## APPENDIX B – Responses to the May Public Draft

### Executive Summary

Several rounds of review were built into the development process of the *Next Generation Science Standards* (NGSS) to make sure that all educators and stakeholders would have opportunities to provide feedback. The first public draft of the NGSS was posted online from May 11 to June 1, 2012. The draft received comments from over 10,000 individuals, including those working together in lead state review teams, school and school district discussion groups, and scientific society commenters. The writers then used this feedback to make substantial revisions to the draft standards.

Overall, the feedback received on the first public draft was very positive. Almost all reviewers indicated that they liked the pedagogical vision, the integration of the three dimensions in the NGSS and the structure of the NGSS itself. In addition to the overall positive feedback the first draft received, there were also critiques of specific issues. The following themes emerged from the comments:

- Concerns that there was too much material
- Suggestions for additional topics to include
- Lack of language clarity
- Concerns about including and addressing engineering and technology
- Confusion about the role of the one practice specified in each performance expectation
- Lack of guidance for incorporating crosscutting concepts
- Lack of specificity in connections to other standards and other subjects
- Concern about the organization of the standards
- Concern about the amount of support that will be needed for implementation of the standards.
- Concerns about the utility of the survey used to collect feedback on the public draft

Based on the feedback, the following changes have taken place:

- 95% of the PEs have been rewritten based on feedback, with more specific and consistent language used.
- A review focused on college- and career-readiness resulted in the removal of some content
- Some content shifted grade levels in elementary
- Engineering has been better integrated into the traditional science disciplines
- More math expectations have been added to the performance expectations
- Course models have been drafted for middle and high school
- "Nature of science" concepts have been highlighted throughout the document
- The practices matrix has been revised
- A new chapter has been added to describe the intent and use of crosscutting concepts through the NGSS
- A new chapter on equity has been drafted about implementation of the NGSS with diverse student groups.
- A glossary of standards terms has been added
- More flexibility of viewing of the standards has been provided with two official arrangements of the performance expectations: by topics and by DCI.

- Additional flexibility was added to the website views of standards, allowing users to turn off
  pop up" description boxes.
- The public feedback survey has been completed revised

During the second public draft review in January 2013, we encourage all stakeholders to review these changes and comment on any other issues that should be addressed. We look forward to your feedback.

## Introduction

Several rounds of review were built into the development process of the *Next Generation Science Standards* (NGSS) to ensure that all educators, stakeholders and the public would have the opportunity to provide feedback.

The first public draft of the NGSS was posted online from May 11 to June 1, 2012. The draft received comments from over 10,000 individuals, including those working together in NGSS lead state review teams, school and school district discussion groups, and scientific society commenters. The feedback was reviewed, coded into sortable spreadsheets and summarized for state and writing team consideration. Where feedback was unclear or conflicting, lead state teams engaged in additional discussions. The writers then used this feedback, along with that of the college- and career-readiness reviews, to make substantial revisions to the draft standards. As a result of the May public review and subsequent state review, 95% of the performance expectations have been rewritten with more specific and consistent language used.

Overall, the feedback received on the first public draft of the NGSS was positive. Almost all reviewers indicated that they liked the pedagogical vision of the NRC document *A Framework for K-12 Science Education*, and the integration of the three dimensions in the NGSS: Science and Engineering Practices, Crosscutting Concepts and Disciplinary Core Ideas. The structure of the NGSS itself received high praise, including the foundation boxes that show the source of the language and ideas in the performance expectations. The presence of clarification statements, assessment boundaries, as well as connections to other standards and the Common Core State Standards, were also almost universally approved of. While these elements were applauded, many commenters took issue with specific wording and connections made.

Most reviewers also liked the functionality and interactivity available in the web presentation of the standards. In contrast, most reviewers did not find the survey provided for feedback on the standards to be user-friendly. The survey -developed for the second public comment period has been improved and made more intuitive for users as a result of these comments.

In addition to the overall positive feedback the first draft received, there were also critiques of specific issues. The following themes emerged from the comments:

- Concerns that there was too much material overall.
- Suggestions for inclusion of certain topics that were not covered in the draft.
- Lack of clarity in the language about performance expectations.
- Concerns about including and addressing engineering and technology.
- Confusion about the role of the one practice specified in each performance expectation.
- Lack of guidance for incorporating crosscutting concepts.
- Lack of specificity in connections to other standards and other subjects.
- Some concern about the organization of the standards.
- Concern about the amount of support that will be needed for implementation of the standards.
- Concerns about the utility of the survey used to collect feedback on the public draft.

**As a result of the comments received on the issues identified above, below is a representative sampling of how each was addressed:**

**Too Much Material**
The Framework and the NGSS set out to define a small set of core ideas that build coherently through the grade levels. While most reviewers indicated that proficiency in the standards was sufficient for student success at the next level, they also noted that practical classroom time constraints could prevent many students from getting to the depth of skills and knowledge required by the standards.

Several topics, such as nuclear processes, were also identified as being beyond the scope of knowledge necessary for college and career readiness. These topics were deemed important only for those students who planned to continue in STEM career paths. In the elementary grade levels, certain topics received feedback about their grade level placement, indicating that some topics would be more appropriate if moved to either a higher or lower grade level.

***Response***
The standards have undergone extensive review to ensure that all content is both necessary and sufficient for student success after high school in the 21st century. In June, university and community college faculty met with workforce readiness experts to examine all of the standards in depth. Their feedback, together with that from the public draft review, led to a deletion of many performance expectations and a reduction of focus in many areas of science. In addition, reviews from cross-disciplinary teams of higher education faculty and the Lead State Review in September led to a further reduction in the content designated in the Disciplinary Core Ideas.

In the K-5 standards, several performance expectations were shifted from one grade level to the next based on the feedback. In addition, the writers worked through all of the K-12 performance expectations to ensure that they are implementable. However, the performance expectations are not intended to be taught independently of others at the same grade level and should still take into account student knowledge and skills built in previous grade levels. For instance, in high school physical sciences, one would not teach about chemical reactions without also addressing the law of conservation of mass.

**Suggestions on inclusion/exclusion of certain topics**
While recognizing the sizable amount of content mastery expected of all students in the NGSS draft, many reviewers voiced concerns about the omission of particular areas of content. As the NGSS writers were tasked with creating a set of standards faithful to the *Framework*, many of the same concerns raised during the Framework development process were raised again. Major themes included requests for more oceans science context to be used in examples, for computer science concepts to be added and for "nature of science" concepts to be made more explicit.

Many high school teachers also expressed concern that specific content normally included in their courses was not in the NGSS, including thermodynamics, stoichiometry, solution chemistry and nitrogen cycles. Some elementary and middle school teachers requested that some commonly-taught topics be added, including human body systems, cell structure, rocks and minerals, and the solar system.

A small number of reviewers asked that evolution not be included in the standards.

Several commenters perceived that "inquiry" was missing from the standards. A few emphasized the importance of students' joy and passion for learning, indicating that this should be made explicit in the standards documents. Finally, many reviewers requested more guidance for implementation with diverse student groups.

In addition to omitted topics, some reviewers requested that the standards also specify the intermediate knowledge necessary for scaffolding toward eventual student outcomes. For example, MS-GDRO includes, as a student outcome, some general knowledge of the role of gene mutations. No part of the NGSS specifies the student outcome of defining a gene – it is instead implicit that in order to demonstrate proficiency in the performance expectations in MS-GDRO, students will have to be introduced to the concept of a gene through curriculum and instruction.

***Response***

One of the important components to the vision of the *Framework* and the NGSS is the focus on a smaller set of core ideas that build over time. With the practical constraints of class time availability and the commitment to remain within the scope of the NRC *Framework*, the NGSS writers were not able to add new core ideas to the standards. They were, however, able to add more context and examples demonstrating potential connections to ocean sciences and computer science. In addition, where nature of science connections already existed in the standards, they were made more explicit and called out in the appropriate foundation boxes.

Much of the feedback requesting the addition of topics traditionally taught in upper-level high school science courses indicated confusion about the purpose of the NGSS. In contrast to many current state standards, the NGSS specifies content and skills required of all students, and are not intended to cover the depth and breadth of content of upper-level science courses. The NGSS are meant to help provide a thorough foundation for student success in any chosen field, and can be supplemented with further in-depth study in particular upper-level science courses.

A key consideration with regard to missing or additional content was the review for college and career readiness in science. As mentioned earlier, a large team of postsecondary faculty and hiring managers from across the country met to review the May draft specifically to determine if the content represented, if understood by high school graduates, would allow for success in post-secondary education and training. In each of the disciplines, (Earth/space, biology/life, chemistry and physics), the outcome did not support adding additional content. In some cases, like stoichiometry, the conceptual understanding for why chemists do stoichiometry was already in the standards. The teams wanted to make the mathematical practice more explicit through the clarification statements, but not have a separate performance expectation requiring that all students do gram to gram calculations. The findings from each discipline review group in the June meeting, as well as from later meetings of cross-disciplinary groups, supported the sufficiency of existing content, and suggested some deletions and de-emphasis.

The NGSS are a set of goals, performance expectations for the end of instruction; they are not a curriculum. Many different methods and examples could be used to help support student understanding of the disciplinary core ideas and science and engineering practices, and the

writers do not want to prescribe any curriculum or constrain any instruction. It is therefore outside the scope of the standards to specify intermediate knowledge and instructional steps.

Evolution was identified in the *Framework* as the basis for understanding all the natural sciences. As such it was included in the NGSS.

The concept and practice of "inquiry" has not been omitted from the NGSS – instead, it is now specified in the eight practices throughout every performance expectation. In addition, a thorough discussion of equity and diversity issues had been planned for inclusion in the standards, and is now drafted. Each performance expectation and associated examples have also been reviewed for appropriateness with all student groups and for relevance to student interests. The writers are committed to the creation of a document that will help encourage all students to engage in and enjoy the study of science.

**Clarity of Language**

Many reviewers remarked that the language in the performance expectations was not clear and user-friendly enough to support consistent implementation—that multiple users would have different interpretations of the same language. More examples and guidance for instruction, assessment, and curriculum development were requested. Requests for clarification were particularly abundant in the feedback describing the practices; the feedback suggested confusion about the meaning and scope of certain practices—particularly "developing and using models".

***Response***

In early drafts of the standards, the writers purposefully did not control for consistent language, in order to provide several different writing styles as models. Based on the public draft feedback and additional feedback from lead states, the different writing styles were assessed and the highest-rated writing style was then adapted for all of the standards. During this process, all performance expectations were carefully reviewed for clarity of language. Although some examples were added, the writers were careful to use language that was general enough to avoid prescribing curriculum and to ensure that performance expectations could be met in multiple ways. To help clarify the meaning of each practice, a separate chapter on the practices was added to this draft of the NGSS.

**Inclusion of Engineering and Technology**

The inclusion of engineering practices and core ideas in the draft NGSS generated a large number of comments. Most reviewers responded positively to the inclusion. Others indicated that engineering shouldn't be in the science standards because of the total amount of content already present in the traditional disciplines and the scarcity of teachers with training in this subject. Still others requested that additional engineering content be added to the NGSS. Of those who liked the inclusion of engineering, many voiced concern that having separate engineering performance expectations, especially in middle school and high school, would either lead to instruction separated from science content or to an omission of the engineering components altogether.

***Response***
Upon direction from the lead states, the writers integrated the ETS1 (Engineering Design) core ideas into the other disciplines. For example, some performance expectations describe the outcomes from both physical sciences core ideas and from engineering design core ideas. This integration resulted in a reduction of the total number of performance expectations. For the January 2013 draft, there will be two different ways to view these same performance expectations: 1) listed within the traditional disciplines, and 2) listed in separate Engineering Design standards.

In addition to this core idea integration, the ETS ideas from the *Framework* are also included in the other two dimensions of the draft NGSS. More engineering practices were specified for the January 2013 draft and incorporated into performance expectations at every grade level. Due to their crosscutting nature, ETS2 (Links among Engineering, Technology, Science, and Society) core ideas have been integrated throughout the standards in a manner similar to that of crosscutting concepts. A full chapter explaining the inclusion of engineering in the NGSS is included in the January draft.

**Specifying one Practice in each Performance Expectation**
While the NGSS draft was widely praised for integrating practices throughout the standards, many reviewers remarked that specifying a particular practice in each performance expectation was too restrictive and that it would be interpreted as prescribing instruction. Some reviewers also felt that the choice of the particular practice included in each performance expectation seemed somewhat arbitrary, and called for the choice to be deliberate.

***Response***
The writers, upon direction from the lead states, have revised the front matter documents to provide a more detailed explanation of the nature of performance expectations – that they specify student outcomes and **not** instruction. To help support student learning, *all practices* should be used in instruction throughout each discipline and each year.

To ensure that the appropriate student practice outcome was selected for each performance expectation, all performance expectations were carefully reviewed for grade-appropriateness, clarity and assessability. The writers also considered the distribution of practices in each discipline and grade level to help ensure that student expectations require increasing proficiency in each practice over time.

**Incorporating Crosscutting Concepts**
Many reviewers remarked that the draft did not make clear how the crosscutting concepts were to be interpreted. Some people interpreted them as additional content; others expressed concern that these concepts would be ignored during implementation of the standards. The specific crosscutting concepts connected to performance expectations also received some criticism; reviewers often suggested that all obvious connections should be spelled out. For example, reviewers commented that a performance expectation about the nature of energy in middle school physical sciences should be connected to the energy and matter crosscutting concept.

***Response***
In response to these concerns, based on the guidance of the lead states, the writers have included a separate chapter in this NGSS draft, describing the use of each crosscutting concept in each grade band. The writers intend for the crosscutting concepts to be an organizing framework that helps students make sense of and connect to core ideas across disciplines and grade bands. They are not intended as additional content. To further specify the rationale behind each crosscutting concept connection in each performance expectation, specific ideas within each concept were bulleted in the foundation boxes, and clarification statements for the connections themselves were added when the connection wasn't obvious.

**Connections to other standards and subjects**
While commenters responded positively to having the "connection box" information in the structure of the standards, many people gave feedback about the specific connections made. More clarity was requested about exactly what part of a standard was connected to another topic or to the Common Core State Standards (CCSS). Many reviewers also noted that certain potential CCSS alignments were missing, and some that were present seemed misplaced or at an incorrect grade level. In addition, many reviewers expressed concern that the lack of mathematics in several performance expectations (particularly in the physical sciences) could reduce the rigor of the NGSS.

***Response***
To help clarify the connections between standards and topics, information about specific performance expectations was added to the connection boxes. The writers also created visuals to show progressions of ideas through time. The CCSS connections underwent additional reviews by the writers of the CCSS, and additional quantitative expectations were added throughout the NGSS. However, the NGSS writers strongly caution developers of instructional materials and assessments that *qualitative* understanding of concepts is too often missed when *quantitative* calculations are the sole focus of instruction and assessment.

**Organization of the Standards**
Many reviewers indicated concern that the current grade-banded organization of the middle and high school standards would not meet their needs in their state. They requested that standards be assigned to a specific grade-level in middle school, and to specific courses in high school. Some states also preferred that standards be arranged according to their disciplinary core idea source in the NRC *Framework*. Confusion was also expressed in reading the names of the standards; the logic behind the names didn't seem apparent and weren't consistent between grades.

***Response***
The NGSS writers recognize the differences in current state policies for the organization of standards. For example, some state science standards are organized by grade levels and some by grade bands; some have integrated science courses in middle school and some have discrete courses. The development of various course models for middle and high school had been planned from the beginning of the project, but was not complete by the time of the first public

draft release of the NGSS. These models provide different suggestions for ways to arrange the standards throughout the grades. A draft of these course models is included in this January 2013 draft of the NGSS.

Regarding the arrangement and naming of standards, the lead states directed that each performance expectation should be named by its disciplinary core idea connection, and that performance expectations should be available in two different groupings: grouped by topic (as in the first public draft) and grouped by disciplinary core idea. Therefore the second public draft is available on the website and in PDFs in both of the arrangements, and users can comment on either one of the arrangements in the survey. Note that this does not increase the total number of performance expectations.

**Implementation Support Needed**

Almost every reviewer noted that the vision laid out in the NRC Framework and embodied by the NGSS will likely require additional professional development and possibly large-scale changes in education systems to ensure that all students can meet all of these standards. For example, it was noted that science is not currently taught at the K-3 level in many schools, and that many students don't currently take chemistry, physics and earth science classes at the high school level. To help them fully understand the vision of the NGSS, reviewers requested vignettes of classroom instruction showing integration of the three dimensions and inclusion of engineering practices and concepts. Many reviewers also commented that implementation of the standards will, in practice, be impossible until aligned assessments are proposed.

***Response***

The NGSS writers recognize the differences between current education practice and that envisioned by the *Framework*. Many organizations, including the National Science Teachers Association, are currently planning for programs and support for teachers and states that adopt and implement the standards. The National Research Council is currently researching recommendations for ways to assess the kind of science education envisioned in the *Framework*. Ultimately, the decision of what assessment to use or develop will be up to each state choosing to adopt the NGSS.

**Public Survey Utility**

Many users reported difficulties navigating through the survey used for the first NGSS public draft comment period. In addition, several groups commented that the calendar period during which the draft was available was a very busy one for K-12 teachers. The NGSS project partners were urged to ensure that the next draft comment period would neither be during a testing period nor during a break when teachers were away and not able to convene to discuss the drafts.

***Response***

Feedback on the draft standards is paramount to the NGSS development process, so the survey was completely rebuilt and integrated with the website to ensure that all users can easily comment on the second public draft of the NGSS. In addition, the second public comment period was postponed until after the winter holidays.