The Next Generation Science Standards

Executive Summary

There is no doubt that science—and, therefore, science education—is central to the lives of all Americans. Never before has our world been so complex and science knowledge so critical to making sense of it all. When comprehending current events, choosing and using technology, or making informed decisions about one's healthcare, science understanding is key. Science is also at the heart of the United States' ability to continue to innovate, lead, and create the jobs of the future. All students—whether they become technicians in a hospital, workers in a high tech manufacturing facility, or Ph.D. researchers—must have a solid K–12 science education.

Through a collaborative, state-led process, new K–12 science standards have been developed that are rich in content and practice and arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education. The Next Generation Science Standards are based on the *Framework for K–12 Science Education* developed by the National Research Council.[1]

Advances in the Next Generation Science Standards

- Every NGSS standard has three dimensions: disciplinary core ideas (content), scientific and engineering practices, and cross-cutting concepts. Currently, most state and district standards express these dimensions as separate entities, leading to their separation in both instruction and assessment. The integration of rigorous content and application reflects how science and engineering is practiced in the real world.
- Scientific and Engineering Practices and Crosscutting Concepts are designed to be taught in context – not in a vacuum. The NGSS encourage integration with multiple core concepts throughout each year.
- Science concepts build coherently across K-12. The emphasis of the NGSS is a focused and coherent progression of knowledge from grade band to grade band, allowing for a dynamic process of building knowledge throughout a student's entire K-12 scientific education.
- The NGSS focus on a smaller set of Disciplinary Core Ideas (DCI) that students should know by the time they graduate from high school, focusing on deeper understanding and application of content.
- Science and engineering are integrated into science education by raising engineering design to the same level as scientific inquiry in science classroom instruction at all levels, and by emphasizing the core ideas of engineering design and technology applications.

[1] The performance expectations were developed using elements from the NRC document and should be cited as, *A Framework for K-12 Science Education,* © 2012, National Academy of Sciences." Moreover, the portion of the standards entitled "Disciplinary Core Ideas" is reproduced verbatim from *A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas*. They are integrated and reprinted with permission from the National Academy of Sciences. © 2012, National Academy of Sciences

- The NGSS content is focused on preparing students for college and careers. The NGSS are aligned, by grade level and cognitive demand with the English Language Arts and Mathematics Common Core State Standards. This allows an opportunity both for science to be a part of a child's comprehensive education as well as ensuring an aligned sequence of learning in all content areas. The three sets of standards overlap and are reinforcing in meaningful and substantive ways.

NGSS Design Considerations

In putting the vision of the *Framework* into practice, the NGSS have been written as performance expectations that depict what the student must do to show proficiency in science. Science and Engineering Practices were coupled with various components of the Disciplinary Core Ideas and Crosscutting Concepts to make up the performance expectations. The NGSS architecture was designed to provide information to teachers and curriculum and assessment developers beyond the traditional one line standard. The performance expectations are the policy equivalent of what most states have used as their standards. In order to show alignment and coherence to the *Framework*, the NGSS include the appropriate learning goals in the Foundation Boxes in the order in which they appeared in the *Framework*. They were included to ensure curriculum and assessment developers should not be required to guess the intent of the performance expectations.

Coupling Practice with Content

State standards have traditionally represented Practices and Core Ideas as two separate entities. Observations from science education researchers have indicated that these two dimensions are, at best, taught separately or the Practices are not taught at all. This is neither useful nor practical, especially given that in the real world science and engineering is always a combination of content and practice.

It is important to note that the Scientific and Engineering Practices are not teaching strategies -- they are indicators of achievement as well as important learning goals in their own right. As such, the *Framework* and NGSS ensure the Practices are not treated as afterthoughts. Coupling practice with content gives the learning context, whereas practices alone are activities and content alone is memorization. It is through integration that science begins to make sense and allows student to apply the material. This integration will also allow students from different states and districts to be compared in a meaningful way.

The NGSS are Standards, not Curriculum

The NGSS are standards, or goals, that reflect what a student should know and be able to do—they do not dictate the manner or methods by which the standards are taught. The performance expectations are written in a way that expresses the concept and skills to be performed but still leaves curricular and instructional decisions to states, districts, school and teachers. The performance expectations do not dictate curriculum; rather, they are coherently developed to allow flexibility in the instruction of the standards. While the NGSS have a fuller architecture than traditional standards—at the request of states so they do not need to begin implementation by "unpacking" the standards—the NGSS do not dictate nor limit curriculum and instructional choices.

Instructional Flexibility

Students should be evaluated based on understanding a full Disciplinary Core Idea. Multiple Scientific and Engineering Practices are represented across the performance expectations for a given Disciplinary Core Idea. Curriculum and assessment must be developed in a way that builds students' knowledge and ability toward the performance expectations. As the NGSS are performances meant to be accomplished at the conclusion of instruction, quality instruction will have students engage in several practices throughout instruction.

Because of the coherence of the NGSS, teachers have the flexibility to arrange the performance expectations in any order within a grade level to suit the needs of states or local districts. The use of various applications of science, such as medicine, forensics, agriculture, or engineering, would nicely facilitate student interest and demonstrate how scientific principles outlined in the *Framework* and NGSS are applied in real world situations.

Next Steps

With the final release of the NGSS in April 2013, states will begin their individual processes to consider adoption. The lead states are under no obligation to adopt, only to seriously consider adoption. There is no set timeline for adoption or implementation. As with all K-12 educational standards, the decision to adopt by any given state is voluntary.

INTRODUCTION

Background
In 2010, the National Academy of Sciences, Achieve, the American Association for the Advancement of Science, and the National Science Teachers Association embarked on a two-step process to develop the *Next Generation Science Standards* (NGSS). The first step of the process was led by The National Academies of Science, a non-governmental organization commissioned in 1863 to advise the nation on scientific and engineering issues. On July 19, 2011, the National Research Council (NRC), the functional staffing arm of the National Academy of Sciences, released the *Framework for K–12 Science Education*. The *Framework* was a critical first step because it is grounded in the most current research on science and scientific learning, and it identifies the science all K–12 students should know.

The second step in the process was the development of standards grounded in the NRC *Framework*. A group of 26 lead states and 40 writers, in a process managed by Achieve, has been working since the release of the *Framework* to develop K-12 Next Generation Science Standards. The standards have undergone numerous state reviews as well as two public comment periods. In April of 2013, the NGSS were released for states to consider adoption.[1]

Why Next Generation Science Standards (NGSS)?
The world has changed dramatically in the 15 years since state science education standards' guiding documents were developed. Since that time, many advances have occurred in the fields of science and science education, as well as in the innovation-driven economy. The U.S. has a leaky K–12 science, technology, engineering and mathematics (STEM) talent pipeline, with too few students entering STEM majors and careers at every level—from those with relevant postsecondary certificates to PhD's. We need new science standards that stimulate and build interest in STEM.

The current education system can't successfully prepare students for college, careers and citizenship unless we set the right expectations and goals. While standards alone are no silver bullet, they do provide the necessary foundation for local decisions about curriculum, assessments, and instruction.

Implementing the NGSS will better prepare high school graduates for the rigors of college and careers. In turn, employers will be able to hire workers with strong science-based skills—not only in specific content areas, but also with skills such as critical thinking and inquiry-based problem solving.

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Framework for K-12 Science Education Dimensions

The *Framework* outlines the three dimensions that are needed to provide students a high quality science education. The integration of these three dimensions provides students with a context for the content of science, how science knowledge is acquired and understood, and how the sciences are connected through concepts that have universal meaning across the disciplines. The following excerpt is quoted from the *Framework.*

<u>*Dimension 1: Practices*</u>

Dimension 1 describes (a) the major practices that scientists employ as they investigate and build models and theories about the world and (b) a key set of engineering practices that engineers use as they design and build systems. We use the term "practices" instead of a term such as "skills" to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice.

Similarly, because the term "inquiry," extensively referred to in previous standards documents, has been interpreted over time in many different ways throughout the science education community, part of our intent in articulating the practices in Dimension 1 is to better specify what is meant by inquiry in science and the range of cognitive, social, and physical practices that it requires. As in all inquiry-based approaches to science teaching, our expectation is that students will themselves engage in the practices and not merely learn about them secondhand. Students cannot comprehend scientific practices, nor fully appreciate the nature of scientific knowledge itself, without directly experiencing those practices for themselves.

<u>*Dimension 2: Crosscutting Concepts*</u>

The crosscutting concepts have application across all domains of science. As such, they provide one way of linking across the domains in Dimension 3. These crosscutting concepts are not unique to this report. They echo many of the unifying concepts and processes in the National Science Education Standards, the common themes in the Benchmarks for Science Literacy, and the unifying concepts in the Science College Board Standards for College Success. The framework's structure also reflects discussions related to the NSTA Science Anchors project, which emphasized the need to consider not only disciplinary content but also the ideas and practices that cut across the science disciplines.

<u>*Dimension 3: Disciplinary Core Ideas*</u>

The continuing expansion of scientific knowledge makes it impossible to teach all the ideas related to a given discipline in exhaustive detail during the K-12 years. But given the cornucopia of information available today virtually at a touch—people live, after all, in an information age—an important role of science education is not to teach "all the facts" but rather to prepare students with sufficient core knowledge so that they can later acquire additional information on their own. —An education focused on a limited set of ideas and practices in science and engineering should enable students to evaluate and select reliable sources of scientific information, and allow them to continue their development well beyond their K-12 school years as science learners, users of scientific knowledge, and perhaps also as producers of such knowledge.

With these ends in mind, the committee developed its small set of core ideas in science and engineering by applying the criteria listed below. Although not every core idea will satisfy every one of the criteria, to be regarded as core, each idea must meet at least two of them (though preferably three or all four).

Specifically, a core idea for K-12 science instruction should:

1. *Have broad importance across multiple sciences or engineering disciplines or be a key organizing principle of a single discipline.*
2. *Provide a key tool for understanding or investigating more complex ideas and solving problems.*
3. *Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge.*
4. *Be teachable and learnable over multiple grades at increasing levels of depth and sophistication. That is, the idea can be made accessible to younger students but is broad enough to sustain continued investigation over years.*

In organizing Dimension 3, we grouped disciplinary ideas into four major domains: the physical sciences; the life sciences; the earth and space sciences; and engineering, technology, and applications of science. At the same time, true to Dimension 2, we acknowledge the multiple connections among domains. Indeed, more and more frequently, scientists work in interdisciplinary teams that blur traditional boundaries. As a consequence, in some instances core ideas, or elements of core ideas, appear in several disciplines (e.g., energy). – NRC Framework for K-12 Science Education pp. 30-31

Translating the *Framework* to Standards

States volunteered to be Lead State Partners for the development of the Next Generation Science Standards (NGSS) by way of a state partnership agreement signed by their chief state school officer and state board of education chair. The agreement included a commitment by states to convening, in-state, broad-based committee(s) ranging from 50 to 150 members to provide feedback and guidance to the state throughout the process. Twenty-six states signed on to be Lead State Partners. The states have provided guidance and direction in the development of the NGSS to the 40-member writing team, composed of K-20 educators and experts in both science and engineering. In addition to six reviews by the lead states and their committees, the NGSS were reviewed during development by hundreds of experts during confidential reviews and tens of thousands of members of the general public during two public review periods.

The *Framework* formed the basis for the development of the NGSS. For the NGSS lead states and writers alignment to the *Framework* was a priority. The NGSS provide the performances students must be able to do at the conclusion of instruction; the *Framework* provides even more detail about the different attributes of the dimensions illustrated by the standards. This section provides brief descriptions of how different components of the *Framework* were used to develop the NGSS and a brief description of the process used to develop the NGSS.

Development of the Performance Expectations

The real innovation in the NGSS is the requirement that students are required to operate at the intersection of practice, content, and connection. Performance expectations are the right way to integrate the three dimensions. It provides specificity for educators, but it also sets the tone for how science instruction should look in classrooms. If implemented properly, the NGSS will result in coherent, rigorous instruction that will result in students being able to acquire and apply scientific knowledge to unique situations as well as have the ability to think and reason scientifically. While this is an innovation in state standards, the idea of performance expectations is used in several other national and international initiatives.

The vision for science education in the 21st century is that all practices are expected to be utilized by educators. Educators and curriculum developers must bear this in mind as they design instruction. For the NGSS development, a key issue in developing the performance expectations was the actual choice of the Practices with the DCI and the Crosscutting Concepts, the transition words between the Practice and the DCI language, and the ability of a student to perform the expectation. Due to the nature of some of the Practices, they could not usually be used as a standalone practice. Often, the "Asking Questions" Practice leads to an investigation that produces data that can be used as evidence to develop explanations or arguments. Similarly, mathematics is implicit in all science. Models, arguments, and explanations are all based on evidence. That evidence can be mathematics. There are specific places the standards require mathematics, but the places where mathematics is not explicitly required should not be interpreted as precluding students from using mathematical relationships to support other practices. Ultimately, the NGSS balance the practices within the performance expectations. However, practices such as models, arguments, and explanations are often more prominent throughout the standards in order to ensure rigorous content receives its due focus.

Disciplinary Core Idea Use and Development

The NGSS were developed based on the grade-band end points identified in the *Framework*. The grade-band endpoints provide the learning progressions with regard to the Disciplinary Core Idea (DCI). Therefore, the DCI grade-band endpoints were placed verbatim into the standards.

The greatest challenge with the core ideas was ensuring a coherent and manageable set of standards. The *Framework* provides many connections across disciplines that will be very helpful as instructional materials are developed. These connections also create challenges in developing standards. The NGSS present clear actionable standards that are not redundant with other standards, yet preserve these important connections. Standards, by their nature, are student achievement goals and deliberately written not to make curricular connections. The NGSS are written not to limit instruction by trying to teach one performance at a time or as the sole instruction.

The other challenge was to ensure a manageable set of standards. The top priority was to ensure coherence and learning progressions. This was accomplished in several ways. First, overlapping or redundant content was eliminated and placed in the area that made most sense. Second, the public feedback and feedback from key stakeholders such as scientific societies and the National Science Teachers Association was used to further prune content that was not critical to understanding the larger Disciplinary Core Idea. Small groups of educators were asked to review the NGSS for their grade-level/grade-band/disciplinary area with an eye toward ensuring teachablity. The NGSS now represent a teachable set of standards based on this review. As with all standards, they represent what all students should know, but do not prohibit teachers from going beyond the standards to ensure their students' needs are met.

Scientific and Engineering Practice and Crosscutting Concept Use and Development
While the *Framework* identified the Scientific and Engineering Practices to use in the standards, the document did not identify the learning progressions associated with them. The NGSS include progressions matrices to identify how the goals for each Scientific and Engineering Practice and Crosscutting Concepts change for students at each grade-band. The matrices were reviewed and revised during development to provide clear guidance to readers of the document. A great deal of time was taken to ensure the NGSS writers all had a common understanding of the Scientific and Engineering Practices and Crosscutting concepts. The NGSS writers strongly encourage states and districts to do the same.

What is Not Covered in the Next Generation Science Standards
The NGSS have some intentional limitations that must be recognized. Some of the most important limitations are listed below.

- The NGSS are not meant to limit science instruction to single Scientific and Engineering Practices. They represent what students should be able to do at the conclusion of instruction, not how they should teach the material.
- 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.
- 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 interest with additional coursework.
- While great care was taken to consider the needs of diverse populations during the development of the NGSS, no one document can fully represent all of the interventions or supports necessary for students with such varying degrees of abilities and needs.

Organization of the Next Generation Science Standards
The standards are organized by grade levels in Kindergarten through fifth grade. The middle and high school standards are grade-banded. A set of model courses for middle school and high school is under development to initiate discussion of how the NGSS could impact middle and high school after implementation.

A real innovation to the NGSS is the overall coherence. As such, the Performance Expectations (the assessable component of the NGSS architecture) can be arranged within a grade level in any way that best represents the needs of states and districts without sacrificing coherence in learning the Disciplinary Core Ideas.

<u>Use of the Next Generation Science Standards in Curriculum, Instruction, and Assessment</u>

The NGSS have been constructed to focus on the performance required to show proficiency at the conclusion of instruction. This focus on achievement rather than the curriculum allows educators, curriculum developers and other education stakeholders the flexibility to determine the best way to help their students meet the standards based on their local needs. Teachers should rely on quality instructional products and their own professional judgment as the best way to implement the NGSS in classrooms. The NGSS open the opportunity to include medicine, engineering, forensics, and other applicable sciences to deliver the standards in ways that interest students and may give them a desire to pursue or STEM careers.

Pairing Practices with Disciplinary Core Ideas is necessary to define a discrete set of blended standards, but should not be viewed as the only combinations that appear in instructional materials. In fact, quality instructional materials and instruction must be able to flexibly apply the science practices students need to experience their use, separately and in combination, in multiple disciplinary contexts. The practical aspect to science instruction is that the Practices are inextricably linked. While the NGSS couples single practices with content, this is intended to be clear about the Practice used within that context, not to limit the instruction.

Curriculum and instruction should be focused on "bundles" of performance expectations to provide a contextual learning experience for students. Students should not be presented with instruction leading to one performance expectation in isolation; rather, bundles of performances provide a greater coherence and efficiency of instructional time. These bundles also allow students to see the connected nature of science and the practices.

Finally, classroom assessment of the NGSS should reflect quality instruction. That is to say, students should be held responsible for demonstrating knowledge of content in various contexts and Scientific and Engineering Practices. As students progress toward the performance expectation, classroom assessments should focus on accumulated knowledge and various practices. It is important here to remember that the assessment of the NGSS should be on understanding the full Disciplinary Core Ideas -- not just the pieces.

The Affective Domain

The affective domain, the domain of learning that involves interests, experience and enthusiasm, is a critical component to science education. As pointed out in A Framework for K-12 Science Education, there is a substantial body of research that supports the close connection between the development of concepts and skills in science and engineering and such factors as interest, engagement, motivation, persistence, and self-identity. Comments about the importance of affective education appear throughout the Framework document. For example:

> *Research suggests that personal interest, experience, and enthusiasm—critical to children's learning of science at school or in other settings— may also be linked to later educational and career choices. (p. 28)*
>
> *Discussions involving the history of scientific and engineering ideas, of individual practitioners' contributions, and of the applications of these endeavors are important components of a science and engineering curriculum. For many students, these aspects are the pathways that capture their interest in these fields and build their identities as engaged and capable learners of science and engineering. (p. 249)*

Learning science depends not only on the accumulation of facts and concepts but also on the development of an identity as a competent learner of science with motivation and interest to learn more. (p. 286)

Science learning in school leads to citizens with the confidence, ability, and inclination to continue learning about issues, scientific and otherwise, that affect their lives and communities. (pp. 286-287)

The NGSS strongly agrees with these goals. However, there is a difference in the purpose of the Framework and the NGSS. The Framework projects a vision for K-12 Science Education, and includes recommendations not only for what students are expected to learn, but also for curriculum, instruction, the professional development of teachers, and assessment.

The purpose of the NGSS is more limited. It is not intended to replace the vision of the Framework, but rather to support that vision by providing a clear statement of the competencies in science and engineering that all students should be able to demonstrate at subsequent stages in their K-12 learning experience. Certainly students will be more likely to succeed in achieving those competencies if they have the curricular and instructional support that encourages their interests in science and engineering. Further, students who are motivated to continue their students and to persist in more advanced and challenging courses are more likely to become STEM-engaged citizens, and in some cases to pursue careers in STEM fields. However, the vision of the Framework is not more likely to be achieved by specifying performance expectations that signify qualities as interest, motivation, persistence, and career goals. This decision is consistent with the Framework, which did not include affective goals in specifying endpoints of learning in the three dimensions that it recommended be combined in crafting the standards.

Supplemental Materials to the Next Generation Science Standards

The final set of Next Generation Science Standards is the result of public feedback, lead state and non-lead state feedback, National Science Teacher Association (NSTA), and national and local critical stakeholder feedback. A short summary of each of the appendices of the NGSS are located below.

Appendix A – Conceptual Shifts **– Immediate Public Release**

The NGSS provide an important opportunity to improve not only science education but also student achievement. Based on the *Framework for K–12 Science Education*, the NGSS are intended to reflect a new vision for American science education. The lead states and writing teams have identified seven "conceptual shifts" science educators and stakeholders need to make to effectively use the NGSS. The shifts are

1. K–12 science education should reflect the real world interconnections in science.
2. The Next Generation Science Standards are student outcomes and are explicitly NOT curriculum.
3. Science concepts build coherently across K–12.
4. The NGSS focus on deeper understanding and application of content.
5. Science and engineering are integrated in science education from K–12.
6. The NGSS are designed to prepare students for college, career, and citizenship.

7. Science standards coordinate with English Language Arts and Mathematics Common Core State Standards.

Appendix B – Responses to Public Feedback – **Immediate Public Release**
The results of Public Feedback and the responses by the lead states and writing team can be reviewed for all areas of the NGSS.

Appendix C – College and Career Readiness – **To Be Released April 26, 2013**
A key component to successful standards development is to ensure the vision and content of the standards properly prepare students for college and career readiness. During the development of the NGSS, a parallel process to ensure the college and career readiness based on the available evidence has been ongoing. The process will continue over the next year as states work together to confirm a common definition.

Appendix D – All Standards, All Students – **Immediate Public Release**
The NGSS are being developed at a historical time when major changes in education are occurring at the national level. On the one hand, student demographics are changing rapidly, while science achievement gaps persist. standards are cognitively demanding, teachers must make instructional shifts to enable all students to meet the requirements for college and career readiness.

The chapter highlights implementation strategies that are grounded in theoretical or conceptual frameworks. It consists of three parts. First, it discusses both *learning opportunities and challenges,* which NGSS present to student groups that have traditionally been underserved in science classrooms. Second, it describes research-based strategies for effective *implementation* of NGSS in the science classroom, school, home, and community. Finally, it provides the *context* for student diversity by addressing changing demographics, persistent achievement gaps, and educational policies affecting non-dominant student groups. The chapter is accompanied by seven case studies of diverse student groups to illustrate science teaching and learning as they engage in NGSS.

Appendix E – Disciplinary Core Idea Progression in the NGSS – **Immediate Public Release**
The NGSS have been developed in learning progressions based on the progressions identified by the grade-band endpoints in the *Framework*. Short narrative descriptions of the progressions are presented for each disciplinary core idea in each of the traditional sciences. These progressions were used in the college- and career-readiness review to determine the learning expected for each idea before leaving high school.

Appendix F – Scientific and Engineering Practices in the NGSS – **Immediate Public Release**
The *Framework* identifies eight science and engineering practices that mirror the practices of professional scientists and engineers. Use of the practices in the performance expectations is not only intended to strengthen students' skills in these practices but also to develop students' understanding of the nature of science and engineering. Listed below are the science and engineering practices from the *Framework*:

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. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

The *Framework* does not specify grade-band endpoints for the Scientific and Engineering Practices, but instead provides a summary of what students should know by the end of grade twelve and a hypothetical progression for each. The NGSS uses constructed grade-band endpoints for the science and engineering practices that are based on these hypothetical progressions and twelfth-grade endpoints. These representations of the science and engineering practices appear in the NGSS and supporting foundation boxes. A complete listing of the specific science and engineering practices used in the NGSS is shown in the document.

Appendix G – Crosscutting Concepts in the NGSS – **Immediate Public Release**
The *Framework* also identifies seven Crosscutting Concepts that are meant to give students an organizational structure to understand the world and help students make sense of and connect Core Ideas across disciplines and grade bands. They are not intended as additional content. Listed below are the Crosscutting Concepts from the *Framework*:

1. Patterns
2. Cause and Effect
3. Scale, Proportion, and Quantity
4. Systems and System Models
5. Energy and Matter in Systems
6. Structure and Function
7. Stability and Change of Systems

As with the Scientific and Engineering Practices, the *Framework* does not specify grade-band endpoints for the Crosscutting Concepts, but instead provides a summary of what students should know by the end of grade twelve and a hypothetical progression for each. To assist with writing the NGSS, grade-band endpoints were constructed for the Crosscutting Concepts that are based on these hypothetical progressions and twelfth-grade endpoints. These representations of the Crosscutting Concepts appear in the NGSS and supporting foundation boxes. A complete listing of the specific Crosscutting Concepts used in the NGSS is shown in the document.

Appendix H – Nature of Science in the NGSS – **Immediate Public Release**
Based on the public and state feedback, as well as feedback from key partners like the National Science Teachers Association (NSTA), steps were taken to make the Nature of Science more prominent in the performance expectations. It is important to note that while the Nature of Science was reflected in the *Framework* through the Practices, understanding the Nature of Science is more than just a Practice. As such, the direction of the lead states was to indicate

Nature of Science appropriately in both Science and Engineering Practices and Crosscutting Concepts. A matrix of Nature of Science across K-12 is also included in this appendix.

Appendix I – Engineering Design in the NGSS - **Immediate Public Release**
The NGSS represent a commitment to integrate engineering design into the structure of science education by raising engineering design to the same level as scientific inquiry when teaching science disciplines at all levels, from kindergarten to grade 12. Providing students a foundation in engineering design allows them to better engage in and aspire to solve major societal and environmental challenges they will face in the decades ahead.

Appendix J – Science, Technology, Society and the Environment – **Immediate Public Release**
The goal that all students should learn about the relationships among science, technology, and society came to prominence in the United Kingdom and the United States starting in the early 1980s. The core ideas that relate science and technology to society and the natural environment in Chapter 8 of *A Framework for K-12 Science Education* (NRC, 2012) are consistent with efforts in science education for the past three decades.

Appendix K – Model Course Mapping in Middle and High School – **To Be Released April 26, 2013**
The NGSS are organized by grade level for kindergarten through grade five, but as grade-banded expectations at the middle school (6-8) and high school (9-12) levels. As states and districts consider implementation of the NGSS, it will be important to thoughtfully consider how to organize these grade-banded standards into courses that best prepare students for post-secondary success. To help facilitate this decision-making process, several potential directions for this process are outlined in this appendix.

Appendix L – Consistency with the Common Core State Standards for Mathematics – **To Be Released April 26, 2013**
Science is a quantitative discipline, which means it is important for educators to ensure that students' learning in science coheres well with their learning in mathematics.[2] To achieve this alignment, the NGSS development team has worked with Common Core State Standards in Mathematics (CCSSM) writing team members to help ensure that the NGSS do not outpace or otherwise misalign to the grade-by-grade standards in CCSSM. Every effort has been made to ensure consistency. It is essential that the NGSS always be interpreted and implemented in such a way that they do not outpace or misalign to the grade-by-grade standards in CCSSM. This includes the development of NGSS-aligned instructional materials and assessments. This appendix gives some specific suggestions about the relationship between mathematics and science in grades K-8.

Appendix M – Consistency with the Common Core State Standards for English Language Arts – **To Be Released April 26, 2013**
Literacy skills are critical to building knowledge in science. To ensure the CCSS literacy standards work in tandem with the specific content demands outlined in the NGSS, the NGSS

[2] See page 16 of the *K-8 Publishers' Criteria for the Common Core State Standards for Mathematics*, available at www.corestandards.org.

development team worked with the CCSS writing team to identify key literacy connections to the specific content demands outlined in the NGSS. As the CCSS affirm, reading in science requires an appreciation of the norms and conventions of the discipline of science, including understanding the nature of evidence used, an attention to precision and detail, and the capacity to make and assess intricate arguments, synthesize complex information, and follow detailed procedures and accounts of events and concepts. Students also need to be able to gain knowledge from elaborate diagrams and data that convey information and illustrate scientific concepts. Likewise, writing and presenting information orally are key means for students to assert and defend claims in science, demonstrate what they know about a concept, and convey what they have experienced, imagined, thought, and learned. Every effort has been made to ensure consistency between the CCSS and the NGSS. As is the case with the mathematics standards, the NGSS should always be interpreted and implemented in such a way that they do not outpace or misalign to the grade-by-grade standards in the CCSS for literacy (this includes the development of NGSS-aligned instructional materials and assessments).

Glossary of Terms – Immediate Public Release
Many abbreviations and policy terms are used throughout the NGSS and its supporting materials. This document provides definitions and descriptions of these terms.