APPENDIX B – Responses to the Public Drafts

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, and the second public draft was posted online from January 8 to January 29, 2013. The draft received comments from over 10,000 individuals during each of the two public review periods, including those in lead state review teams, school and school district discussion groups, and scientific societies. The writers then used this feedback to make substantial revisions to the draft standards.

Overall, the feedback received on both public drafts of the NGSS 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. Most reviewers scored the performance expectations highly, but some also critiqued specific issues and suggested improvements. The following themes emerged from the comments on how to improve the first public draft:

- Concern that there was too much material
- Suggestions for additional topics
- Lack of language clarity
- Concern about how engineering and technology was included and addressed
- 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 needed for implementation of the standards

Based on the feedback, the following changes were made between the first and second public drafts:

- 95% of the Performance Expectations (PEs) were rewritten based on feedback, with more specific and consistent language used
- After a college- and career-readiness review, some content was removed
- Some content shifted grade levels in elementary
- Engineering was integrated into the traditional science disciplines
- More math expectations were added to the performance expectations
- Course models were drafted for middle and high school
- "Nature of science" concepts were highlighted throughout the document
- The practices matrix was revised
- A new chapter was added to describe the intent and use of crosscutting concepts
- A new chapter on equity was drafted about implementation of the NGSS with diverse student groups
- A glossary of terms was added
- More flexibility in viewing the standards was provided by arranging the performance expectations according to both topic and Disciplinary Core Idea (DCI)

Additional flexibility was added to the website, allowing users to turn off pop up description boxes

The feedback on the second public draft indicated that changes had completely addressed some issues, and the percentage of reviewers concerned about the remaining issues was greatly reduced. Those remaining issues included:

- Concern that there was still too much material
- Suggestions for a few additional topics
- Lack of language clarity
- Concern about including and addressing engineering and technology
- Confusion about the role of the one practice specified in each performance expectation
- Concern about the amount of support needed for implementation of the standards
- Confusion about the coding/naming of performance expectations

Based on the feedback, the following changes were made between the second public draft and the final release of the NGSS:

- 75% of the PEs were edited to increase clarity, consistency, and specific feedback.
- A review of the central focus of each DCI from the *Framework* resulted in the removal of about 33% of the PEs and associated DCIs while retaining the progression of DCIs across the grade bands
- Separate ETS1: Engineering Design performance expectations were added to each grade band to supplement performance expectations that had integrated engineering design into the traditional science disciplines
- "Storylines" with essential questions were added to the beginning of each grade band and section to describe the context and rationale for the performance expectations
- The "All Standards, All Students" appendix was expanded to include several vignettes about implementation of the NGSS with diverse student groups
- Performance expectations names were changed from lowercase letters to numbers to avoid confusion with the DCI names. For example, MS-LS1-a became MS-LS1-1

Introduction

Several rounds of review were built into the development process of the 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, and the second public draft was posted online from January 8 to January 29, 2013. The draft received comments from over 10,000 individuals during each of the two public review periods, including those working together in lead state review teams, school and school district discussion groups, and scientific society commenters.

Feedback on the public drafts 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 first public review and subsequent state review, 95% of the performance expectations were rewritten. After the second public draft review period, 75% of the performance expectations were edited to add clarity and consistency across the document. .

Overall, the feedback received on both public drafts of the NGSS was overwhelmingly positive. Almost all reviewers indicated that they liked the pedagogical vision described in the National Research Council 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 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, some commenters suggested improvements regarding specific wording and foundation box connections.

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 about ways to improve the first public draft:

- Concern that there was too much material
- Suggestions for additional topics
- Lack of language clarity
- Concern about how engineering and technology was included and addressed
- 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 needed for implementation of the standards
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Based on this feedback and on additional interim reviews of the standards by the lead states, many changes were made to the standards between the first and second public drafts. The feedback on the second public draft indicated that the changes to the draft had completely

addressed some of the issues, and had greatly reduced the percentage of reviewers that had concerns about the remaining issues. Those remaining issues included:

- Concerns that there was still too much material
- Suggestions for a few 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
- Concern about the amount of support that will be needed for implementation of the standards.

Below is a representative sampling of how each issue identified above was addressed, after a thorough review of the feedback:

Too Much Material

The *Framework* and the NGSS set out to define a small set of core ideas that build on each other coherently through the grade levels. While most reviewers of both the first and second public drafts 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.

In the first public draft, several topics, such as nuclear processes, were identified as being beyond the scope of knowledge necessary for college and career readiness. These topics, for example, were deemed important only for those students who planned to continue in STEM career paths. Similarly, some topics in the elementary levels were deemed more appropriate at either a higher or lower grade level.

To address these issues, the standards underwent extensive review to ensure that all content is both necessary and sufficient for student success after high school in the 21st century. In the K-5 standards, several performance expectations were shifted from one grade level to the next based on the feedback.

In June 2012, 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 first public draft review, led to a deletion of many performance expectations and a greater focus in many discipline areas. 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.

Feedback on the January 2013 draft indicated that the previous reductions in content were not sufficient to allow for the instruction time necessary to build student proficiency in all of the practices, core ideas, and crosscutting concepts. Therefore, additional content was removed by deleting both the performance expectations and associated disciplinary core idea (DCI) endpoints that covered content beyond the central focus of each core idea. For example, the central focus of HS.LS2.B is the effect of cell division and differentiation on growth, so the DCI endpoints that described the details of cellular differentiation were deleted from the expectations of the

standards. The teachers on the NGSS writing team then performed a validity check with the performance expectations to ensure that the scope of the expectations was practical within the realities of a typical school year. In many cases, the deleted endpoints could serve as the beginnings of instructional extensions when time allows.

In addition, changes were made to ensure that the practice and core idea pairings for each performance expectation were appropriate for all students at each grade level. Writers ensured that all the K-12 performance expectations would be implementable within realistic timeframes. The knowledge and skills required by particular performance expectations are not intended to be taught independently of others at the same grade level, and should take into account student knowledge and skills learned at 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, and these skills should build on associated middle school endpoints.

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 of both public drafts voiced concerns about the omission of particular areas of content. As writers were tasked with creating a set of standards faithful to the *Framework*, many of these concerns paralleled those raised during the Framework development process. Major themes from the feedback on the first public draft included requests for more ocean 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.

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 science and computer science between the first and second public drafts. In addition, where nature of science connections already existed in the standards, they were made more explicit in the second public draft and called out in the appropriate foundation boxes. This addition received very positive feedback from most reviewers.

In both the first and second public drafts, many reviewers expressed concern that specific content normally included in high school elective courses was not in the NGSS, including thermodynamics, stoichiometry, solution chemistry and nitrogen cycles. Much of this feedback indicated a misunderstanding of the purpose of the NGSS. In contrast to many current state standards, the NGSS specify content and skills required of <u>all</u> students, and are not intended to replace high school course standards. The NGSS are meant to specify the knowledge and skills that will 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 its relation to college and career readiness in science. As described, 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, as understood by high school graduates, would allow for success in

postsecondary 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, without having a separate performance expectation requiring that all students do gram to gram calculations.

A small number of reviewers in both public draft review periods asked that evolution not be included in the standards. However, an understanding of evolution was identified in the *Framework* as the basis for understanding all the natural sciences. As such, it was included in the NGSS.

In their feedback on the first public draft, 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.
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, many reviewers requested more guidance for implementation with diverse student groups. A thorough discussion of equity and diversity issues had been planned for inclusion in the standards. A draft version was included in the second public draft of the NGSS, and an expanded version with several vignettes is included in the final release. Each performance expectation and associated examples have been reviewed for appropriateness with all student groups and for relevance to student interests. The writers were committed to the creation of a document that will help encourage all students to engage in and enjoy the study of science.

Some reviewers of both public drafts requested that the standards specify the intermediate knowledge necessary for scaffolding toward eventual student outcomes. However, 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 did 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. For example, MS-LS3-1 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 on MS-LS3-1, students will have to be introduced to the concept of a gene through curriculum and instruction.

Clarity of Language

Many reviewers of the first public draft remarked that the language in the performance expectations was unclear and not 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."

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. 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.

The percentage of people with concerns about language clarity was much lower when reviewing the second public draft. Since some concerns still remained, however, the performance expectations that received the highest scores for clarity were used as models for editing most of the other performance expectations. This created clearer and more consistent language, more closely aligned to that in the *Framework.*

Inclusion of Engineering and Technology

The initial inclusion of engineering practices and core ideas in the May 2012 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.

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

Feedback on the integration of engineering in the January 2013 draft was mixed. Reviewers enthusiastically praised the idea of integration as a way to help ensure that engineering design core ideas would be incorporated into science instruction, but commented that the intended engineering design core ideas were not always explicit. The feedback indicated that the integration was not consistently successful.

The writers therefore reintroduced a small set of separate performance expectations addressing ETS1 core ideas at each grade band, to ensure that the engineering design core ideas from the Framework would be clearly represented. In addition, some of the successfully-integrated disciplinary core ideas are still present throughout the other disciplinary standards.

In addition to this core idea integration, the ETS ideas from the *Framework* are included in the other two dimensions of the draft NGSS. Engineering practices are 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 thorough discussion of the inclusion of engineering in the NGSS is in Appendices I and J.

Specifying one Practice in each Performance Expectation

While the NGSS draft was widely praised for integrating practices throughout the standards, many reviewers in both the first and second public drafts remarked that specifying a particular practice in each performance expectation was too restrictive and that it would be interpreted as prescribing instruction.

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.

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.

State standards have traditionally represented Practices and Core Ideas as two separate entities. However, observations from science education researchers have indicated that the result of having these two dimensions separate is that they are either taught separately or the Practices are not taught at all.

Implementation Support Needed

Almost every reviewer in both public drafts 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 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 now researching 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.