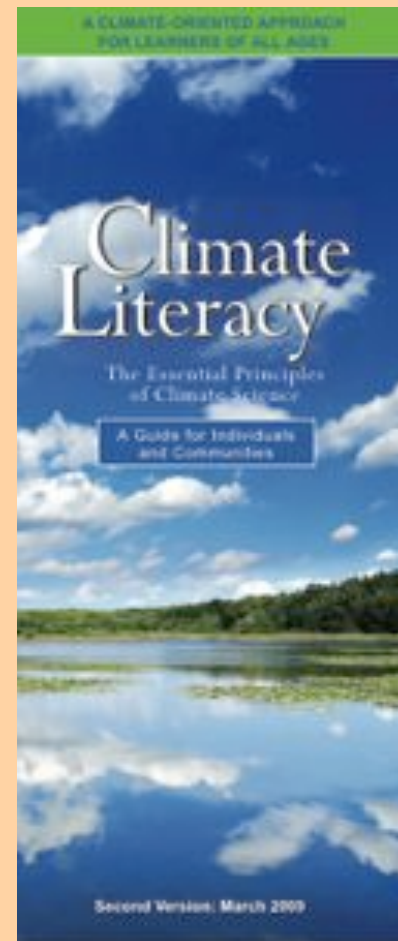
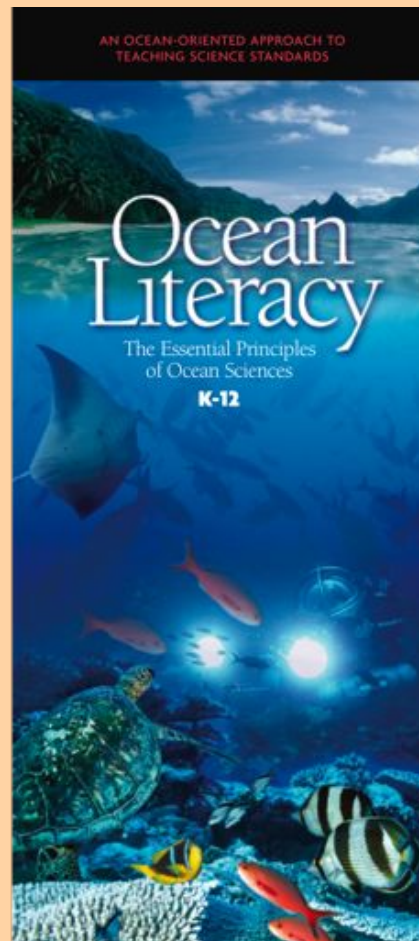
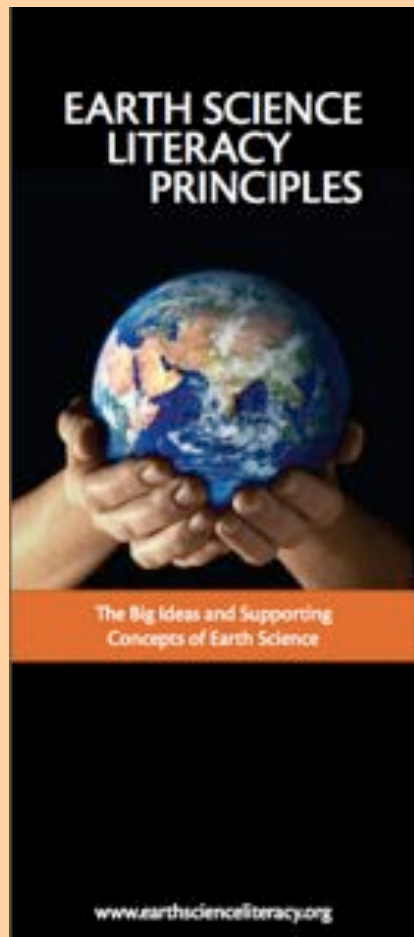
# Engineering, Technology, and Applications of Science Core Ideas

- ETS1 - Engineering Design
- ETS2 - Links Among Engineering, Technology, Science, and Society

# Earth and Space Sciences: Core Ideas

- ESS1 - Earth's Place in the Universe
- ESS2 - Earth's Systems
- ESS3 - Earth and Human Activity

Current work is supported by several recent community-organized literacy efforts  
→ Example, for Geoscience:



NAEP, College Board Earth Science, and Geoscience Literacy Principles

NAEP SCIENCE 2009 (NAGB, 2009)	College Board's 2009 Standards for College Success (Earth Science)	Geoscience Literacy Principles
<b>Earth in Space and Time:</b> Objects in the Universe	<ul style="list-style-type: none"> <li><b>Systems:</b> Planetary Evolution</li> </ul>	
<b>Earth in Space and Time:</b> History of Earth	<ul style="list-style-type: none"> <li><b>History:</b> Relative and Absolute Dating</li> <li><b>History:</b> Rock and Fossil Records</li> </ul>	<b>Earth:</b> Earth is 4.6 billion years old.
<b>Earth Structures:</b> Properties of Earth Materials	<ul style="list-style-type: none"> <li><b>Processes:</b> Rock-Forming Environment</li> </ul>	
<b>Earth Structures:</b> Tectonics	<ul style="list-style-type: none"> <li><b>Processes:</b> Tectonism</li> </ul>	<b>Earth:</b> Earth is continuously changing.
<b>Earth Systems:</b> Energy in Earth Systems	<ul style="list-style-type: none"> <li><b>Processes:</b> Earth's Surface</li> <li><b>Processes:</b> Energy Transfer</li> <li><b>Systems:</b> Atmosphere as a System</li> <li><b>Systems:</b> Oceans as a System</li> <li><b>Systems:</b> Lithosphere as a System</li> </ul>	<p><b>Earth:</b> Earth is a complex system of interacting rock, water, air, and life.</p> <p><b>Earth:</b> Earth is the water planet.</p> <p><b>Ocean:</b> Earth has one big ocean with many features.</p> <p><b>Atmos:</b> Earth has a thin atmosphere that sustains life.</p> <p><b>Atmos:</b> Energy from the Sun drives atmospheric processes.</p> <p><b>Atmos:</b> Earth's Atmosphere continuously interacts with the other components of the Earth System.</p> <p><b>Atmos:</b> Atmospheric circulations transport matter and energy.</p> <p><b>Climate:</b> The Sun is the primary source of energy for Earth's climate system.</p> <p><b>Climate:</b> Climate is regulated by complex interactions among components of the Earth System.</p>
<b>Earth Systems:</b> Climate and Weather	<ul style="list-style-type: none"> <li><b>Processes:</b> Weather Processes</li> <li><b>Systems:</b> Climate</li> </ul>	<p><b>Ocean:</b> The ocean is a major influence on weather and climate</p> <p><b>Atmos:</b> Earth's atmosphere changes over time and space, giving rise to weather and climate.</p> <p><b>Climate:</b> Climate varies over space and time through both natural and man-made processes.</p>
<b>Earth Systems:</b> Biogeochemical Cycles	<ul style="list-style-type: none"> <li><b>Matter&amp;Energy:</b> Water Cycle</li> <li><b>Matter &amp; Energy:</b> Carbon Cycle</li> </ul>	<p><b>Earth:</b> Life evolves on a dynamic Earth and continuously modifies Earth.</p> <p><b>Ocean:</b> The ocean supports a great diversity of life and ecosystems.</p> <p><b>Climate:</b> Life on Earth depends on, is shaped by, and affects climate.</p>
	<ul style="list-style-type: none"> <li><b>Humans:</b> Humans and Natural Resources</li> <li><b>Humans:</b> Humans and Natural Hazards</li> <li><b>Humans:</b> Humans' Impact on the Environment</li> </ul>	<p><b>Earth:</b> Humans depend on Earth for resources.</p> <p><b>Earth:</b> Natural hazards pose risks to humans.</p> <p><b>Earth:</b> Humans significantly alter the Earth.</p> <p><b>Ocean:</b> The ocean makes Earth habitable.</p> <p><b>Ocean:</b> The ocean and humans are inextricably interconnected.</p> <p><b>Atmos:</b> Earth's atmosphere and humans are inextricably linked.</p> <p><b>Climate:</b> Human activities are impacting the climate system.</p> <p><b>Climate:</b> Climate change will have consequences for the Earth System and human lives.</p>



College Board's 2009 Standards for College Success (Earth Science)		NRC Earth and Space Science
Dynamic Earth Processes: Earth's Surface		B11.1 (Earth's Place in the Universe): The Universe and its Stars
Dynamic Earth Processes: Energy Transfer		B11.2 (Earth's Place in the Universe): Earth and the Solar System
Dynamic Earth Processes: Tectonism		B11.3 (Earth's Place in the Universe): The History of Planet Earth
Dynamic Earth Processes: Weather Processes		B12.1 (Earth's Systems): Earth Materials and Systems
Dynamic Earth Processes: Rock-Forming Environment		B12.2 (Earth's Systems): Plate Tectonics and Large-Scale System Interactions
Systems: Atmosphere		B12.3 (Earth's Systems): The Roles of Water in Earth's Surface Processes
Systems: Oceans		B12.4 (Earth's Systems): Weather and Climate
Systems: Lithosphere		B12.5 (Earth's Systems): Biogeology
Systems: Climate		B13.1 (Human Interactions): Natural Hazards
Systems: Planetary Evolution		B13.2 (Human Interactions): Natural Resources
Earth's History: Relative and Absolute Dating		B13.3 (Human Interactions): Human Impacts on Earth Systems
Earth's History: Rock and Fossil Records		B13.4 (Human Interactions): Global Climate Change
Cycles of Matter and Energy: Water Cycle		
Cycles of Matter and Energy: Carbon Cycle		
Humans and the Environment: Natural Resources		
Humans and the Environment: Natural Hazards		
Humans and the Environment: Humans' Impact		

# NSES (1996): Earth and Space Science

TABLE 6.4. EARTH AND SPACE SCIENCE STANDARDS

<b>LEVELS K-4</b>	<b>LEVELS 5-8</b>	<b>LEVELS 9-12</b>
Properties of earth materials	Structure of the earth system	Energy in the earth system
Objects in the sky	Earth's history	Geochemical cycles
Changes in earth and sky	Earth in the solar system	Origin and evolution of the earth system
		Origin and evolution of the universe



# NSES (1996): Science in Personal and Social Perspectives

TABLE 6.6. SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

<b>LEVELS K-4</b>	<b>LEVELS 5-8</b>	<b>LEVELS 9-12</b>
Personal health	Personal health	Personal and community health
Characteristics and changes in populations	Populations, resources, and environments	Population growth
Types of resources	Natural hazards	Natural resources
Changes in environments	Risks and benefits	Environmental quality
Science and technology in local challenges	Science and technology in society	Natural and human-induced hazards Science and technology in local, national, and global challenges

## 1996 National Science Education Standards and the 2011 NRC Framework

National Science Education Standards (1996)		NRC Earth and Space Science
Properties of Earth Materials (K-4)		B11.1 (Earth's Place in the Universe): The Universe and its Stars
Structure of the Earth System (5-8)		B11.2 (Earth's Place in the Universe): Earth and the Solar System
Energy in the Earth System (9-12)		B11.3 (Earth's Place in the Universe): The History of Planet Earth
Geochemical Cycles (9-12)		B12.1 (Earth's Systems): Earth Materials and Systems
Objects in the Sky (K-4)		B12.2 (Earth's Systems): Plate Tectonics and Large-Scale System Interactions
Changes in Earth and Sky (K-4)		B12.3 (Earth's Systems): The Roles of Water in Earth's Surface Processes
Earth's History (5-8)		B12.4 (Earth's Systems): Weather and Climate
Earth in the Solar System (5-8)		B12.5 (Earth's Systems): Biogeology
Origin and Evolution of the Earth System (9-12)		B13.1 (Human Interactions): Natural Hazards
Origin and Evolution of the Universe (9-12)		B13.2 (Human Interactions): Natural Resources
Types of Resources (K-4)		B13.3 (Human Interactions): Human Impacts on Earth Systems
Changes in Environments (K-4)		B13.4 (Human Interactions): Global Climate Change
Populations, Resources, and Environments (5-8)		
Natural Hazards (5-8)		
Population Growth (9-12)		
Natural Resources (9-12)		
Environmental Quality (9-12)		
Natural and Human-Induced Hazards (9-12)		

# Earth and Space Sciences: Core Ideas

- ESS1 - Earth's Place in the Universe
- ESS2 - Earth's Systems
- ESS3 - Earth and Human Activity

# ESS1 - Earth's Place in the Universe

- ESS1.A: The Universe and Its Stars
- ESS1.B: Earth and the Solar System
- ESS1.C: The History of Planet Earth

## ESS2 - Earth's Systems

- ESS2.A: Earth Materials and Systems
- ESS2.B: Plate Tectonics and Large-Scale System Interactions
- ESS2.C: The Roles of Water in Earth's Surface Processes
- ESS2.D: Weather and Climate
- ESS2.E: Biogeology

# ESS3 - Earth and Human Activity

- ESS3.A: Natural Resources
- ESS3.B: Natural Hazards
- ESS3.C: Human Impacts on Earth Systems
- ESS3.D: Global Climate Change

***What's Next??***

## ***What Happened....***

- 1989, President George H.W. Bush organized a Governor's meeting to attempt a standards-based approach to school reform. Result was only a vague endorsement of "voluntary national standards" (didn't go far).  
(Politics of "National" "Standards")



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(Politics of "National" "Standards")

- 1994, President Bill Clinton raised federal money for standards-based reform. Effort left up to states, leading to wild variety of expectations and ideological battles over Math and English curricula.

## ***What Happened....***

- 2001, President George W. Bush pushes through No Child Left Behind.
  - Requires that each state ensures that its students achieve "universal proficiency" in Reading and Math

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  - States get to determine their own standards, resulting in a "Race to the Bottom" as standards are set low enough to obtain "universal proficiency"
    - Example: Mississippi. According to the standards they set for themselves, 89% of Mississippi 4<sup>th</sup>-graders were proficient in reading (best in the country). According to NAEP (National Assessment of Educational Progress), only 18% of 4<sup>th</sup>-graders were proficient in reading (worst in the country).

## ***What Happened....***

2009, President Barack Obama and Secretary of Education Arne Duncan announce \$4.35 billion for "Race to the Top" funds as part of the Stimulus Package

→ Incentives for states to make "dramatic progress" in meeting goals that include improving standards.

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→ March 29, 2010 – Delaware and Tennessee win Phase 1 funding

→ August 24, 2010 – Phase 2 funding goes to the District of Columbia, Florida, Georgia, Hawaii, Maryland, Massachusetts, New York, North Carolina, Ohio, and Rhode Island



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## Common Standards

Building on the excellent foundation of standards states have laid, the Common Core State Standards are the first step in providing our young people with a high-quality education. It should be clear to every student, parent, and teacher what the standards of success are in every school.

[Learn more »](#)



Common Standards



State Adoption



Voices of Support

### Mission Statement

The Common Core State Standards provide a consistent, clear understanding of what students are expected to learn, so teachers and parents know what they need to do to help them. The standards are designed to be robust and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers. With American students fully prepared for the future, our communities will be best positioned to compete successfully in the global economy.

### Common Core State Standards Webinar

Recorded Wednesday, June 30, 2010



DOWNLOAD THE PRESENTATION



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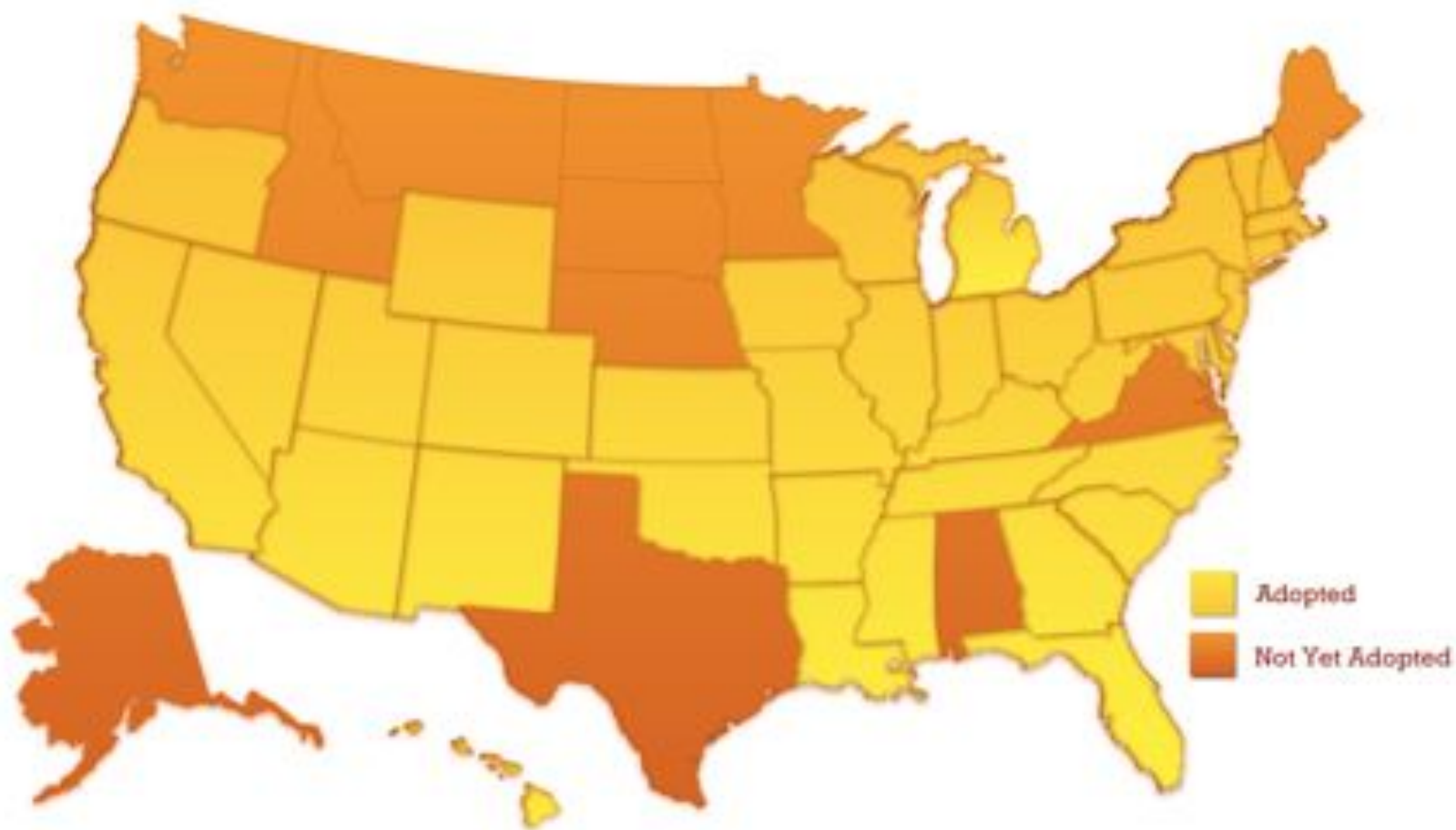
## “Achieve, Inc.!”

Created in 1996 by the nation's governors (CCSSO - The National Governors Association and the Council of Chief State School Officers) and corporate leaders, Achieve is an independent, bipartisan, non-profit education reform organization based in Washington, D.C. that helps states raise academic standards and graduation requirements, improve assessments and strengthen accountability.



The screenshot shows the Achieve website homepage. At the top, there is a navigation bar with links for Home, About, News, Research, Policy, and Contact. Below the navigation bar, the main content area features a large header with the Achieve logo and a brief description of the organization. The central focus is the "AMERICAN DIPLOMA PROJECT NETWORK" section, which includes a map of the United States and text explaining the network's mission. To the right, there is a sidebar with a search bar and several featured resources, including "Achieving the Dream", "PERSPECTIVE", "MATH WORKS", "CONNECTION", "BUSINESS TOOLS", and "Taking Root". The footer contains contact information and a copyright notice.

## In the States





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# Next Generation Science Standards

A joint effort between Achieve, the National Science Teachers Association, the American Association for the Advancement of Science, and the National Research Council is underway to create the foundations for all students to have a solid K-12 science education.

Starting in fall 2009, the National Research Council convened an expert panel to lay the groundwork for the development of a Conceptual Framework that will reflect the best thinking on the nature of the science and engineering education that is needed in the 21st century. A draft of the framework was released in July 2010, and once the final version is released in 2011, Achieve will develop—along with states and other interested stakeholders—next-generation science education standards that are faithful to the NRC Framework, internationally-benchmarked, and rigorous.

### Why is there a two-step process for the development of science standards?

Since the input of the science community is critical to getting the science right, and given that it has been 15 years since science education standards were last revised at

## RELATED CONTENT

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- [National Research Council](#)
- [NRC Science Results News Statement](#)
- [Opportunity Education website](#)
- [OverAchievers Next-Generation Science](#)
- [NRC Frameworks](#)
- [International Science Benchmarking Report](#)
- [Benchmarking for Success](#)
- [Achieve APSC Report](#)

## SEARCH

10/11/10



## From the OverAchievers

news, research and opinions from Achieve staff

### The Economic Value of College and Career Readiness

It is no secret that there is a skills gap in America. Employers are concerned about the ability of our graduates to think critically, communicate well and perform basic tasks in...

10/11/10

PERSPECTIVE

PARCC  
Partnership for Assessment of Readiness for College and Careers

MATH  
WORKS

Taking Root

***National “Next Generation” Science Standards now being written by Achieve, Inc.:***

- The content will be taken from the Framework, but will be combined into complete standards that integrate concepts, big ideas, and practices.
- These are ***not*** part of the “Common Core” (there **will be no** Common Core science standards)
- These will hopefully be adopted by many states or play a major role in influencing new state standards (“*Build it and they will come.*”)