NGSS = Career and College Ready
Making the Case

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http://www.create4stem.msu.edu/ngss

Developed for the Introduction to the Next Generation Science Standards, Michigan State University, May 28, 2013
College and Career Ready

Session Objectives –

• Clarify CCR expectations (university expectations)
• Clarify NGSS role in meeting CCR expectations
• Answer your questions and discussion
NGSS CCR Review

- Michigan team 7 members
- MSU, CMU, LCC, WestShore CC, MDE
Shifting University STEM goals

- Prepare students to engage in evidenced-based reasoning and thinking on scientific problems
- Solve scientific problems through the design and construction of experiments
- Collaborate and communicate about science

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Recognition of Need to Change
NRC Report: Assessing 21st Century Skills
21st Century Skills

- **Cognitive Skills**: non-routine problem solving, critical thinking, systems thinking

- **Interpersonal Skills**: complex communication, social skills, teamwork, cultural sensitivity, dealing with diversity

- **Intrapersonal Skills**: self-management, time management, self-development, self-regulation, adaptability, executive functioning
Helping students learn to think

- Addition of more authentic inquiry at the university level
- Requires students to:
  - Ask questions and define problems
  - Plan and carry out investigations
  - Analyze and interpret data
  - Construct explanations

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Depth vs. Breadth

- High school (and colleges) have focused on breadth
- Breadth encourages:
  - Memorization
  - Few connections between poorly understood concepts
  - Mixing of ideas
- Need to focus less on content, more depth on core ideas
  - Research data supports this approach
  - Identification of core concepts (role of NGSS)
College and Career Ready Students

- Use **technology and tools** strategically in learning and communicating
- Use **argument and reasoning** to do research, construct arguments, and critique the reasoning of others
- **Communicate and collaborate** effectively with a variety of audiences
- **Solve problems**, construct explanations and design solutions

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### Characteristics of Career and College Ready Students

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<tbody>
<tr>
<td><strong>Technology and Tools</strong></td>
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<tr>
<td>• R.7 Integrate and evaluate content presented in diverse formats and media</td>
<td>• Use mathematics, information and computer technology, and computational thinking</td>
<td>• CE 1.3.1 Compose written, spoken, and/or multimedia compositions in a range of genres ... that serve a variety of purposes</td>
<td>• Use appropriate tools strategically</td>
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<td>• Use digital media and visual displays of data to express information SL5; produce and publish writing, interact and collaborate with others W.6; and gather relevant information from multiple sources. W.8</td>
<td>• Develop and use models</td>
<td>• P2.3 Know how to find and organize information from a variety of sources</td>
<td>• Model with mathematics</td>
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<td><strong>Argument and Reasoning</strong></td>
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<td>• Evaluate argument and claims in a text R.8, speech SL3; or write arguments to support claims W.1</td>
<td>• Engage in argument from evidence</td>
<td>• P1.5 Present a coherent thesis when making an argument, support with evidence, articulate and answer possible objections, and present a concise, clear closing.</td>
<td>• Construct viable arguments and critique the reasoning of others</td>
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<td>• W.9 Draw evidence from literary and informational texts to support analysis, reflection, and research</td>
<td>• Analyze and interpret data</td>
<td>• P3.3 Write persuasive/argumentative essays expressing and justifying decisions on public policy issues.</td>
<td>• Reason abstractly and quantitatively</td>
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<td>• SL.4 Present information, findings, and supporting evidence</td>
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<td><strong>Communication and Collaboration</strong></td>
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<td>• SL.1 Effectively converse and collaborate with diverse partners</td>
<td>• Obtain, evaluate, and communicate information</td>
<td>• CE 1.4.3 Develop and refine a position, claim... that will be explored and supported by analyzing different perspectives</td>
<td>• Attend to precision</td>
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<td>• L.3 Use language to comprehend more fully when reading or listening</td>
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<td>• P3.2 Deeply examine policy issues in group discussions and debates (clarify issues, consider opposing views, apply democratic values or constitutional principles, anticipate consequences) to make reasoned and informed decisions.</td>
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<td>• W.4 Produce clear and coherent writing</td>
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<td><strong>Problem Solving</strong></td>
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<tr>
<td>• SL.2 Integrate multiple sources of information in order to make informed decisions and solve problems</td>
<td>• Ask questions (science) and define problems (engineering)</td>
<td>• P3.1 Clearly state an issue as a question of public policy, trace the origins of an issue, analyze various perspectives, and generate and evaluate possible alternative resolutions.</td>
<td>• Make sense of problems and persevere in solving them.</td>
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<td>• W.7 Conduct research projects</td>
<td>• Plan and carry out investigations</td>
<td>• P2.5 Use deductive and inductive problem-solving skills as appropriate to the problem being studied.</td>
<td>• Look for and make sense of structure.</td>
</tr>
<tr>
<td>• <strong>Michigan ELA/Literacy Anchor Standards</strong></td>
<td>• Construct explanations (science) and design solutions (engineering)</td>
<td>• Look for and express regularity in repeated reasoning</td>
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How does NGSS help us achieve these goals?

All students no matter what their future education and career path must have a solid K–12 science education in order to be prepared for college, careers, and citizenship. – NGSS Appendix A, Conceptual Shifts
Science Practices
NGSS and AP/College Board

- Asking questions (science) and defining problems (engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematical and computational thinking
- Constructing explanations (science) and designing solutions (engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

- Asking scientific questions that can be tested empirically and structuring these questions in the form of testable predictions
- Collecting data to address scientific questions and to support predictions
- Searching for regularities and patterns in observations and measurements (i.e., data analysis)
- Using evidence and science knowledge to construct scientific explanations, models, and representations
- Using mathematical reasoning and quantitative applications to interpret and analyze data to solve problems

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NGSS Align with Other Current Standards

- Common Core State Standards
  - English Language Arts/Literacy
  - Mathematics

- C3 Framework being developed for Social Studies

- College Board Standards for College Success
  New AP Standards for Biology (Chemistry next year)

- ACT College Readiness Standards
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Michigan Core Expectations Overview (2006)

Overarching Expectations
21st Century Learning Skills
Policy on Learning Expectations
Habits of Mind ■ ■ ■ ■

Cross-Content Expectations
■ ELA Strands 1 and 2 – Communication and Reading
■ Mathematics Strand 1 – Quantitative Literacy and Logic
■ Science – Inquiry and Reflection
■ Social Studies – General Knowledge, Processes, and Skills
■ ACT College Readiness Standards

ELA HSCE CCSS
MA HSCE CCSS
SC HSCE NGSS
SS HSCE
21st Century Skills

P21 Framework

Learning Skills
- Core Subjects
- Content

Thinking Skills
Information and Communication Skills

Life Skills
Assessments

C’s of Change

- Creativity
- Critical Thinking
- Collaboration
- Communication
- Self-control
- Comprehension

Collier, NCTE 2008

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ACT Science Test

Measures skills required in the natural sciences.

- Interpretation
- Analysis
- Evaluation
- Reasoning
- Problem-solving

Assumes

- 3 years HS science (including Biology, Physical Science and/or Earth Science)
What is NOT Covered in NGSS

- The NGSS have identified the most essential material for students to know and do. The standards were written in a way that leaves a great deal of discretion to educators and curriculum developers. The NGSS are not intended to be an exhaustive list of all that could be included in a student’s science education nor should they prevent students from going beyond the standards where appropriate.

- [But NOT at the expense of meeting the standards.]

NGSS Introduction, p. 5 (print) p. 8 (pdf)

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What is NOT Covered in NGSS

- The NGSS do not define advanced work in the sciences.

- Based on review from college and career faculty and staff, the NGSS form a foundation for advanced work, but students wishing to move into STEM fields should be encouraged to follow their interests with additional coursework.
Questions and Discussion
HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]
STANDARD C2 Forms of Energy

- Students recognize the many forms of energy and understand that energy is central to predicting and explaining how and why chemical reactions occur. The chemical topics of bonding, gas behavior, kinetics, enthalpy, entropy, free energy, and nuclear stability are addressed in this standard.

- Chemistry students relate temperature to the average kinetic energy of the molecules and use the kinetic molecular theory to describe and explain the behavior of gases and the rates of chemical reactions. They understand nuclear stability in terms of reaching a state of minimum potential energy.
STANDARD C2 Forms of Energy

- P2.p1 Potential Energy (*prerequisite*)
- C2.1x **Chemical Potential Energy**
- C2.2 Molecules in Motion (Essential – Assessable on MME)
- C2.2x Molecular Entropy
- C2.3x **Breaking Chemical Bonds**
- C2.4x Electron Movement
- C2.5x Nuclear Stability
Standard C3: Energy Transfer and Conservation

- Students apply the First and Second Laws of Thermodynamics to explain and predict most chemical phenomena.

- Chemistry students use the term enthalpy to describe the transfer of energy between reactants and products in simple calorimetry experiments performed in class and will recognize Hess’s Law as an application of the conservation of energy.

- Students understand the tremendous energy released in nuclear reactions is a result of small amounts of matter being converted to energy.
STANDARD C3 Energy Transfer and Conservation

- P3.p1 Conservation of Energy (prerequisite)
- C3.1x Hess’s Law
- P3.p2 Energy Transfer (prerequisite)
- C3.2x Enthalpy
- C3.3 Heating Impacts (Essential = Assessable on MME)
- C3.3x Bond Energy
- C3.4 Endothermic and Exothermic Reactions (Essential = Assessable on MME)
- C3.4x Enthalpy and Entropy
- C3.5x Mass Defect
C2.1x Chemical Potential Energy

Potential energy is stored whenever work must be done to change the distance between two objects. The attraction between the two objects may be gravitational, electrostatic, magnetic, or strong force. Chemical potential energy is the result of electrostatic attractions between atoms.

- **C2.1a Explain** the changes in potential energy (due to electrostatic interactions) as a chemical bond forms and use this to explain why bond breaking always requires energy.

- **C2.1b Describe** energy changes associated with chemical reactions in terms of bonds broken and formed (including intermolecular forces).

- **C2.1c Compare** qualitatively the energy changes associated with melting various types of solids in terms of the types of forces between the particles in the solid.
C2.3x Breaking Chemical Bonds

For molecules to react, they must collide with enough energy (activation energy) to break old chemical bonds before their atoms can be rearranged to form new substances.

- **C2.3a Explain** how the rate of a given chemical reaction is dependent on the temperature and the activation energy.

- **C2.3b Draw and analyze** a diagram to show the activation energy for an exothermic reaction that is very slow at room temperature.
C3.1x Hess’s Law

For chemical reactions where the state and amounts of reactants and products are known, the amount of energy transferred will be the same regardless of the chemical pathway. This relationship is called Hess’s law.

- **C3.1a** Calculate the $\Delta H$ for a given reaction using Hess’s Law.
- **C3.1b** Draw enthalpy diagrams for exothermic and endothermic reactions.
- **C3.1c** Calculate the $\Delta H$ for a chemical reaction using simple coffee cup calorimetry.
- **C3.1d** Calculate the amount of heat produced for a given mass of reactant from a balanced chemical equation.
C3.2x Enthalpy

Chemical reactions involve breaking bonds in reactants (endothermic) and forming new bonds in the products (exothermic). The enthalpy change for a chemical reaction will depend on the relative strengths of the bonds in the reactants and products.

- **C3.2a Describe** the energy changes in photosynthesis and in the combustion of sugar in terms of bond breaking and bond making.

- **C3.2b Describe** the relative strength of single, double, and triple covalent bonds between nitrogen atoms.
MI Chemistry HSCE

C3.3x Bond Energy

Chemical bonds possess potential (vibrational and rotational) energy.

- **C3.3c Explain** why it is necessary for a molecule to absorb energy in order to break a chemical bond.

C3.4 Endothermic and Exothermic Reactions

Chemical interactions either release energy to the environment (exothermic) or absorb energy from the environment (endothermic).

- **C3.4A** Use the terms endothermic and exothermic correctly to describe chemical reactions in the laboratory.

- **C3.4B Explain** why chemical reactions will either release or absorb energy.
C3.4x Enthalpy and Entropy

All chemical reactions involve rearrangement of the atoms. In an exothermic reaction, the products have less energy than the reactants. There are two natural driving forces: (1) toward minimum energy (enthalpy) and (2) toward maximum disorder (entropy).

- **C3.4c** Write chemical equations including the heat term as a part of equation or using $\Delta H$ notation.
- **C3.4d** Draw enthalpy diagrams for reactants and products in endothermic and exothermic reactions.
- **C3.4e** Predict if a chemical reaction is spontaneous given the enthalpy ($\Delta H$) and entropy ($\Delta S$) changes for the reaction using Gibb’s Free Energy, $\Delta G = \Delta H - T \Delta S$ (Note: mathematical computation of $\Delta G$ is not required.)
- **C3.4f** Explain why some endothermic reactions are spontaneous at room temperature.
- **C3.4g** Explain why gases are less soluble in warm water than cold water.
Resources

- NSTA NGSS Resources- http://www.nsta.org/about/standardsupdate/standards.aspx
- Next Generation Science Standards
- Common Core State Standards www.corestandards.org
- Appendix L- Connections to CCSS-Mathematics
- Appendix M- Connections to CCSS-ELA
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Additional Information
NGSS CCR Review

- June 2012 meeting
- College representatives sought deeper understanding (i.e., particulate nature of mater)
- High school representatives were concerned about content and quantitative skills
- Presentations by ACT, The College Board, CCSS writers, NRC
- Most concerns addressed in later revisions
Summary of information for New CCR Appendix

Three predictors of CCR success based on a literature review.

- Importance of Scientific and Engineering Practice in College- and Career-Readiness in Science
- Importance of Mathematics in College- and Career-Readiness in Science (ACT correlations/ benchmarks)
- Importance of Rigorous Content for College- and Career-Readiness in Science. (On Course for Success)

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Why NGSS?

New science approaches are needed to address:

- Reduction of the United States' competitive economic edge
- Lagging achievement of U.S. students
- Essential preparation for all careers in the modern workforce
- Scientific and technological literacy for an educated society
- Prepare students for their roles as citizens in a technology rich and scientifically complex world.
- Engage students in scientific practices to develop explanations and models.
Support for NGSS

Science educators have long recognized that scientific knowledge and scientific practice are inseparable in the real world: all knowledge is embedded in practice, and all practice requires knowledge. Yet standards documents have routinely separated knowledge from practice, with separate sections or chapters for content, inquiry, nature of science, etc. NGSS does a far better job than any of its predecessors of weaving together practices, crosscutting concepts, and disciplinary core ideas in statements of performance expectations.


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Support for NGSS

In addition, NGSS is based on carefully selected practices and disciplinary core ideas. The eight practices used by NGSS deserve special attention. Rather than equating “scientific practice” with “inquiry,” as other standards tend to do, they recognize a full range of key inquiry, application, and communication practices.


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Summary of information for New CCR Appendix

Three
Michigan Public Comment
In Response to April 2013 NGSS

General Comment Survey Responses

- Overwhelmingly positive responses
- 92 to 98% positive (strongly agree and agree)
- 153 responses (as of 4-30-13)
- Letters of support for adoption
  MSTAs, MMSCN, MI STEM Partnership, MSU CREATE for STEM
Main Focus of Comments

- Strong support for NGSS scope, vision, adoption, and implementation

- Strong supporters stressed need for
  - Professional development to guide transition, beginning with implementation of the practices in current instructional units/lessons
  - Careful planning for continued transition over 3 or 4 years
  - Sharing of resources (open source, online access to exemplars)
  - Opportunities to develop formative (classroom) assessments and to build capacity for teachers to help to develop summative (including state-level) assessments
Main Focus of Comments

- Some teachers expressed support, but articulated concerns about
  - Being given time for professional development
  - Having access to the necessary resources to implement the practices as intended
  - The need for assessments that align with models of good instruction and promote good instruction
  - The need for time to build capacity of teachers to teach the standards before testing the standards
Main Focus of Comments

- Mixed support comments included
  - Misconceptions that will need to be addressed in PD
  - Concerns about the NGSS and college readiness
  - Concerns about need for expensive science equipment
  - Concerns about need for “standardized” courses
  - Concerns about administrators misinterpreting MDE guidance
- Other negative responses and concerns (n=4)
  - Questioned NRC core ideas as “fake” science
  - Overreach, lack of local control