PERFORMANCE

New York City—First Edition

STANDARDS

Science

NEW STANDARDS™

Board of Education of the City of New York

This first New York City edition of the *New Standards™ Performance Standards* for Science was developed under the leadership of Judith A. Rizzo, Ed.D., Deputy Chancellor for Instruction. The project was completed through the joint efforts of the Office of School Programs and Support Services, Margaret R. Harrington, Ed.D., Chief Executive, and the Office of Program Development and Dissemination, William P. Casey, Chief Executive. Elsie Chan, Administrative Assistant Superintendent/Director, New York City Urban Systemic Initiative, (NYC USI), a National Science Foundation Funded Project, supervised the production of this edition in collaboration with the NYC USI Team: Robert J. Kane, Ed.D., Deputy Director, Betty D. Burrell, Stephanie Caporale, Arlene Francis, Jonathan Molofsky, Lawrence Pero, Carl Raab, Myrna Rodriguez, and Anne Judy Walsh, and Laura Rodriguez, Administrative Assistant Superintendent, Office of School Programs and Support Services, Russell Hotzler, Ph.D., University Dean of Academic Affairs, The City University of New York, the New York City Urban Systemic Initiative Advisory Council, Judith Chin, Executive Director, Division of Instructional Support, Robert Tobias, Executive Director, Division of Assessment and Accountability, Lillian Hernandez, Ed.D., Executive Director, Office of Bilingual Education, Evelyn B. Kalibala, Director, Office of Multicultural Education, and Gerald Haber, Assessment Specialist, Office of Performance Standards, Division of Instructional Support.

Printed in the United States of America.

ISBN 1-55839-505-9

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Board of Education of the City of New York
Rudolph F. Crew, Ed.D., Chancellor

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Dear Colleague:

During the past couple of years, you have been hearing and reading about the adoption of *New Standards™ Performance Standards* by the Board of Education of the City of New York. The rationale for this decision is clear: New Standards has developed the best national standards because teachers can use them. The *New Standards™ Performance Standards* are based on common sense as well as academic excellence; and they are ready now.

Two years ago, the first New York City edition *New Standards™ Performance Standards* for English Language Arts, English as a Second Language, and Spanish Language Arts was published. Last fall, the first New York City edition of *New Standards™ Performance Standards* for Mathematics was published. These important pedagogical books were distributed to all teachers, supervisors and administrators in the system. I am delighted to present to you the first New York City edition *New Standards™ Performance Standards*.

Teachers, science supervisors, and administrators representing the 40 school districts and superintendencies, and representatives from colleges, universities, and informal science-rich institutions met regularly during the past two school years to conceptually plan and to calibrate the collection of student work samples contained in this New York City edition *New Standards™ Performance Standards*. This calibration reflects the New York State Learning Standards for Mathematics, Science, and Technology, the New York State Commencement Standards and their assessments, as well as the diversity of our students. The work samples selected for inclusion in this edition show work that illustrates standards-setting performances. They demonstrate that all students can meet high expectations in science. Selections were made as the result of an in-depth examination of the standards and extensive discussion among the members of the group.

The New York City edition enhances the original New Standards work in science. It demonstrates vertical (K-12) and lateral (life science, earth science and physical science) conceptual development, task related student work and correlation of *New Standards™ Performance Standards* Science with New York State *Mathematics, Science, and Technology Learning Standards*, the National Research Council's *Science Education Standards*, and the American Association for the Advancement of Science's *Benchmarks for Science Literacy*.

I expect the New Standards to be used by everyone involved in teaching and learning in our system. At the school level, teachers and administrators should use these standards to set goals, plan for effective instruction, and monitor and assess student performance. Districts and superintendencies should use the standards in all curriculum initiatives and as one way of planning professional development activities. Central staff will work closely with the districts and superintendencies on behalf of their local efforts. Central will also take action to integrate the New Standards throughout the school system.

We all agree that having the highest expectations for our students is a just goal. The Science standards are clear, direct and attainable. Your discussions must now turn to "how good is good enough" and to making the goal a reality. Together we can and will make a positive difference in the lives of our students.

Sincerely,

Rudolph F. Crew, Ed. D.
Chancellor

INTRODUCTION

PREFACE

This volume contains the first New York City edition of the *New Standards™ Performance Standards* for Science. The standards set out in this volume establish the same high expectations for student performance as those published by New Standards—the standards are unchanged from those published by New Standards. What distinguishes this edition is the collection of student work samples included to illustrate the meaning of standard-setting work. The collection has been revised extensively to reflect work produced by students studying in New York City's public schools.

This volume of the New York City edition of the standards focuses exclusively upon Science. The first New York City editions of the *New Standards™ Performance Standards* for Language Arts and Mathematics were published in 1997 and 1998 respectively. A volume focusing upon Applied Learning is in preparation.

ABOUT NEW STANDARDS

New Standards was established in 1991 as a collaboration of the Learning Research and Development Center at the University of Pittsburgh and the National Center on Education and the Economy, in partnership with states and urban school districts. The Board of Education of the City of New York was a member of the New Standards partnership from its inception. The New Standards partners set out to build an assessment system to measure student progress toward meeting national standards at levels that are internationally benchmarked. The performance standards are one of the major products of the New Standards partnership. Support for the development of the performance standards was provided by the Pew Charitable Trusts, the John D. and Catherine T. MacArthur Foundation, the William T. Grant Foundation, and the New Standards partners.

The New Standards Governing Board included chief state school officers, governors and their representatives, and others representing the diversity of the partnership, whose jurisdictions enroll nearly half of the Nation's students. These performance standards were endorsed unanimously by the New Standards Governing Board in June 1996.

The New Standards partnership formally ended in June 1997. Continuing research and development, and technical assistance to support implementation of the products of New Standards, are managed by the National Center on Education and the Economy on behalf of the National Center and the University of Pittsburgh.

ABOUT THE PERFORMANCE STANDARDS

New Standards adopted the distinction between content standards and performance standards that is articulated in *Promises to Keep: Creating High Standards for American Students* (1993), a report commissioned by the National Education Goals Panel. Content standards specify "what students should know and be able to do"; performance standards go the next step to specify "how good is good enough."

These standards are designed to make content standards operational by answering the question: how good is good enough?

The performance standards for Science were based directly on the content standards produced by the National Research Council (1996) and the American Association for the Advancement of Science (1993).

In recent years several reports on standards development have established "standards for standards," that is, guidelines for developing standards and criteria for judging their quality. These include the review criteria identified in *Promises to Keep*, the American Federation of Teachers' "Criteria for High Quality Standards," published in *Making Standards Matter* (1995), and the "Principles for Education Standards" developed by the Business Task Force on Student Standards and published in *The Challenge of Change* (1995). New Standards drew from the criteria and principles advocated in these documents in establishing the "standards" we have tried to achieve in these performance standards.

Standards should establish high standards for all students.

The New Standards partnership resolved to abolish the practice of expecting less from poor and minority children and children whose first language is not English. These performance standards are intended to help bring all students to high levels of performance.

Much of the onus for making this goal a reality rests on the ways the standards are implemented. The New Standards partners adopted a Social Compact, which says in part, "Specifically, we pledge to do everything in our power to ensure all students a fair shot at reaching the new performance standards...This means they will be taught a curriculum that will prepare them for the assessments, that their teachers will have the preparation to enable them to teach it well, and there will be...the resources the students and their teachers need to succeed." These performance standards are built upon the assumptions expressed in that pledge.

There are ways in which the design of the standards themselves can also contribute to the goal of bringing all students to high levels of performance, especially by being clear about what is expected. We have worked to make the expectations included in these performance standards as clear as possible. For some standards it has been possible to do this in the performance descriptions. For example, in Science, we have gone beyond simply listing scientific thinking among our expectations for students. We set out just what we mean by scientific thinking and what things we expect students to be able to do with their scientific thinking. In addition, by providing numerous examples we have indicated the level of complexity of the situations in which students should be able to exercise that scientific thinking.

The inclusion of work samples and commentaries to illustrate the meaning of the standards is intended to help make the standards clearer. Most of the standards are hard to define precisely in words alone. In the conceptual understanding standards (S1-S4), for example, the work samples show what it means to use, represent in multiple ways, and explain the important scientific concepts. The commentaries describe how these aspects of conceptual understanding are evidenced in the student work samples. The work samples and commentaries are an integral part of the performance standards. They give concrete meaning to the words in the performance descriptions and show the level of performance expected by the standards.

The work samples will help teachers, students, and parents to picture work that meets standards and to establish goals to reach for. Students need to know what work that meets standards looks like if they are to strive to produce work of the same quality. Students also need to see themselves reflected in the work samples if they are to believe that they, too, are capable of producing such work. The work samples included in this volume not only illustrate the meaning of the standards but also reflect the diverse backgrounds and experiences of the students studying in New York City's public schools.

STANDARDS FOR STANDARDS

Standards should be rigorous and world class.

Is what we expect of our students as rigorous and demanding as what is expected of young people in other countries—especially those countries whose young people consistently perform as well as or better than ours?

That is the question we are trying to answer when we talk about developing world class standards.

Through successive drafts of these performance standards, New Standards compared our work with the national and local curricula of other countries, with textbooks, assessments, and examinations from other countries and, where possible, with work produced by students in other countries. Ultimately, it is the work students produce that will show us whether claims for world class standards can be supported.

We produced a *Consultation Draft*, which we shared with researchers in other countries. We asked them to review the *Consultation Draft* in terms of their own country's standards and in light of what is considered world class in their field. Included among these countries were Australia, Belgium, Canada, the Czech Republic, Denmark, England and Wales, Finland, France, Germany, Japan, the Netherlands, New Zealand, Norway, Poland, Scotland, Singapore, Sweden, and Switzerland. We asked these reviewers to tell us whether each standard is at least as demanding as its counterparts abroad and whether the set of standards represents an appropriately thorough coverage of the subject areas. We also shared the *Consultation Draft* with recognized experts in the field of international comparisons of education, each of whom is familiar with the education systems of several countries.

Our reviewers provided a wealth of constructive responses to the *Consultation Draft*. Most confined their responses to the Language Arts, Mathematics, and Science standards, though several commended the inclusion of standards for Applied Learning. The reviewers supported the approach we adopted to "concretize" the performance standards through the inclusion of work samples. Similar approaches are being used in some other countries, notably England and Wales and Australia. Some of the reviewers were tentative in their response to the question of whether these performance standards are at least as demanding as their counterparts, noting the difficulty of drawing comparisons in the absence of assessment information, but did offer comparative comments in terms of the areas covered by the standards. Some reviewers provided a detailed analysis of the performance descriptions together with the work samples and commentaries in terms of the expectations of students at comparable grade levels in other countries.

The reviews confirmed the conclusion we had drawn from our earlier analyses of the curricula, textbooks, and examinations of other countries: while the structure of curricula differs from country to country, the expectations contained in these performance standards represent a thorough coverage of the subject areas. No reviewer identified a case of significant omission. In some cases, reviewers noted that the range of expectations may be greater in the *New Standards™ Performance Standards* than in other countries; for example, few countries expect young people to integrate their learning to the extent required by the standards for investigation in New Standards Mathematics. At the same time, a recent study prepared for the Organisation for Economic Co-operation and Development reports that many countries are moving towards expecting students to engage in practical work of the kind required by the New Standards Science standards (Black and Atkin, 1996). The reviews also suggest that these performance standards contain expectations that are at least as rigorous as, and are in some cases more rigorous than, the demands made of students in other countries. None of the reviewers identified standards for which the expectations expressed in the standards were less demanding than those for students in other countries.

We will continue to monitor the rigor and coverage of the *New Standards™ Performance Standards* and assessments in relation to the expectations of students in other countries. In addition to the continued collection and review of materials from other countries, our efforts will include a review of the *New Standards™ Performance Standards* by the Third International Mathematics and Science Study, collaboration with the Council for Basic Education's plan to collect samples of student work from around the world, continued review of the American Federation of Teachers' series, *Defining World Class Standards*, and collaborative efforts with visiting scholars at the Learning Research and Development Center.

Standards should be useful, developing what is needed for citizenship, employment, and life-long learning.

We believe that the core disciplines provide the strongest foundation for learning what is needed for citizenship, employment, and life-long learning. Thus, we have established explicit standards in the core areas of Language Arts, Mathematics, and Science. But there is more. In particular, it is critical for young people to achieve high standards in Applied Learning—the fourth area we are working on.

Applied Learning focuses on the capabilities people need to be productive members of society, as individuals who apply the knowledge gained in school and elsewhere to analyze problems and propose solutions, to communicate effectively and coordinate action with others, and to use the tools of the information age workplace. These are capabilities that were highlighted in *Learning A Living*, a report of the Secretary's Commission on Achieving Necessary Skills (SCANS, 1992).

Applied Learning is not about "job skills" for students who are judged incapable of or indifferent to the challenges and opportunities of academic learning. Applied Learning refers to the abilities all young people will need, both in the workplace and in their role as citizens. They are the thinking and reasoning abilities demanded by colleges and by the growing number of high performance workplaces, those that expect people at every level of the organization to take responsibility for the quality of products and services. Some of these abilities are familiar; they have long been recognized goals of schooling, though they have not necessarily been translated clearly into expectations for student performance. Others break new ground; they are the kinds of abilities we now understand will be needed by everyone in the near future. All are skills attuned to the real world of responsible citizenship and of dignified work that values and cultivates mind and spirit.

Many reviewers of drafts of these performance standards noted the absence of standards for the core area of social studies, including history, geography, and civics. At the time we began our work, national content standards for those areas were only in the early stages of development; we resolved to focus our resources on the four areas we have worked on. As consensus builds around content standards in this additional area, we will examine the possibilities for expanding the New Standards system to include it.

Standards should be important and focused, parsimonious while including those elements that represent the most important knowledge and skills within the discipline.

As anyone who has been involved in a standards development effort knows, it is easier to add to standards than it is to limit what they cover. It is especially easier to resolve disagreements about the most important things to cover by including everything than it is to resolve the disagreements themselves. We have tried not to take the easier route. We adopted the principle of parsimony as a goal and have tried to practice it. At the same time, we have been concerned not to confuse parsimony with brevity. The performance descriptions are intended to make explicit what it is that students should know and the ways they should demonstrate the knowledge and skills they have acquired. For example, the standards relating to conceptual understanding in Science spell out the expectations of students in some detail.

The approach we adopted distinguishes between standards as a means of organizing the knowledge and skills of a subject area and as a reference point for assessment, on the one hand, and the curriculum designed to enable students to achieve the standards, on the other. The standards are intended to focus attention on what is important but not to imply that the standards themselves should provide the organizing structure for the curriculum. In Science, for example, we have established a separate standard for tools and technologies. This does not imply that tools and technologies should be taught in isolation from other elements of Science. Our intention in defining a separate standard for tools and technologies is to make it clear that the work students do should be designed to help them achieve the Tools and Technologies. Skills and tools should not only be among the things assessed but should also be a focus for explicit reporting of student achievement.

Standards should be manageable given the constraints of time.

This criterion follows very closely on the last one, but focuses particularly on making sure that standards are "doable." One of the important features of our standards development effort is the high level of interaction among the people working on the different subject areas. We view the standards for the four areas as a set at each grade level. This orientation has allowed us to limit the incidence of duplication across subject areas and to recognize and use opportunities for forging stronger connections among subject areas through the work that students do. A key to ensuring the standards are manageable is making the most of opportunities for student work to do "double" and even "triple duty" in relation to the standards. Most of the work samples included in this volume demonstrate the way a single activity can generate work that allows students to demonstrate their achievement in relation to several standards within a subject area.

Standards should be adaptable, permitting flexibility in implementation needed for local control, state and regional variation, and differing individual interests and cultural traditions.

These standards are intended for use in widely differing settings. One approach to tackling the need for flexibility to accommodate local control and differing individual interests and cultural traditions is to make the standards general and to leave the job of translating the standards into more specific statements to the people who will use them. We have not adopted that approach. Performance standards need to be specific enough to guide the assessment of students' achievement of the expectations established by the standards; we have tried to make them specific enough to do so. We have also tried to achieve the degree of specificity necessary to do this without unduly limiting the kinds of flexibility outlined above. Most of the standards are expressed in a way that leaves plenty of room for local decisions about the actual tasks and activities through which the standards may be achieved.

However, the specificity needed for standards intended to guide an assessment system does place some limits on flexibility. To tackle these apparently contradictory demands on the standards, we have adopted the notion of "substitution." This means that when users of these standards identify elements in the standards that are inconsistent with decisions made at the local level, they can substitute their own. There is, however, one important provision: substitution only works when what is substituted is comparable with the material it replaces in terms of both the quality and the quantity of expectation.

Standards should be clear and usable.

Making standards sufficiently clear so that parents, teachers, and students can understand what they mean and what the standards require of them is essential to the purpose for establishing standards in the first place. It is also a challenge because, while all of these groups need to understand what the standards are, the kinds of information they need are different. The most obvious difference is between the way in which the standards need to be presented to elementary school students so that they know what they should be striving to achieve and the way in which those same standards need to be presented to teachers so that they can help their students get there. If the standards were written only in a form that elementary school students could access, we would have to leave out information teachers need to do their job.

This version of the standards is written primarily for teachers. It includes technical language about the subject matter of the standards and terms that educators use to describe differences in the quality of work students produce. It could be described as a technical document. That does not mean that parents and students should not have access to it. We have tried to make the standards clear and to avoid jargon, but they do include language that may be difficult for students to comprehend and more detail than some parents may want to deal with. Efforts to make the standards more accessible to audiences other than teachers need to take these differences into account.

Standards should be reflective of broad consensus, resulting from an iterative process of comment, feedback, and revision including educators and the general public.

These performance standards were the result of progressive revisions to drafts over a period of eighteen months. Early drafts were revised in response to comment and feedback from reviewers nominated by the New Standards partners and the New Standards advisory committees for each of the subject areas, as well as other educators.

The *Consultation Draft*, published in November 1995, was circulated widely for comment. Some 1,500 individuals and organizations were invited to review the draft. The reviewers included nominees of professional associations representing a wide range of interests in education, subject experts in the relevant fields, experienced teachers, business and industry groups, and community organizations. In addition, we held a series of face-to-face consultations to obtain responses and suggestions. These included detailed discussions with members of key groups and organizations and a series of meetings at which we invited people with relevant experience and expertise to provide detailed critique of the *Consultation Draft*. We also received numerous responses from people who purchased the *Consultation Draft* and who took the trouble to complete and return the response form that was included with each copy.

The revision of the performance standards was further informed by a series of independently-conducted focus group meetings with parents and other members of the community in several regions of the country, and with teachers who were using the *Consultation Draft*.

The reviewers provided very supportive and constructive commentary on the *Consultation Draft*, both at the broad level of presentation and formatting of the performance standards, and at the detailed level of suggestions for refinements to the performance descriptions for some of the standards. These comments significantly influenced the revisions made to the standards in the preparation of the publication in finished form.

CREATING THE NEW YORK CITY EDITION

Work on "calibrating" the performance standards for use in New York City's public schools began in February 1998 and continued through to the end of May 1999.

The work samples and commentaries form an essential element of the performance standards because they give concrete meaning to the words in the performance descriptions and show the level of performance expected by the standards. While the principal goal of the calibration process was to supplement the collection of student work samples used to illustrate standard-setting performances in the *New Standards™ Performance Standards* with work produced by students in New York City's public schools, a group of New York City educators met with staff of the National Center on Education and the Economy and devised a plan to make the New York City Science Standards more valuable to educators in New York City by showing the relationships among science content standards and by showing conceptual development over the grade spans. To achieve these goals, a group of approximately sixty educators gathered for five days in the Spring of 1998 to serve as a Conceptual Planning Task Force.

Showing the relationships among science content standards

There are two widely used and respected national documents in science which provided the foundation for the work of New Standards: the National Research Council (NRC) *National Science Education Standards* (1996) and the American Association for the Advancement of Science (AAAS) Project 2061 *Benchmarks for Science Literacy* (1993). The AAAS analysis of the Benchmarks and the NRC Draft was helpful in seeing the substantial degree of agreement between the two documents. New Standards partner statements about standards and international documents, including the work of the Third International Mathematics and Science Study and the Organisation for Economic Co-operation and Development, were also used. Many of these sources, like the *Benchmarks*, give greater emphasis to technology and the applications of science than does the NRC.

As the amount of scientific knowledge explodes, the need for students to have deep understanding of fundamental concepts and ideas upon which to build increases; as technology makes information readily available, the need to memorize vocabulary and formulas decreases. There is general agreement among the science education community, in principle, that studying fewer things more deeply is the direction we would like to go. The choices about what to leave out and what to keep are hotly debated. There are 855 benchmarks and the content standards section of the NRC standards runs nearly 200 pages, so there are still choices to be made in crafting a reasonable set of performance standards.

The New Standards Science Standards carried the statement, "The Science standards are founded upon both the National Research Council's *National Science Education Standards* and the American Association for the Advancement of Science's Project 2061 *Benchmarks for Science Literacy*. These documents, each of which runs several hundred pages, contain detail that amplifies the meaning of the terms used in the performance descriptions." The New York City Conceptual Planners said that the document would be much more useful if it showed, explicitly, the statements from these two documents and from New York State's *Learning Standards for Mathematics, Science, and Technology*.

There were three reasons for making the correlations evident:

1. The New York City Science Standards should be self-sufficient; additional standards documents should not be necessary to understand what New York City students are expected to know and be able to do.
2. There is a tremendous degree of agreement among the content statements; teachers and others should be reassured that there are not divergent instructional demands.

3. In a small number of cases, the New York State Learning Standards are slightly different from the New York City Standards; since the State's tests will be based on the State's standards, these differences should be noted.

Thus, the set of related standards are presented so that educators can ascertain the extent of agreement for themselves.

Showing conceptual development over the grade spans

When the goal is deep understanding, it is necessary to revisit concepts over time. Students show progressively deeper understanding as they use the concept in a range of familiar situations to explain observations and make predictions, then use the concept in unfamiliar situations; as they represent the concept in multiple ways (through words, diagrams, graphs, or charts), and explain the concept to another person. The conceptual understanding standards make explicit that students should be able to demonstrate understanding of a scientific concept "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 to meet these standards.

For most people and most concepts, there is a progression from phenomenological to empirical to theoretical, or from a qualitative to a quantitative understanding. New Standards illustrated the progression using one important concept, density, and these student work samples: "Flinkers" at the elementary school level (see page 76), "Discovering Density" at the middle school level (see page 209), and "Density of Sand" at the high school level (see page 412). The New York City Conceptual Planners said that it would be worthwhile to illustrate conceptual development for additional concepts. For each of the major areas of science, they selected five topics or concepts where they would focus the collection of student work. They also drafted tasks that teachers could use to elicit student work so that they could illustrate the variety of curricula that are used in New York City. In addition to density, the Physical Sciences concepts are acids and bases, heat and temperature, energy, force and motion, and chemical reactions. The Life Sciences concepts are interdependence, structure and function, change over time, responding to stimuli, and reproduction and heredity. The Earth and Space Sciences concepts are surface features, weather, rocks and soils, water cycle, and space.

While it was a challenge to find standards-setting work for every concept in the list at every grade level, it was possible to find eight sets of examples that illustrate conceptual development over time—from simple to complex, from descriptive to analytical, from familiar to unfamiliar. Eight such "storylines" are described below. Each storyline demonstrates a progressive level of understanding of a particular concept. As you review the work samples in each storyline, you'll note that some tasks show particular success at moving students into deeper levels of understanding.

Work that Illustrates Conceptual Development Over Time

"STORYLINE"	ELEMENTARY	MIDDLE SCHOOL	HIGH SCHOOL
1. Force and Motion: Simple to Complex Quantification Elementary students measure changes in direction of motion. Middle school students investigate more than one variable influencing motion. High school students quantify effect of temperature on motion.	**Come Back Can**, p. 36	**Mechanical Nut**, p. 86	**The Challenger Disaster**, p. 153
2. Acids and Bases: Phenomenological to Application Elementary students identify acids and bases using an indicator. Middle school students do a quantifiable analysis of pH. High school students work with the molecular structure of acids and bases and apply their analyses to a real-life situation.	**Acid/Base**, p. 40	**Acid Rain**, p. 89	**Buffer Lab**, p. 156
3. Density: Phenomenological to Quantitative Elementary students identify the phenomenon of density. Middle school students quantify density. High school students do error analysis in measurements of density.	**Flinkers**, p. 42	**Discovering Density**, p. 93	**Density of Sand**, p. 169 **Density**, p. 173
4. Response to environment: Simple to Complex Organisms Elementary students identify plant responses to environmental factors. Middle school students identify animal responses to environmental factors. High school students study hormone regulation in humans.	**Bean Farmers**, p. 44 **Water Tolerance**, p. 50 **Toasted Bread vs Non-Toasted Bread**, p. 54	**Snails**, p. 104	**Endocrine Feedback Exercise**, p. 183
5. Interdependence: Organism to System Elementary students identify what lives where. Middle school students analyze the nutritional flow within a specific food web. High school students analyze the ecological impact of predator/prey relationships and other environmental factors.	**Biomes**, p. 52	**Bio Box**, p. 98 **Owl Pellets**, p. 101	**Eagles**, p. 186 **The Invincible Cockroach**, p. 188
6. Reproduction: Whole Organism to Molecular Structure Elementary students discover a life cycle. Middle school students identify genes as the basis of heredity. High school students work with the molecular structure of DNA.	**Butterflies**, p. 47	**It's All in the Genes**, p. 106	**DNA Models**, p. 176 **DNA Concept Map**, p. 179
7. Erosion: Phenomenological to Quantitative Elementary students identify the effects of water on soil. Middle school students quantify the effects of erosion over time.	**Erosion**, p. 62	**River Cutters**, p. 112	——
8. Pendula Elementary students quantify the motion of a pendulum. High school students quantify the effects of changing different variables.	**Pendulum**, p. 38	——	**Pendulum Experiment**, p. 144

Work produced by students in New York City's public schools

The Conceptual Planners thus provided a framework for the work of the Calibration Task Force. All districts and high school superintendencies nominated representatives to complete the correlations and to collect work samples and meet regularly throughout the process to select the work to be included in this New York City edition.

Deciding what constitutes a standard-setting performance

The benchmarks against which these work samples were judged are the work samples that were selected for publication in the *New Standards™ Performance Standards* to illustrate standard-setting performances in relation to various parts of the standards. Those work samples were selected through a variety of strategies designed to tap the judgment of teachers and subject experts around the country about the "level of performance" at which the standards should be set at each of the grade levels: elementary, middle, and high.

We define the elementary school level as being the expectations for student performance at approximately the end of fourth grade; middle school level as the expectations at approximately the end of eighth grade; and high school level as the expectations at approximately the end of tenth grade. We used the concept of grade level as our reference point because it is in common use and most people understand it. However, "at approximately the end of fourth grade," for example, begs some questions. Do we mean the level at which our fourth graders currently perform? Or, do we mean the level at which our fourth graders might perform if expectations for their performance were higher and the programs through which they learn were designed to help them meet those higher expectations? And, do we mean the level at which the highest-achieving fourth graders perform or the level at which most fourth graders should perform?

We set the expectations for level of performance in terms of what we should expect of students who work hard in a good program; that is, our expectations assume that students will have tried hard to achieve the standards and they will have studied in a program designed to help them to do so. These performance standards are founded on a firm belief that the great majority of students can achieve them, providing they work hard, they study a curriculum designed to help them achieve the standards that is taught by teachers who are prepared to teach it well, and they have access to the resources they need to succeed. These conditions form an essential part of the New Standards Social Compact which underpins our belief that all students can and should be expected to meet high standards.

Some of the work samples included in the *New Standards™ Performance Standards* were also included in the *Consultation Draft*; some appeared in earlier drafts as well. The appropriateness of these work samples as illustrating standard-setting performances was the subject of extensive review, through discussions among the New Standards advisory committee for Science and through round-table discussions among experienced teachers and experts in Science. Some of the work samples included in earlier drafts did not pass the scrutiny of these reviews and were not included in the eventual publication. Many additional work samples were identified in the process of consultation and then subjected to the iterative process of review that was used to establish the level at which the standards should be set and the selection of work samples to be used to illustrate the meaning of the standards.

Selecting the work samples included in this New York City edition

The calibration group for the New York City edition of the performance standards followed a similar iterative process of review of collections of work samples to arrive at the selection that is included in this volume. Our goal was to identify candidate work samples for each part of the performance standards as the basis for selecting samples that would reflect the diversity of the communities that make up New York City and to demonstrate different approaches to producing standard-setting work, for example, student work that demonstrates conceptual understanding using the familiar format of expository writing as well as more innovative methods such as creating murals, models, and concept maps. (See "Biomes" on page 104, "DNA Models" on page 433, and "DNA Concept Map" on page 439.)

Districts supported the process by encouraging schools to provide samples of student work for review through their representatives on the group. We organized ourselves according to our expertise and experience at each of the grade spans and in each of the major areas of science and divided responsibility across the various parts of the standards. In this way, sub-groups developed expertise in relation to specific parts of the standards through the experience of reviewing work samples with reference to the relevant performance descriptions and to the work samples and commentaries published in the *New Standards™ Performance Standards*.

When the calibration working group met, we discussed the characteristics of the work samples collected. In some cases, work that was judged as nearly meeting the expectations for standard-setting work was returned to the students who had produced it with an invitation for revision and suggestions about the aspects of the work that would benefit from revision. These students returned revised work for further review.

At each stage of the process, review of the work collected to date helped sharpen our focus on the characteristics we needed to look for in the work we collected. Among the by-products of this process was our growing appreciation of the significance of the tasks or assignments that generate student work in influencing the quality of the product. Put simply, the work students produce generally reflects the assignment they have been given and the instruction on which the assignment is based. We are resolved to make this direct connection between standards and instruction the focus of our continuing efforts to assist all students to meet the expectations illustrated in the work samples in this volume.

Throughout the process, we had to remind ourselves continually that work that illustrates standard-setting performances is not the same as "best" work or "most exceptional" work. Some of the work samples we reviewed exceeded the expectations of the standards. Those work samples do not appear in this collection. We also had to remind ourselves that we were not trying to put together an anthology to celebrate the work students produce, valuable as such anthologies can be. Rather, our purpose was to identify samples of work that would help to give concrete meaning to the qualities described in the performance descriptions and establish the level of performance we should expect of work that is "good enough" to meet the standards. This meant that we chose some work samples over others because they provided clearer exemplification of the "bullet points" in the performance descriptions, even though some of the work we passed over unquestionably counted as "good" work.

We also learned that practice in making judgments about work in relation to the standards pays off. As the number of pieces of student work we had read and reviewed closely grew larger, we became clearer about the meaning of the bullet points in the performance descriptions and more confident of our judgment about the features that need to be demonstrated in work if it is to be considered standard setting. Some pieces of work that we judged to be candidates for inclusion in the collection early in the process did not rate among our judgments later on. Equally, there were some pieces of work that we rejected early in the process and later brought back to the table for further consideration.

Work produced by a diverse range of students

The work samples in this book reflect the diversity of backgrounds and experiences of the students studying in New York City's public schools and the communities of which they are a part. The student work illustrating standard-setting performances in Science comes from schools throughout the city. The work comes from students with a wide range of cultural backgrounds, some of whom have a first language other than English or are studying in ESL or bilingual education programs.

In some cases, the diverse backgrounds and experiences of the students are evident in the work samples. In other cases, the students' work reveals little about who they are. While we worked to ensure that the collection reflected the diversity of our students, we have not made specific reference to these characteristics in the commentaries that accompany the work samples. Work that illustrates a standard-setting performance is standard setting no matter who produced it. What unites the work samples is that they all help to illustrate the performance standards by demonstrating standard-setting performances for parts of one or more of the standards and demonstrate that all students can produce work that meets high expectations.

Genuine student work

In all cases, the work samples are genuine student work. While they illustrate standard-setting performances for parts of the science standards, many samples are not "perfect" in every respect. Some, for example, include imprecise language or graphic representations. Others have some spelling errors or awkward grammatical constructions. We think it is important that the standards are illustrated by means of authentic work samples and accordingly have made no attempt to "doctor" the work in order to correct these imperfections: the work has been included "warts and all." Where errors occur, we have included a note drawing attention to the nature of the mistakes and commenting on their significance in the context of the work.

Resources

Reviewers of the New Standards edition have pointed out that our expectations are more demanding, both in terms of student time and access to resources, than they consider reasonable for all students. We acknowledge the distance between our goals and the status quo, and the fact that there is a tremendous disparity in opportunities between the most and least advantaged students. Indeed, the National Research Council included a program standard that delineates all of the resources–professional development, time, materials, adequate and safe space, and access to the world beyond the classroom–needed to achieve the *National Science Education Standards*. This program standard is reprinted in its entirety in the appendix.

In addition to taking advantage of existing school, district, and board resources, we think that there are two additional strategies that must be pursued to achieve our goals—making better use of existing, out-of-school resources and making explicit the connection between particular resources and particular standards.

Best practice in science has always included extensive inquiry and investigation, but it is frequently given less emphasis in the face of competing demands for student time and teacher resources. An elementary teacher faced with the unfamiliar territory of project work in science or a secondary teacher faced with the prospect of guiding 180 projects and investigations can legitimately throw up his or her hands and say, "Help!" There are many science-related organizations in New York City, such as the American Museum of Natural History, the Bronx Zoo, and the City Parks Foundation, that have science education on their agenda. Thus, we invited representatives of those organizations to participate in the calibration process and have incorporated examples of projects and investigations that are done outside of school to make clear that help is available. There is an extensive list of science-rich organizations, professional organizations for science teaching, and other resources to support teachers and students in the appendix.

All of the district, state, and national documents in science make explicit the need for hands-on experiences and using information tools. Thus, for example, Standard S6, Scientific Tools and Technologies, makes consistent reference to using telecommunications to acquire and share information. We know that more students have access to the Internet at home than at school, so this raises an equity issue. We feel that the best way to encourage schools to make sure that students' access to information and ideas does not depend on what they get at home is to show several examples of work that was enhanced by use of the Internet and other technologies.

ASSESSMENT BASED ON STANDARDS

Performance standards define a student's academic responsibilities and, by implication, the teaching responsibilities of the school. How do we determine whether students have lived up to their academic responsibilities? We assess their work—is it "good enough" by comparison with the standards.

Assessment is an integral component of the educational process. If properly designed and administered, assessments can provide important information to help guide and inform instruction. In order to perform these functions, there must be a strict alignment among standards, educational strategies and resources, and assessments. That is, what we assess must be what we teach, and both must focus on what we want students to know and be able to do—the performance standards.

Assessment takes place in a variety of formats and situations, but a convenient distinction separates informal, ongoing classroom assessment from formal, standardized assessment. The former consists of the evidence teachers collect in class on a continuous basis to track the progress of their students in mastering the skills and material that are taught. The latter are the tests and on-demand assessments administered to all students in specific grades as part of the city- and state-wide assessment programs. Both types of assessment are essential to effective instruction. Ongoing classroom assessment provides continuous feedback on student progress to students, teachers, and parents; standardized assessment measures the mastery of critical skills and concepts at key developmental milestones. Regardless of their differing perspectives, both classroom and standardized assessment must be fully aligned with the performance standards.

The state is redesigning its standardized assessment program in Science based on performance standards that are aligned with the New York State Standards. Fourth grade students currently take the Elementary Science Program Evaluation Test (ESPET) to assess science programs in Grades K-4. ESPET includes an objective test as well as a test of manipulative skills. The state is designing a new science test at Grade 8 to be implemented for the first time in the spring of 2000. This test is designed to show whether students are meeting the higher academic standards that are being required and whether they are on track to passing the new, more rigorous Regents Science examinations in high school. The new science test at Grade 8 will include multiple-choice questions, open-ended questions, and a laboratory project.

Beyond standardized assessment, it is equally important to ensure that the performance standards provide the focus for ongoing classroom assessment. In the absence of standards, teachers are left without a common frame of reference to determine whether the work of their students is good enough. Standards could vary widely from classroom to classroom resulting in wide variation in instruction and achievement. The work samples that form an essential part of the performance standards provide graphic guidance to all teachers in assessing the level and quality of their students' work.

How the assessments are connected to the performance standards

The performance standards define a domain of expected student performances. Take the Science standard S1 at the elementary school level as an example (see page 22). This standard begins with a definition of science concepts that describes what we expect students to be able to do at approximately the end of fourth grade. The performance descriptions go on to spell out expectations for what students will accomplish in terms of demonstrating conceptual understanding, explaining observations and making predictions, and by representing concepts in multiple ways. Furthermore, students are expected to put their reading to work and the standards say so; students have to produce work based on their understanding of particular concepts.

We assess the different elements of the domain defined by a standard by using assessment methods appropriate to the expected performances. Although the assessment system that will fully align with the performance standards is currently under development, some of the components are already in place. The assessment methods comprise a variety of on-demand standardized and ongoing classroom assessments.

The standardized assessments are of two types that differ in format, method of scoring, and the information they provide. One type of assessment serves the purpose of telling us how well students are performing in comparison with standards (standards-referenced assessment); the other compares student performance to that of representative samples of other students (norm-referenced assessment). Typically, the former are performance-based assessments that require students to produce work that is rated by teachers or other professionals using a rubric, or scoring criteria, based on the standards. The latter are usually multiple-choice in format and are machine scored.

In the new state assessment system, these two different types of assessment are used to complement one another. Performance-based assessments are combined with multiple-choice tests in ways that measure both the depth and breadth of student achievement. Moreover, beginning in 2000, the state will revise its Elementary Science Program Evaluation Test (ESPET), add a test at Grades 8, and revise the high school Regents examinations in Science.

Classroom assessment

The last part of Science standard S8a requires that students communicate results to audiences and defend conclusions from peer review. The appropriate assessor for these requirements is the teacher or another adult close to the student who can verify the student's claims for meeting this requirement. This component of the system for assessing achievement of the Science standard is designed to work like a merit badge in the style of the awards developed by the Girl Scouts of the U.S.A. and the Boy Scouts of America.

Raising standards for all students has important implications for the quality of curriculum and instruction. Indeed, one of the most important reasons for setting high standards is to challenge the system to perform for the students. Appropriate assessments based on these high standards can give the system feedback on how well it is doing and what it has to do next.

HOW TO READ THESE PERFORMANCE STANDARDS

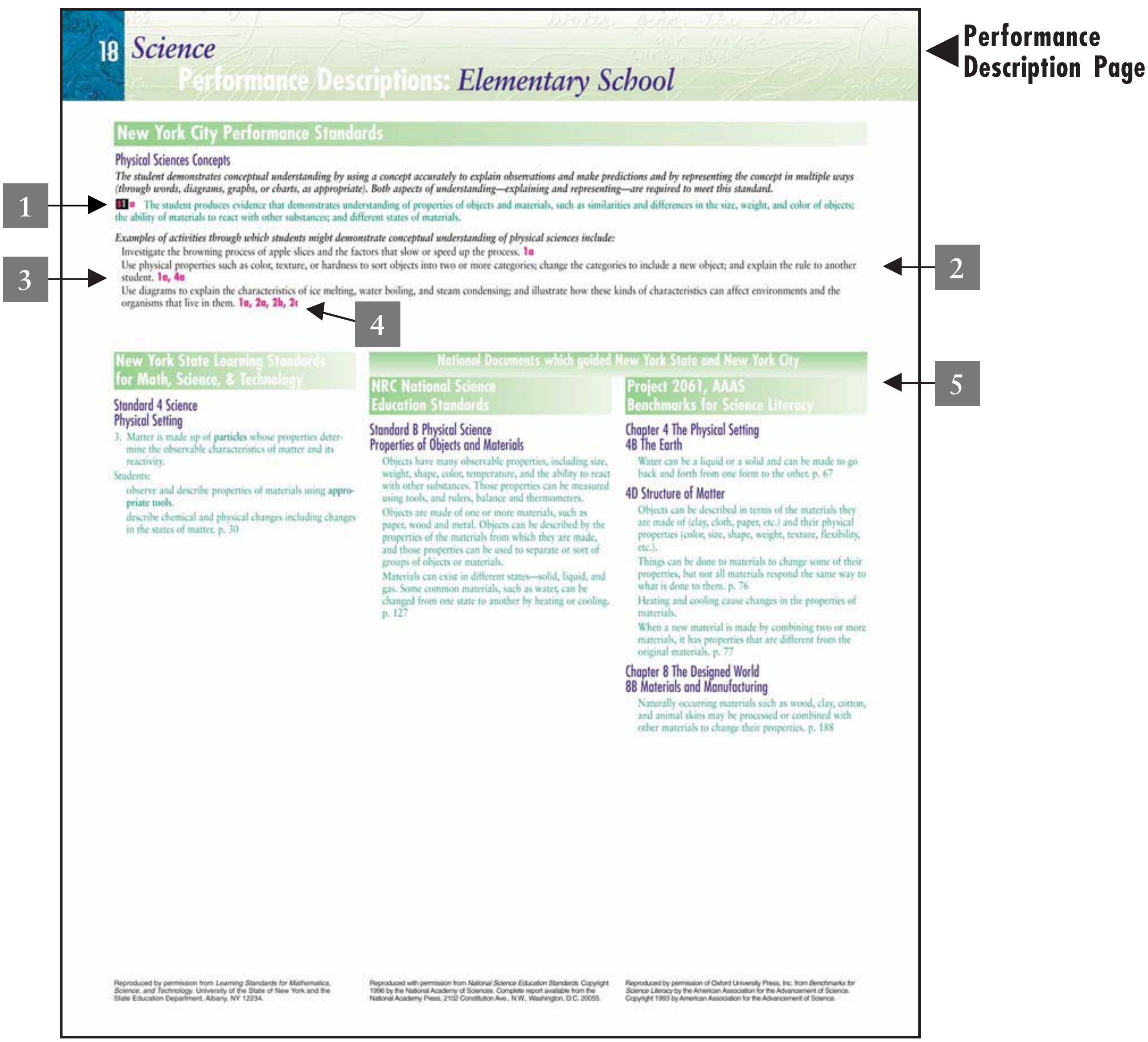
This volume is organized into three main sections: Elementary School (beginning on page 20), Middle School (beginning on page 150), and High School (beginning on page 290). Each section follows the same format.

Each standard is identified by a symbol.

Turn to the performance descriptions for the standards for elementary school on pages 22-53. There are eight standards for Science at each of the three levels, each identified by a symbol. The symbol for the Physical Sciences Concepts standard is **S1**. This symbol appears wherever there is a reference to this standard.

1 Most standards are made up of several parts.

All of the standards are made up of several parts, for example, the Physical Sciences Concepts standard has three parts at the elementary school level. Each part is identified by a lower case letter; for example, the part of the Physical Sciences Concepts standard that refers to properties of objects and materials is **S1a**. These symbols are used wherever there is a reference to the relevant part of a standard.



18 Science

Performance Descriptions: Elementary School

New York City Performance Standards

Physical Sciences Concepts

The 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 to meet this standard.

S1a The student produces evidence that demonstrates understanding of properties of objects and materials, such as similarities and differences in the size, weight, and color of objects; the ability of materials to react with other substances; and different states of materials.

Examples of activities through which students might demonstrate conceptual understanding of physical sciences include:

Investigate the browning process of apple slices and the factors that slow or speed up the process. 1a

Use physical properties such as color, texture, or hardness to sort objects into two or more categories; change the categories to include a new object; and explain the rule to another student. 1a, 4a

Use diagrams to explain the characteristics of ice melting, water boiling, and steam condensing; and illustrate how these kinds of characteristics can affect environments and the organisms that live in them. 1a, 2a, 2b, 2c

New York State Learning Standards for Math, Science, & Technology

Standard 4 Science
Physical Setting

3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Students:

observe and describe properties of materials using appropriate tools.

describe chemical and physical changes including changes in the states of matter. p. 30

National Documents which guided New York State and New York City

NRC National Science Education Standards

Standard B Physical Science
Properties of Objects and Materials

Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, and rulers, balance and thermometers.

Objects are made of one or more materials, such as paper, wood and metal. Objects can be described by the properties of the materials from which they are made, and those properties can be used to separate or sort of groups of objects or materials.

Materials can exist in different states—solid, liquid, and gas. Some common materials, such as water, can be changed from one state to another by heating or cooling. p. 127

Project 2061, AAAS Benchmarks for Science Literacy

Chapter 4 The Physical Setting
4B The Earth

Water can be a liquid or a solid and can be made to go back and forth from one form to the other. p. 67

4D Structure of Matter

Objects can be described in terms of the materials they are made of (clay, cloth, paper, etc.) and their physical properties (color, size, shape, weight, texture, flexibility, etc.).

Things can be done to materials to change some of their properties, but not all materials respond the same way to what is done to them. p. 76

Heating and cooling cause changes in the properties of materials.

When a new material is made by combining two or more materials, it has properties that are different from the original materials. p. 77

Chapter 8 The Designed World
8B Materials and Manufacturing

Naturally occurring materials such as wood, clay, cotton, and animal skins may be processed or combined with other materials to change their properties. p. 188

Performance descriptions tell what students are expected to know and be able to do.

Each part of a standard has a performance description. The performance description is a narrative description of what students are expected to know and be able to do. It is shown in bold type.

2 Examples are the kinds of work students might do to demonstrate their achievement of the standards.

Immediately following the bold-typed performance descriptions for the standard are examples of the kinds of work students might do to demonstrate their achievement. The examples also indicate the nature and complexity of activities that are appropriate to expect of students at the grade level. However, we use the word "example" deliberately. The examples are intended only to show the kinds of work that students might do and to stimulate ideas for further kinds of work. None of the activities shown in the examples is necessarily required to meet the standard.

3 Cross-references highlight the links between the examples and the performance descriptions.

The symbols that follow each example show the part or parts of the standard to which the example relates.

4 Cross-references also highlight links among the standards.

Often the examples that go with the performance descriptions include cross-references to other parts of the standard and parts of other standards.

5 Excerpts from other standards highlight the many similarities and few differences.

Quotations from the *New York State Learning Standards*, the *National Science Education Standards*, and the *Benchmarks for Science Literacy* show the many similarities and few differences among these state and national documents and the *New York City Performance Standards*.

6 Margin notes draw attention to particular aspects of the standards.

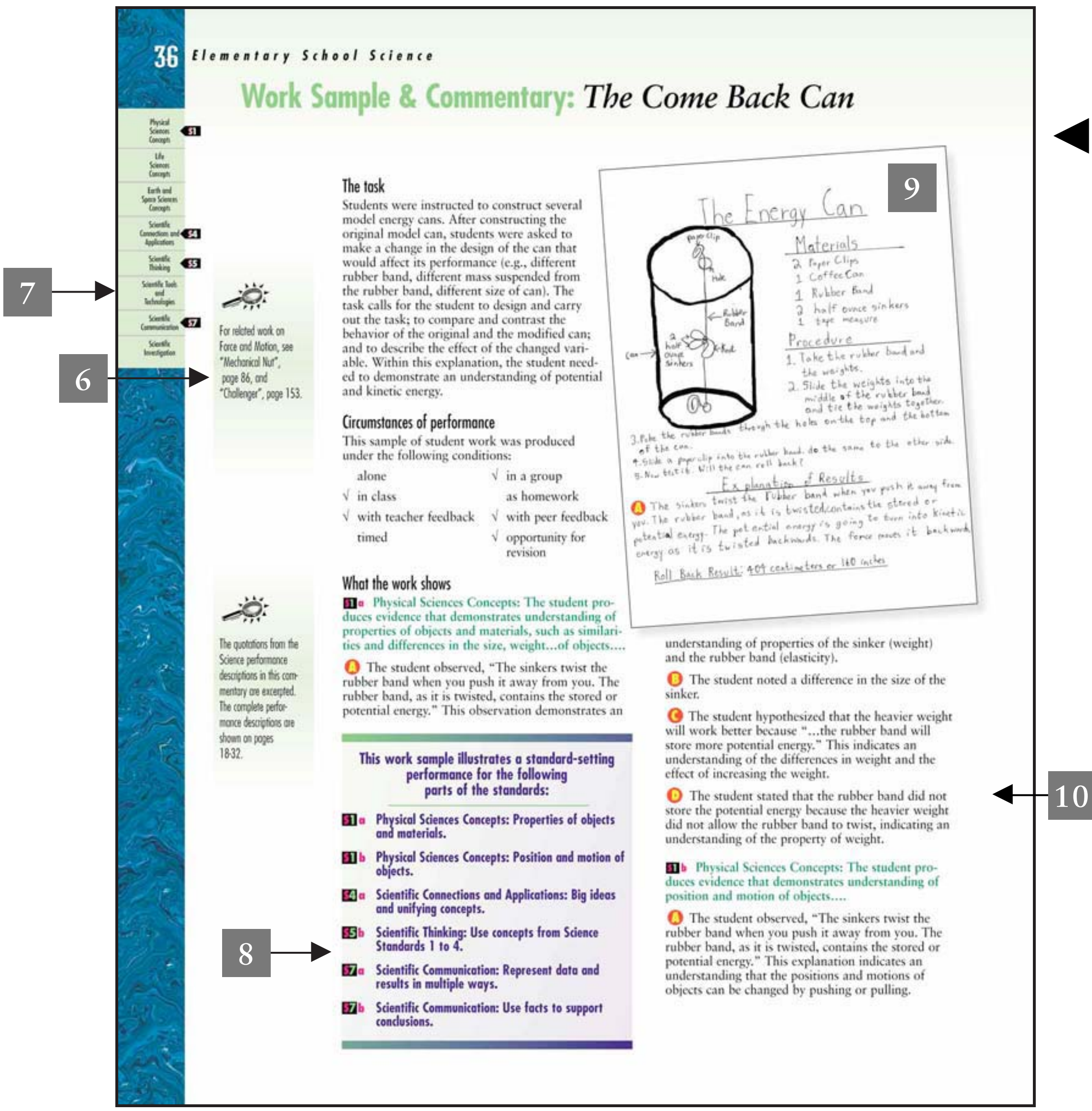
The notes in the margin draw attention to particular aspects of the standards, such as the resources to which students need access in order to meet the requirements of the standards.

Comparing the grade levels.

The Appendix (see page 487) shows the performance descriptions at each of the three grade levels: Elementary, Middle, and High School.

Work samples and commentaries.

Work samples and commentaries appear on the pages immediately following the performance descriptions.


36 Elementary School Science

Work Sample & Commentary: *The Come Back Can*

Physical Sciences Concepts S1
Life Sciences Concepts
Earth and Space Sciences Concepts
Scientific Connections and Applications S4
Scientific Thinking S5
Scientific Tools and Technologies
Scientific Communication S7
Scientific Investigation

For related work on Force and Motion, see "Mechanical Nut", page 86, and "Challenger", page 153.

The task

Students were instructed to construct several model energy cans. After constructing the original model can, students were asked to make a change in the design of the can that would affect its performance (e.g., different rubber band, different mass suspended from the rubber band, different size of can). The task calls for the student to design and carry out the task; to compare and contrast the behavior of the original and the modified can; and to describe the effect of the changed variable. Within this explanation, the student needed to demonstrate an understanding of potential and kinetic energy.

Circumstances of performance

This sample of student work was produced under the following conditions:

alone	√ in a group
√ in class	as homework
√ with teacher feedback	√ with peer feedback
timed	√ opportunity for revision

What the work shows

S1a Physical Sciences Concepts: The student produces evidence that demonstrates understanding of properties of objects and materials, such as similarities and differences in the size, weight...of objects....

A The student observed, "The sinkers twist the rubber band when you push it away from you. The rubber band, as it is twisted, contains the stored or potential energy." This observation demonstrates an understanding of properties of the sinker (weight) and the rubber band (elasticity).

B The student noted a difference in the size of the sinker.

C The student hypothesized that the heavier weight will work better because "...the rubber band will store more potential energy." This indicates an understanding of the differences in weight and the effect of increasing the weight.

D The student stated that the rubber band did not store the potential energy because the heavier weight did not allow the rubber band to twist, indicating an understanding of the property of weight.

S1b Physical Sciences Concepts: The student produces evidence that demonstrates understanding of position and motion of objects....

A The student observed, "The sinkers twist the rubber band when you push it away from you. The rubber band, as it is twisted, contains the stored or potential energy." This explanation indicates an understanding that the positions and motions of objects can be changed by pushing or pulling.

The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 18-32.

This work sample illustrates a standard-setting performance for the following parts of the standards:

- S1a Physical Sciences Concepts: Properties of objects and materials.
- S1b Physical Sciences Concepts: Position and motion of objects.
- S4a Scientific Connections and Applications: Big ideas and unifying concepts.
- S5b Scientific Thinking: Use concepts from Science Standards 1 to 4.
- S7a Scientific Communication: Represent data and results in multiple ways.
- S7b Scientific Communication: Use facts to support conclusions.

Commentary Page

7 Standards are highlighted in the bar at the side of the page.

The bar along the side of the pages showing student work highlights the standards that are illustrated by each work sample.

8 The box at the bottom of the page shows what is illustrated in the work sample.

The shaded box at the bottom of the page lists the parts of the standards that are illustrated in the work sample.

9 Work samples illustrate standard-setting performances.

Each work sample is a genuine piece of student work. We have selected it because it illustrates a standard-setting performance for one or more parts of the standards.

10 The commentary explains why the work illustrates a standard-setting performance.

The commentary that goes with each work sample identifies the features of the work sample that illustrate the relevant parts of the standards. The commentary explains the task on which the student worked and the circumstances under which the work was completed. It draws attention to the qualities of the work with direct reference to the performance descriptions for the relevant standards.

The commentary also notes our reservations about the work.

The commentary also draws attention to any reservations we have about the student work. (See "Genuine student work," page 12.)

Performance Standards = performance descriptions + work samples + commentaries on the work samples.

Performance standards are, thus, made up of a combination of performance descriptions, work samples, and commentaries on the work samples:

- The performance descriptions tell what students should know and the ways they should demonstrate the knowledge and skills they have acquired.
- The work samples show work that illustrates standard-setting performances in relation to parts of the standards.
- The commentaries explain why the work is standard-setting with reference to the relevant performance description or descriptions.

Each of these is an essential component of a performance standard.

Most work samples illustrate a standard-setting performance for parts of more than one standard.

Most work samples illustrate the quality of work expected for parts of more than one standard. For example, some of the work samples selected to illustrate parts of S1, Physical Sciences Concepts, also illustrate a standard-setting performance for part of S5, Scientific Thinking, or for part of S7, Scientific Communication, or, possibly, all of these.

"The Come Back Can" (see page 60) is an example of a work sample that illustrates parts of more than one standard.

New Standards
PERFORMANCE STANDARDS
New York City — First Edition
Science
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Overview of the Performance Standards

OVERVIEW OF THE PERFORMANCE STANDARDS

The middle school standards are set at a level of performance approximately equivalent to the end of eighth grade. It is expected that some students might achieve this level earlier and others later than this grade. (See "Deciding what constitutes a standard-setting performance.")

S Science

S1 Physical Sciences Concepts

- S1a Demonstrates understanding of properties and changes of properties in matter.
- S1b Demonstrates understanding of position and motion and forces.
- S1c Demonstrates understanding of transfer of energy and the nature of a chemical reaction.

S2 Life Sciences Concepts

- S2a Demonstrates understanding of structure and function in living systems.
- S2b Demonstrates understanding of reproduction and heredity and the role of genes and environment on trait expression.
- S2c Demonstrates understanding of regulation and behavior and response to environmental stimuli.
- S2d Demonstrates understanding of populations and ecosystems and the effects of resources and energy transfer on populations.
- S2e Demonstrates understanding of evolution, diversity, and adaptation of organisms.

S3 Earth and Space Sciences Concepts

- S3a Demonstrates understanding of structure of the Earth system.
- S3b Demonstrates understanding of Earth's history.
- S3c Demonstrates understanding of Earth in the Solar System.
- S3d Demonstrates understanding of natural resource management.

S4 Scientific Connections and Applications

- S4a Demonstrates understanding of big ideas and unifying concepts.
- S4b Demonstrates understanding of the designed world.
- S4c Demonstrates understanding of health.
- S4d Demonstrates understanding of impact of technology.
- S4e Demonstrates understanding of impact of science.

S5 Scientific Thinking

- S5a Frames questions to distinguish cause and effect; and identifies or controls variables.
- S5b Uses concepts from Science Standards 1 to 4 to to explain a variety of observations and phenomena.
- S5c Uses evidence from reliable sources to to develop descriptions, explanations, and models.

- **S5d** Proposes, recognizes, analyzes, considers, and critiques alternative explanations; and distinguishes between fact and opinion.
- **S5e** Identifies problems; proposes and implements solutions; and evaluates the accuracy, design, and outcomes of investigations.
- **S5f** Works individually and in teams to to collect and share information and ideas.

S6 Scientific Tools and Technologies

- **S6a** Uses technology and tools to observe and measure objects, organisms, and phenomena, directly, indirectly, and remotely.
- **S6b** Records and stores data using a variety of formats.
- **S6c** Collects and analyzes data using concepts and techniques in Mathematics Standard 4.
- **S6d** Acquires information from multiple sources.
- **S6e** Recognizes sources of bias in data.

S7 Scientific Communication

- **S7a** Represents data and results in multiple ways.
- **S7b** Argues from evidence.
- **S7c** Critiques published materials.
- **S7d** Explains a scientific concept or procedure to other students.
- **S7e** Communicates in a form suited to the purpose and the audience.

S8 Scientific Investigation

- **S8a** Demonstrates scientific competence by completing a controlled experiment.
- **S8b** Demonstrates scientific competence by completing fieldwork.
- **S8c** Demonstrates scientific competence by completing a design.
- **S8d** Demonstrates scientific competence by completing secondary research.