Introducing today’s presenters…

Ted Willard
National Science Teachers Association

Brian Reiser
Northwestern University
Developing the Standards
Developing the Standards
Developing the Standards
Developing the Standards

NRC
July 2011

NEXT GENERATION
SCIENCE
STANDARDS
For States, By States

Achieve
2011-2013

NSTA
Developing the Standards

NRC
July 2011

Achieve
2011-2013

Assessments
Curricula
Instruction
Teacher Development

NEXT GENERATION SCIENCE STANDARDS
For States, By States
NGSS Lead State Partners

Achieve

[Map of the United States with certain states shaded in blue]
NGSS Development Process

In addition to a number of reviews by state teams and critical stakeholders, the process includes two public reviews.

- 1st Public Draft was in May 2012
- 2nd Public Draft will take place in the Fall of 2012

Final Release is expected in the Spring of 2013
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\textbf{IT’S NOT OUT YET!}
A Framework for K-12 Science Education

- Released in July 2011
- Developed by the National Research Council at the National Academies of Science
- Prepared by a committee of Scientists (including Nobel Laureates) and Science Educators.
A Framework for K-12 Science Education

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National Science Teachers Association
www.nsta.org/store
A Framework for K-12 Science Education

Three-Dimensions:

- Scientific and Engineering Practices
- Crosscutting Concepts
- Disciplinary Core Ideas
Scientific and Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
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8. Obtaining, evaluating, and communicating information
Crosscutting Concepts

1. Patterns
2. Cause and effect: Mechanism and explanation
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter: Flows, cycles, and conservation
6. Structure and function
7. Stability and change
## Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>Life Science</th>
<th>Physical Science</th>
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<tr>
<td>LS1: From Molecules to Organisms: Structures and Processes</td>
<td>PS1: Matter and Its Interactions</td>
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<td>LS2: Ecosystems: Interactions, Energy, and Dynamics</td>
<td>PS2: Motion and Stability: Forces and Interactions</td>
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<td>LS3: Heredity: Inheritance and Variation of Traits</td>
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<td>LS4: Biological Evolution: Unity and Diversity</td>
<td>PS4: Waves and Their Applications in Technologies for Information Transfer</td>
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<td>ESS3: Earth and Human Activity</td>
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Closer Look at a Performance Expectation

**MS.PS-SPM.a. Structure and Properties of Matter**

Students who demonstrate understanding can:

a. Construct and use models to explain that atoms combine to form new substances of varying complexity in terms of the number of atoms and repeating subunits. [Clarification Statement: Examples of atoms combining can include Hydrogen (H₂) and Oxygen (O₂) combining to form hydrogen peroxide (H₂O₂) or water(H₂O). [Assessment Boundary: Restricted to macroscopic interactions.]

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Performance expectations combine practices, core ideas, and crosscutting concepts into a single statement.
Closer Look at a Performance Expectation

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Preparing for NGSS:
The Practices of Asking Questions and Defining Problems

Brian J. Reiser

Learning Sciences,
Northwestern University
Overview

- Intro to practices in NRC Framework and NGSS
- Defining the practices of asking questions and defining problems
- Classroom example: Asking questions and explanation
- Classroom example: Defining problems in designing solutions
The NRC Framework and NGSS
The NRC Framework and NGSS
The NRC Framework and NGSS

What is new?
1. Organized around core explanatory ideas
2. Coherence: building and applying ideas across time
3. Central role of scientific practices
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 and computational thinking
6. Developing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
Evolution from Inquiry to Scientific Practices

- THE REAL WORLD
  - Ask Questions
  - Observe
  - Experiment
  - Measure
- COLLECT DATA
  - TEST SOLUTIONS
  - Investigating

ARGUE CRITIQUE ANALYZE

- THEORIES AND MODELS
  - Imagine
  - Reason
  - Calculate
  - Predict
- FORMULATE HYPOTHESES
  - PROPOSE SOLUTIONS
- Developing Explanations and Solutions

THE NATIONAL ACADEMIES
Evolution from Inquiry to Scientific Practices

**THE REAL WORLD**
- Ask Questions
- Observe
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- Measure

**Inquiry**
- Collect Data
- Test Solutions
- Investigating

**ARGUE CRITIQUE ANALYZE**

**THEORIES AND MODELS**
- Imagine
- Reason
- Calculate
- Predict

**FORMULATE HYPOTHESES**
- Propose Solutions

**Developing Explanations and Solutions**

**Inquiry**
Evolution from Inquiry to Scientific Practices

NGSS: Social Interaction and Discourse

The Real World
- Ask Questions
- Observe
- Experiment
- Measure

COLLECT DATA
- TEST SOLUTIONS

Inquiry
- Investigating

ARGUE CRITIQUE ANALYZE

Evaluating

Theories and Models
- Imagine
- Reason
- Calculate
- Predict

FORMULATE HYPOTHESES
- PROPOSE SOLUTIONS

Developing Explanations and Solutions

NGSS: Knowledge Building
- Inquiry
### Which Practices Are Common for Students Learning Science in Your School?

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<thead>
<tr>
<th>Practice</th>
<th>Common or Rare</th>
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Performance Expectation from the 3 Dimensions

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MS.LS-MECE  Matter and Energy in Organisms and Ecosystems

Students who demonstrate understanding can:

...  
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**Science and Engineering Practices**

**Developing and Using Models**
Use and/or construct models to predict, explain, and/or collect data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs. (c)

---

**Disciplinary Core Ideas**

**LS1.C: Organization for Matter and Energy Flow in Organisms**
- In most animals and plants, oxygen reacts with carbon-containing molecules (sugars) to provide energy and produce carbon-dioxide; anaerobic bacteria achieve their energy needs in other chemical processes that do not need oxygen. (c)

**LS2.B: Cycle of Matter and Energy Transfer in Ecosystems**
- Food webs are models that demonstrate how matter and energy is transferred between producers (generally plants and other organisms that engage in photosynthesis), consumers, and decomposers as the three groups interact—primarily for food—within an ecosystem

---

**Crosscutting Concepts**

**Systems and System Models—**Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. Models are limited in that they only represent certain aspects of the system under study. (c)

**Energy and Matter**
Matter is conserved because atoms are conserved in physical and chemical processes. Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.
Questions about the big picture of practices in NGSS?
ASKING QUESTIONS & DEFINING PROBLEMS
Asking Questions and Defining Problems

Science...

• ...begins with a question about a phenomenon, e.g. “Why is the sky blue?”
• ...seeks to develop theories that provide explanatory answers
• ...formulating empirically answerable questions about phenomena.
• GOAL: explanations, models, theories
Asking Questions and Defining Problems

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Engineering...
- ...begins with a **problem** or **need**, e.g., “designing improved solar cells”
- ...ask questions to define the engineering problem, determine criteria for a successful solution, and identify constraints.
- GOAL: a solution that balances criteria (e.g., feasibility, cost, safety, legal requirements) to address the problem
By Grade 12 students should be able to...

• Ask *explanatory* questions about the natural and human-built worlds (e.g., *How do bees get food? Why did that bridge collapse?*)
• Formulate and refine questions that can be answered empirically
• Use questions to design an inquiry or construct solutions to problems.
• Ask probing questions as part of scientific argumentation to develop models, explanations, and problem solutions
  – Identify the premises of an argument
  – Ask for elaboration of reasoning
  – Question interpretations, propose alternatives
  – Refine a research question or engineering problem
  – Define an engineering need, define constraints, challenge solutions
  – *How do you know? What evidence supports that argument?*
Where do Questions Come From?

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- ARGUE CRITIQUE ANALYZE

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Where Do Questions Lead?

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TEST SOLUTIONS

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Developing Explanations and Solutions
CLASSROOM EXAMPLE:
ASKING QUESTIONS
Driving question
What is going on inside our bodies that helps us get energy to do the things we do?

(from NSF-funded middle school materials, published 2012)
Driving question
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Questions
What is my body made of?

Investigations
Microscope investigations

Explanations
We are made out of cells.
Driving question
What is going on inside our bodies that helps us get energy to do the things we do?

Questions
- What is my body made of?
- Where does food go?

Investigations
- Microscope investigations
- Food digestion, blood glucose

Explanations
- We are made out of cells.
- Food goes thru digestive system into blood stream.
**Questions**

- What is my body made of?
- Where does food go?
- Where is blood taking the food?

**Explanations**

- We are made out of cells.
- Food goes thru digestive system into blood stream.
- Blood stream takes food to cells all over the body.

**Driving question**

What is going on inside our bodies that helps us get energy to do the things we do?
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What is going on inside our bodies that helps us get energy to do the things we do?

Questions
- What is my body made of?
- Where does food go?
- Where is blood taking the food?
- Can food get into the cells?

Investigations
- Microscope investigations
- Food digestion, blood glucose
- Trace food in circ. system
- Onion cell, cell model exps.

Explanations
- We are made out of cells.
- Food goes thru digestive system into blood stream.
- Blood stream takes food to cells all over the body
- Both water and glucose can cross membrane to get in
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<td>Lower O₂ in exhaled air</td>
<td>Oxygen used in chemical reaction to release energy from food.</td>
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Organizing investigations around questions

Driving question

Questions
- Investigation Question
- Investigation question
- Investigation question

Investigations
- Investigation of phenomena
- Investigation of phenomena
- Investigation of phenomena

Explanations
- Initial explanation
- Add to/revise explanation
- Add to/revise explanation

Real world and classroom phenomena
“After being inhaled, oxygen goes through the respiratory system, then the circulation system or blood, and goes throughout the body to all the cells. Oxygen is used to burn the food the body needs and get energy for the cells for the body to use. For anything to burn, it must have energy and oxygen. To then get the potential energy in food, the body needs oxygen, because it is a reactant. When we burned the cashew, the water above it increased, giving it thermal energy and heating it up. Therefore, food is burned with oxygen to get energy.”

(Source: 7th grade, suburban district, Apr 2010)
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Questions so far?
CLASSROOM EXAMPLE: DEFINING PROBLEMS
Defining a problem

- Big question: *How does water quality affect the ecology of a community?*
- Disciplinary core ideas: population interactions, abiotic factors in ecosystems; water flow in ecosystems; watersheds

*(from NSF-funded middle school materials, published 2010)*
Scenario

FabCo Wants to Move In
A mid-sized manufacturing company called FabCo has contacted the town council. FabCo manufactures cloth. FabCo is looking for a new location to build its company headquarters and manufacturing plant. FabCo is very interested in relocating to Wamego...
Initial Definition of the Problem

Sounds Great! So, What’s the Problem?

Many of the residents, including some town council members, are concerned. They worry that FabCo could mean problems for their community. Now the land is used for agriculture. If FabCo comes to town, the use of the land will change. The land will be needed for residential, commercial, and industrial purposes. Some people wonder if this will change the river and the wildlife of Wamego.

Ten miles downstream is the resort town of St. George. People use the river for fishing, swimming, boating, hiking, and camping in the area. The residents of are worried that the changes in Wamego might affect their lives.
As you answer the *Big Question*, you will also take on the challenge of giving advice to the town council of Wamego. What should they take into account in deciding whether or not to let FabCo move in? What will be the ecological advantages of FabCo building its *plant* in Wamego? What ecological problems might the project cause? What ecological problems do you think might arise if FabCo moves in? What do you need to know more about to give the Wamego town council advice?
Central performance expectation:

- Students should be able to present evidence to the Wamego town council that would explain what will or might happen to the town’s water and land resources if a new manufacturing facility is built along the river.

Practices:

- Defining problems
- Designing solutions
- Argument from Evidence
Project Board to Track Questions and Ideas

Create a Project Board

- What do we think we know?
- What do we need to investigate?
- What are we learning?
- What is our evidence?
- What does it mean for the challenge or question?

To get started on this Project Board, you need to identify and record the important science question you need to answer: How does water quality affect the ecology of a community? You also need to record your challenge: What advice should we give Wamego?
How does water quality affect the ecology of a community?

1) I will be concerned about the turbidity and trout living condition changes when FabCo moves in.

2) FabCo would make waste water to affect the pH, dissolved oxygen, and temperature levels (which are the narrow trout living conditions), and when FabCo is built it would clear out soil affecting turbidity.

3) With bad living conditions, the trout will clear out and die out. So then the food web will be altered and changed. The ecosystem will also be in danger and also will animal population.

4) I suggest FabCo move closer to Hwy 24, away from the river, so exposed soil will be less likely dumped into the river. Also, FabCo’s waste water should be limited, cooled, and purified as much as possible before being dumped, like pouring it into a hole in the ground, filling it, and then dumping it.

5) As soon as FabCo’s plant is finished, a turbidity test should be taken. Another should be taken the next rainfall. Also, every week starting the day after moving in, pH, dissolved oxygen, and temperature tests must be taken.
How does water quality affect the ecology of a community?

FabCo would make wastewater to affect the pH, dissolved oxygen, and temperature levels (which are the narrow trout living conditions). And when Fabco is built, it would clear out soil, affecting turbidity.
How does water quality affect the ecology of a community?

With bad living conditions, the trout will clear out or die out. So then the food web will be altered and change. The ecosystem will also be in danger, and so will animal populations.
How does water quality affect the ecology of a community?

I suggest FabCo move closer to Highway, away from the river, so exposed soil will be less likely dumped into the river. Also FabCo’s waste water should be limited, cooled, and purified as much as possible, before being dumped, like pouring it into a hole in the ground, filtering it, and then dumping it.
Defining Problems Leads to...

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 and computational thinking
6. Developing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
Defining Problems Leads to...

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**Example Performance Expectation from DRAFT NGSS**

<table>
<thead>
<tr>
<th>HS.PS-E</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students who demonstrate understanding can:</td>
<td></td>
</tr>
<tr>
<td><strong>HS.PS-E.f. Identify problems and suggest design solutions to minimize or slow the energy flow into or out of a system to counteract a system’s tendency to move toward equilibrium.</strong> [Clarification Statement: Design solution examples can include insulation, microchip temperature control, cooking electronics, and roller coaster design.] [Assessment Boundary: Design solutions are limited to mechanical and thermal systems.] (c)</td>
<td></td>
</tr>
</tbody>
</table>
| The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Asking Questions and Defining Problems</strong></td>
<td><strong>PS3.B: Conservation of Energy and Energy Transfer</strong></td>
<td></td>
</tr>
<tr>
<td>Define a problem about the natural or designed world considering criteria for successful results or solutions and constraints or limits on acceptable solutions.</td>
<td>- Uncontrolled systems always evolve toward more stable states...</td>
<td></td>
</tr>
<tr>
<td><strong>Constructing Explanations and Designing Solutions</strong></td>
<td><strong>PS3.D: Energy in Chemical Processes</strong></td>
<td></td>
</tr>
<tr>
<td>Apply scientific knowledge to solve design problems by taking into account possible unanticipated effects.</td>
<td>- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment...</td>
<td></td>
</tr>
<tr>
<td><strong>Systems and System Models</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Systems can be designed to do specific tasks. When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions: Asking Questions and Defining Problems

• *Real* questions and problems are not just an exercise.
• Teachers and curriculum materials can anchor the process, but students need to construct questions and problems.
• Questions/problems lead to investigations, explanations designs, arguments from evidence.
• Teachers and curriculum materials need to support the integration of the practices to make them meaningful and effective for learning.
The Importance of Questions

Half of science is putting forth the right questions. – Sir Francis Bacon, 16th century

My mother made me a scientist without ever intending to. Every other Jewish mother in Brooklyn would ask her child after school: So? Did you learn anything today? But not my mother. “Izzy,” she would say, “did you ask a good question today?” That difference — asking good questions — made me become a scientist. – Isidor Isaac Rabi (1898-1988), American Physicist, Nobel Laureate
Student Questions Open Up Possibilities in Classroom Science

All adventures, especially into new territory, are scary.
– Sally Ride (1951-2012), Physicist; First American woman in Space; Founder, Sally Ride Science
Questions?
Follow up questions:

Brian J. Reiser
Learning Sciences, Northwestern University
Reiser@northwestern.edu
NSTA Efforts around NGSS
NSTA Outreach

- Inform science education community about the NGSS draft
- Encourage science educators to have a voice by engaging in the review process
- Help educators study and learn more about the document
NSTA Website (nsta.org/ngss)
<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/11</td>
<td>Asking Questions and Defining Problems</td>
<td>Brian Reiser</td>
</tr>
<tr>
<td>9/25</td>
<td>Developing and Using Models</td>
<td>Christina Schwartz and Cynthia Passmore</td>
</tr>
<tr>
<td>10/9</td>
<td>Planning and Carrying Out Investigations</td>
<td>Rick Duschl</td>
</tr>
<tr>
<td>10/23</td>
<td>Analyzing and Interpreting Data</td>
<td>Ann Rivet</td>
</tr>
<tr>
<td>11/6</td>
<td>Using Mathematics and Computational Thinking</td>
<td>Robert Mayes and Bryan Shader</td>
</tr>
<tr>
<td>11/20</td>
<td>Constructing Explanations and Designing Solutions</td>
<td>Katherine McNeill and Leema Berland</td>
</tr>
<tr>
<td>12/4</td>
<td>Engaging in Argument from Evidence</td>
<td>Joe Krajcik</td>
</tr>
<tr>
<td>12/18</td>
<td>Obtaining, Evaluating and Communicating Information</td>
<td>Philip Bell, Leah Bricker, and Katie Van Horne</td>
</tr>
</tbody>
</table>

All take place on Tuesdays from 6:30-8:00 pm ET
Next Web Seminar
September 25th (two weeks from today)

Developing and Using Models

Teachers will learn more about:

- how modeling tools are used to develop questions, predictions, and explanations, analyze and identify flaws in systems, and communicate ideas;
- methods where models are used to build and revise scientific explanations and proposed engineered systems; and
- how measurements and observations are used to revise models and designs.

Christina Schwarz
Michigan State University

Cindy Passmore
University of California, Davis
Graduate Credit Available

Shippensburg University will offer one (1) graduate credit to individuals who attend or view all eight webinars.

Participants must either:

- Attend the live presentation, complete the survey at the end of the webinar, and obtain the certificate of participation from NSTA, or
- View the archived recording and complete the reflection question for that particular webinar.

In addition, all participants must complete a 500 word reflection essay.

The total cost is $165.

For information on the course requirements, as well as registration and payment information visit www.ship.edu/extended/NSTA
Community Forums

Pedagogy and Research Forums

- **Evaluation and Assessment**
  A public forum discussing formative, summative, and dynamic assessments and evaluations.
  - 35 Topics
  - 398 Posts
  - Last Post: by Eugene Pascual, Sat Sep 08, 2012 5:58 PM
  - IPAD & IPOD Assessment tools

- **New Teachers**
  - 11 Topics
  - 141 Posts
  - Last Post: by Maureen Stover, Thu Sep 06, 2012 2:47 PM
  - First Day/Week of School

- **Next Generation Science Standards**
  - 0 Topics
  - 0 Posts

- **Professional Development**
  - 65 Topics
  - 752 Posts
  - Last Post: by Janice Eala, Sat Sep 08, 2012 3:50 AM
  - Summer Conferences, Workshops etc

- **Research in Science Education**
  Science educators discuss the classroom implications of the latest science education research.
  - 29 Topics
  - 340 Posts
  - Last Post: by Carolyn Mohr, Yesterday, 10:20 AM
  - Pressing challenges facing Science education today
These three conferences will include a number of sessions about the K–12 Framework and the highly anticipated Next Generation Science Standards.

Among the sessions will be an NSTA sponsored session focusing on the Scientific and Engineering Practices.
NSTA Print Resources

NSTA Reader’s Guide to the Framework

NSTA Journal Articles about the Framework and the Standards
Thank you to the sponsor of tonight’s web seminar:

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