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A Nation at Risk Revisited

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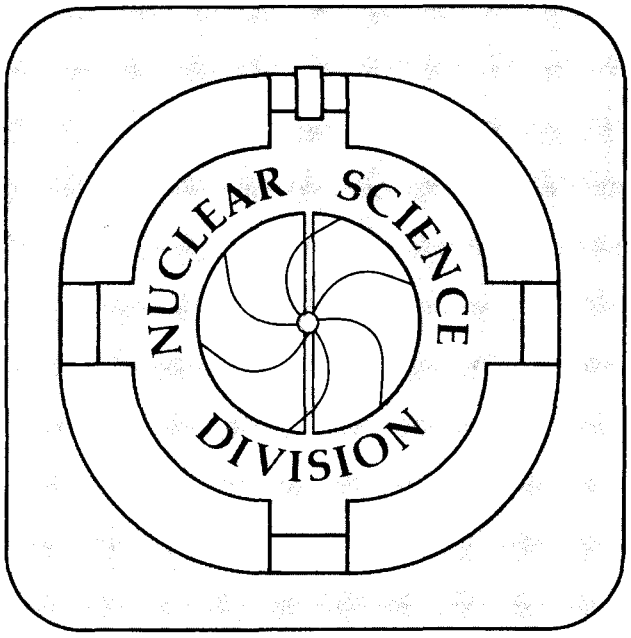

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A NATION AT RISK REVISITED

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Part I

A NATION AT RISK REVISITED

The Report - A Nation at Risk

The time of writing of this essay coincides with the tenth anniversary of the inception of The National Commission on Excellence in Education, which issued the now famous report, "A Nation At Risk."[1] Secretary of Education Terrel H. Bell phoned me on August 17, 1981, to describe the proposed Commission, its goals, meeting agenda and 18-month time scale for presentation to President Ronald Reagan of its report and recommendations for renovation of pre-college education. After I turned him down because I thought I just didn't have the time, I received another phone call on August 19, 1981, from the designated Commission Chairman, David Pierpont Gardner (at that time President of the University of Utah, to become President at the University of California in 1983). He persuaded me to reverse my decision and to serve as a member of the 18-member Commission. Yvonne W. Larsen, immediate Past-President of the San Diego City School Board, served as Vice Chairman and Milton Goldberg, as Executive Director of the Commission.

The Commission, which became operative on August 26, 1981, met a total of eight times, generally in Washington, D.C., with the first meeting on October 9-10, 1981, the decisive penultimate meeting on January 21-22, 1983, and the final meeting on April 26, 1983 (Figure 1). In addition, there were about a dozen public hearings, panel discussions and symposia, including testimony from some 250 experts, and about five dozen commissioned papers by educational experts, to help us formulate our conclusions and recommendations.

Our final report, "A Nation At Risk: The Imperative for Educational

Reform," was handed to President Reagan, in a ceremony well attended by interested members of the public, government officials and the press, at the White House on April 26, 1983. We had gone through a period of contentious argument before we could agree on these dramatic opening paragraphs:

> *Our Nation is at risk. Our once unchallenged preeminence in commerce, industry, science and technological innovation is being overtaken by competitors throughout the world.... the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a Nation and as a people. What was unimaginable a generation ago has begun to occur- others are matching and surpassing our educational attainments.*
>
> *If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war. As it stands, we have allowed this to happen to ourselves.... We have, in effect, been committing an act of unthinking, unilateral educational disarmament.*

We succeeded in drawing almost unprecedented attention from educators, parents, public and press. (Incidentally, President Reagan used the occasion to advocate voluntary prayer in schools, and tuition tax credits and abolishing the Department of Education, but the press, of course, could find no reference to these suggestions in our report. Ironically, the overwhelmingly favorable reception of our report also doomed his plan to abolish the Department of Education.)

It is now apparent that the pre-college educational crisis and the urgent need for educational reform are broadly perceived as being a top priority. Since the report, "A Nation At Risk," there have been over 100 reports by a wide spectrum of American organizations that have emphasized the deplorable state of pre-college education in science and math in the

United States today. These reports indicate that while some progress has been made, there is still much work to be done to resolve this crisis in education. This should become apparent from what follows in this essay.

Recommendations and Responses

The recommendations in "A Nation At Risk" are worth repeating here with some comments on the progress that has been made in implementing them.[2,3]

Recommendation A: Content.

We recommend that State and local high school graduation requirements be strengthened and that, at a minimum, all students seeking a diploma be required to lay the foundations in the Five New Basics by taking the following curriculum during their 4 years of high school: (a) 4 years of English; (b) 3 years of mathematics; (c) 3 years of science; (d) 3 years of social studies; and (e) one-half year of computer science. For the college-bound, 2 years of foreign language in high school are strongly recommended in addition to those taken earlier.

Although many states have raised their high school graduation requirements, their requirements still fall far short of this recommendation. The three years of science are needed to insure that high school graduates include chemistry or physics, or preferably both, in their curriculum. Only four states have upgraded the requirements to require three years of science for graduation from high school. By 1990, 37 states required four years of English, 28 required three or more years of social studies, and 10 states required three years of mathematics.

Recommendation B: Standards and and Expectations:

We recommend that schools, colleges, and universities adopt more rigorous and measurable standards, and higher expectations, for academic performance and student conduct, and that 4-year colleges and universities raise their

requirements for admission. This will help students do their best educationally with challenging materials in an environment that supports learning and authentic accomplishment.

Some progress has been made on this. Many colleges and universities have raised their requirements for admission. However, there is very little progress in raising entrance requirements to include substantially more science. There is some movement in the direction of upgrading the entrance requirements of the University of California to include three years of science.

Recommendation C: Time.

We recommend that significantly more time be devoted to learning the New Basics. This will require more effective use of the existing school day, a longer school day, or a lengthened school year.

Longer school days are reported in 40% of high schools, 30% of middle schools, and 34% of elementary schools. A longer school year has been established in 17% of high schools, 16% of middle schools, and 18% of elementary schools. More homework has been required in 27% of high schools, 30% of middle schools, and 32% of elementary schools. Thus, while some progress has been made, there is still a long way to go.

Recommendation D: Teaching.

This recommendation consists of seven parts. Each is intended to improve the preparation of teachers or to make teaching a more rewarding and respected profession. Each of the seven stands on its own and should not be considered solely as an implementing recommendation.

Because of the special relevance of this to what follows, I quote the seven parts.

1. Persons preparing to teach should be required to meet high

educational standards, to demonstrate an aptitude for teaching, and to demonstrate competence in an academic discipline. Colleges and universities offering teacher preparation programs should be judged by how well their graduates meet these criteria.

2. Salaries for the teaching profession should be increased and should be professionally competitive, market-sensitive, and performance-based. Salary, promotion, tenure, and retention decisions should be tied to an effective evaluation system that includes peer review so that superior teachers can be rewarded, average ones encouraged, and poor ones either improved or terminated.

3. School boards should adopt an 11-month contract for teachers. This would ensure time for curriculum and professional development, programs for students with special needs, and a more adequate level of teacher compensation.

4. School boards, administrators, and teachers should cooperate to develop career ladders for teachers that distinguish among the beginning instructor, the experienced teacher, and the master teacher.

5. Substantial nonschool personnel resources should be employed to help solve the immediate problem of the shortage of mathematics and science teachers. Qualified individuals, including recent graduates with mathematics and science degrees, graduate students, and industrial and retired scientists could, with appropriate preparation, immediately begin teaching in these fields. A number of our leading science centers have the capacity to begin educating and retraining teachers immediately. Other areas of critical teach need, such as English, must also be addressed.

6. Incentives, such as grants and loans, should be made available to attract outstanding students to the teaching profession, particularly in those areas of critical shortage.

7. Master teachers should be involved in designing teacher preparation programs and in supervising teachers during their probationary years."

Many of these recommendations are the subjects of later comments in this essay. I shall comment here on only parts 1 and 5:

1. Teaching standards have been subjected to some changes. Today's teachers are tested in 39 states as compared to only a handful

of states in 1980. Three states test only for admission to teacher education programs, 18 test only for teacher certification, and 18 test for both admission and certification.

5. The number of science centers in the United States has nearly doubled since the appearance of "A Nation At Risk," to a total of several hundred, and they serve as an integral part of the educational community. They serve 10 million students annually--six million at the center and four million through outreach programs. Some 100 centers conduct teacher training workshops serving more than 50,000 teachers annually.

Recommendation E: Leadership and Fiscal Support.

We recommend that citizens across the Nation hold educators and elected officials responsible for providing the leadership necessary to achieve these reforms, and that citizens provide the fiscal support and stability required to bring about the reforms we propose.

Because I am going to expand on this later I quote one of the implementing recommendations for this.

The Federal Government has the primary responsibility to identify the national interest in education. It should also help fund and support efforts to protect and promote that interest. It must provide the national leadership to ensure that the Nation's public and private resources are marshaled to address the issues discussed in this report.

As "a final word" in "A Nation At Risk," "we call upon the National Academy of Sciences, National Academy of Engineering, Institute of Medicine, Science Service, National Science Foundation, Social Science Research Council, American Council of Learned Societies, National

Endowment for the Humanities, National Endowment for the Arts, and other scholarly, scientific, and learned societies for their help" in the implementation of our recommendations.

Many of these organizations are making contributions to this effort. I shall mention the programs of one, Science Service (an institution devoted to the public understanding of science), which I have served as Chairman for the last 25 years. Science Service sponsors the annual Westinghouse Science Talent Search for high school seniors, in which 40 finalists (with scholarships for the top ten), are chosen from 300 Honorable Mentions, who are selected from some 20,000 participants. The 2,000 finalists for the last 50 years, were invited to a reunion meeting and dinner in Washington, D.C., on March 3-4, 1991. Of these 2,000 finalists, five have won the Nobel Prize; two, the Fields Medal (highest honor in the field of mathematics); eight have won MacArthur Foundation Fellowships; 51 have been named Sloan Fellows; and 28 have been elected to the National Academy of Sciences. Seventy per cent of those who are old enough have earned a Ph.D. or an M.D.

Science Service also sponsors the annual International Science and Engineering Fair, started in 1950, with more than 750 student contestants from over 400 affiliated fairs in the United States and foreign nations. It culminates a selection process involving thousands of school and regional fairs, their student participants, and their 800 judges from science, engineering, medicine and industry. Students in the 9th through 12th grades compete for more than 575 awards, given by over 50 societies, federal agencies, universities and corporations.

Science Service publishes Science News, the only weekly news magazine of science in the United States, that brings to its readers a rapid

overview of all fields of science and of public issues of science in a compact, well-written form. Science News serves the needs of both scientists and the lay public.

Overall, the lack of progress in implementing the recommendations of the report, "A Nation At Risk," has been discouraging. Recently budget crises in city after city, and in state after state, have led to the broad scale firing of teachers. (In California, the amount of support per student has actually decreased during the last three years.)

In his testimony[4] on February 20, 1991 before the Committee on Science, Space and Technology of the House of Representatives, D. Allan Bromley, Director, Office of Science and Technology Policy (OSTP), had this to say: "At the pre-college level, mathematics and science achievement in the United States is a disgrace, with American students typically scoring at or near the bottom in international comparisons of industrialized countries."

In the following sections of this essay I shall, following a description of the central role of science in our society, describe a number of current and planned future efforts to improve pre-college science education.

The Central Role of Science

We all recognize that we live in a rapidly changing, increasingly high technology world. I have characterized our present age as that of the Third Revolution. The Revolution of Independence gave birth to our nation and established the democratic principles on which our classical concept of "equality of opportunity"--largely through education--is based. The Industrial Revolution rewarded the American spirit of inventiveness and made us leaders in the world's economy, blessed with an extremely high standard of living. The Third Revolution, the Revolution of Science, has already

transformed how we understand our world--through the remarkable expansion of knowledge in a few decades--and is radically altering almost every aspect of our lives. Our response to the challenges of the revolution in science will, quite simply, decide our future. Our most valuable resources are our intelligence and ingenuity. As a nation, we pride ourselves on our history of pioneering new technologies; in the future much will depend not only on that capacity for innovation but also on our general preparedness to participate in the practice and production of those technological advances. The strength of our technological and scientific enterprise will determine our economic well-being, our security and our health and safety.

Science plays a central role in the world of today. Research in basic science leads to advances in applied science and then to widespread practical applications of this acquired knowledge in the derived technology. Incremental scientific advances, as well as major discoveries, result in new technologies of great commercial importance. They can give us entire new industries, as in the case of advances in molecular biology. They can give us whole new ranges of products, as in the case of polymer chemistry. They can revolutionize other technologies and industries, as has been the case for the transistor and the laser.

Basic research leads to the creation not only of new products but also new industrial processes and manufacturing systems. These can greatly increase industrial productivity, reduce costs, and improve the quality of products. For example, advances in microelectronics are aiding the production of automobiles, steel, and many other manufactured goods. Discoveries in biology are influencing the processing and production of pharmaceuticals, foods, and chemicals.

This country cannot afford another generation of students that is ill-

prepared to respond to the worldwide rapid growth of scientific knowledge and technological power. The nation's future depends on them. The National Science Foundation has predicted a shortfall of about half a million scientists and engineers by the end of the century. It is particularly frightening that this shortfall is happening at a time when overall educational standards in our country are dismally low in comparison to those of our major industrial competitors. (Japan produces more engineers than the United States -- the U.S. produces more attorneys than any other country.)

However, it's not just the future scientists and engineers who need a better foundation in math and science. We must improve general science education for all of our young (and not only for those who plan to continue their education and become professional scientists, mathematicians or engineers) because we need a large number of scientifically literate, nonprofessional workers with the understanding and skills to manufacture, operate, and repair increasingly complex technological equipment. Future employment opportunities, necessary to replace jobs lost in our declining "smokestack industries," will be in areas requiring technical sophistication and will depend on a work force endowed with a practice in learning and the flexibility of mind to adapt to a society constantly changing. The old concept of a replaceable worker standing in a production line and doing one thing over and over is obsolete. The workplace demands workers who understand the automated equipment that they use and who can adjust and repair it. They must understand and apply the statistics of quality control and make decisions which require knowledge and judgment. The definition of "basic skills" is changing to include such areas as critical thinking, problem-solving, decision-making, reasoning, teamwork, adaptability, and

computer literacy. (Oregon has approved an education plan that would be the first in the nation to establish a statewide apprenticeship program that would include preparation for work in technical fields and improve the quality of Oregon's workforce. The students would choose between job training or a college preparatory curriculum after the 10th grade.) Federal funding to train and retrain American workers has dropped more than 50% (from $13.2 billion to $5.6 billion) from its level in 1980. Most other countries devote a much higher percentage of their GNP to workplace training.

We must actively recruit and prepare, for these more sophisticated jobs, young people from what have been traditionally underrepresented populations--women and minorities. It has been estimated that white males, regarded only a generation ago as the mainstays of the economy, will comprise only 15% of the net additions to the labor force between 1985 and 2000. Nationwide, in 1985 one in five 18-year-olds was black or Hispanic; in 2010 the ratio will be one in three. The workforce in 2000 is estimated to be 82% minorities and women. The need to increase the participation of minorities and women as scientists and engineers is also apparent--blacks constitute only 2.3% and Hispanics only 4% of the Ph.D. candidates and the number of female engineers has actually been declining during the last ten years.

In addition to the need for trained scientists, mathematicians and engineers, and nonprofessional workers with an understanding of complex technological equipment, we need widespread understanding of science among the general population. The vitality of a democracy assumes a certain "core of knowledge" shared by everyone which serves as a unifying force. It is fundamental to the effectiveness of our democratic system that our

citizens be able to make informed judgments on the more and more complex issues of scientific and technological public policy. Decisions must be made which are of critical importance to our health and safety.

There can be no doubt that scientific literacy, a solid understanding of science and mathematics, is now more important than ever before--and there is irrefutable evidence that the skills of our youth are not only not progressing with the increasing demands--but actually are deteriorating at an alarming rate. Besides our need for improvement in pre-college education in science there is need for the broad-scale addition of science courses for non-science majors at the post-secondary level. While our nation's needs for both an educated citizenry and a technologically trained workforce have grown by leaps and bounds, our ability to satisfy those needs has diminished. We must act now to reverse this self-destructive trend.

We all have an important stake in the success of our education system, and every part of our society must be involved in meeting the challenge. Education is an investment, not an expense. The Committee for Economic Development reports that each year's class of dropouts costs the nation about $240 billion in crime, welfare, health care, and services. For every $1.00 spent on education, it costs $9.00 to provide services to dropouts. For example, about 80% of all prison inmates are school dropouts, and each inmate costs the nation about $28,000 per year.

There is good news, however. Trends in SAT scores are not universally discouraging. One positive trend is the narrowing of the gap between minority and non-minority students. Between 1978 and 1988, scores of black students rose 21 points on the verbal and 30 points on the math portions of the SAT. Native Americans, Asians and Hispanics also showed gains.

Some Proposals and Programs

Nationwide, many proposals and programs (with overlapping and interlacing suggestions) have been developed by people committed to improving the quality of pre-college education in this country and the future prospects for our youth and our economy.

In September 1989 governors from almost every state in the Union attended the summit conference convened by President Bush in Charlottesville, Virginia. Six national goals[5] were established at that time and announced by President Bush in his 1990 State of the Union message:

> *Goal 1: By the year 2000, all children in America will start school ready to learn.*
>
> *Goal 2: By the year 2000, we will increase the percentage of students graduating from high school to at least ninety per cent.*
>
> *Goal 3: By the year 2000, American students will leave grades four, eight, and twelve having demonstrated competency over challenging subject matter, including English, mathematics, science, history and geography.*
>
> *Goal 4: By the year 2000, U.S. students will be first in the world in science and mathematics achievement.*
>
> *Goal 5: By the year 2000, every adult American will be literate and possess the knowledge and skills necessary to compete in a global economy and exercise the rights and responsibilities of citizenship.*
>
> *Goal 6: By the year 2000, every school in America will be free of drugs and violence and offer a disciplined environment conducive to learning.*

Just recently (in July 1991) the National Science Foundation started a program conceived in conjunction with the National Governors' Association. In this program, called the Statewide Systemic Initiative (SSI), thousands of scientists and engineers throughout the nation, from both academia and

industry, are expected to participate. The initial $75 million program is to be augmented by various levels of matching funds for the initial ten selected states--from state sources, local companies, private foundations and other non-federal sources--so as to sustain the program when NSF funding terminates. The money will be used to operate programs that bring working scientists into the classroom, to train future teachers, and to run workshops and summer programs to enhance the skills of present teachers. A second round is planned for next year with the hope that up to ten more states will be selected.

On October 9-10, 1989 I co-hosted with Secretary of Energy Admiral James D. Watkins a major educational summit at the Lawrence Hall of Science. On May 22, 1990 we held a press conference in Washington, D.C. to announce our plan of action[6]. I would like to give you a brief summary of our goals and objectives. I quote:

> *We endorse the following goals, to be achieved by the year 2000:*
>
> *1. Students. American elementary and secondary students will receive excellent preparation in science in every grade.*
>
> > *Performance. American students will be the best in the world in their knowledge of mathematics and science.*
> >
> > *Curriculum. The Nation will have in place an integrated, interdisciplinary core curriculum for mathematics and science in pre-school through high school.*
>
> *2. Teachers. The Nation's mathematics and science teaching professionals will attain their rightful place as full-share partners in the scientific community and will become empowered to prepare this generation of children for lives of discovery in the 21st Century.*
>
> > *Enrichment. Each year 10% of the Nation's teachers will be provided with high-quality teacher*

enhancement programs in hands-on science.

Partners. Scientists, engineers, and mathematicians will serve as volunteer expert education partners to bring cutting-edge science into the Nation's classrooms, in numbers equaling 10% of the teaching force.

3. Underrepresented Groups. Significantly greater numbers of female, minority, disabled, and disadvantaged students will complete a K-12 education program, advance to the highest levels of mathematics and science education, enter careers in mathematics and science, and complete teaching programs in these fields.

4. Public Literacy. Citizens will understand and derive excitement from confronting new frontiers in science, mathematics, and technology and will appreciate their potential for bettering our society and our world.

Science Alliances. Mathematics and science community alliances including partners from government, education, and business, will be established or significantly expanded in 10% of the Nation's school districts over the next 24 months.

5. Competitive Work Force. The Nation will have a diversified work force, competent in mathematics and science and equipped to meet the technological demands of the 21st Century.

Secretary Watkins has inaugurated and implemented an extensive and effective program of utilizing the scientists and resources of the national laboratories of the Department of Energy to aid schools in improving and extending science and mathematics education. In Part II of this essay I describe, as an example of this, some of the contributions of the Lawrence Berkeley Laboratory.

Over the past year the Committee on Education and Human Resources of the Federal Coordinating Council for Science, Engineering and Technology (FCCSET) has been working on defining how the federal government can contribute to meeting the 1989 Governors National

Education Goal No. 4. (By the year 2000, U.S. students will be first in the world in science and mathematics achievement.). I would commend to you their recently released (February 1991) report, entitled "By the Year 2000: First in the World."[7] The Committee, chaired by Secretary of Energy Watkins, had the benefit of participation from top leaders of federal agencies. As Admiral Watkins wrote in his letter conveying the report to Assistant to the President for Science and Technology Allan D. Bromley:

> *This is a groundbreaking document. Never before has an Administration presented an interagency budget for mathematics, science, engineering and technology education. Along with this coordinated budget and priorities for future growth, this report includes another valuable resource for policy makers, educators and the public: a comprehensive inventory of mathematics and science education programs and activities across the entire Federal government—a snapshot of where the Federal government stands at the beginning of the decade.*

The task of guiding the intellectual (and often social) development of our young is an all-important one. We must begin to recognize teachers' contributions not only by adequately compensating them for their service, but also by giving them due respect which would motivate them to refine their skills and expand their knowledge to meet future challenges. There are a number of vital new programs and proposals which address this need.

Another thing about the FCCSET's Committee report that encourages me is the recognition that a top priority should be to increase the supply of well-trained science and mathematics teachers. Half of the newly employed teachers of mathematics, science, and English are not qualified to teach these subjects. This probably accounts for the fact that so many students are turned off from math and science in the early grades. Fewer than one-third of U.S. schools have qualified physics teachers. In part as a result of this, 30% of our high schools offer no courses in physics; 17% offer none in

chemistry, and 70% offer none in earth or space science.

According to the FCCSET Committee report[7],

> *In the United States today there are 2.3 million public school teachers. in grades K-12. The Department of Education estimates that over the next decade, we must hire 1.6 million new teachers, or an average of 160,000 teachers a year. Yet our primary source of new teachers, college students majoring in education, has fallen 55% since 1972. Today we are graduating only about half the teachers we will need to bridge the gap in the future. If it is becoming difficult to recruit teachers, it is even harder to retain them. Twenty per cent of new teachers leave during their first year, and more than half leave before the sixth year.*

On April 8, 1991 President Bush announced his strategy, based on the Governors' Conference of September 1989, to move the nation toward achieving the national education goals and educational excellence for all Americans--"America 2000, the President's Education Strategy."[8] "America 2000" builds on four related themes:

(1) **Creating better and more accountable schools for today's students.** This includes establishing world class standards for what our children should know and be able to do in five core subjects: English, mathematics, science, history and geography (while opposing a national curriculum or federalizing our education system). Through the efforts of the National Education Goals Panel, a system of voluntary examinations will be developed and made available for all fourth, eighth, and twelfth grade students in the five core subjects. The concept of "choice" of schools for parents and students will be provided and promoted; federal funds would follow each child to the school of choice rather than being allocated to public schools on the basis of enrollment. The states are encouraged to consider differential pay and financial and other awards for those who excel in teaching, teach core subjects, teach in challenging settings, or serve as mentors

for new teachers.

(2) **Creating a New Generation of American Schools for tomorrow's students.** America's business leaders will establish and mobilize private resources for the **New American Schools Development Corporation,** whose mission will be to help communities create schools that will reach national education goals. Congress will be asked to provide $550 million in one-time start-up funds to create at least 535 New American Schools that "break the mold" of existing school designs, with the cooperation of the nation's governors, state legislatures and civic leaders.

(3) **Transforming America into "A Nation of Students."** This calls on Americans to move from "A Nation At Risk" to "A Nation of Students" (identified as "The Learning Society" in our report "A Nation At Risk."

(4) **Making our communities places where learning will happen.** Communities are called on to adopt as their own the six national education goals (of the governor's education conference of September 1989). Parents are to become more involved in their children's education and in the work of the New American Schools. The Administration will undertake better coordination of federal programs with corresponding state and local activities.

President Bush announced on July 8, 1991, the formation of the private, non-profit corporation, the **New American Schools Development Corporation,** with the hope that businesses will donate as much as $200 million for the creation of the 525 experimental schools intended to be models of reform for the nation. The members of the board of this Corporation consist of 18 business, education and political leaders. The National School Boards Association immediately criticized this proposal as

too limited to move "a nation of 16,000 school districts, almost three million teachers, and 40 million students, toward excellence by the end of the decade."

I am extremely pleased by the appointment last May of Lamar Alexander as Secretary of Education and of David Kearns as his Deputy. Immediately following the publication of "A Nation At Risk," Mr. Alexander, then Governor of Tennessee, acted to push through far-reaching and effective educational reforms. He made it clear that education was a top priority for the State of Tennessee, and I am hopeful that he will be as dynamic a leader for change in the federal government. Mr. Kearns used his platform as chairman of the Xerox Corporation to bring out in the open some of the deficiencies of our emerging workforce, to advocate decisive action to improve every American's opportunities, and to urge the participation--using both financial and human resources--of the private sector. I am looking forward to seeing this new team in action.

There are many interesting new curriculum development projects. Among the most fascinating to me is an initiative by the American Association for the Advancement of Science (AAAS), Project 2061 (so named to make clear its goal of revolutionizing the teaching of science by the time of the arrival of the next Halley's Comet). Its report, "Science for All Americans" (1989)[9] makes fascinating reading: it represents Phase I (Goals) of the project by attempting to define what basic core of scientific knowledge should be included in the education of all young Americans. Phase II (Formulation) makes recommendations on new science curricula, instructional materials, testing methods, teacher training, school organization, and educational research and development programs. Phase III (Implementation) will probably take a good deal longer to accomplish!

Another idea which has been picked up and further developed by the National Science Teachers Association (NSTA) is called "Scope, Sequence. and Coordination"[10] Students in grades 7 through 12 would study biology, chemistry, physics and earth sciences each year, concentrating on phenomenological studies in 7th and 8th grades, empirical studies in 9th and 10th grades, and theoretical studies in 11th and 12th grades. With leadership coming from Tom Sachse (Manager, Math/Science/Environmental Education Unit for the State of California) and Bill Honig (the able California State Superintendent of Schools), a plan to test these ideas in 100 schools across California has been developed and proposed for funding.

The California State Department of Education is implementing in the fall of 1991 a new **Science Framework for California Schools,**[11] a student-centered program that develops concepts and an enhanced understanding of the connections among the disciplines of science. To help implement this in the San Francisco Bay Area the **Science Education Academy of the Bay Area (SEABA)** is being created. The mission of the Academy is to coordinate teacher education efforts of over 25 institutions (e.g., the Lawrence Hall of Science, the Lawrence Berkeley Laboratory, the Lawrence Livermore National Laboratory, the Stanford Linear Accelerator, the Exploratorium, the California Academy of Sciences) so that all K-12 science teachers (some 35,000 in number) in the nine-county Bay Area become fully qualified and effective in delivering the best science education available. Besides programs to educate teachers, some are available to educate school administrators (i.e., **the Principals for the Advancement of Leadership in Science, PALS, Network program,** offered by the Lawrence Livermore National Laboratory). The functions of SEABA would include (1) coordination and dissemination on teacher education opportunities in the

Bay Area, (2) data collection and reporting on teachers' professional development activities, and (3) provision of opportunities for networking among teacher educators in the Bay Area.

On a broader scale the U.S. Department of Energy is developing Regional Consortia. Based on the SEABA model, the Far West Laboratory for Educational Research and Development is proposing the establishment of a **Science and Mathematics Multi-State Implementation Network (SAMMIN),**[12] involving states within the Western Region, including Arizona, California, Nevada and Utah. The objectives of this project include (1) the establishment of a Multi-State Science and Mathematics Resource Clearinghouse, (2) the establishment of a model Urban Science Resource Network, (3) the dissemination to science and mathematics educators throughout the region and the nation of the most current information in emerging issues in science and mathematics education, models for providing professional development for science and mathematics teacher leaders, and high quality products available for science and mathematics instruction, and (4) the cultivation of leadership in the Western Region science and mathematics community.

Another initiative, of increasing importance, is the growing involvement of the corporate world in contributing to the improvement of pre-college education, as illustrated by the essays in this book. Worth mentioning in this connection is California's Educational Partnership Week, the statewide "Principal for a Day" program, sponsored by Chambers of Commerce and the business world, in which I had the privilege of participating on April 30, 1991, as the Principal of Morrill Middle School in San Jose.

Another initiative of California's diverse business community, of which

I served as co-chairman during 1983-1985, was that of the Math Science Task Force, sponsored by the California Roundtable and the California Round Table on Educational Opportunity; the resulting report, **"The Challenge of Improving Mathematics and Science Education in California,"**[13] recommended:

> (1) THAT ALL TEACHERS OF SCIENCE AND MATHEMATICS BE QUALIFIED IN SUBJECT MATTER THEY TEACH WITHIN THE NEXT FIVE YEARS. (2) That businesses, and scientific, technical, and professional organizations, post-secondary institutions, the State Department of Education, community organizations, and K-12 educators form local partnerships throughout the state to observe the needs and to identify improvements in mathematics and science education in their schools, and jointly plan and implement these improvements.

Unfortunately, there was no follow up action to try to implement these recommendations. However, these are still valid and desirable objectives for implementation.

The business community can play an important role in solving the problem of pre-college science and mathematics education. It is not possible to mention all of the organizations involved, or potentially involved, but I shall mention some leading local and statewide participants--Industry Initiatives for Science and Math Education (IISME), about which I shall have more to say later, the Industry Education Council of California (the sponsor of this book of essays), the California Business Roundtable (Education Committee), the Bay Area Council, and the California Engineering Foundation; on a broader scale, we have the National Alliance for Business and The Triangle Coalition (a consortium representing industry, education,

and science and industry).

In its 1991 so-called "annual report card on federal spending for education," the National Education Association (NEA) criticized the Bush Administration for not adequately funding the Head Start program (the highly regarded early childhood program) and the remedial program for disadvantaged children. *(An adequately funded Head Start program would help fund Goal I of the September 1989 governors report--By the year 2000, all children in America will start school ready to learn.)* The report concluded that the federal commitment to public education declined over the 1980s. Other organizations have also criticized the lack of adequate funding for the Head Start program. Also, in July 1991, the American Federation of Teachers criticized the Bush Administration's "school choice" plan, (part of theme No. 1 of President Bush's strategy announced on April 18, 1991 as described above) under which federal funds would follow each child (through the use of "vouchers") instead of being allocated to public schools on the basis of enrollments; it was stated that this would provide financial aid for private schools rather then help public schools achieve the national educational goals. This plan has also been criticized by many other organizations. Perhaps the "school choice" plan, which has the advantage that it would force schools to make needed improvements, would be more acceptable if it were limited to public schools.

Some Personal Suggestions

There have been many suggestions for how to improve pre-college teaching, especially in science, mathematics and technology: enact state laws to raise standards in education, place more computers in the schools, lengthen the school day and year, increase the requirements in science and

mathematics, provide incentives to attract college graduates into science teaching, raise teachers' salaries, establish more teacher recognition programs, establish teacher mentor programs, increase summer teacher training opportunities, reform teacher credentialing to make retired scientists eligible to teach, establish more magnet schools featuring science and mathematics, reform schools of education, develop new teaching materials and curricula, utilize more science centers for teacher training and curricula development, form partnerships and alliances to bring business into collaboration with schools to improve science education, improve collaborations between higher education and schools, institute standardized tests for students and teachers, demand that school educators and leaders reform themselves, institute free market competition for students' choice of schools, increase parents' interest and participation in schools, increase school budgets, decrease number of students per classroom, ameliorate some of the social problems (drugs, violence, vandalism, poverty, teenage pregnancies), establish statewide and national strategies for pre-college education, etc.

Each of these suggestions has some importance. In many cases some progress has been made. However the remaining task is of monumental magnitude and a solution (or solutions) to the problem will require effort on an extraordinarily high level. And overall reform will require the infusion of vast amounts of money--DOLLARS.

Obviously, I cannot comment on all of these problems, or even on several of them, in the space available to me. I shall comment on two aspects that I deem of prime importance.

On the first item I can be brief. We need to refashion the method by which we educate our pre-college teachers, especially in the fields of

science and mathematics. We need to establish a system, throughout our colleges and universities nationwide, whereby students majoring in science or mathematics can obtain pre-college teaching credentials upon completing a four-year curriculum. We must eliminate the extra year of methods courses traditionally required by Schools of Education. Cooperation between science and mathematics departments and Schools of Education (not easily arranged) to include essential methods courses during the four-year curriculum, and modification in teacher credentialing requirements, should make this possible. At the University of California, Berkeley, discussions are underway between representatives of the College of Chemistry and School of Education to provide a joint cooperative program whereby chemistry majors can qualify for pre-college teaching credentials on the basis of a four year (or four years plus a summer session) curriculum. The American Chemical Society is spearheading a national move in this direction--a chemistry/education option that would enable chemistry majors to qualify for pre-college teacher certification upon completion of a four-year curriculum. In a related movement, teacher credentialing should be, and in many parts of the country is being, modified so as to allow qualified (perhaps with some instruction in educational methods) retired industrial and military scientists to augment the pre-college science teaching force.

The other aspect that I want to emphasize is that the federal government (in collaboration with the states) should assume leadership in the effort to reform pre-college science education. Historically, the federal government has instigated major new reforms in education. The Morrill Act of 1862 established the land-grant universities; the World War II "G.I. Bill" instigated the now prevalent federal financial help for young people to attend college; the creation, in 1950, of the National Science Foundation led

to the creation of an effective system of support of graduate (and more recently undergraduate and pre-college) education in science; the now largely defunct National Defense Education Act (NDEA), inspired by the advent of Sputnik, provided funds to states for building and equipping high school laboratories and providing elementary schools with laboratory equipment and instigated the still operating Eisenhower State Mathematics Science Education Program. It is amazing that no comparable action has been undertaken by the federal government to meet the challenge of the present crisis in pre-college science education. (Education is the only profession that has not been radically reshaped by modern technology).

The federal government should establish national goals and standards, cast in very concrete terms, for pre-college education, should keep the problem and suggested solutions before the public through an adequate number of meaningful statements by the president (an indispensable action) and other leaders, should take the lead in extensive K-12 curriculum reform, take the lead in modernizing the educational system, give special attention to the needs of minorities, define the roles of federal, state and local involvement, establish a national R & D capability in pre-college education, and, especially, broaden the base for federal support for pre-college science education.

Of these, broadening the base for federal support for pre-college science education is of prime importance. (Overall, federal funding for education has declined since 1980, a trend that has continued during the Bush administration.) Probably the paramount requirement for improving pre-college science education is to attract to the teaching profession well qualified science majors. This can only be done by raising salaries dramatically! This would cost, nationally, tens of billions of dollars

additional per year. Although this is traditionally a local or state responsibility I think that it cannot be done without federal help. Other areas of presumed federal responsibility for pre-college science education--such as curriculum reform, modernization and educational R & D would add additional billions of dollars per year. This presents a sizeable problem. In a rational environment, not necessarily forthcoming in the near future, such a financial cost could be met by cutting back on no longer needed military spending. Actually, overall national security would be much enhanced if this federal money were devoted to such civilian national security needs.

Some Other Considerations

F. James Rutherford of the American Association for the Advancement of Science, the prime mover of Project 2061 referred to above, has some interesting suggestions in a paper prepared for the Carnegie Commission on Science, Technology and Government (which is engaged in an exhaustive, carefully prepared and eagerly awaited analysis, with recommendations for remedial actions, of our educational crisis). Rutherford makes a number of recommendations:

1. Creation of a National Council for Educational Excellence in Science, whose main responsibilities would be to coordinate the federal effort, to monitor progress, to keep the president, participating agencies, Congress, governors, and general public, informed on progress and to recommend ways to accelerate progress.

2. Creation of a National Educational Telecommunications Network which would, among other things, work with the private sector to orchestrate the design of the nation's technology capability.

3. Creation of a National Teacher Recruitment Task Force to

organize and coordinate a comprehensive effort to reach set quantitative and qualitative goals (e.g., some number of new teachers meeting specified national standards for the teaching of science and mathematics by 2005, a given proportion of which will be minority and female). In doing so, a program would be designed that incorporates the successful techniques of the military services (use of TV, visits to schools, incentives) and sports coaches (scouting, encouragement, incentives), reaches back into the junior high schools, and extends through undergraduate and graduate school.

4. Creation of an Education Reform Trust Fund, whose sole purpose would be to provide capital for serious, large-scale, long-term school reform on favorable terms. It might be modeled after the IMF/World Bank or New York City's MAC. It would provide long-term, low-interest loans from a capital reserve (that itself could be created in a variety of creative ways), or by guaranteeing commercial bank loans, or some mix of them, provided the borrowing state or city agreed to certain terms.

5. Creation of a National Library of Education, comparable to the national Library of Medicine, to provide similar services to those of the National Library of Medicine to educational professionals, learners, parents, policy makers, and the general public. Fortunately, many of the core ingredients already exist in the Department of Education. These include: The National Center for Educational Statistics, the Office of Research, the National Assessment of Educational Progress, the National Diffusion Network, the two programs for the support of innovation, and all of the Library and Learning Technologies programs.

It should be clear from the preceding account that our nation needs a clearly defined plan of action if we are going to meet the goals for reform of our pre-college education in science and mathematics by the year 2,000 or soon thereafter. Perhaps, the forthcoming report of the Task Force on K-12 Science and Mathematics Education of the Carnegie Commission on Science, Technology, and Government will help serve that purpose.

Conclusion

The report, "A Nation At Risk," initiated a decade ago, stated that "we must dedicate ourselves to the reform of our education system for the benefit of all." Emphasizing pre-college education, and the central role of science in today's high technology, internationally competitive society, the report made five broad recommendations for the improvement of education in our country. Although some progress has been made, the goal that these recommendations "be implemented over the next several years" has not been realized in substantial measure.

Improvements in pre-college education in science and mathematics are needed in order to provide (1) the needed number of scientists and engineers, (2) workers with the understanding and skills to manufacture, operate and repair increasingly complex technological equipment, and (3) widespread understanding of science (scientific literacy) among the general population. Numerous programs and proposals, including some from the corporate world (the focus of this book of essays), have been suggested and implemented in order to achieve these goals.

Emphasized in this essay are (1) the need to refashion the method by which we educate and reward our pre-college science teachers and (2) the central role of our federal government in establishing national goals and

standards and providing massive financial support for pre-college science education. Without these actions, I believe the attempts to solve our national problem of pre-college science education will fail.

In part II of this essay the important role of science centers in curriculum development, teaching students, and educating and retraining teachers is described, in particular that of the University of California's Lawrence Hall of Science (Figure 2). Also featured is the role of national laboratories, especially the University of California's Lawrence Berkeley Laboratory (Figure 2).

PART II

The Lawrence Hall of Science

The Lawrence Hall of Science, which Professor Marian C. Diamond serves as Director and I as Chairman, is an institution committed to improving the quality of mathematics and science instruction for pre-collegiate students. For over two decades the Hall has dedicated its superior resources as part of the University of California to the continuing battle against educational mediocrity.

The Lawrence Hall of Science was conceived in 1958 and built in 1968 as a memorial to Ernest O. Lawrence, the University of California's first Nobel Laureate and inventor of the cyclotron. As a dynamic research and educational institution, the Hall continues today, 23 years after its dedication in 1968 to focus its efforts on three main objectives:

1. To improve the quality of mathematics and science instruction for the benefit of pre-collegiate students through the development of innovative math and science courses and accompanying curriculum materials and teacher training services;
2. To augment the mathematics and science instruction provided by our schools offering special mathematics and science courses at the Hall; and
3. To enhance the knowledge, appreciation, and enjoyment of mathematics and science for the general public by providing the community with a math and science center.

For over two decades, the Hall has also provided innovative leadership in pre-collegiate math and science education through the publication of

major curricula. Millions of students and 100,000 teachers in the U.S. use LHS-produced materials. Curricula and exhibits developed by the Hall are currently used by schools and science centers in all 50 states and in over 30 countries. Each year, over 700 educators from around the world visit the Hall to learn new techniques to improve science and mathematics instruction. For the effective utilization of these programs and materials, the Hall provides comprehensive teacher training workshops and seminars. It instructs 20,000 teachers each year to improve their science and mathematics knowledge as well as their instruction techniques.

The Hall has about 300,000 visitors each year. It provides classes for over 50,000 students a year at the Hall and for another 125,000 children in schools within a 100-mile radius.

I would like to briefly describe a few of our many programs:

Industry Initiatives for Science and Mathematics Education (IISME) is a collaborative effort of the Lawrence Hall of Science and Bay Area industries designed to prevent attrition of our present science and mathematics teachers. This program selects excellent teachers to work in well-paid industry positions during the summer in order to familiarize the teachers and industry with each others' needs, problems, and successes. These teachers do real work--not busy work-- and have made significant contributions to their host companies as well as upgraded their knowledge of modern science. These jobs augment the teachers' annual salaries, thus helping to prevent permanent teacher job-shifting to more lucrative industry positions. IISME was created in 1985 by 14 Bay Area companies. Since then the Lawrence Hall of Science and sponsor companies, considerably expanded in number, have awarded over 400 meaningful summer jobs to high school teachers. IISME has helped create a nationwide

network of affiliated summer fellowship programs for teachers. IISME affiliates and "sister" programs now exist throughout California, and in 15 other states, and in Denmark. Many other internship programs are in formative stages.

CURRICULUM DEVELOPMENT:

Chemical Education Material Study (CHEM Study) is an integrated program of written materials and films developed to improve the teaching of chemistry at high school level, funded by the National Science Foundation. It emphasizes the discovery method and the experimental approach to learning. Materials from this program have been translated into 17 foreign languages, and are used throughout the world. The 24 films have recently been revised and updated.

Great Explorations in Math and Science (GEMS) is a curriculum development program originally funded by the Carnegie Corporation and The Mellon Foundation with equipment donations from Apple Computer, to finalize and disseminate, nationally, the Hall's well-tested science and mathematics instructional activities and lesson plans (pre-school through grade 9). GEMS also has received grants from Chevron USA, the Hewlett-Packard Corporation and the McDonnell-Douglas Corporation and, under a grant from the National Science Foundation, leader's workshops have been held throughout the United States. GEMS also includes some of the Hall's exhibits and their accompanying learning activities so these may now be used by other science centers and museums. To date, 30 GEMS teacher guides (used by 100,000 teachers to instruct 2 million students) have

been published, as well as two teacher handbooks, one leader's handbook, two exhibit guides, two assembly guides, and one parent's guide for use throughout the United States..

Science Curriculum Improvement Study (SCIS) is a course content improvement project that has developed a sequential, articulated elementary school science program. This program is based upon the structure of science as seen by contemporary scientists, is consistent with a current view of the intellectual development of children, and reflects the experience of elementary school teachers working with preliminary SCIS units. Developed in the late 1960s, it is now used in over 20% of the nation's elementary schools.

Health Activities Project (HAP K-8) is a science-based health program for students in schools. The primary goal is to help children understand that they are in control of their own well-being. The program is experience-based with extensive participatory activities including experiments, data collection, and analysis.

Chemical Education for Public Understanding Program (CEPUP) supported by industry and foundations, has been developed to increase public knowledge of toxic substances and hazardous materials and their safe use, storage, and disposal. This is accomplished, on a national scale, by developing modules of materials for junior-high-school-age students and the general public, setting up an on-site computer-based information center, and having available printed information and audio-visual materials for business, industry, and the general public.

TEACHER TRAINING:

Science for Science Teachers (S_4ST) provides upgrading opportunities for junior high school science teachers by increasing their science knowledge. UC Berkeley faculty and master teachers use a practical experiment-based approach to help these teachers return to their science classroom better prepared to develop positive attitudes among their junior high school students.

Institute for Chemical Education (ICE) teaches the fundamentals of chemistry to high school chemistry teachers during six-week summer institutes. Part of a national ICE program, the Hall works with teachers to teach the fundamentals and to increase teachers' familiarity with the use of instrumentation in chemistry. Lectures, discussions, and problem-solving sessions are also used to improve those teachers' abilities to teach chemistry.

EQUALS (operating at the elementary, secondary and postsecondary levels) encompasses programs for teachers, counselors, administrators, and parents. It promotes participation of students and adults, particularly women and girls (and minorities), in mathematics courses and computer education and encourages their interest and involvement in math-based fields of study and work. LHS provides teacher training through programs such as EQUALS to over 10,000 teachers each year. The network of educators at schools, universities, and colleges, and community agencies using these materials, methods and programs, extends throughout the United States, and includes Australia, Canada, Costa Rica, New Zealand, South Africa and Sweden. Over 50,000 teachers have participated in these programs since 1977.

Family Math teaches parents how to help their children

(preschool through high school) with math at home, informs parents of the role mathematics plays in their children's studies and career choices, and creates a family enjoyment of mathematics. The project provides training and curriculum materials (book and film) to help parents (over 40,000 families since 1984) and teachers establish Family Math classes in their schools. Nationwide in scope, the curriculum is also available in Spanish and Swedish.

STUDENT PROGRAMS:

Alliance for Collaborative Change in Education in School Systems/Cooperative College Preparatory Program (ACCESS/CCPP), established in 1980, is an effort of UC Berkeley and the Lawrence Hall of Science, and the Oakland and San Francisco School Districts, to strengthen the capacity of the Districts' middle and secondary schools to prepare minority students for college. University staff work daily at school sites providing a wide range of technical assistance, training, and student support to improve mathematics, English, and science curriculum and instruction; school management policy and organization; counseling; and parent involvement

Center for Multisensory Learning (CML) specializes in science and computer education for disabled students. CML staff conducts workshops for disabled students at the Hall, trains teachers to use the SAVI/SELPH (Science Activities for the Visually Impaired/Science Enrichment for Learners with Physical Handicaps) science program in their classrooms, and organizes special events that enhance opportunities for disabled students to enjoy science and technology experiences.

The Full Option Science System (FOSS) Project is an integrated teacher education and classroom instruction package for general education of grades 3 - 6. The instruction component is based on tested, reliable science activities from the SAVI/SELPH project. FOSS is an activity-based enrichment program using inquiry, problem solving, and collaborative learning techniques to build student understanding of important science concepts and relationships. The activities support a philosophy of learning that is based on multisensory observation, experimentation, and interdisciplinary application of ideas. Most important, however, the activities are easy to use and exciting for students. The same attributes that make FOSS activities good learning units for students make them good training units for teachers. Teachers will become confident, competent science teachers using the science content and methods of the FOSS activities. FOSS is one of eight projects recently funded by NSF under the Special Materials Development Solicitation. Encyclopaedia Britannica Educational Corporation is the publishing partner in this project.

Mathematics, Engineering, Science Achievement (MESA) program, supported by over 100 corporations and numerous foundations, school districts and agencies, is designed to increase the number of underrepresented minorities who graduate from high school with the mathematics, science, and English necessary to pursue math-based curricula in college. MESA's Pre-College Program operates in over 200 high schools and serves about 8,000 students in California. It provides study assistance; academic, university, and career advising; field trips; summer programs; and scholarship

incentive awards. Established 20 years ago, MESA has prepared nearly 40,000 (now over 14,000 annually) underrepresented minority students in California for careers in math-based fields. The SAT scores of MESA students are better than the national and statewide averages and 80% of MESA high school graduates go on to college, compared with 57% of all California high school graduates. MESA's university-level program, the Minority Engineering Program (MEP), is designed to increase the number of underrepresented minorities who receive B.S. degrees in engineering and related fields. MEP operates on about 20 UC and CSU and other campuses, involving about 4,000 students. It provides matriculation and university admissions assistance, tutoring, freshman transition programs, academic and personal counseling, career development and summer jobs, and financial aid and scholarships. The retention rate of MEP students is dramatically better than that of students who do not receive such support. The MESA program has been so successful that it has served as a model for similar programs that have been established in ten other states, including New Mexico, Maryland, South Dakota and Colorado.

This summary has included only a sample of the many curriculum development, teacher training and student programs at the Lawrence Hall of Science. The Hall also features, besides its instructive, interactive exhibits; a wide range of lectures, colloquia, and films; Saturday night stargazing; biology, chemistry, and physics laboratories and workshops; instructional classes; summer camps; family activities; Science Discovery Theater; party workshops; and other activities.

The Lawrence Berkeley Laboratory

The Lawrence Berkeley Laboratory (LBL), a multi-program national laboratory adjacent to the campus of U.C. Berkeley, is operated for the U.S. Department of Energy by the University of California. In its 60 year history, LBL has provided education and training to thousands of students and college faculty from across the country through opportunities to participate in forefront research and development.

LBL established a Center for Science and Engineering Education (CSEE) in 1987, consolidating newly developed precollege programs with ongoing undergraduate student, college faculty, and minority outreach programs. Roland Otto serves as Director of CSEE. Today LBL, along with eight other Department of Energy national laboratories and 30 specialized laboratories, is actively involved in precollege mathematics, science, and technology education reform, and revitalization. Programs include in-service teacher training, school system change initiatives, materials development, and student programs to attract, reward and retain students in careers in mathematics, science, engineering and science teaching.

TEACHER TRAINING:

Teacher Research Associate (TRAC) program is a research participation program for high school and middle school teachers at over 20 U.S. Department of Energy laboratories. For eight weeks in the summer of 1991, 35 teachers from 18 states, the Philippines, and Puerto Rico, worked at LBL as research associate members of a team of scientists, engineers, technicians and graduate students. These teachers had the opportunity to develop new skills and update their

knowledge in science and mathematics. They developed new materials for their classrooms, and prepared presentation teachers workshops for colleagues in their schools, districts and states. Since 1983, LBL has had over 150 teacher research associates participate in the program. LBL's pilot program in this area led to the establishment of the DOE-Wide Program providing over 150 TRAC positions annually. Teachers receive reward, revitalization and recognition through the program.

In partnership with the Lawrence Hall of Science and the UC Berkeley School of Education, over 200 Bay Area teachers annually attend the "Updating Science Knowledge for Instruction" seminars series. Four seminars are provide throughout the school year by outstanding scientists such as J. Michael Bishop, a Nobel Prize winner in medicine, one of last year's speakers.

STUDENT PROGRAMS:

High School Honors Program in the Life Sciences is a two week summer workshop for select high school students representing the fifty states, the District of Columbia, Puerto Rico and several foreign countries. Students have hands on experience with modern cell and molecular biology. This program is one of seven two-week programs at DOE national laboratories focusing on frontier science and technology areas.

The High School Science Symposium is a competition between teams of students from over 16 local high schools in which they are judged on presentations on science and society issues. The program was developed by the Lawrence Hall of Science and is sponsored by

LBL's CSEE. Laboratory scientists and graduate students serve as judges along with other scientists from the community. In the spring, a Science Bowl competition is held at LBL with the winning high school competing at the national level against other Department of Energy regional winners.

The Center for Science and Engineering Education provides coordination for after-school tutoring by LBL staff.

SCHOOL SYSTEM CHANGE PROGRAMS

Bay Areas Science and Technology Education Collaboration (BASTEC) is a school change partnership program. Following the the National Math/Science Education Action Conference at the Lawrence Hall of Science in October of 1989 (described in Part I), LBL joined with Lawrence Livermore National Laboratory, Stanford Linear Accelerator Center and Sandia-Livermore National Laboratory, and the Lawrence Hall of Science to develop a collaboration with the Oakland Unified School District. Since 1989, BASTEC has grown to include 23 Bay Area organizations, and university partners working to improve science and math education for all K-12 grade students in the District. Over 200 teachers participated in BASTEC sponsored workshops during the summer of 1991, including workshops to train teachers in the use of materials developed by the Lawrence Hall of Science, such as GEMS (described in the preceding section on the Lawrence Hall of Science.). Every one of the 92 schools in the District benefited from BASTEC programs by the end of the summer. A teacher needs assessment workshop and a California State Framework conference reached over 600 teachers in the first year. Mini-grants for field trips

and science lessons as well as a "Student Science and Technology Awareness Day" has provided over 3,000 students in the district with hands on science enrichment experiences. The Department of Energy has named BASTEC as one of its initiatives and provides foundation support for the operation and education programs through the Lawrence Berkeley Laboratory.

CURRICULUM DEVELOPMENT:

Research at LBL results in new images and information that are being provided to teachers and students through the development and dissemination of enrichment materials for the mathematics and science curriculum. An outstanding example is the **Contemporary Physics Education Project (CPEP)** which has developed the "Standard Model of Fundamental Particle and Interactions" chart and accompanying materials. LBL physicists are playing a lead role in the 18 member group of physicists and physics teachers comprising CPEP. The chart has been requested by more than 1,500 teachers from across the country and by many physics faculty from around the world. From the Center for Science and Engineering Education, over 2,000 education packets on topics such as the carbon dioxide and global climate change problem, scanning tunneling electron microscopy, and earthquakes, have been disseminated to local schools. Following the 1989 San Francisco earthquake, packets with the quake's seismograph were distributed to 500 elementary and middle schools in the Bay Area.

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Figures

Figure 1. Members of the National Commission on Excellence in Education with Terrel Bell (Secretary of Education) April 26, 1983.

Back Row: L. to R: Bill Baker, Robert Haderlein, Gerald Holton, Glenn Seaborg, Al Quie, Emeral Crosby, Charles Foster, and Anne Campbell

Front Row: L to R: Norman Francis, Annette Kirk, Margaret Marston, Yvonne Larsen, David Gardner, Terrel Bell, Jay Sommer, Shirley Gordon, and Frank Sanchez

Figure 2. Looking west, view of the Lawrence Hall of Science with the Lawrence Berkeley Laboratory immediately behind. In the background are the Berkeley campus, the City of Berkeley, San Francisco Bay and San Francisco.

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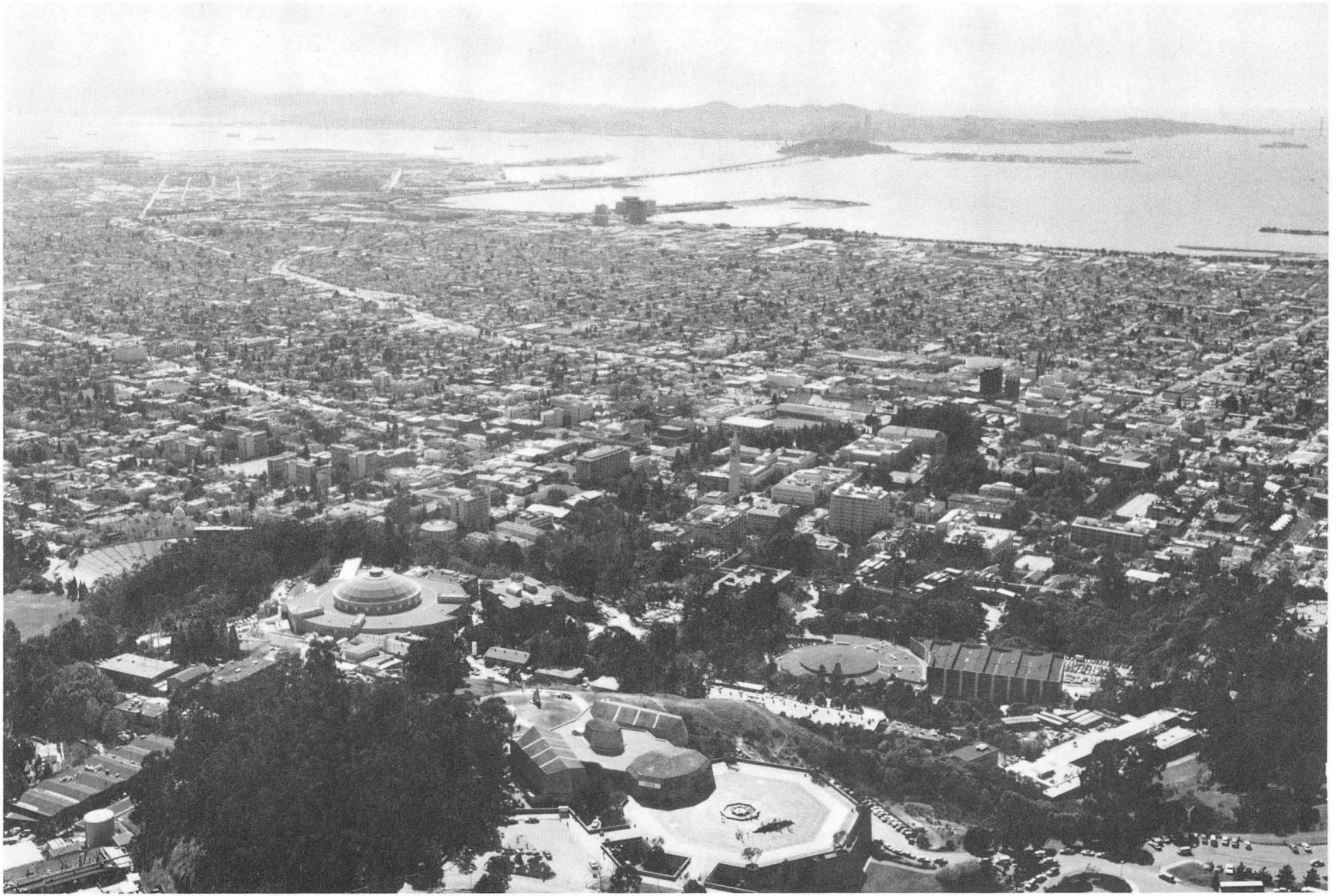

CBB 913-1672

Figure 2. Looking west, view of the Lawrence Hall of Science with the Lawrence Berkeley Laboratory immediately behind. In the background are the Berkeley campus, the City of Berkeley, San Francisco Bay and San Francisco.

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