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ABSTRACT

Project 2061 was initiated in 1985 with the goal of making Americans science literate. This report presents an update on the progress of Project 2061 and supplements the book "Science for All Americans" (SFAA). In the section of this report entitled "Background" is a brief overview of the project, an outline of purposes and attributes, and a summary of the content of SFAA. The second part of this report, "Work in Progress," describes how the six school-based design teams are going about their work, and what the chief products of this research and development phase of the work will be. The third part of this report, "In the Meantime," suggests steps that educators can take right away to foster reform that is in harmony with the philosophy of Project 2061. These include making science teaching consistent with the nature of scientific inquiry, reflect scientific values, and counteract learning anxieties. In addition, science teaching should extend beyond the school and teaching should take its time. (PR)

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UPDATE

PROJECT 2061

EDUCATION FOR A CHANGING FUTURE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

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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 134,000 scientists, engineers, science educators, policymakers, and interested citizens among its individual members, making it the largest general scientific organization in the world. The Association has as its goals to: further the work of scientists; facilitate cooperation among them; foster scientific freedom and respc ibility; 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**.

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PREFACE

It is time to bring you up to date. Not counting three years of prior planning, **Project 2061** started in 1985 and published *Science For All Americans* (SFAA) in 1989. Now here it is 1992 already, and our next publications are still some distance off. This *UPDATE* is intended to serve as an interim briefing.

If you wonder what **Project 2061** is and what it has accomplished, I strongly suggest that you obtain a copy of *SFAA* from Oxford University Press, New York. That report describes our philosophy and approach in some detail. Its recommendations on what all students should know and be able to do in science, mathematics, and technology by the time they have finished school essentially define science literacy. To give you an idea of what to expect, the first part of this *UPDATE*, "Background," presents a brief overview of the Project, an outline of its purposes and attributes, and a summary of the content of *SFAA*.

For those of you who are already familiar with the Project, the second part of *UPDATE*, "Work in Progress," describes how the six school-based design teams are going about their work, and what the chief products of this R&D phase of our work will be. The third part of *UPDATE*, "In the Meantime," suggests steps that educators can take right away to foster reform that is in harmony with the philosophy of **Project 2061**.

There is more that we would like to tell you about our work than what appears in this brief progress report. Our rapidly growing network of connections—with other like-minded national reform efforts, scientific and educational associations, and states—and our developing plans for additional resources to help in the eventual implementation of 2061 reforms, would, I believe, interest you. But, in the interest of brevity, we decided to focus here on the aspects of our work that have the highest priority.

You will find information on these and other aspects of **Project 2061** in our quarterly newsletter, *2061 Today*. If you would like to be on the mailing list to receive it without cost, please let us know by telephone (202/326-6666) or by letter (**Project 2061**, AAAS, 1333 H Street NW, Washington, D.C. 20005).

As I meet with educators and education policymakers around the country, I am heartened to discover how many remain fully committed to significant reform in science, mathematics, and technology education. Even in the best of times, it is hard to effect large changes in a system so massive and diverse, and no one is claiming that these are such times. But **Project 2061** assumed, from the beginning, that achieving science literacy nationwide would be neither easy nor brief—and it was designed accordingly. Project 2061 will continue for as long as its help matters.

F. James Rutherford
Director, Project 2061

BACKGROUND

PROJECT 2061

IS	IS NOT
long term	quick fix
science literacy	technical sophistication
systemic change	patchwork
collegial consensus	official wisdom
scientists and educators	either alone
research based	compilation
conceptual understanding	isolated facts
connections	coverage
teachers creating change	teachers only implementing
cross-grade teamwork	traditional isolation
shared learning	tracking
interdisciplinary	subject specific
all schools	select schools
alternative curriculum models	a new orthodoxy

PURPOSE

In the last decade, science literacy—which embraces literacy in all the sciences, mathematics, and technology—has emerged as a major educational goal in America (and in many other countries, as well). The overarching purpose of **Project 2061** is to contribute to the attainment of that goal nationwide. Certainly, the production of scientists and engineers remains a national need and cannot be neglected, but in the long run that need will not be met unless widespread understanding and interest in science exists within the general population. Moreover, the future of our democracy and economy depends on children receiving a good education in the sciences

The American Association for the Advancement of Science initiated **Project 2061** in 1985, a year when Comet Halley approached the earth's vicinity. That coincidence prompted the Project's name in the realization that children who would live to see the return of the Comet in 2061 would soon be starting their school years. Thus, the purpose of **Project 2061** is expressed in terms of students' needs. Our intent is to help the nation create an educational system that:

- Maximizes the variety of career options and employment opportunities open to all graduates;
- Enables all American's to participate fully and intelligently in making sound personal, social, and political decisions involving science and technology;
- Engages students, intellectually and emotionally, with the great scientific and technological adventure that dominates our culture and our age, so that they can follow the world of science with interest, feel a part of it, and relate its discoveries to their own lives;
- Gives students, in the daily classroom, a sense of the relevance of what they are studying to their own problems, interests, and ways of thinking about the world.

APPROACH

Certain attributes set **Project 2061** apart. As an approach to reform in science education, **Project 2061**:

- Defines "science education" to include all of the natural, physical, social, and behavioral sciences, mathematics, technology, and engineering, and their interrelationships.
- Cares about meaningful learning, not sheer coverage. Thus, in the face of the huge quantity of information that confronts students today in the name of education, the Project is working toward radically reducing the total content of the curriculum so that as students mature they can pursue significant topics in depth and in different contexts
- Seeks to transform the common core of education for all children in all grades, kindergarten through high school.
- Pays attention to education as a system in which the various parts—goals, curriculum, materials, testing, policies, teacher preparation, the organization of instruction, etc.—must be in harmony rather than at odds with each other.
- Is fundamentally and by design a long-term project that expects to take decades to achieve its ultimate goals on a nationwide basis (while having near-term impact as well)
- Is designed to be richly collaborative, eventually involving those who determine policy, allocate resources, influence decisionmakers, and operate schools—but this collaboration is carefully phased to match the overall project strategy In all of this, teachers have a central, creative role

PHASES

Project 2061 has a three-phase pl n of purposeful and sustained action that will contribute to the critically needed reform of education in science. mathematics, and technology

Phase I focused on the substance of science literacy *Science For All Americans* (*SFAA*) and the five reports of the scientific panels constitute the chief products of that phase. The purpose of Phase I was to establish a conceptual base for reform by spelling out the knowledge, skills, and attitudes all students should acquire as a consequence of their total school experience from kindergarten through high school.

Phase II involves teams of educators and scientists transforming *SFAA* into several alternative curriculum models for use by school districts and states During this phase, the Project is also drawing up blueprints for reform related to the preparation of teachers, materials and technologies for teaching, testing, equity, and other school issues. While engaged in creating these new resources. Project 2061 is trying to enlarge significantly the nation's pool of experts in science curriculum reform and is continuing its effort to publicize the need for nationwide science literacy

Phase III will be a widespread collaborative effort, lasting a decade or longer, in which many groups active in educational reform will use the resources of Phases I and II to move the nation toward science literacy Strategies for implementing these reforms in the nation's schools will be developed by those who have a stake in the effectiveness of the education system and who will take into account the history, economics, and politics of change

SCIENCE FOR ALL AMERICANS

CHAPTERS 1-3 focus on the nature of science, mathematics, and technology as human enterprises, how they differ, and how they resemble one another.

CHAPTERS 4-9 present a scientific view of the world:

THE PHYSICAL SETTING—The Universe, The Earth, Forces That Shape the Earth, The Structure of Matter, Transformations of Energy, The Motion of Things, and The Forces of Nature
THE LIVING ENVIRONMENT—Diversity of Life, Heredity, Cells, Interdependence of Life, Flow of Matter and Energy, Evolution of Life
THE HUMAN ORGANISM—Human Identity, Life Cycle, Basic Functions, Learning, Physical Health, Mental Health
HUMAN SOCIETY—Cultural Effects on Behavior, Group Organization and Behavior, Social Change, Social Trade-Offs, Forms of Political & Economic Organization, Social Conflict, Worldwide Social Systems
THE DESIGNED WORLD—The Human Presence, Agriculture, Materials, Manufacturing, Energy Sources, Energy Use, Communications, Information Processing, Health Technology
THE MATHEMATICAL WORLD—Numbers, Symbolic Relationships, Shapes, Uncertainty, Summarizing Data, Sampling, Reasoning

CHAPTERS 10-12 give essentials of the scientific endeavor

HISTORICAL PERSPECTIVES—Displacing the Earth From the Center of the Universe, Uniting the Heavens and Earth, Uniting Matter and Energy, Time and Space, Extending Time, Setting the Earth's Surface in Motion, Understanding Fire, Splitting the Atom, Explaining the Diversity of Life, Discovering Germs, Harnessing Power
COMMON THEMES—Systems, Models (Physical, Conceptual, and Mathematical), Constancy, Stability and Equilibrium, Conservation, Symmetry, Patterns of Change, Trends, Cycles, Chaos, Evolution, Possibilities, Rates, Interactions, Scale
HABITS OF MIND—Values and Attitudes, Knowledge of Inherent Values, Reinforcement of General Societal Values, Social Value of Science-Mathematics-and-Technology, Attitudes Toward Learning, Skills (Computational, Estimation, Manipulation, Observation, Communication, and Critical-Response).

CHAPTERS 13-15 lay out the principles of effective learning and teaching within the context of reform

WORK IN PROGRESS

STRATEGY

Phase II of **Project 2061** takes the learning outcomes specified in *Science For All Americans* as the basis for redesigning how science is taught and learned through a radical reform of schooling. Thus, Phase II—Redesigning the Education System—offers the strategic links between Phase I and Phase III. These links include:

PRODUCT DEVELOPMENT—developing the intellectual tools needed to transform K-12 science education;

OUTREACH—increasing support for change by building alliances;

RESOURCES—fostering the production of instructional materials that will be needed once implementation begins;

LAUNCHING REFORM—implementing 2061 at a limited number of prepared sites and building momentum through other carefully selected sites.

All of these tasks contribute to the 2061 strategy. Among them, the development of reform tools has the highest current priority. Four types of tools are under intense development:

Benchmarks for Science Literacy
Alternative Curriculum Models
Resource Database
Blueprints for Reform

The quality and utility of these tools will set the limit on the impact **Project 2061** can have. The reform tools will, of course, eventually be judged on their own merit: first, by those who will decide whether to use them or not; then, by how helpful they turn out to be in actual use. Meanwhile, the "process" by which these tools are being developed is meant to establish their credibility and to increase the likelihood that they will, in fact, contribute significantly to the science literacy reform movement.

Perhaps the most important questions of process have to do with who is doing the work and under what circumstances. Thus, the discussion of work in progress that follows will start with a description of the Phase II design teams, their work, and the analysis they have been applying to *SFAA*. Then each of the four tools mentioned above—benchmarks, models, database, and blueprints—will be briefly discussed

THE PROCESS

Clearly, Phase II work on curriculum design had to take place where learning and teaching occur—in the schools of America. Six R&D sites were selected to represent, collectively, the demographic characteristics of school districts in this country.

The conditions for selection were demanding. State and local superintendents had to commit time, space, and funds without expectations for a near-term product. Local universities had to be willing to contribute intellectual resources and technical assistance from their faculties. And, most important, a cadre of creative teachers had to be willing to commit several years of time and effort to a radical reform initiative for science literacy.

After considering many outstanding possibilities, the sites selected were:

ELBERT, GREENE, AND OGLETHORPE Counties, Georgia—rural school districts near Athens.

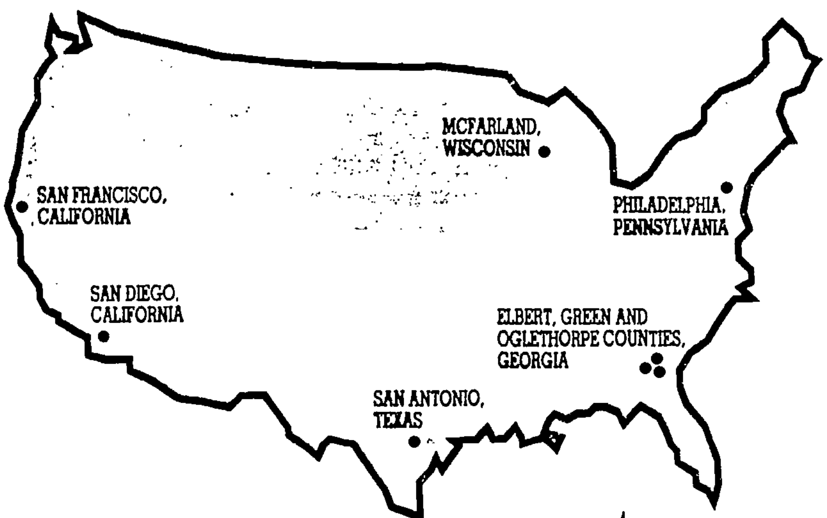
MCFARLAND, Wisconsin—a small-town school district near Madison.

PHILADELPHIA, Pennsylvania—an inner-city school district with a largely African-American population.

SAN ANTONIO, Texas—four school districts with a largely Hispanic population.

SAN DIEGO, California—a multicultural and largely urban/suburban school district.

SAN FRANCISCO, California—a mixed-ethnic and more inner-city school district.



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At each site, a team of 25 educators—cutting across grades and disciplines—was assembled by an open democratic process. Each included:

5 elementary teachers
5 middle school teachers
10 high school teachers
3 principals
2 curriculum specialists

The teams include teachers of different subjects and disciplines: arithmetic, algebra, geometry, and calculus; general science, earth and space science, biology, chemistry, and physics; technology, home economics, and vocational education; social studies and history; language arts; and, of course, elementary teachers who deal with much of that and more.

Among the teams are teachers who work with average students, students with learning problems, students of unusual talent, motivated and unmotivated students, and students with the whole range of home and community circumstances.

Moreover, as the teams went about their work, they were provided with up to 40 days of release time per year, computers at home and at work, a dedicated work space in each schoool district, telecommunications linkages to each other and to the Project center, consultants, and a budget for materials and travel.

During the academic year, each team pursued its work in a different way. They all devoted time, however, to individual and group study, to the analysis of learning patterns among children, to the achievement of particular learning goals, to the collection of ideas from other teachers and administrators, and to the exploration of new ways of configuring the learning experience. And they debated intensely each other's proposals, however unusual, in the light of how they might or might not contribute to achieving the science literacy goals of **Project 2061**. The discussion of backmapping, next, provides a brief glimpse of one aspect of this, the analysis of learning sequences.

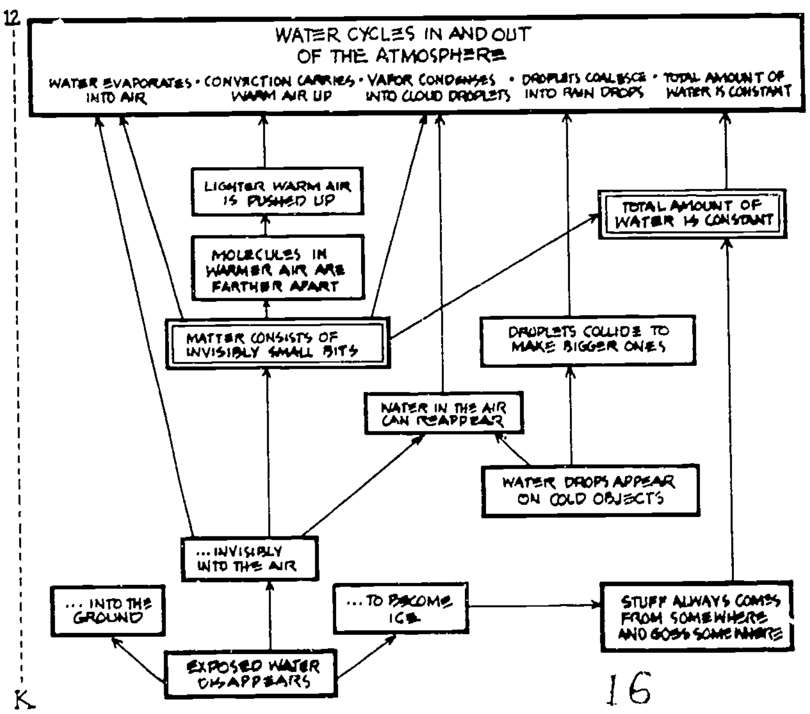
BACKMAPPING

The first step for the teams in developing curriculum models was to determine the progression of understanding by which students might eventually arrive at the learning outcomes in *Science For All Americans* (*SFAA*). The task was to plan how students would achieve the knowledge, skills, and habits of mind that are expected of science literate graduates as a consequence of elementary and secondary schooling. In a sense, such planning involved thinking backwards.

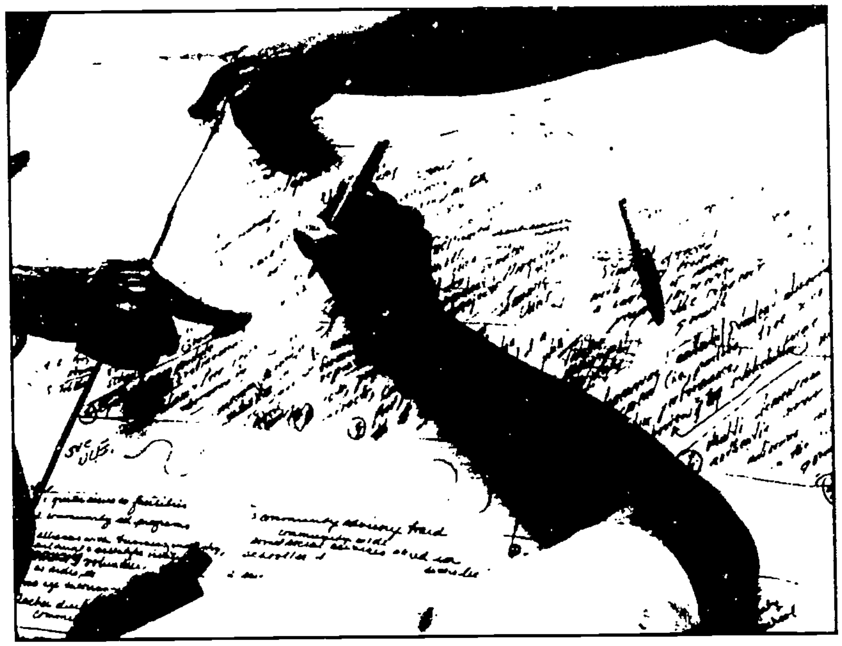
What components of each outcome should somewhat younger students already have in order to understand new material? Each major concept in *SFAA* was mapped backwards to specify the preceeding concepts needed to make sense of the new. Then each concept within these maps was placed at a rough grade level for when students would best be able to learn it. An example is the water cycle, as quoted from *SFAA*.

> The cycling of water in and out of the atmosphere plays an important part in determining climatic patterns—evaporating from the surface, rising and cooling, condensing into clouds and then into snow or rain, and falling again to the surface, where it collects in rivers, lakes, and porous layers of rock. There are also large areas on the earth's surface covered by thick ice (such as Antarctica), which interacts with the atmosphere and oceans in affecting worldwide variations in climate.

An example is this backmap of students' understanding of the water cycle.



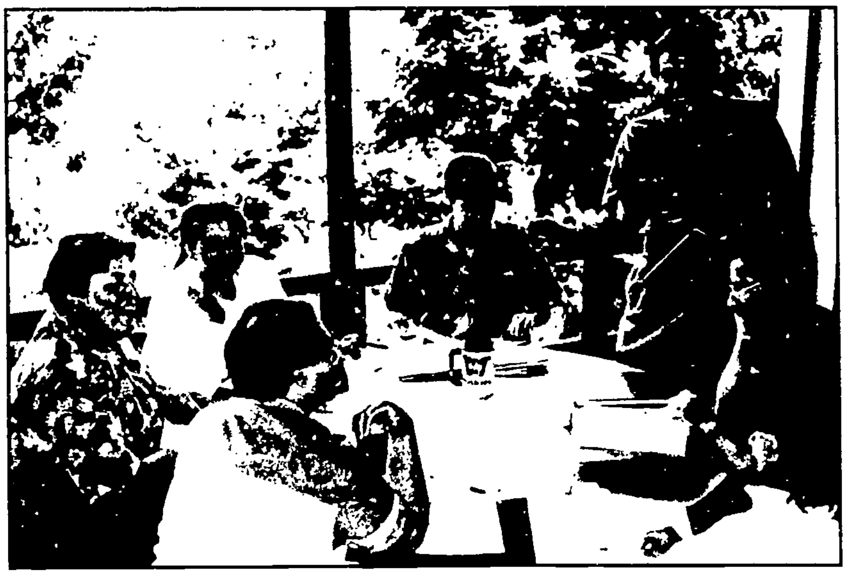
As a critical mass of these backmaps were produced, ideas emerged for activities and learning experiences that could serve multiple understandings at each grade level. For example, a particular concept may be recognized as a prerequisite for two or three other learning outcomes. Thus, maps gradually become interlaced to produce broad patterns of conceptual growth. These interlaced maps then provided the teams with a basis for thinking through the context and organization of the entire curriculum.



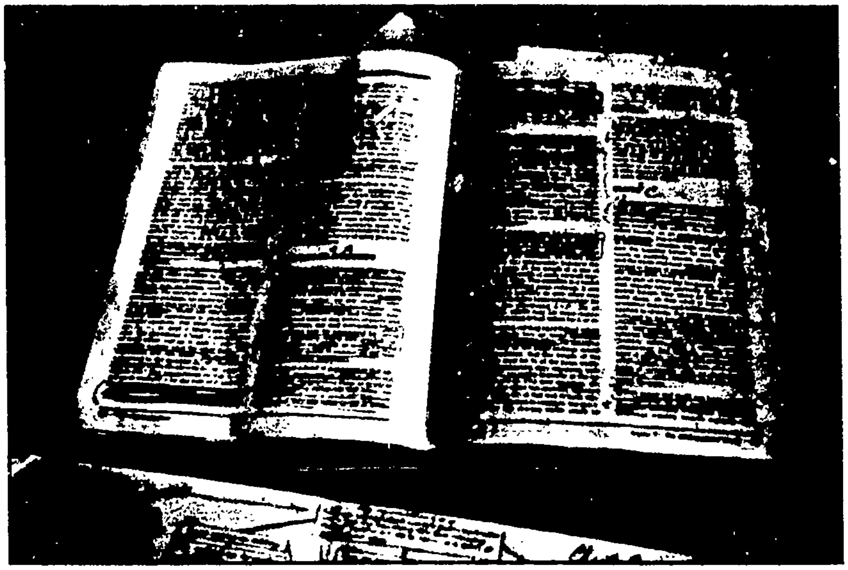
SUMMER WORK SESSIONS

In contrast to the academic year, most of the work by the teams during the summer took place with the teams together. These summer work sessions provided the teams with an opportunity to query each other and to share ideas. Summers also made possible an extraordinary assembly of expert consultants in one place for the benefit of all 150 team members. These consultants came from universities, national laboratories, schools, government, business, and industry. They also came from a wide array of disciplines and fields in the natural and social sciences, mathematics and statistics, engineering, medicine, agriculture, public health, ethics, and education.

The purposes of the summer schedule—two weeks at the home site and four weeks at a university—varied from year to year. In general, these summers were intended to continue and extend the work carried out during the school year: improving everyone's understanding of science, mathematics, and technology, and the connections among them; becoming more sophisticated in curriculum design; and developing teamwork and communication skills. The emphasis also shifted from summer to summer. Thus:



In **SUMMER 1989**, the teams met at the University of Colorado in Boulder. Special attention was placed on developing a work plan and a communications system that would link members of a eam to each other and the teams to the Project headquarters at AAAS. This first summer was also a time to become familiar with what is going on in science, engineering, mathematics, and medicine and with how leaders in those fields think and go about their work.



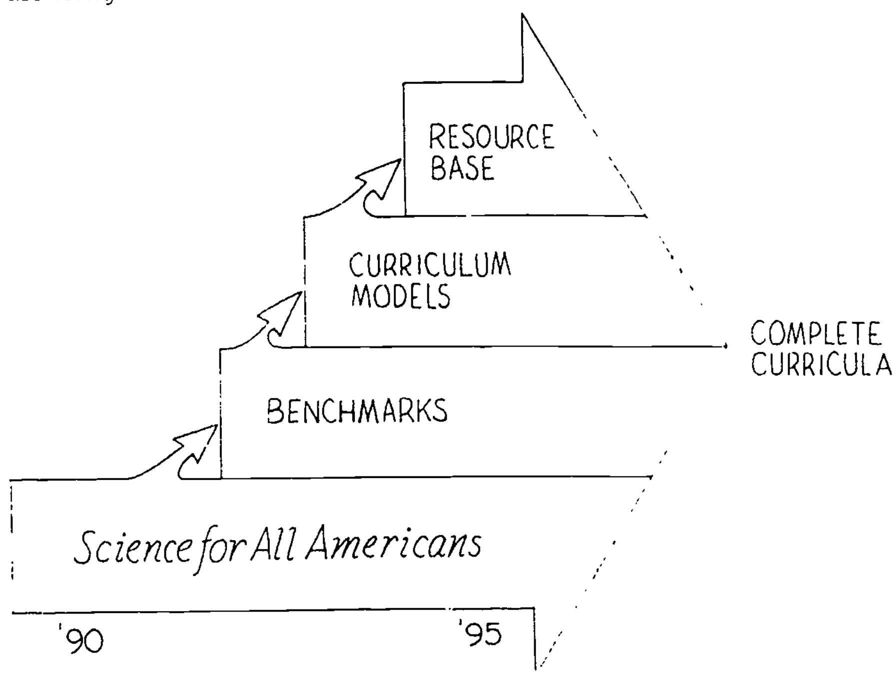
In **SUMMER 1990** at the University of Wisconsin in Madison, the emphasis was on backmapping and on begininng to think about curriculum issues in depth. This summer was a time for exploring the interesting connections within and among the sciences, mathematics, and technology, and between them and the arts and humanities.

In **SUMMER 1991** at the University of Washington in Seattle, the work was divided up. Each team sent an editorial group to present its draft curriculum model and to review those of the other teams. Out of this came the decision to draw on the best ideas of all six drafts to produce four distinct models for further development. Other team members concentrated on other tasks, including planning for outreach and communications, designing the computerized resource database, and beginning to plan for Phase III.

BENCHMARKS AND NATIONAL STANDARDS

The **Project 2061** progression runs like this:

> First establish science literacy learning outcomes for all children by the time they finish school. *Science For All Americans* has done that and has widespread support from scientists and educators. *SFAA* is being used by some states to formulate curriculum guidelines and by some schools to modify what they teach.
>
> The learning outcomes in SFAA then serve as a base for setting benchmarks, which are expressions of learning outcomes in greater detail and at several grade levels—2, 5, 8, and 12, in the case of **Project 2061**. These benchmarks will provide schools with another curriculum design tool to use along with *SFAA*



> The benchmarks, in turn, are being used by the Project as part of the model-building effort. The resulting curriculum models will provide the most powerful tool yet for science education reform
>
> The impact of the curriculum models will be enhanced when the related resource database comes on line. Among the resources in the database will be assessment materials and techniques keyed to the benchmarks.

Thus, benchmarks will have a major role to play in the **Project 2061** reform strategy. But how do they relate to national standards? In the broadest sense, a standard is something used as a base for comparison, either to determine accuracy, estimate quantity, or judge quality. Education standards tend to draw on the last two meanings. In practice, standards may take the form of requirements established by authorities, indicators of relative levels of achievement, or achievement norms approved by professions. **Project 2061**'s Benchmarks are standards of the last of these.

At the same time **Project 2061** has been creating standards, which for several reasons it characterizes as "benchmarks," the President, the Congress, and governors have all called for establishing national education standards. The timing is fortunate. **Project 2061**'s work in progress then has an opportunity to extend its influence beyond what it already has on state guidelines and on the National Assessment of Educational Progress in setting the grade 4, 8, and 12 objectives for the 1994 science assessment.

The National Research Council of the National Academy of Sciences has been asked by the U.S. Secretary of Education to orchestrate the creation of national standards in science education. The AAAS, the National Science Teachers Association, and many other groups will contribute to this collaborative effort. There is already agreement that both *Science For All Americans* and the benchmarks currently being drafted by **Project 2061** will be taken into consideration.

CURRICULUM MODELS

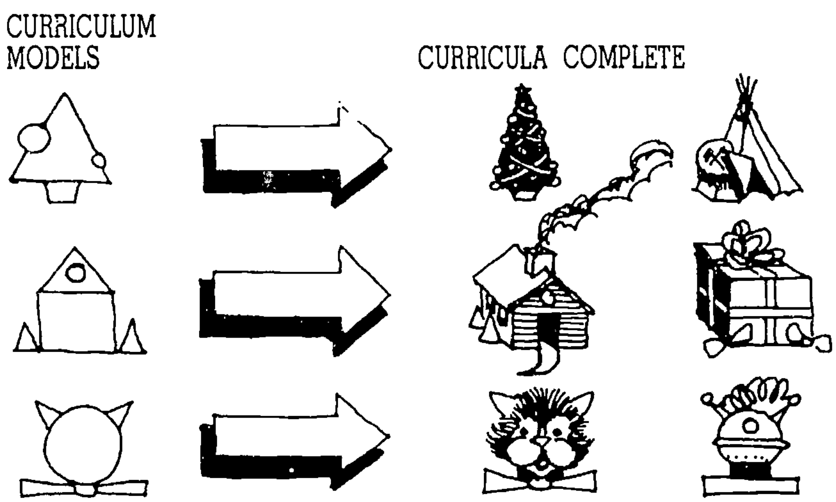
Project 2061 is engaged in producing curriculum models. Since no tradition in education exists for the creation and use of such forms, questions are appropriate about just what they are, what purposes they are intended to serve, how they are different from actual curricula, why the Project would produce curriculum models instead of curricula, who is producing the models, how they are being produced, how many there will be, and what the differences are among them.

WHAT ARE CURRICULUM MODELS, AND WHAT PURPOSES ARE THEY INTENDED TO SERVE?

A model of something is not the thing itself but a simplified version of it. Whether models are physical, mathematical, or conceptual (or some combination of these), their value lies in suggesting how things work or might work. A curriculum model, in the **Project 2061** scheme of things, is a description of a possible curriculum in enough detail to enable educators to create an actual curriculum having the properties of the model. The model should also influence the development of new learning materials and new teacher education programs.

HOW ARE CURRICULUM MODELS DIFFERENT FROM ACTUAL CURRICULA?

First, a curriculum model needs to specify the content domain covered, the students served, and the grades spanned. For **Project 2061**, this means science literacy for all students across all grades—in contrast, say, to high school physics for college-bound seniors. Then a curriculum model should indicate the learning goals being served, provide a rationale for a curriculum design, and describe the kinds of learning experiences that students will have and roughly when. Moreover, the model should stipulate the conditions necessary for proper functioning. In short—Domain, Goals, Rationale, Design, and Conditions; but not course outlines, lessons plans, materials, or a precise timetable.



Curriculum models: A sketch from the 1991 summer work session.

In contrast to a model, actual curriculum contains the level of detail that is needed to schedule students and to carry out day-to-day instruction. Curriculum indicates what texts and other materials will be used, what the sequence of topics will be, how students will be evaluated, and the like. Above all, curriculum specifies the contexts in which various topics will be encountered—a reflection of the location of the school and the particular interests of the teachers. The difference between curriculum models and complete curricula is suggested by the drawing.

WHY DOESN'T PROJECT 2061 PRODUCE ACTUAL CURRICULA?

Project 2061 is based on the premise that, in the final analysis, only those who work with children in a particular place at a particular time can make the critical judgments about specifics of their curriculum. Moreover, the Project does not have the capability for developing the materials of instruction, certainly not all of those needed to serve alternative K-12 curricula in science, mathematics, and technology. The contribution of Project 2061 is to provide other educators with the tools they need to do the job.

WHO IS DEVELOPING THE 2061 MODELS?

The six school-based teams are all contributing to the design of the models. They are basing their work on the findings of cognitive and social research, on the accumulated craft knowledge of teachers, and on their own experience. On the one hand, their work is reviewed by curriculum specialists and university scholars; on the other hand, teams have been encouraged to be as inventive as they can.

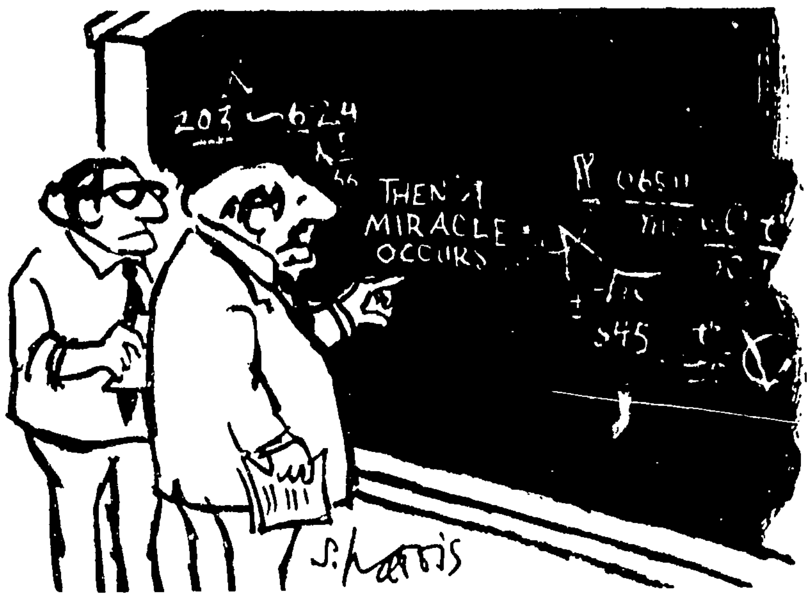
To that end, the design teams were asked to disregard the constraints of the current education system (including their own local school system) in order to be free to develop truly creative and forward-looking models. Necessarily then, the teams had to specify whatever conditions of time, space, materials, policy, teacher preparation, etc., that curricula based on their models would require to function effectively.

WHAT WILL THE DIFFERENCES BE AMONG THE PROJECT 2061 MODELS?

At this time, the models are still under development, so their final shape is not altogether clear. Looking at the range of organizational, pedagogical, and conceptual attributes that might distinguish one model from another, the teams have decided that "conceptual" distinctions best characterize the models. All models will be designed to meet the 2061 benchmarks and *SFAA* learning outcomes. All will call for the use of diverse teaching approaches—inquiry and design projects, Socratic seminars, case studies, independent study, team learning, and teaching by students—and the use of various print, electronic, and multi-media materials. All will have some conceptual elements in common, emphasizing one conceptual approach over the others.

These conceptual distinctions, as now being developed by the Project, are:

> A model emphasizing **HOW THE WORLD WORKS** centers on explaining natural phenomena, objects, and processes of



"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

interest to young people. As the students mature, these explanations are based more and more on scientific and engineering principles and quantitative thinking. A premium is placed on students learning how to learn and on communicating their understandings to other students.

An **INQUIRY** model would cover much of the same territory, but place more emphasis on science as a way of knowing. This approach would feature historical case studies, the study of actual research papers, and the conduct of real research in the natural and social sciences. This model would emphasize science as a social and cultural endeavor as much as one of individual creativity.

A **DESIGN** model would pay more attention to engineering thinking, the solution of real-world problems for which there is no ideal solution, and the understanding of the technologies that shape our lives.

A model organized around **HUMAN CONCERNS** would emphasize interdisciplinary studies that could involve the arts and humanities as well as science and technology. The intent would be to help students view the same world issues—environment, resources, health, etc.—through various conceptual lenses.

The details of these alternative curriculum models are yet to be fashioned, but it is important to note that each distinct model will be expected to result in all of the learning outcomes in *Science For All Americans* and in the **Benchmarks for Science Literacy**

RESOURCE DATABASE

School districts wanting to elaborate **Project 2061** models into complete curricula for successful implementation will require access to information on all aspects of 2061 reform. Such information might include resources about curriculum design, results of research on children's development, feedback from implementation efforts, as well as more general information on science education reform.

Project 2061 is developing a computerized resource database that will list the most appropriate information available for teaching science, mathematics, and technology. The automated capability of a database will be especially useful to all states and school districts actively engaged in implementing 2061 models. The listings will include print, film, video, computer disk, and multimedia, and will be updated periodically and evaluated for scientific accuracy. The database will require a guide for its use, which will be published and revised as feedback from trial use becomes available. The information will include:

- The relation between each concept in *Science For All Americans*, in both narrative and graphic display, and any component of a 2061 model.
- Sources of background material on the philosophy, structure, and operation of each of the 2061 models.
- Descriptions and sources of published teaching and learning materials and activities keyed to the models.
- Descriptions of tactics and strategies that have worked.
- State and federal programs that provide resources for teacher training and other needs related to reform.
- School and university consultants who understand the 2061 approach.
- Sources of help from the private sector.

BLUEPRINTS FOR REFORM

Project 2061 is taking a systems approach to reform. The alternative curriculum models produced by the design teams in Phase II will not succeed in achieving science literacy for ALL students unless ALL key aspects of the system are reformed in support. To assist in these reform initiatives, Phase II will produce **BLUEPRINTS FOR REFORM** on eleven key aspects of the education system. Each blueprint will indicate current conditions and theories, the requirements of the curriculum models, the likely obstacles to implementation, and practical recommendations on how to achieve reform.

Development of the blueprints and curriculum models will proceed somewhat parallel because of their mutual implications. Thus, experts engaged to produce the blueprints will work as consultants with the design teams. Publication is expected in late 1993. As work in progress, each blueprint is better described at this stage by some of the questions to be addressed.

TEACHER EDUCATION—Can teachers deliver a kind of education that they have not experienced themselves? What kind of teacher education should universities provide? What background knowledge and skills do teachers need to work successfully with the 2061 curriculum models? How can teachers reshape their role to foster reform?

ASSESSMENT—What changes in methods and policy are needed for the implementation of 2061's curriculum models? Does national assessment serve instruction, accountability, or policy? What are the merits of performance tests? Which audiences require assessment information? Should the form vary for the audience? Can a baseline for science literacy be developed against which to measure the progress of 2061 reform?

MATERIALS & TECHNOLOGY—Can the instructional material requirements of 2061 reform be foreseen? Which 2061 innovations seem best suited to a technical solution? Can the current school market meet these needs? Will textbooks yield to reference books and story books? Can computer software rise to the challenge? Are useful developments currently under way?

CURRICULUM CONNECTIONS—How will the current organization of subject matter adapt to the 2061 common-core curriculum? How can connections be made without diminishing the integrity of other disciplines? Can 2061's integrated approach to curriculum accommodate the arts and humanities as well? Are modifications needed for science majors and non-science majors?

SCHOOL ORGANIZATION—How does the organization of schools constrain or enable reform? Is the current school culture open to the 2061 approach to teaching and learning? Will the interdisciplinary connections of the 2061 curriculum models affect how school time is organized? What range of alternatives would be acceptable for the different curriculum models?

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PARENTS AND THE COMMUNITY—Has the role of parents and the community evolved with school reform? How is parental and community participation built into 2061's alternative curriculum models? What can parents who are not science literate do to nurture science literacy? What can be learned better in the community outside the school?

HIGHER EDUCATION—How does post-secondary science education interface with the high school curriculum? What changes in undergraduate programs are needed in response to *Science For All Americans*? Are new college courses needed? Should any be phased out? Will courses for non-science majors differ from those for science majors or for teachers? What institutional incentives are needed? Will admission and graduation requirements change?

BUSINESS AND INDUSTRY—Are students prepared for an increasingly technological workplace and marketplace? How does science literacy affect U.S. competitiveness in world trade? Can industry be appropriate partners with educators? Do technology-based industries have a special role? What resources and leadership can local businesses bring to science instruction? What is the balance between public education and private interests?

EDUCATIONAL RESEARCH—What kind of research knowledge is needed for reform? Should the current directions and priorities in research be changed? How can access to good research be expedited for practitioners? What forms should research take to be most useful?

EQUITY—What steps can be taken to ensure that 2061's curriculum models achieve science literacy for ALL students? How can 2061-based curricula address the differences between ethnic groups, communal groups, and ability groups? Do priorities exist within equity considerations?

EDUCATIONAL POLICY—How has policy inhibited past reform initiatives? What major challenges does the current education system pose for the implementation of 2061 curriculum models? What possibilities are currently constrained? What changes will be needed in the laws, regulations, and official standards that govern the operation of schools? How could modifications of current policy be achieved? What effects have recent state initiatives in science and mathematics curriculum reform had?

IN THE MEANTIME

STEPS TOWARD REFORM

One drawback of a systemic, long-term approach to reform is that long intervals separate the appearance of products. More frustrating still, action at the school and classroom level may be deferred as goals are carefully articulated, possible innovations thoroughly explored, benchmarks and guidelines created, resources marshalled, and strategies formulated.

Steps now toward reform can, nevertheless, be taken outside this slower but deliberate approach of **Project 2061**. The more schools and teachers do now in the spirit of Project 2061's vision of reform for science literacy, the more able they will be to use the tools and resources that the Project develops. For example:

Schools might set up cross-grade, cross-discipline teams to begin thinking through the implications of *Science For All Americans* for their policies, practices, and curriculum. Recommendations that they formulate could be the basis for engaging educators and citizens in a long-term, district-wide plan of action.

At the department level within individual schools, teachers could begin the process of systematically eliminating marginal content in order to have time to put more emphasis on truly significant knowledge and skills. In doing this, they will want to seek the collaboration of colleagues in nearby colleges and universities and do so in a way that will lead to an ongoing and mutually helpful relationship.

Teachers in a school can begin to look for and try out interesting ways to make connections across disciplines. Anything that can reduce the barriers among the sciences and between science, mathematics, and technology and the arts and humanities will contribute to science literacy.

Science and education faculties, in collaboration with elementary and secondary teachers from nearby schools, can develop plans for helping current teachers acquire knowledge and skills in *SFAA* and initiate reforms in their own institutions to ensure that future teachers are literate in science, regardless of the grades or subjects that they may teach.

More generally, teachers can help each other incorporate into their teaching the principles of effective learning and teaching that underlie all of the curriculum models being developed by **Project 2061**. The first step might be to hold a series of seminars to examine in detail the recommendations presented in *SFAA* (see the accompanying box), which could lead to some classroom changes, such as:

Learning how to find out what understandings individual students have on various topics;

Providing students with better feedback on their understandings;

Increasing the use of team approaches;

Shifting classwork toward inquiry and away from learning predetermined answers;

Making sure that girls and minorities are fully engaged in all science and technology activities;

Expecting and rewarding clear and accurate expressions, both written and oral, and helping those in need to improve; and

Decreasing dependence on textbooks and worksheets.

The task ahead of us is monumental. The needed reform of science, mathematics, and technology education will take the best and long-term efforts of all of us. To have our collective contributions add up to progress toward reform, however, we must pull in more or less the same direction. For now, *Science For All Americans* provides a guiding light. Before long, *SFAA* will be joined by related benchmarks, models, blueprints, database, and other reform tools to expedite your work.

PRINCIPLES OF EFFECTIVE LEARNING AND TEACHING

(FROM CHAPTER 13, *SCIENCE FOR ALL AMERICANS*)

PRINCIPLES OF LEARNING

Learning is Not Necessarily an Outcome of Teaching
What Students Learn is Influenced by Their Existing Ideas
Progression in Learning is Usually from the Concrete
to the Abstract
People Learn to Do Well Only What They Practice Doing
Effective Learning by Students Requires Feedback
Expectations Affect Performance

PRINCIPLES OF TEACHING

TEACHING SHOULD BE CONSISTENT WITH THE NATURE OF SCIENTIFIC INQUIRY

Start With Questions About Nature
Engage Students Actively
Concentrate on the Collection and Use of Evidence
Provide Historical Perspectives
Insist on Clear Expression
Use a Team Approach
Do Not Separate Knowing From Finding Out
Deemphasize the Memorization of Technical Vocabulary

SCIENCE TEACHING SHOULD REFLECT SCIENTIFIC VALUES

Welcome Curiosity
Reward Creativity
Encourage A Spirit of Healthy Questioning
Avoid Dogmatism
Promote Aesthetic Responses

SCIENCE TEACHING SHOULD AIM TO COUNTERACT LEARNING ANXIETIES

Build on Success
Provide Abundant Experience in Using Tools
Support the Roles of Girls and Minorities in Science
Emphasize Group Learning

SCIENCE TEACHING SHOULD EXTEND BEYOND THE SCHOOL

TEACHING SHOULD TAKE ITS TIME

APPENDIX

NATIONAL COUNCIL ON SCIENCE AND TECHNOLOGY EDUCATION

The AAAS appointed a distinguished group of scientists and educators to advise, guide, and support the reform efforts of **Project 2061**. This advisory board during Phase II is chaired by DR. FRANKLYN JENIFER, President of Howard University, Washington, D.C. The other Council members are:

BILL ALDRIDGE
Executive Director, National Science Teachers Association

RAUL ALVARADO, Jr.
Senior Engineering Scientist, McDonnell-Douglas Corporation

FRANCISCO J AYALA
Professor of Biological Sciences, University of California at Irving

WILLIAM O. BAKER
Retired, Chairman of the Board,
AT&T Bell Telephone Laboratories

DIANE J. BRIARS
Director, Division of Mathematics, Pittsburgh Public Schools, Pennsylvania

PATRICIA L. CHAVEZ
Statewide Executive Director, New Mexico MESA, Inc.

JOAN DUEA
Professor of Education, University of Northern Iowa

STUART FELDMAN
Division Manager, Computer Systems Research, Bellcore

ERNESTINE FRIEDL
Professor Emeritus, Department of Cultural Anthropology, Duke University, North Carolina

LINDA FROSCHAUER
Sixth Grade Teacher, Weston Middle School, Connecticut

MARY HATWOOD FUTRELL
Senior Fellow and Associate Director, Center for the Study of Education, George Washington University (former President, National Education Association), Washington, D C.

ROBERT GAUGER
Chair, Technology Department,
Oak Park & River Forest High School, Illinois

SHIRLEY A. HILL
Professor of Education and Mathematics,
University of Missouri-Kansas City

GREG JACKSON
Director, Educational Studies and Special Projects,
Massachusetts Institute of Technology

CHERRY H. JACOBUS
Trustee, State Board of Education, Michigan

DAVID KENNEDY
State Science Supervisor,
Office of Superintendent of Public Instruction, Washington

GEORGE KOURPIAS
President, International Association of
Machinists & Aerospace Workers

KENNETH MANNING
Professor of the History of Science,
Massachusetts Institute of Technology

JOSE F. MENDEZ
President, Ana G. Mendez Educational Foundation

FREDA NICHOLSON
Executive Director, Science Museums of Charlotte, Inc.,
North Carolina

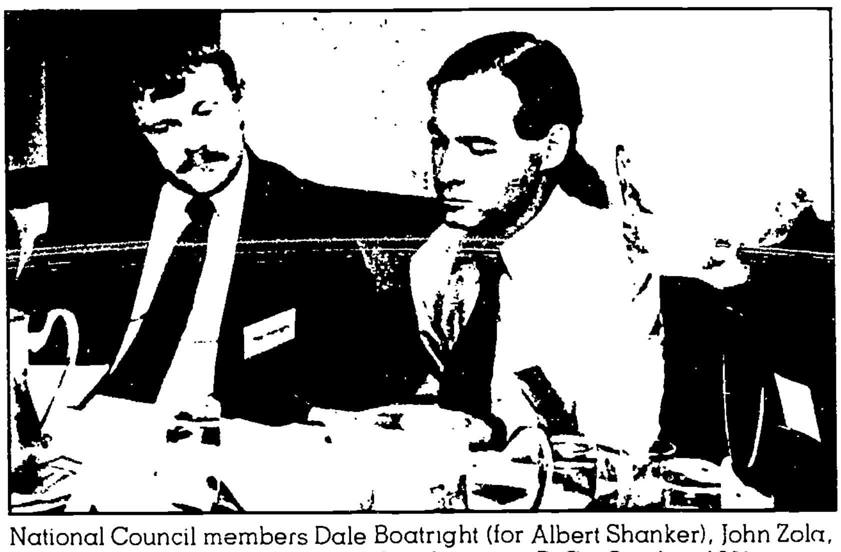
JAMES R. OGLESBY
Assistant to the Chancellor, University of Missouri-Columbia

GILBERT S. OMENN
Dean, School of Public Health and Community Medicine,
University of Washington

LEE ETTA POWELL
Professor of Education, George Washington University,
Washington, D.C.
(former Superintendent of Cincinnati Public Schools)

THOMAS ROMBERG
Director, Education Research Center,
University of Wisconsin, Madison

MARY BUDD ROWE
Professor of Science Education, Stanford University, California



National Council members Dale Boatright (for Albert Shanker), John Zola, and Shirley Hill at a meeting in Washington, D.C., October 1991.

F. JAMES RUTHERFORD
Chief Education Officer,
American Association for the Advancement of Science

ALBERT SHANKER
President, American Federation of Teachers

GLORIA TAKAHASHI
Teacher, Science Department, La Habra High School, California

WALTER WAETJEN
Chair, Technology Education Advisory Council,
International Technology Education Association

WILLIAM WINTER
Attorney-at-Law, Watkins Ludlam & Stennis
(former Governor of the State of Mississippi)

JOHN ZOLA
Teacher, Social Sciences, Fairview High School, Colorado

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