THE BIRTH OF *SCIENCE FOR ALL AMERICANS*

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In 1985, Project 2061 was officially created by a vote of the Board of Directors of the American Association for the Advancement of Science (AAAS), quickly followed by funding from the Carnegie Corporation of New York and the Andrew W. Mellon Foundation. At the time, a distinguished member of the AAAS Board told me that "Project 2061" was the worst name for a project that he had ever encountered. The problem, he said, was that nobody would know what it meant. I responded that that was just the point—people would have to ask, giving us the chance to point out the long-term nature of the project using the nice coincidence of Comet Halley's 1985 visit and its next one in the year 2061, approximately a human life span.

The project's first and perhaps most significant product, *Science for All Americans*, was published in 1989. So now in the year of its twentieth birthday, let me share with you a brief rendition of the *Science for All Americans* story—how it got started, how it was produced, what it turned out to be.

THE START

It's funny how things come about. Perhaps *Science for All Americans* can thank its existence on Ronald Reagan, or maybe on my long history of failed reform undertakings, or maybe on a book. Or on the blues—mine and those of the AAAS. Begin with mine. On Inauguration Day, 1981, my wife and I were in Oaxaca, Mexico, trying to lift my spirits as I contemplated turning to some occupation other than science education—or to any education livelihood, for that matter.

My blue mood was earned. In 1976, I was appointed by President Carter to serve as assistant director of the National Science Foundation (NSF) responsible for all education and public understanding of science programs. With the full support of the NSF director, Richard Atkinson, and the deputy director, the late George Pimentel, I had made headway in increasing the education directorate's budget, strengthening its research focus (including, fortunately, enticing the late Mary Budd Rowe to leave her own research in order to join me at NSF and head up our research division), building coherence within and among the various grant programs in the directorate, and gaining staff support for taking greater risks (while seeking greater reform payoffs) in making award decisions. So far, so good.

When the U.S. Department of Education (ED) was established, I was appointed by the president to be the assistant secretary of education with responsibility for organizing and launching the Office of Educational Research and Improvement (OERI) and for establishing close collaboration with NSF in behalf of science education reform. The chief purpose of OERI was to improve the nation's educational research and statistics capabilities and to link them closely to the improvement of educational practices. In a short time, my colleagues and I were able to develop near and long-term plans for achieving those goals. The future of sustained science education reform was looking up.

And then came the election. The immediate cause of my funk was less the inauguration of Ronald Reagan itself than the pledge he had made to wipe out the NSF education directorate and to eliminate ED. My reaction in 1981 to this promised abandonment of my government work—added to the disappointing effects of my high school and university reform efforts, along with those of so many others led me to wonder whether significant and lasting reform was even possible. Were my colleagues and I caught up in a dream world of our own making? Were the reform efforts of the 1950s and 60s and ‘70s naïve, misguided, doomed from the beginning? Was it the reformers who were at fault, or the system? Or both? Or neither?

I had with me in Oaxaca *General Education in a Free Society*; I had come across it one day in 1947 while reading books that I could not afford to buy in a San Francisco book store. “The Red Book,” as it came to be known, was a report of a committee appointed by James Bryant Conant, the president of Harvard University. It included 175 pages on general education in secondary schools, of which only 17 were devoted to science in secondary general education. But those few pages led me for the first time to consider science education, rather than science, as a profession. So after consulting some scientists and educators, it was off to Stanford University and in two years an M.A. in science education—and thence to high school science teaching. Then in Mexico, more than 30 years later, I reread the book, though I found it badly dated, it rekindled my determination to continue in science education in one way or another.

At the same time, there was reason enough for the AAAS to be in a mood as blue as my own. In the 1950s and ‘60s, the AAAS had been very active in science education. Among other major accomplishments, it produced *Science—A Process Approach*, one of the highly regarded curriculum innovations of the Sputnik reform era. But with the national decline of commitment to science education reform beginning in the 1970s, the AAAS and most of the other organizations participating in the reform movement scaled back their involvement drastically.

By the late 1970s, it had become clear to the AAAS that as the leading general scientific society in the world it had a responsibility to again move aggressively to foster nationwide reform of science education particularly at the K-12 level. But this intention was clearly being handicapped, if not paralyzed, by the new administration’s policy with regard to education, since any major AAAS science education reform undertakings would need funding from NSF certainly and ED probably.

With a science education staff of only three and dim prospects for federal support, AAAS had little to cheer about. Fortunately, the late William Carey, executive officer of the AAAS at the time, was not to be deterred by the discouraging outlook. He invited me to join him in developing plans and actions to give life to the AAAS desire to engage the scientific community energetically and knowledgeably in a sustained K-12 science education reform effort. That put an end to my indecision about what to do next, and I quickly took him up on his offer. Neither of us knew where this partnership would lead, or what the odds of its success were, but from my perspective the challenge was more enticing than returning to university life.

As you would expect, I undertook this challenge with many notions already in mind — perhaps more correctly thought of as predispositions—with regard to science education reform. From 1949 to 1981 I was engaged in science education reform in various contexts and places—high school science teacher, university professor of science education, and federal government education officer. Over the years I initiated and directed a number of reform projects, perhaps the best known being the Carnegie Science-Humanities Project in California, Harvard Project Physics, and Project City Science in New York. One might well classify them as failures in that they did not survive. But it is from those experiences that I acquired a set of beliefs about science education reform—some fortifying my existing convictions, others changing them—that eventually led me to my role in the creation of Project 2061 and its first product, *Science for All Americans.*

From my perspective AAAS was the ideal organization for bringing to bear what I had learned in my career up to that point. AAAS has a large membership that cuts across the entire scientific spectrum; it is held in high regard nationally and internationally, including by science policy makers; its board of directors is composed of outstanding scientists, most of whom care about and are informed on science education from K-12 to post-doc; its journal *Science* reaches scientists and science educators throughout the world; and being over a hundred years old, it was likely to be in business for decades to come.

The AAAS Plan

The plan we eventually came up with consisted of two phases. The purpose of the first phase was to create and launch some activities that would increase the AAAS presence and capabilities in science education reform nationally and provide a rationale for recruiting a staff of talented individuals eager to be involved in innovative undertakings. This would enable AAAS to make some immediate contributions to the improvement of science education, while garnering up-to-date information on the status of science education, reestablishing connections with school, university, and state leaders in science education, and impressing the scientific community of the crucial importance of its informed participation in the reform of K-12 science education in America.

If the first phase of the AAAS reentry into science education reform was tactical, the second was strategic. Its purpose was to come up with a way for the AAAS to contribute significantly to science education reform, drawing on its strength as the world's largest scientific society encompassing the entire array of basic and applied sciences, and leading to significant and lasting improvements. Two years of study and consultation with teachers, school administrators, teacher educators, scientists, and policy makers led to these conclusions about previous reform:

It had been piecemeal and fragmented—not systemic in any sustained sense.

It had been unfocused—the nation had no clear notion of where it should be headed with regard to the science education of all students.

It had been short-sighted and impatient—the nation concentrated most of its attention on near-term problems, favoring solutions that would likely show quick results.

Our task was to come up with a strategic plan that would avoid those weaknesses, while building on AAAS strengths. The result was Project 2061. Briefly, the Project 2061 strategy was based on these propositions:

The ultimate aim of Project 2061 would be the attainment of lasting reforms that make possible the attainment of science literacy by all K-12 students by the time they graduate from high school.

"Science" in science literacy was to be broadly conceived to include the physical, biological, and social sciences, and the interrelationships among those sciences and mathematics and technology.

What constitutes science literacy was to be defined in terms of **explicit learning goals** that are compelling and challenging yet attainable. These are to be defined as final rather than as accumulating grade-band learning goals, and without reference to teaching methods or materials. The goals were to be generated without involvement of or financial support from the federal government, in order that their authority will derive from the scientific community rather than from any agency of government.

The undertaking must concentrate on the **long-term**. As such it must somehow take into account that in our huge, disaggregated education system, that actual reform activities will necessarily be carried out by many different organizations, institutions, and individuals; that authority and financial resources are and will remain widely dispersed; and hence that innovative but lasting changes cannot be brought about in a hurry —as history has demonstrated time and again that there are no easy or magical reforms. In short, Project 2061 would concentrate on fostering continuous improvement over the decades, rather than over the next 5 to 10 years.

Project 2061 was to confine itself to **developing reform tools** to be used by others in local, state, and national reform efforts. The first of these tools must be the set of explicit learning goals, which then will serve as the intellectual foundation for all succeeding tools.

THE PROCESS

The recommendations in *Science for All Americans* are not those of a single person, nor are they those of a committee. They emerged, instead, from a lengthy process designed to capture both the daring insights of the individual and the critical confrontation of the group. Briefly, the steps were these:

Scientific panels appointed by the AAAS were charged with coming up with recommendations in five domains: the biological and health sciences; mathematics; the physical and information sciences and engineering; the social and behavioral sciences; and, technology. Each panel met frequently over a two-year period, often inviting consultants to meet with them to present ideas and to participate in the discussion of particular suggestions being put forward by one or more panel members.

The panels started with only a few conditions. They were:

1. The statement of literacy learning goals must encompass science (basic and applied, natural and social), mathematics, and technology, and their interdependencies, the nature of science as well as its conclusions, and both knowledge and skills. A rendition in terms of the "school" sciences (earth science, biology, chemistry, and physics) was deliberately to be avoided in order to arrive at a more conceptual view of science literacy. Moreover, the statement must itself be expressed in language that is both scientifically sound and illustrative of the language sufficient for science literate citizens.

2. In the process, current practices and circumstances (curricula, textbooks, tests, teacher knowledge, etc.) are not to be taken into account. The final statement must steer clear of developing goals to accommodate current materials and practices, but rather set goals that will eventually become the basis for the creation better materials and practices by others in the future.

3. The final reports must be able to pass muster in both the scientific and educational communities. It was not required, however, that they express a universal consensus, but should have enough support and be compelling enough for a nationwide consensus to build.

As the panelists began, consideration was given first to the ideas that seemed to be of unusual scientific importance, because there is simply too much knowledge for anyone to acquire in a lifetime, let alone 13 years. This meant favoring content that has had great influence on what is worth knowing now and what will still be worth knowing decades hence, and ruling out topics mainly of only passing technical interest or limited scientific scope. In particular, concepts were to be chosen that could serve as a lasting foundation on which to build more knowledge over a lifetime. The choices then had to meet important criteria having to do with human life and with the broad goals that justify universal public education in a free society. The selection criteria were:

> *Utility*. Will the proposed content—knowledge or skills—significantly enhance the graduate's long-term employment prospects? Will it be useful in making personal decisions?
>
> *Social Responsibility*. Is the proposed content likely to help citizens participate intelligently in making social and political decisions on matters involving science and technology?
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> *The Intrinsic Value of Knowledge*. Does the proposed content present aspects of science, mathematics, and technology that are so important in human history or so pervasive in our culture that a general education would be incomplete without them?
>
> *Philosophical Value*. Does the proposed content contribute to the ability of people to ponder the enduring questions of human meaning such as life and death, perception and reality, the individual good versus the collective welfare, certainty and doubt?
>
> *Childhood Enrichment*. Will the proposed content enhance childhood (a time of life that is important in its own right and not solely for what it may lead to in later life)?

As the number of proposed goals that survived this critical test grew, another condition was added: each proposition was to be accompanied by a suggestion of what should be stricken from the list to make room for the new candidate. Needless to say, this resulted in heated debate. And then, from time to time, the panels had an opportunity to study and criticize one another's tentative recommendations. At the conclusion of its deliberations, each panel submitted a report to the National Council on Science and Technology Education summarizing its conclusions.

The national council had been appointed by the AAAS Board with the responsibility for providing quality control over the panels and the 2061 staff. The staff—primarily me and the late Andrew Ahlgren—met regularly with the panels, took notes, and audio recorded the sessions. By mutual agreement we took on the responsibility for drafting copy covering territory common to all of the panels, such as the nature of the scientific endeavor, history, and cross-cutting themes. Panel members submitted ideas and criticized successive drafts.

After all of that, each panel submitted a final report to Project 2061. With that material in hand, Chick Ahlgren joined me in writing successive drafts of *Science for All Americans*, each draft of which was subjected to extensive reviews by scientists and educators. The final draft went to the AAAS Board of Directors, which after careful consideration gave its endorsement. *Science for All Americans* was published in 1989—the culmination of a four-year undertaking—and quickly became the best seller in the history of the American Association for the Advancement of Science.

THE PRODUCT

So *Science for All Americans* represents the informed thinking of the science, mathematics, and technology communities as nearly as such a thing can be ascertained. It is a consensus, to be sure, but not a superficial one of the kind that would result from, say, a survey or a conference. The process cannot be said to have led to the only plausible set of recommendations on the education in science, mathematics, and technology for all children, but it certainly yielded recommendations in which the nation can have confidence. (Moreover, it has been studied by education and science ministries around the world and has been translated into Japanese, Chinese, and Spanish.)

Science for All Americans presents an ambitious but attainable vision that emphasizes meanings, connections, and contexts rather than fragmented bits and pieces of information and favors quality of understanding over quantity of coverage. The organization of *Science for All Americans* was designed to serve several purposes. Thus:

> *Chapters*. Each chapter deals with a major set of related topics. Collectively, the chapter titles lay out a conceptual framework for understanding science that people can use throughout their lives as they gain new knowledge about the world.
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> *Headings*. Within each chapter, headings such as Forces That Shape the Earth or Interdependence of Life identify the conceptual categories that all students should be familiar with. A list of all the headings would provide an approximate answer to the question of the scope, but not the content, of the specific recommendations.
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> *Paragraphs*. Under each heading are paragraphs that express the residual knowledge, insights, and skills that people should possess after the details have faded from memory. If high school graduates were interviewed about a topic—Information Processing, say—they should be able to come up, in their own words, with the ideas sketched in the paragraphs under that heading.
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> *Vocabulary*. The language of the recommendations is intended to convey the level of learning advocated. The recommendations are written for today's educated adults, not students—but the technical vocabulary is limited to what would be desirable for all students to command, as a minimum, by the time they finish school. This vocabulary should be viewed as a product of a sound education in science, mathematics, and technology, but not its main purpose.

As I write this, nearly 20 years has passed since the appearance of *Science for All Americans*, it is going on 30 years since the plan that led to the formulation of *Science for All Americans* got underway, and 60 since my stealth reading of *General Education in a Free Society* first got me on this bumpy, uncharted road in science education reform leading to *Science for All Americans*. So now one might fairly ask, just how well does that first-born product of Project 2061 reflect that journey and the determination of the American Association for the Advancement of Science to build a conceptual base for reform? The best answer is in the document itself. Those of you reading this probably know *Science for All Americans* very well, but as a convenience let me here provide a summary, chapter by chapter, taken directly from the introduction of each chapter.

Chapter 1: The Nature of Science
Over the course of human history, people have developed many interconnected and validated ideas about the physical, biological, psychological, and social worlds. Those ideas have enabled successive generations to achieve an increasingly comprehensive and reliable understanding of the human species and its environment. The means used to develop these ideas are particular ways of observing, thinking, experimenting, and validating. These ways represent a fundamental aspect of the nature of science and reflect how science tends to differ from other modes of knowing. This chapter focuses on three principal subjects: the scientific world view, scientific methods of inquiry, and the nature of the scientific enterprise.

Chapter 2: The Nature of Mathematics
Mathematics relies on both logic and creativity, and it is pursued both for a variety of practical purposes and for its intrinsic interest. For some people, and not only professional mathematicians, the essence of mathematics lies in its beauty and its intellectual challenge. For others, including many scientists and engineers, the chief value of mathematics is how it applies to their own work. Because mathematics plays such a central role in modern culture, some basic understanding of the nature of mathematics is requisite for scientific literacy. To achieve this, students need to perceive mathematics as part of the scientific endeavor, comprehend the nature of mathematical thinking, and become familiar with key mathematical ideas and skills.

Chapter 3: The Nature of Technology
As long as there have been people, there has been technology. Indeed, the techniques of shaping tools are taken as the chief evidence of the beginning of human culture. On the whole, technology has been a powerful force in the development of civilization, all the more so as its link with science has been forged. Technology—like language, ritual, values, commerce, and the arts—is an intrinsic part of a cultural system and it both shapes and reflects the system's values. In today's world, technology is a complex social enterprise that includes not only research, design, and crafts but also finance, manufacturing, management, labor, marketing, and maintenance. The ideas in this chapter are sorted into three sections: the connections of science and technology, the principles of technology itself, and the connections of technology and society.

Chapter 4: The Physical Setting
Humans have never lost interest in trying to find out how the universe is put together, how it works, and where they fit in the cosmic scheme of things. The development of our understanding of the architecture of the universe is surely not complete, but we have made great progress. Given a universe that is made up of distances too vast to reach and of particles too small to see and too numerous to count, it is a tribute to human intelligence that we have made as much progress as we have in accounting for how things fit together. This chapter focuses on two principal subjects: the structure of the universe and the major processes that have shaped the planet earth, and the concepts with which

science describes the physical world in general—organized for convenience under the headings of matter, energy, motion, and forces.

Chapter 5: The Living Environment

People have long been curious about living things—how many different species there are, what they are like, where they live, how they relate to each other, and how they behave. Scientists seek to develop the concepts, principles, and theories that enable people to understand the living environment better. This chapter focuses on six major subjects: the diversity of life, the transfer of heritable characteristics from one generation to the next; the structure and functioning of cells, the interdependence of all organisms and their environment; the flow of matter and energy through the grand-scale cycles of life; and how biological evolution explains the similarity and diversity of life.

Chapter 6: The Human Organism

As similar as we humans are in many ways to other species, we are unique among the earth's life forms in our ability to use language and thought. Having evolved a large and complex brain, our species has a facility to think, imagine, create, and learn from experience that far exceeds that of any other species. We have used this ability to create technologies and literary and artistic works on a vast scale, and to develop a scientific understanding of ourselves and the world. This chapter presents recommendations for what scientifically literate people should know about themselves as a species. It focuses on six major aspects of the human organism: human identity, human development, the basic functions of the body, learning, physical health, and mental health.

Chapter 7: Human Society

As a species, we are social beings who live out our lives in the company of other humans. We organize ourselves into various kinds of social groupings, such as nomadic bands, villages, cities, and countries, in which we work, trade, play, reproduce, and interact in many other ways. Unlike other species, we combine socialization with deliberate changes in social behavior and organization over time. Consequently, the patterns of human society differ from place to place and era to era and across cultures, making the social world a very complex and dynamic environment. This chapter covers recommendations about human society in terms of individual and group behavior, social organizations, and the processes of social change.

Chapter 8: The Designed World

The world we live in has been shaped in many important ways by human action. We have created technological options to prevent, eliminate, or lessen threats to life and the environment and to fulfill social needs. We have dammed rivers and cleared forests, made new materials and machines, covered vast areas with cities and highways, and decided—sometimes willy-nilly—the fate of many other living things. In a sense, then, many parts of our world are designed—shaped and controlled, largely through the use of technology—in light of what we take our interests to be. This chapter sets forth recommendations about certain key aspects of technology, with emphasis on the major human activities that have shaped our environment and lives. It focuses on eight basic technology areas: agriculture, materials, manufacturing, energy sources, energy use, communication, information processing, and health technology.

Chapter 9: The Mathematical World
Mathematics is essentially a process of thinking that involves building and applying abstract, logically connected networks of ideas. These ideas often arise from the need to solve problems in science, technology, and everyday life—problems from how to model certain aspects of a complex scientific problem to how to balance a checkbook. This chapter presents recommendations about basic mathematical ideas, especially those with practical applications that together play a key role in almost all human endeavors. The focus here is on seven kinds of mathematical patterns: the nature and use of numbers, symbolic relationships, shapes, uncertainty, summarizing data, sampling data, and reasoning.

Chapter 10: Historical Perspectives
There are two principal reasons for including some knowledge of history among the recommendations. One reason is that generalizations about how the scientific enterprise operates would be empty without concrete examples. For this purpose, any number of episodes might have been selected. A second reason is that some episodes in the history of the scientific endeavor are of surpassing significance to our cultural heritage. Although other choices may be equally valid, the ten accounts selected for this chapter clearly fit our dual criteria of exemplifying historical themes and having cultural salience: the planetary earth, universal gravitation, relativity, geologic time, plate tectonics, the conservation of matter, radioactivity and nuclear fission, the evolution of species, the nature of disease, and the Industrial Revolution.

Chapter 11: Common Themes
Some important themes pervade science, mathematics, and technology and appear over and over again, whether we are looking at an ancient civilization, the human body, or a comet. They are ideas that transcend disciplinary boundaries and prove fruitful in explanation, in theory, in observation, and in design. This chapter presents recommendations about some of those ideas and how they apply to science, mathematics, and technology. Here, thematic ideas are presented under four main headings: systems, models, constancy and change, and scale.

Chapter 12: Habits of Mind
Science, mathematics, and technology are built upon a distinctive set of values, they reflect and respond to the values of society generally, and they are increasingly influential in shaping shared cultural values. Similarly, there are certain thinking skills associated with them that young people need to develop during their school years. Taken together, these values, attitudes, and skills can be thought of as habits of mind because they all relate directly to a person's outlook on knowledge and learning and ways of thinking and acting. The first part of the chapter focuses on four specific aspects of values and attitudes: the values inherent in science, mathematics, and technology; the social value of science and technology; the reinforcement of general social values; and people's attitudes toward their own ability to understand science and mathematics. The second part of the

chapter focuses on skills related to computation and estimation, to manipulation and observation, to communication, and to critical response to arguments.

The Impact

How influential *Science for All Americans* has been is not for me to say, I suppose, but the signs are reassuring. Consider:

> *Science for All Americans* begat *Benchmarks for Science Literacy* and *Atlas of Science Literacy*, a collective resource unlike any other in the history of K-12 science education that is widely used nationally and internationally; and
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> Project 2061, the home of *Science for All Americans*, a quarter of a century later, lives on, backing up *Science for All Americans* and its progeny with important publications such as *Resources for Science Literacy* and *Designs for Science Literacy*, and pursuing activities with states and universities that help move the nation toward the realization of the vision expressed in *Science for All Americans*.

Nevertheless, I am aware that that does not mean *Science for All Americans* turned out be some sort of silver bullet. In my paper “Is Our Past Our Future? Thoughts on the Next 50 Years of Science Education Reform in the Light of Judgments on the Past 50 Years” based on my 2005 NSTA Paul F-Brandwein Lecture (*Journal of Science Education and Technology*, December 2005), I claimed the following:

> *On the whole*, our collective reform efforts since the end of World War II have not added up to significant and sustained improvements in the quality of K-12 science education in America. We have not achieved what we *should* have, what we *could* have.

To which I now add, Not Yet. After all, 2061 is still some way off.