MARYLAND

STATE DEPARTMENT OF EDUCATION

Analysis of the
Voluntary State Curriculum (VSC) in Science
Grades Pre-K–8

Achieve, Inc.

2005

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Maryland State Department of Education
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INTRODUCTION

In response to a proposal request from the state, Achieve reviewed the draft of Maryland's Pre-K–8 Voluntary State Curriculum (VSC) in Science (dated May 2004). This report summarizes our findings and also reflects the discussion that followed our presentation to representatives of the Maryland State Department of Education on October 18, 2004.

METHODOLOGY

Achieve's review is based on our criteria for analyzing content standards as compared to our benchmark standards. These criteria include the following general categories: rigor, progression, focus, coherence and manageability, clarity and organization, specificity, and measurability. Achieve's state benchmark standards in science are as follows: Indiana's K–8 standards, Delaware's K–12 standards and Massachusetts' K–12 standards. Because state documents are largely based on the National Science Education Standards and the standards contained in *AAAS Project 2061: Benchmarks for Science Literacy*, Achieve considers these benchmarks as well. To help reviewers conduct a systematic analysis, Achieve formulated guiding questions. However, as important as the criteria, benchmarks and guiding questions are for enabling a comprehensive and thorough review, they are tools; in the end, the quality of Achieve's review rests upon the expertise and diligence of its reviewers.

Authoritative review of grade-level expectations in science is especially challenging in that science education comprises distinct fields of study — Earth/space science, life science, chemistry, physics and environmental science (an interdisciplinary field) — unified by common understandings based on the nature of the science enterprise, scientific reasoning, the relationship of science to technology and the history of science. Achieve therefore contracted with six expert reviewers to ensure each of Maryland's content standards (2.0–5.0) was evaluated by at least two reviewers with deep expertise in the field; most were reviewed by three. All six reviewers, as well as an expert in the field of cognition and development, also examined Standard 1.0 (Science Skills and Processes) because it cuts across all fields of science. Similarly, five reviewers examined Standard 6.0 (Environmental Science) because its content is based on understandings drawn from Earth/space science, life science, chemistry and physics. In addition to this preliminary report, Achieve prepared the several documents to support and clarify our overall findings and recommendations:

- Side-by-Side Comparison of Maryland's Pre-K–2 Inquiry Strand in Standard 1.0 with Achieve's Benchmarks
- Standard 1.0 Alternative Format and Organization (Science Skills and Processes)
- Overview of the Current Organization of Content Standards (2.0–5.0)
- Detailed Suggestions for Revision of the Content Standards (2.0–6.0)

BACKGROUND

It is important to acknowledge at the outset that it is incredibly challenging to organize a set of pre-K–8 standards for science that does justice to the science and also is sensitive to the reality that elementary teachers are by and large generalists — responsible for teaching multiple subjects — who typically have had minimal preparation in the sciences. Moreover, there is no one correct set of science standards, and numerous solid articulations exist, as Achieve's adoption of multiple benchmarks attests. Exemplary standards result from constructing a coherent and effective framework derived from the tenets of the science disciplines and filling in that framework by focusing on the most important content for all learners. Requisite knowledge and skills must be described in clear language, painstakingly sequenced topic-by-topic and grade-by-grade and anchored with examples to ensure expectations for student performance are clear, specific and assessable.

FINDINGS

It requires considerable time and effort to produce a document of the complexity of Maryland's draft VSC in Science, and Maryland's current draft shows evidence of much thoughtful work. The state has a good foundation it can build on to improve its standards and take them to the next level. Because benchmarking tends to be primarily a gap analysis, the bulk of this preliminary report will focus somewhat disproportionately on areas for improvement — ways that Maryland can strengthen its VSC in Science.

AREAS OF STRENGTH

Rigor

In general, the understandings and skills delineated in Maryland's standards for Earth/space science, life science, chemistry and physics compare favorably with the content found in Achieve's benchmark standards in science. Essential knowledge and skills are identified with a few exceptions. The chemistry standard (4.0) is particularly robust, having well-developed connections within its component strands and cross connections with the remaining content standards (2.0–6.0). It can serve as a model for the state to use as it goes about strengthening other standards. Maryland's VSC in Science also generally encompasses the understandings and skills students need to succeed at the next level and leads to "capstone" performances at grade 8, equivalent in large part to those delineated in Achieve's benchmarks.

Focus

Reviewers found that, for the most part, the standards, indicators and objectives emphasize core science knowledge essential for all students to learn. Reviewers did not find obviously extraneous or insignificant knowledge or skills included in the science standards. However, the necessity of establishing assessment limits in preparation for constructing science tests — as required by NCLB — is an opportunity for the state to look back from grade 8 at the supporting content in prekindergarten through grade 7, strand by strand, to determine if judicious pruning would make the VSC in Science more manageable, connected and focused.

Consistency in "Grain Size"

One aspect of specificity is arriving at a consistent "grain size" in developing indicators and objectives — avoiding swings from overly general statements to narrow, "atomistic" statements. Consistency in grain size helps clarify expectations and guide lesson planning and assessment. Few states have succeeded in this to the extent that Maryland has.

Measurability

A positive feature of Maryland's VSC in Science is that its indicators and objectives are written in measurable terms. In contrast to some other state science standards, Maryland has avoided the use of verbs such as *explore* or *investigate* that call attention to the process of learning but fail to zero in on the results of that learning.

PRIORITY AREAS FOR IMPROVEMENT

Achieve's expert reviewers agreed that the following five areas should be given priority in revising the current draft of Maryland's pre-K–8 VSC in Science:

- Standard 1.0: Science Skills and Processes (Overall)
- Grade-Level Appropriateness (Primarily Standard 1.0)
- Coherence and Connectivity (All Standards)
- Standard 3.0: Life Science (Overall)
- Illustrative Examples (All Standards)
- Verb Choice (All Standards)

Standard 1.0: Science Skills and Processes (Overall)

Maryland's Science Skills and Processes standard requires extensive revision if it is to be effective in helping the state realize its vision for developing a powerful science curriculum. The skills and processes require adjustment in terms of connections to content, grade-level placement, progression, focus and the language (and illustrative examples) used to describe expectations for students, especially in the early grades. Achieve constructed a side-by-side comparison of Maryland's pre-K–2 expectations with selected benchmark documents to highlight differences in expectations and language. A number of significant differences are readily apparent: In grade 1, Maryland calls for students to "seek information from readings, investigation, and or oral communication." In contrast, AAAS *Benchmarks for Science Literacy* for kindergarten through grade 2 states, "People can often learn about things around them by just observing things carefully, but sometimes they can learn more by doing something to the things and noting what happens." [1] Two differences are immediately apparent. First, there is no mention of observation in grade 1 (nor in grade 2) in Maryland's standards, although it is mentioned in prekindergarten and kindergarten. Observation is a skill fundamental to science inquiry and needs to be included at every level. Second, the language in the AAAS document evokes a

[1] American Association for the Advancement of Science, *Benchmarks for Science Literacy – Project 2061*. (New York: Oxford University Press, 1993).

primary setting and speaks in terms that are user friendly for teachers of early grades, essentially implying the kind of activities that would be instructionally effective. Maryland's language is, in contrast, overly formal. This is not a trivial distinction. Standards documents must be accurate, but they also should be written in language that is meaningful to teachers who have not had the benefit of extensive coursework in science, so they can act on their essential messages.

There are other key differences between Maryland's Science Skills and Processes standard and the benchmark documents that were identified by reviewers. A major concern is the absence of connections between the Science Skills and Processes standard and the content standards. Teachers need to see how specific skills and processes are to be employed by children to generate their own knowledge and understanding of the critical concepts embedded in Earth/space science, life science, chemistry, physics and environmental science. Without explicit connections, the skills and processes could end up being taught as separate units, almost completely divorced from the content standards.

A related concern is the lack of clarifying or illustrative examples. While the absence of examples that communicate the level of performance required in the content standards is an issue that needs to be addressed in all of the standards, it is particularly acute for science skills and processes. Without illustrations to signal the level of cognitive demand and to suggest complementary assessments, teachers will be hard pressed to put into practice the kind of teaching and learning the state intends. An effective way to make concrete connections is to provide examples that ground skills and processes by describing proficient performances pitched at the appropriate grade level. Delaware makes connections by providing an example of an activity for each indicator that clarifies what the indicator is asking for and implies the level of rigor and an apt assessment.

Reviewers also called attention to the need for a more carefully wrought progression — a thoughtfully staged evolution of knowledge and skills, generally moving from the simple to the complex and from the concrete to the abstract. To achieve this, content must be introduced at appropriate grades, and knowledge and skills must grow in intellectual demand from year to year. Currently, within the Science Skills and Processes standard, there are virtually no discernable differences between whole grade spans in the scientific inquiry and critical thinking strands.

Inquiry and critical thinking are not separate areas of study — they operate conjointly in the generation of new scientific knowledge and therefore are fundamental to developing the habits of mind that prepare students for living and working in a global, information-based society. Additional restructuring recommendations target the issue of grade-level appropriateness and connectivity with the content standards.

To address these concerns, Achieve recommends that Maryland consider an alternative organizational schema for its science skills and processes standard that would combine and restructure Strand A: Science Inquiry and Strand B: Critical Thinking. (Achieve prepared an example of an alternative to the current organization of Standard 1.0. The example provided is incomplete and is provided for illustrative purposes only, as a way to help teachers see the many connections that exist between inquiry and critical thinking and the content standards. It also emphasizes that science process skills should not be taught in isolation from meaningful science content.)

The alternative schema sorts science processes and skills into two major categories: *basic*, which includes observing, classifying, measuring, communicating, inferring and predicting; and *integrated*, which includes controlling variables; formulating hypotheses; collecting, recording, organizing and interpreting data; conducting "fair tests" and experiments; conducting field investigations; and conducting research using databases and electronic resources. The categories are not tied to particular grade levels, but they are useful for calling attention to the skills inherent in doing science and to "capstone" performances at the close of the primary, intermediate and middle school junctures. For example, most children grasp the notion of a "fair test" by the end of the intermediate grades. The categories also have utility for developing language for objectives apt for a given grade level and for constructing examples that make grade-level connections within and among the standards.

That said, the alternative schema is not meant to suggest that children in the early elementary grades cannot engage in meaningful, holistic investigation — where many of the skills are naturally integrated. Recent research, in fact, suggests that there are fewer developmental constraints than science educators originally thought and that even preschoolers informally strive to make sense of the world by observing, inferring, predicting and synthesizing information. As the National Research Council noted in 1996, "From the earliest grades, students should experience science in a form that engages them in the active construction of ideas and explanations and enhances their opportunities to develop the abilities of doing science."[2]

Adopting this schema or another well-conceived alternative should make it easier for Maryland to remedy the weaknesses in Standard 1.0 as it now exists. Additional recommendations regarding Standard 1.0 will be addressed later in this report.

Grade-Level Appropriateness (Primarily Standard 1.0)

As noted in the discussion of Standard 1.0, reviewers called for "a more carefully wrought progression — a thoughtfully staged evolution of knowledge and skills, generally moving from the simple to the complex and from the concrete to the abstract." There is agreement that each of the standards, with the possible exception of Standard 2.0: Chemistry, would benefit from a further review and adjustment of the development of skills, concepts and performance expectations as children advance in grade, culminating in the capstone experiences defined in the grade 8 standards. (Chapters 14 and 15 in AAAS *Benchmarks for Science Literacy*[3] contain valuable insights that inform the discussion of grade-level appropriate practice.)

Coherence and Connectivity (All Standards)

When a set of standards is coherent, they convey a unified vision of the discipline and make evident connections among the major areas of study. Maryland's VSC in Science does not yet capture significant relationships among the standards — i.e., key concepts, the way they are linked, and how the study of one complements and reinforces the study of another. One approach the state should consider is to highlight and make explicit several unifying concepts, themes or

[2] Center or Science, Mathematics, and Engineering Education, National Research Council*, Inquiry and the National Science Education Standards: A Guide for Teaching and Learning* (National Academy of Sciences, 2000), 39.
[3] American Association for the Advancement of Science, *Benchmarks for Science Literacy – Project 2061* (New York: Oxford University Press, 1993).

"big ideas" — such as systems, models, or constancy and change — among the content standards as appropriate.

Once the science skills and processes standard has been revised, all the standards need to be examined closely for interconnectivity — i.e., connections among the strands within a given standard, connections between the Science Skills and Processes (Standard 1.0) and the Content standards (2.0–6.0), connections among the content standards themselves (for example, the centrality of thermodynamics in Earth/space, life and physical science), and connections between each of the standards with mathematics.

Reviewers noted the high degree of overlap between pre-K–3 science and mathematics content. Many high-performing countries delay a separate treatment of science until grade 4 because of this overlap. Although Achieve is not taking that position, it does recommend that Maryland closely align indicators and objectives in science and mathematics to maximize instructional effectiveness and manageability. Similarly, the state should seek opportunities to link science instruction with English language arts. Maryland has a separate reading standard devoted to reading and comprehending informational text, a skill that students increasingly need for employment in an information-based economy. For example, producing a grade-level reading list of recommended trade books that complement the core content areas taught in science in a given year could improve achievement in both areas. Maryland calls for informational writing in its writing standard and for students to communicate their findings in its science inquiry strand. The overlap exists; the state will want to help teachers realize the potential of an integrated approach to lesson planning. This should help elementary teachers who may feel overwhelmed by the sheer bulk of material they are expected to cover in a given year.

Standard 3.0: Life Science (Overall)

Of the content standards, Life Science (Standard 3.0) requires the most attention. In addition to noting the need for explicit links to the other standards, reviewers were concerned with gaps in content and the need for a stronger progression of knowledge and skills. The following are key recommendations regarding the inclusion of essential content:

- Add a strand devoted to the *interaction of living things*; add an indicator regarding the dependence of living things on the non-living environment and the effect of living things on the environment, some aspects of which are addressed in Standard 6.0: Environmental Science.
- Amplify the treatment of *systems* in living organisms and make the survival needs of living organisms explicit.
- Improve the development of *evolution*, giving attention to the cumulative evidence for the theory, including the importance of the fossil record (Delaware's treatment of evolution can serve as a model).
- Include a specific objective regarding *form/structure and function* (Indicator 2 in grade 5 addresses form/function).
- Expand the treatment of *ecology* beyond grade 6.
- Consider adding a strand in *human biology* unless the topic is covered sufficiently in the health curriculum; add an objective that calls for students to identify the observable structures of cells.

- Delineate grade-level indicators for grades 4–8 in the genetics strand to strengthen progression (Indiana has a well-developed strand that can serve as a template).
- Include *life cycles* in the genetics strand or under the strand currently titled "Cellular."
- Reconsider the placement of certain content. For example, *innate vs. learned behavior* should be moved to a grade level beyond grade 4, and cells should be introduced and developed with a logical flow of ideas in grade 7.
- Retitle two strands: Strand A: "Cellular" should instead be called "Diversity" or "Characteristics of Living Things," because all of the indicators are related to diversity and interdependence; Strand D: "Biochemistry" (an area usually found in high school biology courses) should be renamed "Flow of Matter & Energy," given that the Voluntary State Curriculum is meant for grades pre-K–8.

Illustrative Examples (All Standards)

Reviewers were in complete accord concerning the need for examples to clarify objectives, pinpoint the cognitive level of demand of the objectives and make connections among the standards concrete — particularly for Standard 1.0 — as noted above.

Verb Choice (All Standards)

The purpose of standards is to describe what students should know and be able to do. Standards establish performance expectations for students. This means that when developers of standards choose a verb for an indicator or objective, they are sending a message about teaching, learning and assessment. Verb choice is of paramount importance. All reviewers brought up concerns regarding the limitations of the use of verbs ostensibly selected to make the science standards parallel the language used in the reading and mathematics standards. However, the overuse of the verbs *recognize*, *identify* and *explain* may suggest to teachers that science is best learned by reading a textbook and best assessed with multiple-choice pencil-and-paper tests. Moreover, it also is the case that *recognize* and *identify* represent low levels of cognitive demand — i.e., simple recall. The National Science Education Standards often use *understand*, which can be an effective choice if it is well defined. New Standards makes the point that a "student demonstrates conceptual understanding by using a concept accurately to explain observations and make predictions and by representing the concept in multiple ways (through words, diagrams, graphs, or charts, as appropriate). Both aspects of understanding — explaining and representing — are required …"[4]

[4] New Standards, *Performance Standards. Volume 1 – Elementary School* (National Center on Education and the Economy and the University of Pittsburgh, 1997).

ADDITIONAL CONSIDERATIONS

While the following set of recommendations are not of the same weight as those above, many of these can be readily incorporated and will contribute to improving individual standards and strands and strengthen the document as a whole.

Standard 2.0: Earth/Space Science

This content standard basically is well developed and, with a few adjustments, could attain the level of quality of the Chemistry standard (4.0). Astronomy (Strand D), for example, is exceptional and only requires minor revisions. An objective regarding the *distance scale* should be added. Objectives regarding the *reasons for the seasons*, as well as those calling for students to explain the *phases of the moon and eclipses*, should be moved to upper elementary school, when students have the capability to make systematic observations and use models to understand these concepts and to grasp more completely the concepts of *gravity* and the *spherical earth*. Maryland also should consider combining the separate treatments of *tectonics* in grades 6 and 8 and should seize the opportunity that the topic presents to show how cumulative evidence leads to the acceptance of a scientific theory. Doing so would help students grasp the nature of the scientific enterprise and provide a substantive case study in the history of science.

Standard 5.0: Physics

Like the Earth/Space Science standard, Physics is a robust standard, and its capstone performances generally are equivalent to those of Achieve's benchmarks. The Physics strands are well articulated and have considerable potential for links with other content standards, but connections are not yet realized. Reviewers emphasized that *energy* is the leading concept in physics — just as *evolution* is in biology and *conservation of mass* is in chemistry — and should be a unifying thread connecting the standards. *Systems* also could be used to great advantage in identifying commonalities among the principal disciplines of science.

Again, like Earth/space science, some indicators and objectives, such as Indicator D.3: Wave Interactions, should be assigned to later grades. Another concern is that, given the centrality of *conservation of energy*, this standard is insufficiently developed. In addition, the language of Strand A: Mechanics reflects a high school perspective and should be examined vis-à-vis Achieve's benchmarks with an eye toward ensuring that its expectations and language are grade-level appropriate. The table below illustrates the wide difference in capstone expectations concerning the 8th-grade level in *mechanics* between Maryland's VSC Science draft and the benchmarks recommended by AAAS.

MD VSC Science Draft	Benchmarks (AAAS)
Grades 6–8	***By the end of the 8th grade, students should know that*:**
• Recognize and describe the motion of an object qualitatively and quantitatively. • Recognize and explain that forces cause specific changes in the speed and direction of a moving object. • Identify and explain Newton's Laws of Motion (the first and second): the Law of	• An unbalanced force acting on an object changes its speed or direction of motion, or both. If the force acts toward a single center, the object's path may curve into an orbit around the center.

Inertia and the Force Law. • Identify and explain the difference between mass and weight. • Recognize and explain that energy cannot be created or destroyed but instead can be changed from one form into another (Law of Conservation of Energy). • Recognize and describe the interactions between moving objects in mechanical systems using potential energy, kinetic energy and momentum. • Recognize and explain that every object exerts gravitational force on every other object.	

Standard 6.0: Environmental Science

Reviewers found the Environmental Science standard to be well framed — avoiding advocacy while raising issues of sustainability. However, reviewers pointed out that the Environmental Science standard did not demand a working knowledge of the content in the Earth/space, life and physical sciences and that its strands might better be incorporated into other standards or strands. To be specific, the content of both Strand A: Flow of Matter and Energy and Strand B: Interdependence of Organisms could be meshed with Strand E: Ecology in Life Science, while Strand C: Natural Resources and Human Needs could be combined with Technology.

Standard 1.0: Technology Strand

Maryland's Technology strand, housed within the Science Skills and Processes standard, is robust and broadly conceived. Reviewers were of two minds concerning the best way to treat and develop this strand. Massachusetts has broken-out a separate standard for engineering. This is a direction Maryland might want to pursue in the long run, given the wealth of careers available in that field in the state and the nation and the relative scarcity of American students who pursue engineering careers. If Maryland were to take this direction, two of the current indicators under Technology (Indicator D.1: Making Models and Indicator D.2: Using Tools and Materials) should be retained in the Science Skills and Processes standard because they cut across all areas of science. The remaining three indicators (D.3: Design, Plan and Construct Objects; D.4: Evaluate and Modify Designs; and D.5: Inventions) could become part of a separate engineering standard.

Additional Recommendations Regarding Restructuring (Standard 1.0)

Safe Procedures (Objective A.4.1) currently is a part of the Science Skills and Processes standard but needs to have its objectives broken out, made specific and integrated within the content standards as appropriate. In other words, safety rules should be incorporated into related strands. For example, safety rules regarding electricity should accompany Physics Standard 5.0, Strand C: Electricity and Magnetism.

Also, reviewers pointed out that the content of Maryland's Strand E: History of Science has much less to do with the actual historical development of the discipline than it does with science as a human endeavor. An alternative approach would be to integrate the content of this strand with Scientific Inquiry Strand A and to incorporate a few case studies that exemplify the way in which scientific knowledge evolves into the content standards. Plate tectonics was cited earlier, and another example is Darwin's finches.

When revisions are complete, Maryland should develop a comprehensive matrix with more detail than the one Achieve developed to establish an overview of the VSC in Science. Having a mechanism to track and adjust indicators would help ensure the following:

- Core knowledge and skills are situated in the optimum grade with all prerequisites in place.
- Knowledge and skills to be taught in each grade are related and constitute a manageable amount of content.
- No significant gaps in core content appear in strands across the grades.
- Content evolves in cognitive complexity from one grade to the next.
- Language is precise enough for teachers to understand the level of performance expected of students.
- Examples are provided for clarification.
- Opportunities for connections across and within strands are made visible.

Finally, the state should consider writing an introduction to the standards as a whole, as well as an introduction to each standard at each grade level. Grade-level introductions should highlight essential content that is a prerequisite for understanding new content to be introduced, the focus of the current year's course of study, and significant connections to content that will be the subject of further study.

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APPENDIX

Biographies of Achieve Staff and Reviewers

ACHIEVE'S STAFF

MATTHEW GANDAL
EXECUTIVE VICE PRESIDENT, ACHIEVE

Matthew Gandal joined Achieve in 1997, shortly after governors and business leaders created the organization. He opened the organization's Washington, DC, office and helped build its programs and services.

As executive vice president, Gandal has senior responsibility for overseeing Achieve's major initiatives. He supervises Achieve's work with states and helps shape the organization's national agenda. Gandal played a lead role in organizing the 1999 and 2001 National Education Summits attended by governors, corporate CEOs and education leaders from across the country.

Gandal has extensive experience reviewing academic standards and education policies in the United States and abroad. He has written dozens of reports and articles on the topic. He also has served on a variety of national and international panels and has helped advise academic standards commissions and legislative bodies in numerous states.

Before joining Achieve, Gandal was the assistant director for educational issues at the American Federation of Teachers, where he oversaw the national organization's work on education standards, testing and accountability. Gandal helped AFT launch a variety of programs and publications designed to support standards-based reform efforts in states and school districts. He was the author and chief architect of *Making Standards Matter*, an annual AFT report evaluating the quality of the academic standards, assessments and accountability policies in the 50 states. He also wrote a series of reports entitled *Defining World Class Standards*, which compared student standards and achievement in the United States with those of other industrialized nations.

Prior to his role with AFT, Gandal served as assistant director of the Educational Excellence Network, an organization founded by Checker Finn and Diane Ravitch. In addition to work on domestic policy issues, he was responsible for directing a series of projects aimed at helping emerging democracies around the world build democratic education systems.

Gandal is a proud graduate of the public school system in Maryland. He earned a bachelor's degree in philosophy from Trinity College in Hartford, CT. He lives in Maryland with his wife and three children.

JEAN SLATTERY
DIRECTOR, BENCHMARKING INITIATIVE, ACHIEVE

Jean Slattery has been with Achieve since 1999 and currently serves as director for the Benchmarking Initiative. She was supervising director of curriculum development and support in Rochester, NY, from 1989 to 1997, with responsibility for overseeing the work of all subject-area directors in the K–12 instructional program. Her earlier responsibilities as a district-level administrator included serving as director of the middle school (1987–89) and junior high

(1985–87) programs. During this period, she initiated Teachers as Partners, a peer-coaching staff development program funded by the Ford and Matsushita (Panasonic) Foundations.

Slattery served as a peer consultant on standards and assessment for the U.S. Department of Education. She also has served as a consultant to the Washington, DC, school district; San Diego Unified School District; a Washington state consortium of rural schools; and the Arkansas and Illinois departments of education. She also has worked for the Council for Basic Education (CBE) on projects involving the Flint Community School District, the Nevada Education Department, and the Cleveland Municipal School District.

Slattery received a bachelor's degree in chemistry from Albertus Magnus College, a master's degree in science education from Yale University and a doctorate in science curriculum from the University of Rochester.

JOSEPH L. ACCONGIO
RESEARCH ASSOCIATE IN SCIENCE, ACHIEVE

Joseph L. Accongio is a project administrator and science research associate for Achieve, Inc. He is the former principal/superintendent of the Charter School of Science & Technology in Rochester, NY. He also was the school's director of program development and the primary charter recipient. He has been principal of both the Nathaniel Rochester Community School and Thomas Jefferson Middle School in Rochester and was the house administrator of the Discovery Magnet at Frederick Douglass Middle School. Accongio also has served as executive assistant to the director of curriculum development and support, curriculum coordinator/evaluator, program developer, general science teacher, chemistry teacher, and biology teacher in the Rochester City School District.

Accongio spent a year as director of school services with the Children's Television Workshop, creators of *Sesame Street*, *3-2-1 Contact,* and *Square One TV*. He developed a series of teachers' guides for the science and mathematics shows and conducted numerous workshops on using these popular shows in the classroom. He also co-wrote a monograph on science assessment entitled *Classroom Assessment — Key to Reform in Science Education.*

He received a doctorate in curriculum planning from the State University of New York (SUNY) at Buffalo, a master's degree in education from SUNY at Brockport and a bachelor's degree in general sciences from the University of Rochester.

CONSULTANTS AND EXPERT REVIEWERS IN SCIENCE

Achieve relied on the expertise of nationally respected experts in academic content, national standards, curriculum and instruction, and assessment design to inform and conduct the Standards-to-Benchmark Standards comparisons.

ERMA ANDERSON

Erma Anderson is a former science and mathematics teacher. She served as a content specialist with the National Science Teachers Association's (NSTA) teacher mentoring initiative, e-Mentoring for Student Success (eMSS). She also serves as NSTA liaison to the Enviroliteracy project, the writing of online environmental modules for high school students. Prior projects at NSTA include development and implementation of the Teacher Center, a series of summer workshops for middle school teachers on implementing the National Science Education Standards; development of the Standards Awareness kits; development of sciLINKS; and project manager of *Scope, Sequence and Coordination of Secondary School Science*, a science curriculum reform project of NSTA.

Prior to her work with NSTA, Anderson was an Einstein Fellow in the U.S. Senate and a senior program officer with the National Research Council, where she assisted with the development of the National Science Education Standards. She taught high school science and mathematics and was an adjunct faculty member at the graduate and undergraduate levels at Drexel University, Frederick Community College, Slippery Rock University, Lock Haven State University and Wilson College, teaching science and mathematics courses for teachers. She served as content consultant to the Pennsylvania Department of Education in the writing of the STEEP (Science, Technology, Ecology, Environment, Processes) assessment handbook.

She has served as the science specialist to the Council for Basic Education's Schools Around the World project and in the development of several state and district curriculum frameworks. She worked with Education Trust to review the alignment of state exit standards to college entrance exams and in the evaluation of teacher education exams (report titled *Not Good Enough*).

Anderson has considerable experience developing and facilitating workshops with formal and informal science education entities such as Jason Academy, Educational Field Studies, National Institute of Medicine, United States Forestry Service, National Park Service, school districts and states.

HAROLD PRATT

Harold Pratt is a private consultant working in all areas of science education. From May 1996 until July 1999, he was the director of science projects in the Center for Science, Mathematics, and Engineering Education at the National Research Council (NRC). He has had extensive administrative and curriculum development experience at the local and national levels. Prior to joining the Center, he directed the revision of *Science for Life and Living* at the Biological Sciences Curriculum Study in Colorado Springs, CO. From October 1992 to December 1994, he served as a senior program officer at the NRC for the National Science Education Standards Project. From 1986 to 1991, he was the executive director of curriculum for the Jefferson County

(CO) Public Schools, the largest district in Colorado, with an enrollment of more than 80,000 students. Prior to that, he served the district as the science coordinator for 23 years. He has co-written or directed the development of three science textbooks and a book on educational leadership, and he has published numerous articles and book chapters. He is a fellow of the American Association for the Advancement of Science and was selected by the National Science Education Leadership Association (formerly the National Science Supervisors Association) as the first recipient of the Nation's Outstanding Science Supervisor Award. In 1999, the National Science Teachers Association (NSTA) honored him with the Distinguished Service to Science Education Award. He served as president of NSTA in 2001–02 .

SENTA A. RAIZEN

Senta A. Raizen has been involved in science education, including curriculum improvement, for nearly four decades. As director of the National Center for Improving Science Education at WestEd, she has led or participated in many national and international projects aimed at science education reform. Heading a study sponsored by the U.S. Department of Education, Raizen was responsible for a series of reports dealing with curriculum, teaching and assessment reform in science education at the elementary, middle and high school levels. She has written, co-written or edited numerous books and many articles in science and technology education. Raizen serves in an advisory capacity to several national and international education studies.

Previously, Raizen served as a chemist at Sun Oil Company and the National Academy of Sciences, program officer at the National Science Foundation, senior researcher at the Rand Corporation, associate director of the National Institute of Education, and study director for the National Research Council.

Raizen holds undergraduate and graduate degrees in chemistry from Guilford College and Bryn Mawr College. She also holds a teaching certificate from the University of Virginia.

CARY SNEIDER

Cary Sneider is vice president for educator programs at the Museum of Science in Boston, where his current objective is to help schools implement state standards in technology and engineering. Sneider's interests have focused on helping students unravel their misconceptions in science and on new ways to link science centers and schools to promote student inquiry. He currently is principal investigator of the New England Space Science Initiative in Education (NESSIE), with support from NASA, and Predicting the Future: The Science and Technology of Weather Forecasting, which is funded by the National Science Foundation. He also serves as a member of two boards at the National Research Council: the Board on Science Education and the Board of the Center for Education. His publications include teachers' guides for the elementary, middle and high school levels; articles about the instructional uses of computers; and research studies on how children acquire concepts and skills in science. He helped develop the *National Science Education Standards* (National Academy Press, 1996) and contributed to *Designing Professional Development Programs for Teachers of Mathematics and Science* (Corwin Press, 1998). In 1997, he received the Distinguished Informal Science Education Award from NSTA, and in 2003 he was named National Associate of the National Academy of Sciences.

Gerald M. Stokes

Gerald M. Stokes is the director of the Joint Global Change Research Institute, a collaborative effort between the Pacific NW National Laboratory (PNNL) and the University of Maryland. Previously, he has served as an associate laboratory director of PNNL, responsible for the Environmental and Health Sciences Division, the basic research division. He also has held a variety other scientific and management positions during his 27-year tenure at PNNL. He served as the chief scientist for the Department of Energy's Atmospheric Radiation Measurement program from 1990–98. He has served previously on the National Committee on Science Education Standards and Assessment. He holds a bachelor's degree in physics from the University of California at Santa Cruz and both a doctorate and a master's degree in astronomy and astrophysics from the University of Chicago. His research interests include climate and the design of large-scale field research facilities. He has written or co-written more than 80 book chapters, journal articles and reports on topics such as the interstellar medium, atmospheric spectroscopy, energy utilization and climate policy.

David J. White

David White currently is the science program coordinator for the Vermont Department of Education. He is responsible for the development, coordination and implementation of the statewide science assessment program, Vermont-PASS. He co-directs the development of Vermont's Grade Level Expectations in Science, the Vermont Science Initiative, and the development and implementation of local comprehensive science assessment systems. He is the National Science Teachers Association District II director for Vermont, New Hampshire, and Maine, and he is a member of the board of directors of the Council of State Science Supervisors.

White has been involved in a number of valuable experiences related to standards-based curriculum, instruction and assessment, including the National Science Education Standards project (Working Group on National Assessment Standards), the Education Development Center's K–12 Science Curriculum Dissemination Center project and the AAAS Project 2061 Science Assessment Analysis Program.

White is a former senior research associate with WestEd, where he worked on PASS (Partnership for the Assessment of Standards-based Science) and related projects. He also served as a science assessment consultant for the Vermont Department of Education and the Vermont Institute for Science, Mathematics, and Technology. His most recent teaching experience was at Barre Town Middle and Elementary School in Barre, VT, where he served as science and mathematics resource teacher and science curriculum coordinator for 12 years. Prior to that, he spent 15 years as a teacher in several elementary, middle and high schools. He has a bachelor's degree from Seton Hall University and a master's degree in science curriculum and instruction from the University of Vermont.