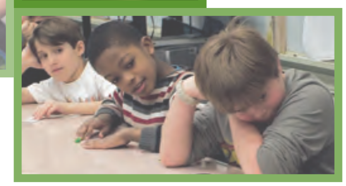
PART I

A VISION FOR K-12 SCIENCE EDUCATION

Copyright © National Academy of Sciences. All rights reserved.



1

A NEW CONCEPTUAL FRAMEWORK

Science and engineering—significant parts of human culture that represent some of the pinnacles of human achievement—are not only major intellectual enterprises but also can improve people's lives in fundamental ways. Although the intrinsic beauty of science and a fascination with how the world works have driven exploration and discovery for centuries, many of the challenges that face humanity now and in the future—related, for example, to the environment, energy, and health—require social, political, and economic solutions that must be informed deeply by knowledge of the underlying science and engineering.

Many recent calls for improvements in K-12 science education have focused on the need for science and engineering professionals to keep the United States competitive in the international arena. Although there is little doubt that this need is genuine, a compelling case can also be made that understanding science and engineering, now more than ever, is essential for every American citizen. Science, engineering, and the technologies they influence permeate every aspect of modern life. Indeed, some knowledge of science and engineering is required to engage with the major public policy issues of today as well as to make informed everyday decisions, such as selecting among alternative medical treatments or determining how to invest public funds for water supply options. In addition, understanding science and the extraordinary insights it has produced can be meaningful and relevant on a personal level, opening new worlds to explore and offering lifelong opportunities for enriching people's lives. In these contexts, learning science is important for everyone, even those who eventually choose careers in fields other than science or engineering.

Copyright © National Academy of Sciences. All rights reserved.

The conceptual framework presented in this report of the Committee on a Conceptual Framework for New K-12 Science Education Standards articulates the committee's vision of the scope and nature of the education in science, engineering, and technology needed for the 21st century. It is intended as a guide to the next step, which is the process of developing standards for all students. Thus it describes the major practices, crosscutting concepts, and disciplinary core ideas that all students should be familiar with by the end of high school, and it provides an outline of how these practices, concepts, and ideas should be developed across the grade levels. Engineering and technology are featured alongside the physical sciences, life sciences, and earth and space sciences for two critical reasons: to reflect the importance of understanding the human-built world and to recognize the value of better integrating the teaching and learning of science, engineering, and technology.

By framework we mean a broad description of the content and sequence of learning expected of all students by the completion of high school—but not at the level of detail of grade-by-grade standards or, at the high school level, course descriptions and standards. Instead, as this document lays out, the framework is intended as a guide to standards developers as well as for curriculum designers, assessment developers, state and district science administrators, professionals responsible for science teacher education, and science educators working in informal settings.

There are two primary reasons why a new framework is needed at this time. One is that it has been 15 or more years since the last comparable effort at the national scale, and new understandings both in science and in teaching and learning science have developed over that time. The second is the opportunity provided by a movement of multiple states to adopt common standards in mathematics and in language arts, which has prompted interest in comparable documents for science. This framework is the first part of a two-stage process to produce a next-generation set of science standards for voluntary adoption by states. The second step—the development of a set of standards based on this framework—is a state-led effort coordinated by Achieve, Inc., involving multiple opportunities for input from the states' science educators, including teachers, and the public.

A VISION FOR K-12 EDUCATION IN THE SCIENCES AND ENGINEERING

The framework is designed to help realize a vision for education in the sciences and engineering in which students, over multiple years of school, actively engage in scientific and engineering practices and apply crosscutting concepts to deepen

Copyright © National Academy of Sciences. All rights reserved.

their understanding of the core ideas in these fields. The learning experiences provided for students should engage them with fundamental questions about the world and with how scientists have investigated and found answers to those questions. Throughout grades K-12, students should have the opportunity to carry out scientific investigations and engineering design projects related to the disciplinary core ideas.

By the end of the 12th grade, students should have gained sufficient knowledge of the practices, crosscutting concepts, and core ideas of science and engineering to engage in public discussions on science-related issues, to be critical consumers of scientific information related to their everyday lives, and to continue to learn about science throughout their lives. They should come to appreciate that science and the current scientific understanding of the world are the result of many hundreds of years of creative human endeavor. It is especially important to note that the above goals are for all students, not just those who pursue careers in science, engineering, or technology or those who continue on to higher education.

We anticipate that the insights gained and interests provoked from studying and engaging in the practices of science and engineering during their K-12 schooling should help students see how science and engineering are instrumental in addressing major challenges that confront society today, such as generating sufficient energy, preventing and treating diseases, maintaining supplies of clean water and food, and solving the problems of global environmental change. In addition, although not all students will choose to pursue careers in science, engineering, or technology, we hope that a science education based on the framework will motivate and inspire a greater number of people—and a better representation

Copyright © National Academy of Sciences. All rights reserved.

The framework is designed to help realize a vision for education in the sciences and engineering in which students, over multiple years of school, actively engage in scientific and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields.

of the broad diversity of the American population—to follow these paths than is the case today.

The committee's vision takes into account two major goals for K-12 science education: (1) educating all students in science and engineering and (2) providing the foundational knowledge for those who will become the scientists, engineers, technologists, and technicians of the future. The framework principally concerns itself with the first task—what all students should know in preparation for their individual lives and for their roles as citizens in this technology-rich and scientifically complex world. Course options, including Advanced Placement (AP) or honors courses, should be provided that allow for greater breadth or depth in the science topics that students pursue, not only in the usual disciplines taught as natural sciences in the K-12 context but also in allied subjects, such as psychology, computer science, and economics. It is the committee's conviction that such an education, done well, will excite many more young people about science-related subjects and generate a desire to pursue science- or engineering-based careers.

Achieving the Vision

The framework is motivated in part by a growing national consensus around the need for greater coherence—that is, a sense of unity—in K-12 science education. Too often, standards are long lists of detailed and disconnected facts, reinforcing the criticism that science curricula in the United States tend to be "a mile wide and an inch deep" [1]. Not only is such an approach alienating to young people, but it can also leave them with just fragments of knowledge and little sense of the creative achievements of science, its inherent logic and consistency, and its universality. Moreover, that approach neglects the need for students to develop an understanding of the practices of science and engineering, which is as important to understanding science as knowledge of its content.

The framework endeavors to move science education toward a more coherent vision in three ways. First, it is built on the notion of learning as a developmental

Copyright © National Academy of Sciences. All rights reserved.

progression. It is designed to help children continually build on and revise their knowledge and abilities, starting from their curiosity about what they see around them and their initial conceptions about how the world works. The goal is to guide their knowledge toward a more scientifically based and coherent view of the sciences and engineering, as well as of the ways in which they are pursued and their results can be used.

Second, the framework focuses on a limited number of core ideas in science and engineering both within and across the disciplines. The committee made this choice in order to avoid shallow coverage of a large number of topics and to allow more time for teachers and students to explore each idea in greater depth. Reduction of the sheer sum of details to be mastered is intended to give time for students to engage in scientific investigations and argumentation and to achieve depth of understanding of the core ideas presented. Delimiting what is to be learned about each core idea within each grade band also helps clarify what is most important to spend time on and avoid the proliferation of detail to be learned with no conceptual grounding.

Third, the framework emphasizes that learning about science and engineering involves integration of the knowledge of scientific explanations (i.e., content knowledge) and the practices needed to engage in scientific inquiry and engineering design. Thus the framework seeks to illustrate how knowledge and practice must be intertwined in designing learning experiences in K-12 science education.

Limitations of This Framework

The terms "science," "engineering," and "technology" are often lumped together as a single phrase, both in this report and in education policy circles. But it is important to define what is meant by each of these terms in this report—and why.

In the K-12 context, science is generally taken to mean the traditional natural sciences: physics, chemistry, biology, and (more recently) earth, space, and environmental sciences. In this document, we include core ideas for these disciplinary areas, but not for all areas of science, as discussed further below. This limitation matches our charge and the need of schools for a next generation of standards in these areas. Engineering and technology are included as they relate to the applications of science, and in so doing they offer students a path to strengthen their understanding of the role of sciences. We use the term engineering in a very broad sense to mean any engagement in a systematic practice of design to achieve solutions to particular human problems. Likewise, we broadly use the term technology to include all types of human-made systems and processes—not in the

Copyright © National Academy of Sciences. All rights reserved.

limited sense often used in schools that equates technology with modern computational and communications devices. Technologies result when engineers apply their understanding of the natural world and of human behavior to design ways to satisfy human needs and wants. This is not to say that science necessarily precedes technology; throughout history, advances in scientific understanding often have been driven by engineers' questions as they work to design new or improved machines or systems.

Engineering and technology, defined in these broad ways, are included in the framework for several reasons. First, the committee thinks it is important for students to explore the practical use of science, given that a singular focus on the core ideas of the disciplines would tend to shortchange the importance of applications. Second, at least at the K-8 level, these topics typically do not appear elsewhere in the curriculum and thus are neglected if not included in science instruction. Finally, engineering and technology provide a context in which students can test their own developing scientific knowledge and apply it to practical problems; doing so enhances their understanding of science—and, for many, their interest in science—as they recognize the interplay among science, engineering, and technology. We are convinced that engagement in the practices of engineering design is as much a part of learning science as engagement in the practices of science [2].

It is important to note, however, that the framework is not intended to define course structure, particularly at the high school level. Many high schools already have courses designated as technology, design, or even engineering that go beyond the limited introduction to these topics specified in the framework. These courses are often taught by teachers who have specialized expertise and do not consider themselves to be science teachers. The committee takes no position on such courses—nor, in fact, on any particular set of course sequence options for students at the high school level. We simply maintain that some introduction to engineering practice, the application of science, and the interrelationship of science, engineering, and technology is integral to the learning of science for all students.

The committee's vision takes into account two major goals for K-12 science education: (1) educating all students in science and engineering and (2) providing the foundational knowledge for those who will become the scientists, engineers, technologists, and technicians of the future.

Copyright © National Academy of Sciences. All rights reserved.

More generally, this framework should not be interpreted as limiting advanced courses that go beyond the material included here—all students at the high school level should have opportunities for advanced study in areas of interest to them, and it is hoped that, for many, this will include further study of specific science disciplines in honors or AP courses. Such course options may include topics, such as neurobiology, and even disciplines, such as economics, that are not included in this framework.

Social, Behavioral, and Economic Sciences

Although some aspects of the behavioral sciences are incorporated in the framework as part of life sciences, the social, behavioral, and economic sciences are not fully addressed. The committee did not identify a separate set of core ideas for these fields for several reasons.

First, the original charge to the committee did not include these disciplines. Second, social, behavioral, and economic sciences include a diverse array of fields (sociology, economics, political science, anthropology, all of the branches of psychology) with different methods, theories, relationships to other disciplines of science, and representation in the K-12 curriculum. Although some are currently represented in grades K-12, many are not or appear only in courses offered at the high school level.

Third, the committee based the framework on existing documents that outline the major ideas for K-12 science education, including the *National Science Education Standards* (*NSES*) [3], the *Benchmarks for Science Literacy* [4] and the accompanying *Atlas* [5], the *Science Framework for the 2009 National Assessment of Educational Progress* (*NAEP*) [6], and the *Science College Board Standards for College Success* [7]. Most of these documents do not cover all of the fields that are part of the social, behavioral, and economic sciences comprehensively, and some omit them entirely.

Fourth, understanding how to integrate the social, behavioral, and economic sciences into standards, given how subjects are currently organized in the K-12 system, is especially complex. These fields have typically not been included as part of the science curriculum and, as noted above, are not represented systematically in some of the major national-level documents that identify core concepts for K-12 science. Also, many of the topics related to the social, behavioral, and economic sciences are incorporated into curricula or courses identified as social studies and may be taught from a humanities perspective. In fact, the National Council for the Social Studies has a set of National Curriculum Standards for Social Studies that

Copyright © National Academy of Sciences. All rights reserved.

includes standards in such areas as psychology, sociology, geography, anthropology, political science, and economics [8].

The limited treatment of these fields in this report's framework should not, however, be interpreted to mean that the social, behavioral, and economic sciences should be omitted from the K-12 curriculum. On the contrary, the committee strongly believes that these important disciplines need their own framework for defining core concepts to be learned at the K-12 level and that learning (the development of understanding of content and practices) in the physical, life, earth, and space sciences and engineering should be strongly linked with parallel learning in the social, behavioral, and economic sciences. Any such framework must also address important and challenging issues of school and curriculum organization around the domain of social sciences and social studies.

Our committee has neither the charge nor the expertise to undertake that important work. Thus, although we have included references to some of the social, behavioral, and economic issues connected to the sciences that are the focus of our own framework (see, for example, Core Idea 2 in engineering, technology, and applications of science), we do not consider these references to define the entirety of what students should learn or discuss about social, behavioral, and economic sciences.

In a separate effort, the National Research Council (NRC) has plans to convene a workshop to begin exploring a definition of what core ideas in the social, behavioral, and economic sciences would be appropriate to teach at the K-12 level and at what grade levels to introduce them. As noted above, there are many quite distinct realms of study covered by the terms. Given the multiplicity and variety of disciplines involved, only a few of which are currently addressed in any way in K-12 classrooms, there is much work to be done to address the role of these sciences in the development of an informed 21st-century citizen. It is clear, however, to the authors of this report that these sciences, although different in focus, do have much in common with the subject areas included here, so that much of what this report discusses in defining scientific and engineering practices and crosscutting concepts has application across this broader realm of science.

Computer Science and Statistics

Computer science and statistics are other areas of science that are not addressed here, even though they have a valid presence in K-12 education. Statistics is basically a subdiscipline of mathematical sciences, and it is addressed to some extent in the common core mathematics standards. Computer science, too, can be seen

Copyright © National Academy of Sciences. All rights reserved.

as a branch of the mathematical sciences, as well as having some elements of engineering. But, again, because this area of the curriculum has a history and a teaching corps that are generally distinct from those of the sciences, the committee has not taken this domain as part of our charge. Once again, this omission should not be interpreted to mean that computer science or statistics should be excluded from the K-12 curriculum. There are aspects of computational and statistical thinking that must be understood and applied in learning about the sciences, and we identify these aspects, along with mathematical thinking, in our discussion of science practices in Chapter 3.

ABOUT THIS REPORT

The Committee on a Conceptual Framework for New K-12 Science Education Standards was established by the NRC to undertake the study on which this report is based. Composed of 18 members reflecting a diversity of perspectives and a broad range of expertise, the committee includes professionals in the natural sciences, mathematics, engineering, cognitive and developmental psychology, the learning sciences, education policy and implementation, research on learning science in the classroom, and the practice of teaching science.

The committee's charge was to develop a conceptual framework that would specify core ideas in the life sciences, physical sciences, earth and space sciences, and engineering and technology, as well as crosscutting concepts and practices, around which standards should be developed. The committee was also charged with articulating how these disciplinary ideas and crosscutting concepts intersect for at least three grade levels and to develop guidance for implementation (see Box 1-1).

Scope and Approach

The committee carried out the charge through an iterative process of amassing information, deliberating on it, identifying gaps, gathering further information to fill these gaps, and holding further discussions. In our search for particulars, we held three public fact-finding meetings, reviewed published reports and unpublished research, and commissioned experts to prepare and present papers. At our fourth meeting, we deliberated on the form and structure of the framework and on the content of the report's supporting chapters, to prepare a draft framework for public release in July 2010. During the fifth and sixth meetings, we considered the feedback received from the public and developed a plan for revising the draft framework based on this input (see below for further details).

Copyright © National Academy of Sciences. All rights reserved.

BOX 1-1

COMMITTEE CHARGE

An ad hoc committee will develop and define a framework to guide the development of science education standards. In conducting the study and preparing its report, the committee will draw on current research on science learning as well as research and evaluation evidence related to standards-based education reform. This will include existing efforts to specify central ideas for science education, including the *National Science Education Standards*, AAAS Benchmarks, the 2009 NAEP Framework, and the redesign of the AP courses by the College Board.

The conceptual framework developed by the committee will identify and articulate the core ideas in science around which standards should be developed by considering core ideas in the disciplines of science (life sciences, physical sciences, earth and space sciences, and applied sciences) as well as crosscutting ideas such as mathematization,* causal reasoning, evaluating and using evidence, argumentation, and model development. The committee will illustrate with concrete examples how crosscutting ideas may play out in the context of select core disciplinary ideas and articulate expectations for students' learning of these ideas for at least three key grade levels. In parallel, the committee will develop a research and development plan to inform future revisions of the standards. Specifically in its consensus report, the committee will

- identify a small set of core ideas in each of the major science disciplines, as well as those ideas that cut across disciplines, using a set of criteria developed by the committee
- develop guidance on implementation of the framework
- articulate how these disciplinary ideas and crosscutting ideas intersect for at least three grade levels
- create examples of performance expectations
- discuss implications of various goals for science education (e.g., general science literacy, college preparation, and workforce readiness) on the priority of core ideas and articulation of leaning expectations
- develop a research and development plan to inform future revisions of the standards

*Mathematization is a technical term that means representing relationships in the natural world using mathematics.

The nature of the charge—to identify the scientific and engineering ideas and practices that are most important for all students in grades K-12 to learn—means that the committee ultimately had to rely heavily on its own expertise and collective judgments. To the extent possible, however, we used research-based evidence and past efforts to inform these judgments. Our approach combined

Copyright © National Academy of Sciences. All rights reserved.

evidence on the learning and teaching of science and engineering with a detailed examination of previous science standards documents. It is important to note that even where formal research is limited, the report is based on the collective experience of the science education and science education research communities. All the practices suggested have been explored in classrooms, as have the crosscutting concepts (though perhaps under other names such as "unifying themes").

Design Teams

The committee's work was significantly advanced by the contributions of four design teams, which were contracted by the NRC to prepare materials that described the core ideas in the natural sciences and engineering and outlined how these ideas could be developed across grades K-12. Each team had a designated leader who provided guidance and interacted frequently with the committee. The materials developed by the teams form the foundation for the core disciplinary ideas and grade band endpoints described in this report (Chapters 5-8). A list of the design team participants appears in Appendix D.

The design teams were asked to begin their work by considering the ideas and practices described in the *NSES* [3], *AAAS Benchmarks* [4], *Science Framework for the 2009 NAEP* [6], and *Science College Board Standards for College Success* [7] as well as the relevant research on learning and teaching in science. The teams prepared drafts and presented them to the committee during the closed portions of our first three meetings. Between meetings, the teams revised their drafts in response to committee comments. Following the release of the July 2010 draft (see the next section), the leaders of the design teams continued to interact with committee members as they planned the revisions of the draft framework. No members of the design teams participated in the discussions during which the committee reached consensus on the content of the final draft.

The framework and subsequent standards will not lead to improvements in K-12 science education unless the other components of the system—curriculum, instruction, professional development, and assessment—change so that they are aligned with the framework's vision.

Copyright © National Academy of Sciences. All rights reserved.

Public Feedback

The committee recognized early in the process that obtaining feedback from a broad range of stakeholders and experts would be crucial to the success of the framework. For this reason, we obtained permission from the NRC to release a draft version of the framework for public comment.

The draft version was prepared, underwent an expedited NRC review, and was released in early July 2010. It was then posted online for a period of three weeks, during which time individuals could submit comments through an online survey. In addition, NRC staff contacted over 40 organizations in science, engineering, and education, notifying them of the public comment period and asking them to hold focus groups to gather feedback from members or to at least notify their members of the opportunity to comment online. The NRC also worked closely with the National Science Teachers Association, the American Association for the Advancement of Science, Achieve, Inc., and the Council of State Science Supervisors both to facilitate the public input process and to organize focus groups. Finally, the committee asked nine experts to provide detailed feedback on the public draft.

During the 3-week public comment period, the committee received extensive input from both individuals and groups: a total of more than 2,000 people responded to the online survey. More than 30 focus groups were held around the country, with 15-40 participants in each group. The committee also received letters from key individuals and organizations. A list of the organizations that participated in the focus groups or submitted letters is included in Appendix A.

NRC staff, together with the committee chair, reviewed all of the input and developed summaries that identified the major issues raised and outlined possible revisions to the draft framework. Committee members reviewed these summaries and also had the opportunity to review the public feedback in detail. Based on discussions at the fifth and sixth meetings, the committee made substantial revisions to the framework based on the feedback. A summary of the major issues raised in the public feedback and the revisions the committee made is included in Appendix A.

Structure of the Report

The first nine chapters of this report outline the principles underlying the framework, describe the core ideas and practices for K-12 education in the natural sciences and engineering, and provide examples of how these ideas and practices should be integrated into any standards.

Copyright © National Academy of Sciences. All rights reserved.

The remaining four chapters of the report address issues related to designing and implementing standards and strengthening the research base that should inform them. Chapter 10 articulates the issues related to curriculum, instruction, and assessment. Chapter 11 discusses important considerations related to equity and diversity. Chapter 12 provides guidance for standards developers as they work to apply the framework. Finally, Chapter 13 outlines the research agenda that would allow a systematic implementation of the framework and related standards. The chapter also specifies the kinds of research needed for future iterations of the standards to be better grounded in evidence.

NEXT STEPS

The National Governors Association and the Council of Chief State School Officers have developed "Common Core State Standards" in mathematics and language arts, and 43 states and the District of Columbia have adopted these standards as of early 2011. The anticipation of a similar effort for science standards was a prime motivator for this NRC study and the resulting framework described in this report.

To maintain the momentum, the Carnegie Corporation commissioned the nonpartisan and nonprofit educational reform organization Achieve, Inc., to lead states in developing new science standards based on the NRC framework in this report. There is no prior commitment from multiple states to adopt such standards, so the process will be different from the Common Core process used for mathematics and language arts. But it is expected that Achieve will form partnerships with a number of states in undertaking this work and will offer multiple opportunities for public comment.

As our report was being completed, Achieve's work on science standards was already under way, starting with an analysis of international science benchmarking in high-performing countries that is expected to inform the standards development process. We understand that Achieve has also begun some preliminary planning for that process based on the draft framework that was circulated for public comment in summer 2010. The relevance of such work should deepen once the revised framework in this report, on which Achieve's standards will be based, is released. It should be noted, however, that our study and the framework described in this report are independent of the work of Achieve.

The framework and any standards that will be based on it make explicit the goals around which a science education system should be organized [9]. The committee recognizes, however, that the framework and subsequent standards will not

Copyright © National Academy of Sciences. All rights reserved.

lead to improvements in K-12 science education unless the other components of the system—curriculum, instruction, professional development, and assessment—change so that they are aligned with the framework's vision. Thus the framework and standards are necessary but not sufficient to support the desired improvements. In Chapter 10, we address some of the challenges inherent in achieving such alignment.

Copyright © National Academy of Sciences. All rights reserved.

REFERENCES

1. Schmidt, W.H., McKnight, C.C., and Raizen, S. (1997). *A Splintered Vision: An Investigation of U.S. Science and Mathematics Education*. U.S. National Research Center for the Third International Mathematics and Science Study. Boston, MA: Kluwer Academic.
2. National Academy of Engineering and National Research Council. (2009). *Engineering in K-12 Education: Understanding the Status and Improving the Prospect*. Committee on K-12 Engineering Education. L. Katehi, G. Pearson, and M. Feder (Eds.). National Academy of Engineering. Board on Science Education, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.
3. National Research Council. (1996). *National Science Education Standards*. National Committee for Science Education Standards and Assessment. Washington, DC: National Academy Press.
4. American Association for the Advancement of Science. (1993). *Benchmarks for Science Literacy*. Project 2061. New York: Oxford University Press. Available: http://www.project2061.org/publications/bsl/online/index.php?txtRef=http%3A%2F%2Fwww%2Eproject2061%2Eorg%2Fpublications%2Fbsl%2Fdefault%2Ehtm%3FtxtRef%3D%26txtURIOld%3D%252Ftools%252Fbsl%252Fdefault%2Ehtm&txtURIOld=%2Fpublications%2Fbsl%2Fonline%2Fbolintro%2Ehtm [June 2011].
5. American Association for the Advancement of Science. (2007). *Atlas of Science Literacy, Volumes 1 and 2*. Project 2061. Washington, DC: Author.
6. National Assessment of Educational Progress. (2009). *Science Framework for the 2009 National Assessment of Educational Progress*. Washington, DC: U.S. Government Printing Office. Developed for the National Assessment Governing Board. Available: http://www.nagb.org/publications/frameworks/science-09.pdf [June 2011].
7. College Board. (2009). *Science College Board Standards for College Success*. Available: http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf [June 2011].
8. National Council for the Social Studies. (2010). *National Curriculum Standards for Social Studies: A Framework for Teaching, Learning, and Assessment*. Silver Spring, MD: Author.
9. National Research Council. (2006). *Systems for State Science Assessment*. M.R. Wilson and M.W. Bertenthal (Eds.). Committee on Test Design for K-12 Science Achievement. Board on Testing and Assessment, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Copyright © National Academy of Sciences. All rights reserved.

Copyright © National Academy of Sciences. All rights reserved.