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ABSTRACT

In June 1985, the American Association for the Advancement of Science launched a long-term effort to reform science, mathematics, and technology education for the 21st century. This effort, Project 2061, took into account all students, grades, and aspects of the K-12 education system and focused on science literacy rather than the more narrowly construed science disciplines. This booklet describes Project 2061 and documents its progress over the last decade. Contents include: (1) "A New Vision of Science Education"; (2) "Defining Science Literacy"; (3) "Help from School-District Teams"; (4) "Establishing Benchmarks; (5) Project 2061 and National Standards; (6) Rethinking the Curriculum"; (7) "Reforming the System"; (8) "Science Literacy for a Changing Future"; (9) "National Council on Science and Technology Education"; (10) "Project 2061 Staff"; and (11) "For Further Help." (JRH)

Project 2061

Project 2061

Science Literacy for a Changing Future

A Decade of Reform

American Association for the Advancement of Science
Washington, D.C.

Contents

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erican Association for the vancement of Science

Founded in 1848, the American Association for the Advancement of Science (AAAS) is the world's largest federation of scientific and engineering societies, with nearly 300 affiliate organizations. In addition, AAAS counts more than 140,000 scientists, engineers, science educators, policy makers, and interested citizens among its individual members, making it the largest general scientific organization in the world. The Association's goals are to further the work of scientists; facilitate cooperation among them; foster scientific freedom and responsibility; improve the effectiveness of science in the promotion of human welfare; advance education in science; and increase public understanding and appreciation of the importance and promise of the methods of science in human progress.

The AAAS wishes to express its gratitude to the following for their generous support of Project 2061:

Carnegie Corporation of New York

John D. and Catherine T. MacArthur Foundation

Andrew W. Mellon Foundation

Robert N. Noyce Foundation

The Pew Charitable Trusts

International Business Machines Corporation

National Science Foundation

U.S. Department of Education

California State Department of Education

Georgia Department of Education

Texas Education Agency

Wisconsin Department of Public Instruction

Ten years ago, AAAS, the Carnegie Corporation of New York, and the Andrew W. Mellon Foundation launched a project that promised to be radical, ambitious, comprehensive, and long-term—in other words, risky and expensive. Although "systemic reform" has since become a national buzzword, Project 2061's approach to reform was seen, at the time, as exceptionally broad. It took into account all students, all grades, and all aspects of the K-12 education system. It focused on science literacy, rather than the more narrowly construed "science disciplines." And, it included the natural and social sciences, mathematics, and technology.

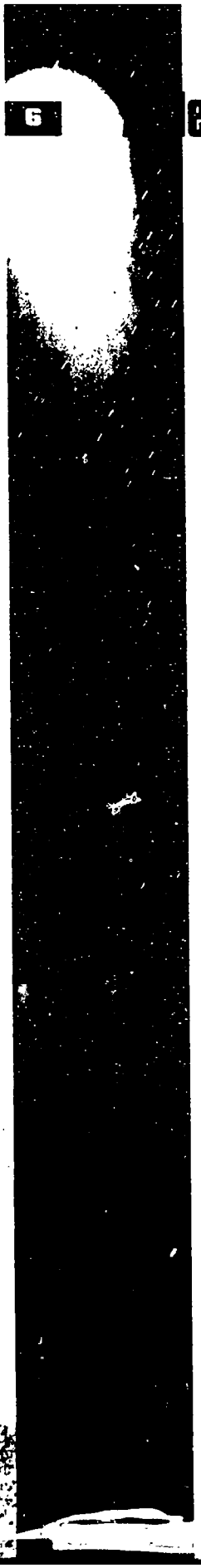
Even more extraordinary was Project 2061's plan to forge a consensus on learning goals as the basis for all other changes to the education system. Is it possible, critics asked, for experts in science, mathematics, and technology to agree on one set of learning goals for all high-school graduates? But without this underlying agreement on national learning goals, education reforms would work at cross purposes. At best, reform would continue to be haphazard, piecemeal, and ultimately unsuccessful. Haphazard had been done before; successful was worth shooting for.

To further heighten our funders' anxiety, Project 2061 announced that it would need at least a quarter of a century to achieve its goals. Such long-term plans defied conventional wisdom, which held that reform projects, unlike institutions, couldn't possibly survive more than a few years. Ten was pushing it; twenty-five was simply out of the question. But the nation's schools needed more than a quick fix this time.

The AAAS Board and Project 2061's original funders recognized all of these risks. Fortunately, they also saw promise in taking a bold new approach to reform. How has that promise been fulfilled? That's what this booklet is all about.

The work and achievements of the Project 2061 staff, its School-District Centers, consultants, and associates have been made possible by the Project's many funders. Over the past decade, the number of foundations, government agencies, and corporations supporting Project 2061 has steadily increased. Today, ten years after they first invested in a radical new approach to reforming science education, Carnegie and Mellon continue to support Project 2061 generously. To them and to all of Project 2061's supporters, we express our gratitude for their confidence and our appreciation for their commitment to education reform.

F. James Rutherford
Director, Project 2061



6 ew Vision of Science Education

In June 1985, the American Association for the Advancement of Science launched a long-term effort to reform science, mathematics, and technology education for the 21st century. That same year, Halley's Comet was approaching the sun, prompting the new project's originators to consider all of the scientific and technological changes that a child entering school in 1985 would witness before the return of the Comet in 2061—hence the name, Project 2061. In ten years, Halley's Comet has raced past Jupiter. The kindergartners who started school in 1985 are now high-school sophomores. And Project 2061 has helped to focus the nation's reform efforts by defining science literacy in its 1989 report *Science for All Americans* and then specifying learning goals for grades 2, 5, 8, and 12 in *Benchmarks for Science Literacy* in 1993.

"Project 2061 proposes a fundamental reformation of science, mathematics, and technology education..."

March 1985 proposal to the Carnegie Corporation of New York

Project 2061's influence on science education reform is in evidence throughout the country. Both *Science for All Americans* and *Benchmarks for Science Literacy* are being used by teachers, teacher educators, curriculum developers, and reform groups at the local, state, and national levels. Its vision is helping to guide the work of state curriculum framework committees, developers and publishers of instructional and assessment materials, state and urban systemic reform initiatives and the National Research Council in its effort to formulate national science education standards.

In promoting science literacy, Project 2061 has also drawn national attention to the importance of improving science education for *all* students, engaging the scientific community in education reform, involving teachers in important decisions about the curriculum, and investing time and resources in long-term, system-wide change.

But the fact that Project 2061 has been successful—with generous support from public and private funders, eager acceptance and use of its products by educators, and the enthusiastic collaboration of other reform initiatives—says as much about the widely felt need for improving science education as it does about Project 2061's strategy.

The Need for Science Literacy

By the mid-1980s, a number of reports had taken a critical look at trends in public education. The news was not good. One of the first and most compelling of these reports was *A Nation at Risk: The Imperative for Educational Reform*, released in 1983 by the National Commission on Excellence in Education. *A Nation at Risk* warned of a national education crisis and urged reform of the entire system. Dozens of reports over the next few years supported the Commission's conclusions, citing American students' low test scores and poor showing in international studies of student achievement. The 1986 National Assessment of Educational

Progress revealed that average science proficiency among students was, despite modest increases in the 1980s, still below 1970 levels.

Many reports on education also alluded to the nation's decline as an economic and technological world leader, implicitly (and at times explicitly) linking this decline to the failures of the education system. Taken up by the media, the reports impressed upon educators and the general public the importance of improving education–especially science and technology education–to prepare students and the nation to compete in a high-tech world.

This climate inspired numerous reform projects in the 1980s and early 90s. In 1981, AAAS put science literacy at the top of its priority list and instituted a series of programs to help the nation's schools produce science-literate graduates. It also began to explore the possibilities for a large-scale project that would bring lasting reform to science education. Taking into consideration the accomplishments and failures of previous reform efforts, AAAS worked out the details of a radical reform strategy. By 1985, AAAS had attracted the funding to launch Project 2061.

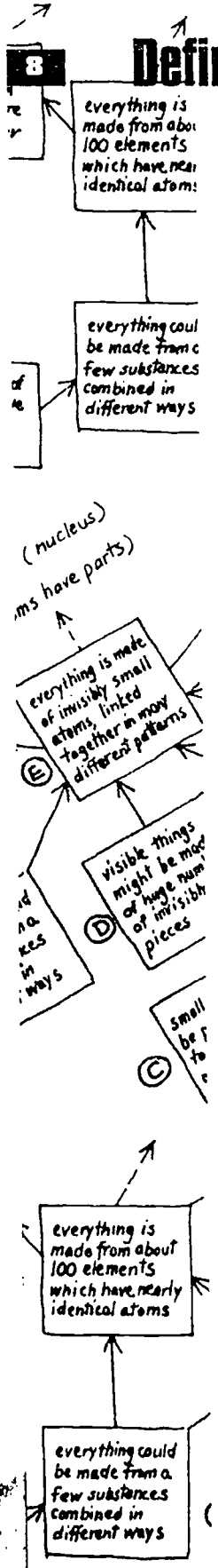
From the start, Project 2061 emphasized the importance of science itself as one of the great human adventures. Its work is based on the premise that only those who are science literate can share in the excitement of finding out who we are, where we are, and how we relate to all living things and to our natural surroundings.

Unfortunately, most Americans are not science literate. Project 2061's first major report, *Science for All Americans*, attributed this failure to problems like the crushing workloads of teachers, antiquated support systems, and poor training; textbooks and methods of instruction that impede scientific inquiry, critical thought, and recognition of connections among ideas; and an overstuffed curriculum that offered some topics in needless detail while overlooking ideas and skills crucial to science literacy. But, as the following will show, *Science for All Americans* did not dwell on the failures of the education system.

APRIL 1983

The National Commission on Excellence in Education releases *A Nation at Risk: The Imperative for Educational Reform.*

Defining Science Literacy



The chief intent of *Science for All Americans* was to provide a fresh, critical look at what science was most worth learning—the first such comprehensive effort in decades. It represents almost four years of work by Project 2061 staff and its advisory board, and two years of work by five panels of scientific experts in broadly-defined fields (Biological and Health Sciences, Social and Behavioral Sciences, Physical and Information Sciences and Engineering, Mathematics, and Technology).

When first convened in 1985, the panels were encouraged to disregard the existing curriculum as they debated the question, "What should all high-school graduates know and be able to do in science, mathematics, and technology?" To avoid overloading the curriculum, the panels agreed to identify only those ideas of surpassing importance to science literacy. Their thoughtful recommendations appeared in five panel reports. These, in turn, served as the basis for *Science for All Americans*, which presents a coherent set of learning goals for adult science literacy.

Science for All Americans, along with the five panel reports, was released in February 1989. It helped to establish science literacy as an important national goal for all students and focused the nation's attention on ideas that have become central to science education reform. For example:

- Reform must be comprehensive, involving all children, all grades, and all subjects. And reform must be long term. Instead of settling for a quick fix for the curriculum, reformers must take the time to address all facets of the education system.
- Curriculum reform should be shaped by a vision of the lasting knowledge and skills students need to acquire by the time they become adults. This includes both a core of specific knowledge and skills for all and additional learning opportunities that serve the particular needs and interests of individual students.
- The common core of learning in science, mathematics, and technology should center on science literacy, including connections among the natural and social sciences, mathematics, and technology and between those areas and the arts, humanities, and vocational subjects as well.
- Schools should not try to teach more but less, so that what is taught can be learned well. The core curriculum should omit many of the specialized terms and memorized procedures that too often substitute for the understanding required for science literacy.
- Promoting equity in science education is a priority. All students should be served equally well in the light of their various circumstances, needs, and vocational aspirations. Race, ethnicity, culture, gender, economic circumstances, physical limitations, and location should be taken into account in designing and implementing an effective curriculum—not as excuses for shortchanging some students.

"This pioneering effort has profound implications for the future of our nation and, indeed, of the world."

David A. Hamburg, President, Carnegie Corporation of New York

- A common set of learning goals need not dictate uniform curricula, teaching methods, or materials–variety is important. In response to state and district requirements, student backgrounds and interests, teacher preferences, and local environments in this country, reform should lead to greater curriculum diversity than is common today.

Science for All Americans argued the importance of reforming the curriculum to promote science literacy and specified what all children should know and be able to do in science, mathematics, and technology by the time they complete high school. These goals do not describe how curriculum and instruction should be organized, but rather the knowledge and skills that science-literate adults should have at their command.

A Nontraditional Approach

Project 2061's idea of science literacy was a radical departure from that implicit in the nation's typical science curricula. Rather than confine itself to particular school science disciplines, *Science for All Americans* construed the notion of science literacy broadly, focusing on interconnected understandings in the natural and social sciences, mathematics, and technology. It further included knowledge about the nature of the scientific enterprise itself, historical episodes of exceptional significance in the development of science, and themes that cut across science, mathematics, and technology. *Science for All Americans* includes recommendations in the following areas:

Chapters 1-3 describe what should be known about the nature of science, mathematics, and technology as related endeavors, including their similarities, connections, and differences.
Chapter 1: *The Nature of Science* focuses on three related topics: the scientific world view, scientific methods of inquiry, and the nature of the scientific enterprise; **Chapter 2:** *The Nature of Mathematics* describes logical and creative processes involved in both theoretical and applied mathematics; and **Chapter 3:** *The Nature of Technology* describes the relation of technology to science, problems of design, and issues in expanding technology to change the world.

Chapters 4-9 present what should be known about views of the world as depicted by current science. **Chapter 4:** *The Physical Setting* describes basic knowledge about the matter and energy contents and structure of the universe and the physical principles on which it seems to run; **Chapter 5:** *The Living Environment* delineates basic ideas about how living things function and how they interact with one another and their environment; **Chapter 6:** *The Human Organism* discusses our species as one that is in some ways like other living things and in some ways unique; **Chapter 7:** *Human Society* considers individual and group behavior, social organization, and the process of social change; **Chapter 8:** *The Designed World* reviews principles of how people shape and control the world through some key areas of technology; **Chapter 9:** *The Mathematical World* presents basic mathematical ideas, especially those with practical application, that together play a key role in almost all human endeavors.

Chapters 10-12 further extend the definition of science literacy to include prominent episodes in the history of science, common themes, and habits of mind.
Chapter 10: *Historical Perspectives* illustrates the scientific enterprise with 10 historical examples of exceptional significance in the development of science; these deal with discoveries about the planetary

JUNE 1985

AAAS launches a national project to improve K-12 science, mathematics, and technology education.

OCTOBER 1985

Project 2061's scientific panels begin work to define science literacy.

JANUARY 1986

National Council on Science and Technology Education, Project 2061's advisory board, convenes for the first time.

MAY 1986

Project 2061 staff begin work on *What Science Is Most Worth Knowing*, later to become *Science for All Americans*.

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Science for All Americans

Chapter 13: Effective Learning and Teaching examines the principles that underlie all Project 2061 tools:

- Science teaching should foster and build on students' curiosity and creativity. Teaching should begin with questions and phenomena that are interesting and familiar to students. Abstract understanding often has to be built upon concrete examples.
- Instruction should emphasize the quality of understanding rather than the quantity of information. Technical vocabulary should be stressed only insofar as it contributes to understanding–and never as a substitute for understanding.
- Concepts are learned best when they are encountered in a variety of contexts and expressed in a variety of ways. Some concepts will only be learned when students restructure their thinking in the light of compelling evidence.
- If students ultimately are expected to apply ideas in novel situations, think critically, analyze information, communicate scientific ideas, make logical arguments, and work as part of a team, they must have opportunities to practice doing so in many contexts.
- Students also need many and varied opportunities to engage in the activities associated with science–such as collecting, observing, sketching, interviewing, and using instruments. The collaborative nature of scientific and technological work calls for frequent group activity in the classroom.
- Learning experiences should foster both scientific knowledge of the world and scientific habits of mind. Students should routinely question evidence, logic, and claims. They should encounter problems that require them to identify relevant evidence and offer their own interpretations of what the evidence means.
- Students should encounter many scientific ideas presented in historical context. They should become aware of the influence of society on the development of science and technology, and the impact of science and technology on society.

earth, universal gravitation, relativity, geologic time, plate tectonics, the conservation of matter, radioactivity and nuclear fission, the evolution of species, germs as a source of disease, and the industrial revolution. Chapter 11: *Common Themes* presents general concepts that cut across science, mathematics, and technology. These themes–systems, models, stability, constancy and change, and scale–can serve as tools for scientific thinking about diverse phenomena and provide insights into how the world works. Chapter 12: *Habits of Mind* sketches the attitudes, skills, and ways of thinking that are essential to science literacy.

In addition to its content recommendations, *Science for All Americans* also includes a chapter that lays out some principles of effective learning and teaching (see box at left). Many of these ideas have struck a chord with teachers and teacher educators around the country and have figured prominently in the local curriculum models developed by the Project's school-district teams of teachers

Taken together, *Science for All Americans* coherent content recommendations and suggestions for teaching and learning have fostered national discourse on important education issues, influencing the direction of education reform and demanding new approaches to curriculum design and instruction.

Help from School-District Teams

After the publication of *Science for All Americans*, Project 2061 turned its attention ro several tasks—introducing the ideas in *Science for All Americans* to reformers throughout the nation, developing tools to help educators redesign their curricula around science literacy goals, and thinking through *Science for All Americans*' implications for other aspects of the education system. Project 2061 wanted the help of teachers in all of these tasks, but particularly in the development of curriculum-design tools that would be credible and useful to other teachers. To reflect the geographic and demographic differences of the nation's school districts, it established school-district teams in six areas:

Georgia–three rural school districts (Elbert, Greene, and Oglethorpe Counties) near Athens;

Wisconsin–a small, suburban school district (McFarland) near Madison;

Philadelphia, Pennsylvania–one of the largest school districts in the country, with over 200,000 students, most of them African-American or Hispanic;

San Antonio, Texas–four independent school districts with a large, inner-city Hispanic population;

San Diego, California–a multicultural school district in urban/suburban San Diego; and

San Francisco, California–an inner-city school district with great ethnic diversity.

So that they could plan for 13 years of schooling in science, mathematics, and technology, each team included five elementary teachers, five middle school teachers, ten high school teachers, one principal from each level, and two curriculum specialists. These were drawn from a wide range of disciplines, including the life and physical sciences, social studies, mathematics, technology, and even the humanities. AAAS and each school district arranged for financial, intellectual, and practical support–including university consultants, clerical help, office space, computers, reference materials, travel funds, and other resources that would enable the teams to think creatively about the curriculum and to become leaders of curriculum reform.

Initially, teams set out to design curriculum models that school districts could use to plan curricula responsive to local needs and conducive to science literacy. The teams were encouraged to be as imaginative as possible and not to limit their vision of what a K-12 curriculum could look like. By the summer of 1991, each of the teams had drafted a curriculum model to address the goals in *Science for All Americans*. Working backward

"Sites have been selected that represent the rich variety of American community life and that at the same time give us a good chance, to succeed..."

F. J. Rutherford, Director
Project 2061, April 6, 1989

JANUARY 1988

Project 2061 analyzes comments on draft *Science for All Americans* from 160 reviewers.

MAY 1988

Staff begin to identify school district partners, looking first to California and Texas, both influential in education.

JULY 1988

Meeting in Aspen, CO, with teachers, science and mathematics supervisors, curriculum experts, and university educators to plan for Project 2061 school district teams.

AUGUST 1988

National Council approves *Science for All Americans* for submission to AAAS Board.

Project 2061 School–District Centers

Georgia builds a leadership cadre.

Teams of teachers from five schools in rural Georgia are defining a professional development plan that will help them and, ultimately, other educators to collaborate more fully with their peers, increase their understanding of *Science for All Americans* and *Benchmarks for Science Literacy*, and raise their awareness of what teaching to specific benchmarks—or learning goals—demands. These plans focus on using Project 2061 tools to analyze curriculum materials for their match to benchmarks.

Philadelphia emphasizes long-term teacher education.

Through university pre-service programs, a first -year teacher workshop series, and a state-wide workshop program, the Philadelphia Center strives to enhance teacher education opportunities. Working with K-12 school clusters, the Center is also engaged in the analysis and design of curriculum that reflects Project 2061 principles and plays a significant role in connecting Project 2061's reform vision with Philadelphia's Urban Systemic Initiative and with the school district's reform agenda, "Children Achieving."

San Antonio collaborates with other reform efforts.

As part of an overall reorganization, the San Antonio Center is developing strong linkages with other reform initiatives in the district. The Center leadership is drafting a long-term Project 2061 professional development program for teachers that will contribute to the district's emphasis on strengthening science, mathematics, and technology education in all of the schools.

San Diego influences district reform.

The San Diego Center is helping to guide restructuring measures by disseminating Project 2061 principles, strategies, and tools through districtwide professional development programs and collaboration with other reform initiatives in the area. Using Project 2061's curriculum materials analysis and design procedures, the Center is also preparing curriculum units to supplement the district's recently adopted curriculum materials for grades 7-9.

San Francisco implements challenge-based learning experiences.

Working with the staff of nine schools, the Center is helping teachers develop and implement challenge-based learning experiences—multi-faceted tasks that engage students in investigating and responding to environmental and social issues, in making decisions and solving problems of local and global concern, in designing and creating products and performances, or asking "How do we know what we know?" These experiences target Project 2061's science literacy and learning goals.

Wisconsin plans for professional development.

Working with the Center for the Advancement of Science, Mathematics, and Technology, the Wisconsin Center has expanded to become Project 2061's first statewide team. It is developing a variety of professional development programs focused on Project 2061's principles, strategies, and tools.

from these adult science literacy goals, they were able to identify a series of learning goals for younger students. Then, working together, the teams began to create a common set of learning goals, or benchmarks, for various grade levels. Out of this effort came the 1993 publication, *Benchmarks for Science Literacy*.

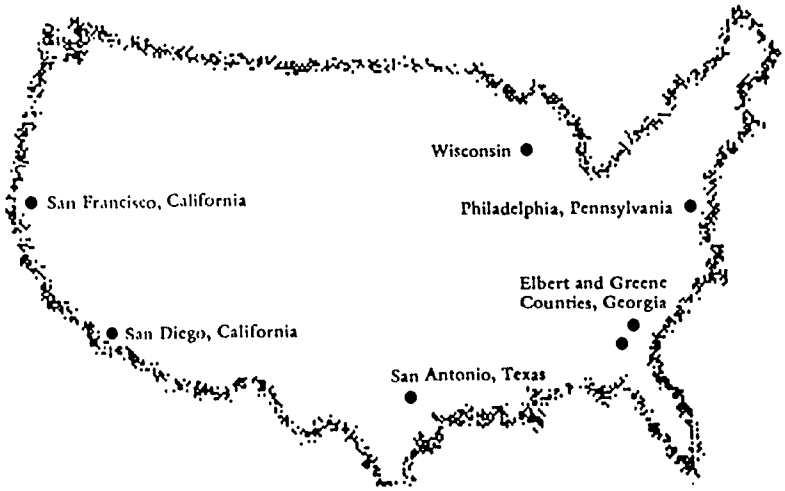
New Roles for School-District Teams

Since the release of *Benchmarks for Science Literacy*, the teams have been looking at their curriculum models to see how well they address *Benchmarks*' learning goals and how to tie them more specifically to *Benchmarks*. What they have discovered about identifying and analyzing curriculum resources has been extremely helpful in developing workshops for educators and in creating the forthcoming Project 2061 tools, *Resources for Science Literacy* and *Designs for Science Literacy*.

The role of the school-district teams has evolved significantly over the past six years. At first, the six teams undertook the same tasks and met *en masse* once a year at summer institutes to discuss their progress and share ideas related to curriculum reform. Since 1993, however, the teams, now called School-District Centers, have worked with Project staff to establish their own work agendas, which increasingly reflect local priorities.

Over the years, the Centers' work has created a core group of school-based educators who have developed a richer understanding of science, mathematics, and technology and a broad educational perspective. Many of the Center members now lead Project 2061 workshops around the country. With their talent and unique experiences, Center members are also in demand as speakers at local and national education events. Many serve on boards and advisory councils for other reform initiatives and work with their state education agencies to shape the development of curriculum frameworks around *Benchmarks for Science Literacy*.

Project 2061 School-District Centers



JANUARY 1989

Project 2061 holds pre-publication symposium on *Science for All Americans* at AAAS Annual Meeting in San Francisco.

FEBRUARY 1989

AAAS releases *Science for All Americans* at news conference at National Press Club in Washington, D.C.

MARCH 1989

National Council of Teachers of Mathematics publishes *Curriculum and Evaluation Standards for School Mathematics*.

MARCH 1989

Representatives from six prospective school-district team meet in Atlanta for leadership conference and orientation meeting.

rican Association for the

14 Establishing Benchmarks

By 1992, nearly 100,000 copies of *Science for All Americans* were in circulation. Not only was the National Research Council drawing extensively on it to produce national science education standards, but at least 15 states—including California, Texas, and New York—and numerous school districts were using *Science for All Americans* in their curriculum frameworks and reform efforts. Many others indicated that they would soon follow suit.

Universities were using *Science for All Americans* in their preservice teacher education courses; the Consensus Planning Committee preparing for the 1994 National Assessment of Educational Progress in Science used *Science for All Americans* as a starting point for its content specifications in physical science, earth science, biological science, and interdisciplinary themes. Project 2061 was kept busy responding to requests for briefings, workshops, and speeches on *Science for All Americans* and its implications for reform.

In establishing goals for adult science literacy, *Science for All Americans* did not specify what students should learn–or when–on their way to becoming science literate. The task remained to develop practical guidelines that school districts nationwide could adopt in planning their own K-12 curricula to meet the goals in *Science for All Americans*.

In April 1989, teachers at Project 2061's six school-district sites began working with the Project staff on research and development toward this end. Initially focusing on developing curriculum models around the goals for high school graduates in *Science for All Americans*, the teams soon found it necessary to identify grade-level expectations for earlier grades. Strikingly, they all settled on much of the same content and the same four grade levels.

"...one of the first concrete steps in the so-called standards movement.... an effort to teach all students a basic core of knowledge."

The Washington Post,
October 26, 1993

Benchmarks for Science Literacy

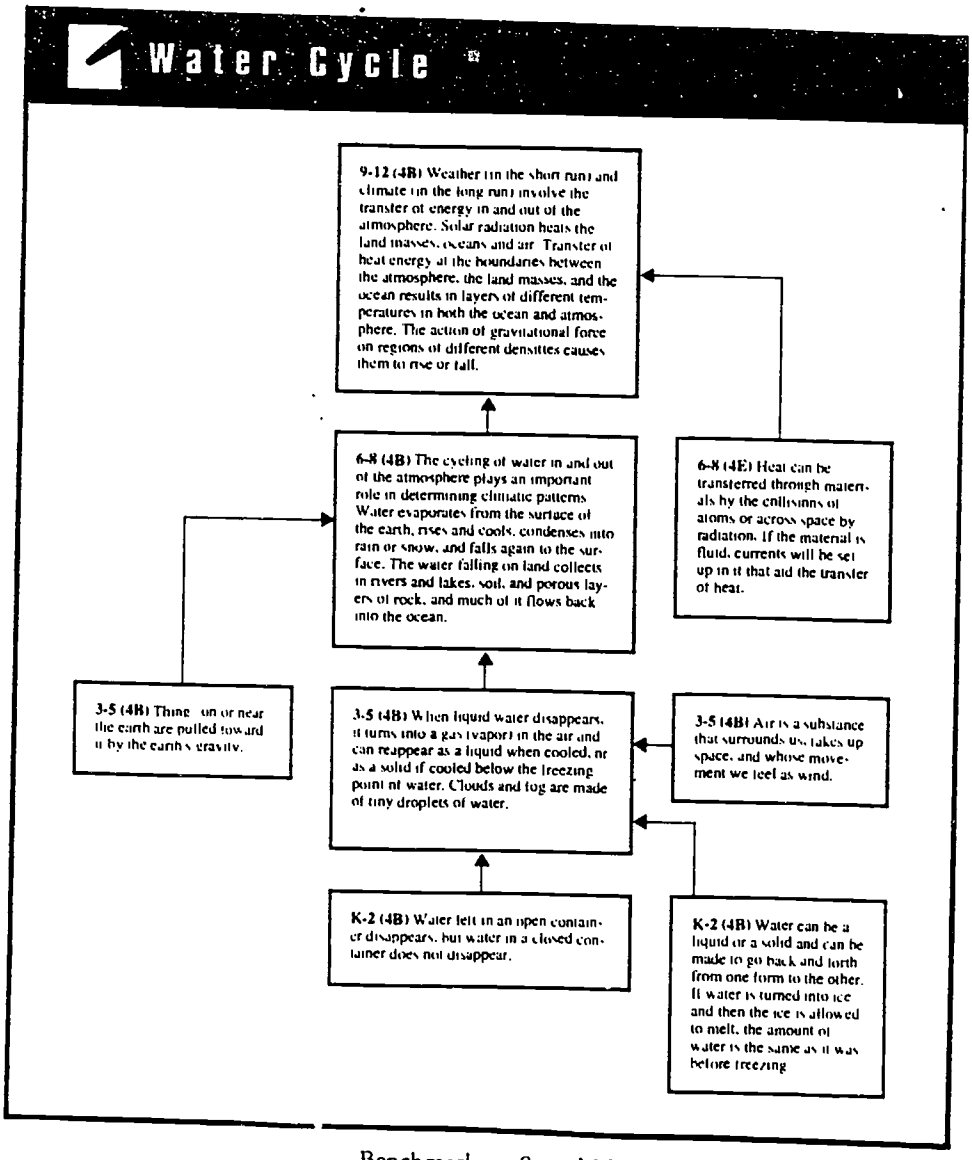
Building on the work of the teams and also on education research about student learning, Project 2061 published *Benchmarks for Science Literacy* in 1993. Intended primarily as a tool for curriculum design, *Benchmarks* translates the adult goals for science literacy presented in *Science for All Americans* into learning goals—or benchmarks—for the ends of grades 2, 5, 8, and 12. The response to *Benchmarks* by educators, scientists, and the general public was overwhelmingly positive. The first printing of 30,000 books sold out in just a few months, and today over 70,000 copies are in circulation.

Benchmarks for Science Literacy differs greatly from conventional tools for curriculum planning:

- *Benchmarks* is a tool to be used by educators in designing a curriculum that makes sense to them and that meets the goals for science literacy recommended in *Science for All Americans*. *Benchmarks* does not advocate any particular curriculum design; in fact, it should allow greater curriculum diversity than is common today.
- *Benchmarks* is a compendium of specific science-literacy goals that can be organized however one chooses.
- *Benchmarks* specifies thresholds rather than average or advanced performance. It describes levels

APRIL 1989

Six School-district teams begin their work with Project 2061.



Benchmark — Strand Map

JULY 1989

School-district teams convened at the University of Colorado, Boulder, for first Summer Institute.

SEPTEMBER 1989

President Bush and the nation's governors meet for an education summit in Charlottesville, VA, to establish national performance goals and America 2000 strategy.

JULY 1990

Project 2061 Summer Conference held at Madison, WI.

of understanding and ability that all students are expected to reach on the way to becoming science literate.

- *Benchmarks* sets learning goals at the ends of grades 2, 5, 8, and 12, rather than the more common 4th-, 8th-, and 12th-grade checkpoints. Teachers in the Project's school-district teams felt strongly that the developmental difference between a kindergartner and an 8th grader demanded more than one checkpoint.
- *Benchmarks* concentrates on the common core of learning that contributes to the science literacy of all students. It does not spell out all science, mathematics, and technology goals that belong in the K-12 curriculum. Most students have interests, abilities, and ambitions that extend beyond the core studies.
- *Benchmarks* avoids technical language used for its own sake. The number of technical terms that most adults must understand is relatively small. Accordingly, the 12th-grade benchmarks use only those technical terms that usually appear in the vocabularies of science-literate people. The language in the benchmarks for earlier grades is intended to signal the nature and sophistication of understandings to be sought.
- *Benchmarks* is informed by research. Research on students' understanding and learning bears significantly on the selection and grade placement of the benchmarks. *Benchmarks* Chapter 15 offers a survey of the research that was influential.
- *Benchmarks* is a developing product. It will undergo periodic updates as more research on learning becomes available and as users report their experiences.

Project 2061 school–district teams at first Summer Institute, July 1989

APRIL 1991

President Bush releases America 2000 strategy and six National Education Goals.

JULY 1991

Project 2061 hosts a Summer Conference at the University of Washington, Seattle. Teams share their draft curriculum models and discuss a plan to develop "benchmarks."

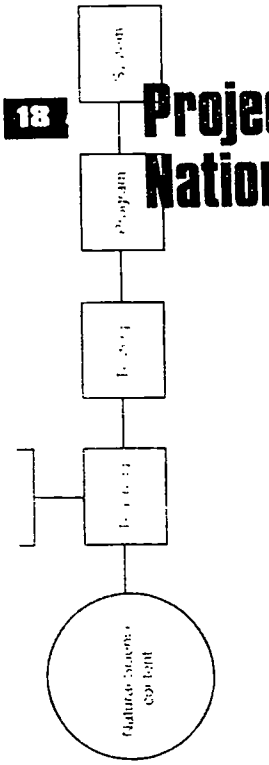
AUGUST 1991

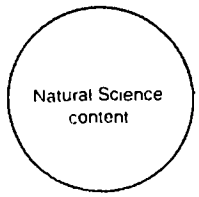
U.S Department of Education provides initial funding to National Academy of Sciences for developing science education standards.

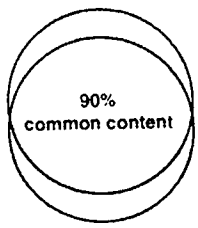
Careful consideration went into the content and sequence of benchmarks to ensure that they reflect a logical progression of ideas, with adequate early-grade benchmarks anticipating the more difficult benchmarks for later grades. *Benchmarks* reflects Project 2061's emphasis on the interconnectedness of ideas within and among science, mathematics, and technology knowledge, providing essays and a cross-reference feature to make these connections explicit.

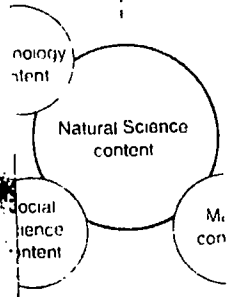
Benchmarks for Science Literacy is also available on disk in DOS, MacIntosh, and Windows formats. *Benchmarks on Disk* further encourages curriculum connections by allowing users to search for benchmarks related by key words. Disk users can also examine up to 30 sample benchmark-strand maps that trace, through sequences of benchmarks, student understanding from rudimentary ideas intelligible to kindergartners toward the more sophisticated goals in *Science for All Americans.*

Benchmarks for Science Literacy and *Benchmarks on Disk* have influenced the reform efforts of curriculum committees, state departments of education, teacher education faculty, and many others. *Benchmarks* has also evoked considerable interest among curriculum developers, many of whom want to tie their products more closely to the learning goals in *Benchmarks.*









18 Project 2061 and National Standards

In September 1989, President George Bush and the nation's governors met in Charlottesville, Virginia, to discuss the crisis in education and establish national performance goals in education. Their education summit resulted in a strategy to start a "populist crusade" to reform education around six national education goals by the year 2000—and, led to federal legislation to support states in implementing the goals.

Two of the six national goals addressed science education reform specifically, recommending that all students "leave grades four, eight, and twelve having demonstrated competency in challenging subject matter including English, mathematics, science, history, and geography..." and calling for U.S. students to be "first in the world in science and mathematics achievement" by the year 2000. To meet these goals "world class standards" would be required.

Congress then established a National Council on Education Standards and Testing, which consulted a wide range of experts and examined the work already done by AAAS's Project 2061, the National Council of Teachers of Mathematics, and state curriculum framework committees. The Council concluded that voluntary national standards, tied to assessments, were indeed feasible and desirable.

> "...*National Science Education Standards* and *Benchmarks for Science Literacy*... represent common ground for the content of science education..."
>
> Rodger W. Bybee, chair of the Content Working Group for the National Science Education Standards Project
> *The Science Teacher*, October 1995

Developing Standards

The National Council of Teachers of Mathematics (NCTM) had been engaged for several years in an attempt to identify what all school students should know and be able to do in mathematics. A month after the release of *Science for All Americans* in 1989, the NCTM released its *Curriculum and Evaluation Standards for School Mathematics*. The recommendations in these two reports came to be widely accepted, helping to focus the reform movement on specific learning goals.

In August 1991, the U.S. Department of Education provided the National Academy of Sciences (NAS) with initial funding to take the lead in developing a set of standards for science education that would be widely agreed upon by all constituencies. In recognition of Project 2061's related work and reputation as a leader in education reform, NAS's National Research Council (NRC) included several Project 2061 staff members and school teachers from the Project's school-district teams on the committees developing and reviewing the *National Science Education Standards (NSES)*. The NRC expects to release a final version of the science education standards by the end of 1995.

In related fields, the National Council for the Social Studies (NCSS) published its *Curriculum Standards for Social Studies*

in 1994, and the International Technology Education Association initiated the Technology for All Americans Project in 1995.

Common Ground

Teachers and other curriculum planners will be reassured to know that all of these documents indicate a strong consensus on the content of the curriculum. The NRC has relied heavily on the work of Project 2061 in crafting its content standards. The relationship between the two organizations is stated in the introduction to the 1994 draft *NSES*:

> "...the many individuals who have developed the content standards sections of the *National Science Education Standards* have drawn extensively on and have made independent use and interpretation of the statements of what all students should know and be able to do that are published in *Science for All Americans* and *Benchmarks for Science Literacy*...."

Like *Benchmarks*, the mathematics, social studies, and science standards documents (1) were developed by experts in science, mathematics, and technology (including teachers); (2) provide an explicit set of K-12 learning goals; (3) recommend goals that are developmentally appropriate for students; and (4) provide guidance in reducing curriculum content so that the most important ideas can be explored in depth.

Comparisons with *Benchmarks*

To help educators make more informed use of the mathematics, social studies, and science education standards together or separately, Project 2061 has analyzed them and prepared a detailed comparison of each with *Benchmarks for Science Literacy*. All three comparisons reveal considerable overlap which should reassure educators that there is general agreement among experts on what concepts and skills are important for all students to learn. The few areas where the documents differ can serve as the basis for discussion by curriculum committees about how local students will best be served.

Because most school districts and state curriculum committees do not have the time or the resources to analyze the documents, Project 2061 includes its three comparisons in its forthcoming reform tool, *Resources for Science Literacy: Professional Development.*

JANUARY 1992

The Congressionally appointed National Council on Education Standards and Testing releases report advocating adoption of national education standards.

JULY 1992

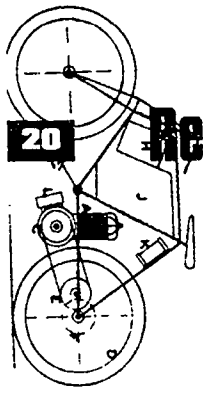
Project 2061 holds Summer Conferences at Cornell University, Ithaca, NY. Teams refine curriculum maps and benchmark statements.

JANUARY 1993

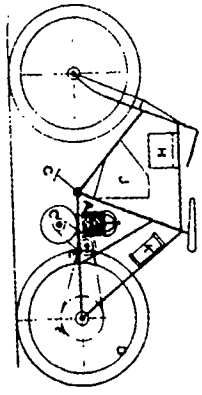
Project 2061 releases draft *Benchmarks* for large-scale review.

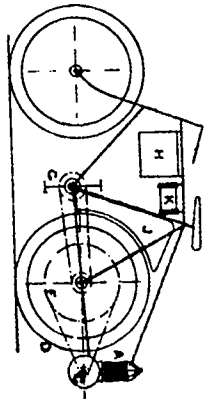
MARCH 1993

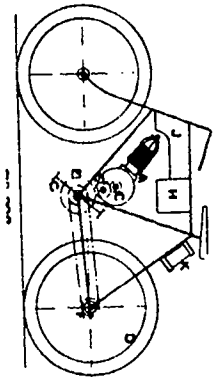
Staff begins to revise *Benchmarks* draft based on comments from 1,300 reviewers.

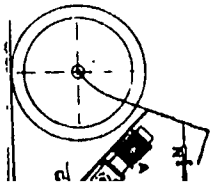


20 Rethinking the Curriculum









With a growing national consensus on the learning goals of science education, Project 2061 has now turned its attention to helping educators implement reforms at many levels. Two new tools, *Resources for Science Literacy* and *Designs for Science Literacy* are under development and will be helpful to educators who want to redesign their curricula around learning goals.

Resources for Science Literacy

Project 2061 receives frequent requests from educators for assistance in identifying curriculum resources that are consistent with *Benchmarks for Science Literacy* and *Science for All Americans*. Their requests have prompted Project 2061 to develop a two-part tool, *Resources for Science Literacy*, to help educators improve their own understanding of science literacy and their ability to locate and analyze curriculum materials suitable for their students. *Resources for Science Literacy: Professional Development* will be released in spring 1996, with *Resources for Science Literacy: Curriculum Materials* following in winter 1996. Both will be available on CD-ROM with companion print volumes.

Professional Development will direct teachers to a variety of information and materials (see box on page 21) that illustrate many aspects of science literacy and its implications for K-12 education and will help them fill in gaps in their own knowledge of science, mathematics, and technology and their interconnections. It will familiarize teachers with science literacy and with the ideas and skills that students of various ages need to develop on their way to science literacy. *Resources for Science Literacy: Professional Development* will be useful to higher education institutions planning preservice and inservice education, school districts designing staff development programs, and individual teachers wishing to improve their understanding of science literacy.

> "Are any of the ideas too difficult for 18 year-olds? NO! They are only beyond the experience of today's 18 year-olds, given the education that they have not had. The understandings advocated are within the reach of all."
>
> from a review of the draft of *Science for All Americans*, Dr. Thomas Romberg, Director, National Center for Research in Mathematical Sciences Education

Curriculum Materials will identify curriculum resources that serve the learning goals in *Benchmarks for Science Literacy* and will help curriculum developers to use *Benchmarks* as they develop new resources or enhance existing ones.

Information like the following will appear on this disk:

- Descriptions of books, films, computerized resources, museum exhibits, and other exceptional materials and activities, recommended for their overall quality and their match to learning goals in *Benchmarks*.
- An explanation of how Project 2061 analyzes curriculum materials for their relevance to learning goals, including a tutorial to help educators who wish to carry out their own analyses.

Resources for Science Literacy: Professional Development will offer a carefully selected collection of references, workshop activities, research, analyses, and course plans that illustrate many aspects of science literacy and its implications for K-12 science education. Hypertext links will allow users to search for resources that relate to specific topics presented in *Science for All Americans*. The CD-ROM will contain:

- *Science for All Americans*. The book's full text will be accessible and will be linked to all of the other components (except the *Workshop Leader's Guide*) on the CD-ROM.

- *Workshop Leader's Guide*. Developed and field-tested by Project 2061 staff, teachers from Project 2061's six School-District Centers, and education consultants, the *Guide* includes a variety of presentations, activities, and supplementary materials that can be used to design Project 2061 workshops or as a tutorial on *Science for All Americans* and *Benchmarks*.

- Comparisons of *Benchmarks* to National Standards. Included here are analyses of how *Benchmarks for Science Literacy* relates to three sets of national content standards—the National Research Council's *National Science Education Standards*, the National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics*, and the National Council for the Social Studies' *Curriculum Standards for Social Studies*.

- College Courses. Descriptions of 15 undergraduate college courses provide guidance and suggestions for designing syllabi to teach college students particular concepts from *Science for All Americans*. These may also be helpful as personal study guides for learning more about specific topics in science, mathematics, and technology.

- Cognitive Research. This introduction to cognitive research literature sheds light on the ability of students of various ages to understand many of the topics in *Science for All Americans* and *Benchmarks for Science Literacy*. In addition, the full text of *Benchmarks'* Chapter 15: The Research Base is included on the CD-ROM.

- Science Trade Books. More than 200 citations identify an array of books written for general readers on all areas of science, technology, and mathematics. Full bibliographic information, reviews, and other descriptive data will be provided. Each book will be linked to specific chapters and sections in *Science for All Americans*.

OCTOBER 1993

Project 2061 releases *Benchmarks for Science Literacy*.

MARCH 1994

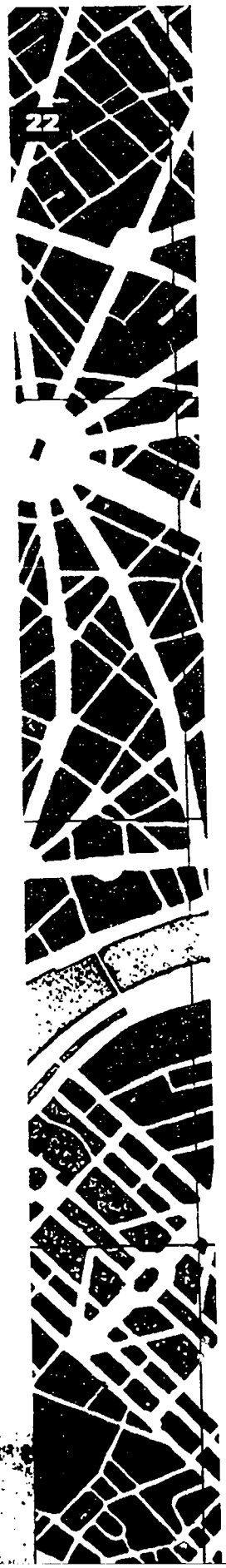
President Clinton signs *Goals 2000: Educate America Act* into law.

JUNE 1994

Project 2061 conducts its first professional development session for Project 2061 workshop leaders in Columbia, MD.

JULY 1994

Project 2061 publishes *Benchmarks for Science Literacy on Disk* for MS-DOS.



- Interactive utilities that will enable educators to update their own databases with additional resources and add commentary to existing items.

Resources for Science Literacy: Curriculum Materials will be useful to anyone, especially teachers, engaged in curriculum planning or design.

Designs for Science Literacy

Educators enthusiastic about *Science for All Americans* and *Benchmarks for Science Literacy* have let us know that they would like some further guidance on how to reshape the entire curriculum. In response, Project 2061 is developing *Designs for Science Literacy*, which will work through many of the issues involved in designing a K-12 curriculum around goals for science literacy. Though meaningful, lasting reform requires a sustained effort, *Designs* will suggest how educators can see some near-term results as it provides direction for long-term, system-wide reform.

Designs will include the following:

- A discussion of goal-directed reform in general, and of the learning goals and principles of learning and teaching that define a Project 2061 curriculum.
- A description of the design approach and its usefulness in curriculum reform.
- Advice on getting started in curriculum design—on ridding the core curriculum of terms and topics that do not serve science literacy, building connections into the curriculum, linking resources and assessment to learning goals, diversifying instruction, attending to relevant research, and focusing professional development on specific learning goals.
- Advice on undertaking radical curriculum reform. This includes discussion of curriculum blocks, curriculum models, and computer-assisted curriculum design.
- A systematic process for configuring K-12 curricula around Project 2061's learning goals while taking into account local and state policies, resources, and preferences.
- References to research that supports the recommendations in *Designs*.

Even though its emphasis will be on the core curriculum in science, mathematics, and technology, *Designs* will link those studies to the arts and humanities, to vocational education, and to other components of the total curriculum. It also will look at ways to enable students to pursue individual talents and interests beyond the core studies. *Designs for Science Literacy* is scheduled for publication in print and electronic form in 1996.

Reforming the System

For science education reform to succeed and persist on a large scale, it must radically transform the entire K-12 curriculum and all related aspects of the education system. In *Blueprints for Reform*, Project 2061 will lay out the full picture of how the various parts of the education system should change to support a curriculum for science literacy. Project 2061 is also effecting change by sharing its ideas with other reform initiatives and offering workshops to help educators get started in making changes in their school districts.

Blueprints for Reform

Project 2061 convened expert groups to prepare a dozen concept papers on aspects of the education system that must change to accommodate the curriculum reforms it has proposed. Ideas from these papers will appear in an integrated report, *Blueprints for Reform*. *Blueprints* will cover the following areas:

- **Teacher Education** will describe the changes needed in preservice and inservice teacher education to produce teachers with the knowledge and skills needed to implement curricula based on Project 2061 goals and principles.
- **Materials and Technology** will identify what new resources are needed, what mechanisms to identify and access them will be effective, and what kinds of policies must be adopted to support the development and use of such resources.
- **Assessment** will specify what immediate and future assessment needs are demanded by Project 2061 curriculum-design principles, from in-class assessment during instruction, to program evaluation by schools, to monitoring education progress at state and national levels.
- **Curriculum Connections** will focus on important linkages among the natural and social sciences, mathematics, and technology, and also between them and the arts and humanities, and will suggest how such linkages can be fostered in the curriculum.
- **School Organization** will consider what alternatives for school organization will best enable Project 2061 curricula to work. This paper will discuss such issues as grade structure, teacher collaboration, control of curriculum materials and assessment, and how time and space in school might be organized.
- **Family and Community** will point out what will be needed for families and communities to understand Project 2061 reform recommendations and what kinds of commitment and effort from them are needed.
- **Business and Industry** will examine such issues as preparing students to enter an increasingly technological workplace and marketplace, the role of science literacy in U.S. competitiveness, appropriate partnerships between business and education, and resources and leadership that local business can bring to science instruction.

> "We must start from scratch. Little will be gained by simply revising....old subject matter, tinkering with the instructional system, modifying assessment techniques, or reorganizing institutions."
>
> Paul DeHart Hurd
> Professor Emeritus, Stanford University
> *Educational Leadership*, October 1991

SEPTEMBER 1994

The National Council for the Social Studies released its *Curriculum Standards for Social Studies.*

OCTOBER 1994

Project 2061's Teacher Education Conference at Michigan State University is attended by representatives of 17 institutions.

SEPTEMBER 1995

Project 2061 releases MacIntosh and Windows versions of *Benchmarks on Disk.*

- **Higher Education** will address such issues as what changes are needed in admission requirements to accommodate changes in high-school course structure and assessment methods, and how undergraduate education should build on *Science for All Americans*–especially for college students who may become teachers.
- **Policy** will examine the entire policy picture, including how policy has inhibited past reform initiatives, challenges posed by the current education system for the implementation of Project 2061 reform, changes that may be needed in laws and regulations that govern schools, and how modifications of current policy might be achieved.
- **Finance** will consider the implications of Project 2061 reform recommendations for the allocation of money and other resources. It will examine the financial base for education and the potential availability of resources needed to implement reform, including possibilities for changing schools without incurring greater costs.
- **Equity** will recommend education policies to ensure that science literacy is attainable by all students. It will also contribute to other *Blueprint* papers and serve as a check for them.
- **Research** will discuss the education research questions that arise in other *Blueprint* papers, *Benchmarks*, and *Designs*, as well as in initial attempts to implement Project 2061 reform. In addition, this paper will consider what mechanisms can permanently link research with practice.

Project 2061 is currently planning a series of conferences to draw educators from around the country into discussion of the recommendations in the 12 background reports; the integrated report will reflect these discussions. By offering analysis of the various aspects of the education system and well-debated recommendations for their reform, *Blueprints* should conrribute greatly to the systemic-reform efforts now underway in many states and school districts.

"Exploring Parts and Wholes" at a Project 2061 Workshop

Project 2061 Collaboration

Because reform of the entire education system in this country will take a concerted effort, Project 2061 regularly collaborates with other national, state, and local initiatives interested in promoting science literacy.

Collaboration with Standards Developers

The agreement between *Benchmarks for Science Literacy* and the *National Science Education Standards* is due in good part to the close working relationship between Project 2061 and the National Research Council (NRC) of the National Academy of Sciences. Because this collaboration resulted in compatible sets of learning goals, Project 2061 and the NRC have worked out an agreement on the mutual use of each other's products.

By taking on the task of comparing the science, social studies, and mathematics of standards with *Benchmarks* and discussing these comparisons with the National Council of Teachers of Mathematics, the National Council for the Social Studies, and the NRC, Project 2061 has laid the groundwork for future collaboration with these organizations.

Collaboration with National Education Organizations

Project 2061 has worked with a number of groups, including the National Science Educational Leaders Association and the Eisenhower Consortia of Regional Labs, to prepare them to offer technical assistance on *Benchmarks* to their participating school districts and states. Project 2061 regularly presents at regional and national meetings of the National Science Teachers Association, the Association for Super-vision and Curriculum Development, the National School Boards Association, Association for the Education of Teachers in Science, and the National Association for Research in Science Teaching, among others.

Other national curriculum reform projects have also drawn on Project 2061's work.

Other national curriculum reform projects have also drawn on Project 2061's work. For example, The National Science Teachers Association incorporated many of *Science for All American's* content goals and principles of teaching and learning into its major reform project, Scope, Sequence, and Coordination (SS&C). Like Project 2061, SS&C called attention to the importance of carefully sequencing concepts over several years at progressively higher levels of abstraction and interrelating topics from various science disciplines.

Collaboration with States and Cities

Since Project 2061 shared pre-publication drafts of *Science for All Americans* with the California Science Framework committee in 1989, dozens of states have drawn on it and on *Benchmarks* in their work. In the past several years, Project staff and school-district team members have offered direct assistance to state curriculum

Project 2061 Workshops

Many educators using *Science for All Americans* or *Benchmarks for Science Literacy* to create or revise their curriculum frameworks, plan local curricula, or even to enhance their classroom teaching have contacted Project 2061 requesting advice on how to use these tools most effectively. In response, Project 2061 staff, consultants, and veteran workshop leaders from each of the school-district teams developed and tested workshop modules on understanding and using *Benchmarks* and *Science for All Americans*.

The three dozen school-district team members and other consultants who helped develop the modules are now leading *Benchmarks* workshops around the country. In the past year, they have helped the Project meet over 150 workshop requests from teacher groups, curriculum committees, and professional organizations at the district and state levels.

These popular workshops typically review why change in education is needed, why Project 2061 believes change is possible, and how Project 2061 tools can help educators make changes. Depending on the needs and interests of a given audience, workshop leaders instruct participants in using *Science for All Americans* and *Benchmarks for Science Literacy* for one or more of a variety of purposes: to select and adapt curriculum materials, to analyze instruction, to analyze student learning, to improve lesson design, to gauge how well a state or district framework addresses science literacy, and so on. Participants have been enthusiastic about the workshops, many asking for follow-up sessions.

In addition to workshops, Project 2061 shares its work in presentations at numerous national and regional education conferences, and plans to offer a series of national conferences on issues raised by *Blueprints for Reform* and *Designs for Science Literacy*.

framework committees, including those in Maryland, Alabama, Maine, Maryland, Michigan, and Texas. In addition, the Project has been providing regular workshops and presentations to the Council of State Science Supervisors.

Project 2061 also has found opportunities to work with several of the Statewide Systemic Initiatives sponsored by the National Science Foundation. In particular, the school-district teams in Philadelphia, San Antonio, and San Diego have been closely involved with the Urban Systemic Initiatives in their respective cities.

Collaboration with Curriculum Developers

The publication of *Benchmarks* evoked considerable interest among curriculum developers, many of whom want to tie their products more closely to the learning goals in *Benchmarks*. Project 2061 has held workshops for developers from the Association for the Integration of Mathematics and Science (AIMS), the Lawrence Hall of Science, the Technical Education Research Center (TERC), and the Biological Science Curriculum Study (BSCS), among others. Informal science programs are important too, and Project

2061 staff has begun to comsuit with several, including the Mid-West Public Garden Collaborative, Inc., which is developing lesson packets for students visiting their museum and gardens, and with the Cranbrook Institute of Science near Detroit, which is redesigning its science museum consistent with *Benchmarks*.

Collaboration with Teacher Education Faculty

Because successful implementation of Project 2061 reforms will depend in great part on the preparation and support teachers receive, Project 2061 recently sponsored several teacher education conferences for university faculty from around the country. The first in the series was held last fall at Michigan State University and involved science, mathematics, technology, and education faculty from 17 universities in discussion of Project 2061's teacher education *Blueprint* paper. This year, Project 2061 sponsored two meetings—in Columbia, Maryland, and Denver, Colorado—in which teacher educators participated in and critiqued a *Benchmarks* workshop on analyzing curriculum resources and designing instruction. Feedback from attendees will be very helpful as Project 2061 develops more presentations for a growing teacher-education audience.

28 Science Literacy for A Changing Future

When Project 2061 was launched, it did not have to impress upon the public the importance of science literacy. A strong case had already been made for science literacy in reports and speeches by prominent educators, observant economists and entrepreneurs, and concerned scientists and engineers. Instead, Project 2061's challenge was to characterize science literacy in a way useful to educators, and then to help them make science literacy goals the foundation of reform.

Much has been accomplished over the past decade, and much remains to be done. Significant, lasting reform will require more resources—both financial and human—more time, and, above all, more patience. But the cost of not making such investments is high. As *Science for All Americans* reminded reformers in 1989, the wisdom with which people use science and technology will, to a large extent, determine the fate of individual human beings, the nation, and the world:

- *Science, energetically pursued, can provide humanity with the knowledge of the biophysical environment and of social behavior that it needs to develop effective solutions to its global and local problems.*
- *By emphasizing and explaining the dependency of living things on each other and on the physical environment, science fosters the kind of intelligent respect for nature that should inform decisions on the uses of technology; without that respect, we are in danger of recklessly destroying our life-support system.*
- *Scientific habits of mind can help people in every walk of life to deal sensibly with problems that often involve evidence, quantitative considerations, logical arguments, and uncertainty; without the ability to think critically and independently, citizens are easy prey to dogmatists, flimflam artists, and purveyors of simple solutions to complex problems.*
- *Technological principles relating to such topics as the nature of systems, the importance of feedback and control, the cost-benefit-risk relationship, and the inevitability of side effects give people a sound basis for assessing the use of new technologies and their implications for the environment and culture; without an understanding of those principles, people are unlikely to move beyond consideration of their own immediate self-interest.*
- *Although many pressing global and local problems have technological origins, technology provides the tools for dealing with such problems, and the instruments for generating, through science, crucial new knowledge; without the continuous development and creative use of new technologies, society will limit its capacity for survival and for working toward a world in which the human species is at peace with itself and its environment.*

(from the Preface to *Science for All Americans*, 1989)

National Council on Science and Technology Education

Throughout its 10 years, Project 2061 has been advised by the National Council on Science and Technology Education, successive advisory boards whose members are drawn from the scientific, educational, and business communities. The original Council guided the scientific panels and Project staff through the publication of the five panel reports and *Science for All Americans*. As the Project entered its next phase and began to work more closely with school-district educators, the Council was reconfigured to include more teachers and school administrators. The Council continues to evolve as the Project takes on new challenges. The Council recently added several members from business and industry and welcomed a new chairman.

Members are listed below with their affiliations at the time of their service on the Council. Current members are indicated by an asterisk.

Donald Langenberg, Chair*
Chancellor
University of Maryland Systems

Bill Aldridge
Executive Director
National Science Teachers Association

Raul Alvarado, Jr.*
Small Business Office Space Station Division
McDonnell-Douglas Corporation

Paula Apsell
Executive Director
NOVA-WGHB

William O. Baker*
Retired, *Chairman of the Board*
AT&T Bell Telephone Laboratories

Catherine Belter*
Chair, PTA Education Commission
The National PTA

Frederick Herbert Bormann
Oastler Professor of Forest Ecology
Yale University

Diane J. Briars*
Director, Division of Mathematics
Connelley Technical School Support Services
Pittsburgh Public Schools

Margaret Burbidge
University Professor and Director of the Center for Astrophysics and Space Sciences
University of California, San Diego

John J. Burns
Vice President for Research
Hoffman-LaRoche, Inc.

Patricia L. Chavez*
Director of Corporate Relations & Advancement
The University of New Mexico

Edward David
President
Exxon Research and Engineering Company

Marvin Druger*
Chairman and Professor
Department of Science Teaching
Syracuse University

Joan Duea*
Professor of Education
University of Northern Iowa

Stuart Feldman*
Dept. Group Manager
Thomas J. Watson Research Center
IBM

Ernestine Friedl
Professor of Anthropology
Duke University

Linda Froschauer*
Teacher
Weston Middle School
Connecticut

Mary Hatwood Futrell
Senior Fellow and Associate Director, Center for the Study of Education
The George Washington University

Patsy D. Garriott*
Education Initiatives Representative
Eastman Chemical Company

Robert Gauger
Chairperson, Technology Department
Oak Park and River Forest High School, Illinois

Robert Glaser
Director of the Learning Research and Development Center
University of Pittsburgh

Shirley A. Hill
Professor of Education and Mathematics
University of Missouri-Kansas City

Gregory A. Jackson*
Director of Academic Computing
Massachusetts Institute of Technology

Cherry H. Jacobus*
Vice President, Marketing
Goodwill Industries

Franklyn G. Jenifer
President
Howard University

Robert T. Jones*
Executive Vice President
National Alliance of Business

David Kennedy*
State Science Supervisor
Office of Superintendent of Public Instruction
Washington

George Kourpias*
President
Intl Association of Machinists and Aerospace Workers

Judith Lanier
Dean, College of Education
Michigan State University

Margaret L. A. MacVicar
Dean of Undergraduate Studies
Massachusetts Institute of Technology

Arturo Madrid
President, Thomas Rivera Center, Claremont College

Kenneth R. Manning*
Professor of the History of Science
Massachusetts Institute of Technology

Ray Marshall
Professor of Economics and Public Affairs
University of Texas at Austin

Walter E. Massey
Vice President for Research
University of Chicago

Jose F. Mendez*
President
Ana G. Mendez University System

Alice Moses
Associate Program Director for Leadership
National Science Foundation

Frederick Mosteller
Professor of Biostatistics
Harvard School of Public Health

Freda Nicholson*
Executive Director
Science Museums of Charlotte, Inc.

James R. Oglesby
Assistant to the Chancellor
University of Missouri-Columbia

Gilbert S. Omenn*
Dean, School of Public Health and Community Medicine
University of Washington

George C. Pimentel
Director, Laboratory of Chemical Biodynamics
University of California, Berkeley

Robert E. Pollack
Dean, Columbia College
Columbia University

Henry O. Pollak
Assistant Vice President
Mathematical Communications and Computer Sciences Research Lab
Bell Communications Research

Lee Etta Powell*
Professor of Educational Administration
Dept. of Educational Leadership
The George Washington University

Vincent E. Reed*
Vice President, Communications
The Washington Post

Thomas Romberg*
Director
National Center for Research in Mathematical Sciences Education
Madison, Wisconsin

Mary Budd Rowe*
Professor of Science Education
Stanford University

David Sanchez*
Vice-Chancellor for Academic Affairs
Texas A&M University System

Ted Sanders
State Superintendent of Education
Illinois

Albert Shanker*
President
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