In Search of Mr. Wizard

Presidential Address to the American Society for Clinical Investigation, Seattle, Washington, 4 May 1991

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Fellow members of the ASCI, members of the AFCR and AAP, colleagues, and guests. It has been a high honor and privilege for each of us, officers and councilors, to have represented and served you during the past year. I particularly want to acknowledge the dedication, hard work, and uniform excellence of our council members with whom it has been such a pleasure to work during this past year.

As you have heard, 250 physician/scientists were nominated this year for membership in this organization. The most challenging responsibility of this office has been to preside over the selection process for membership mandated by our By-Laws. The outstanding credentials of the nominees and the multitude of significant and productive lines of inquiry being pursued by each of these individuals might easily lull one into believing that our nation's scientific enterprise is thriving. Indeed, the intellectual riches so evident in the work presented at this meeting could easily perpetuate this view.

Unfortunately, considerable evidence argues otherwise. Samuel Coleridge once mused that, "In today, already walks tomorrow." I would submit that our biomedical research enterprise is not in good condition and is ill-prepared to confront the challenges we face in the next decade, let alone the next century. One might raise the question whether this should be a priority. Simply put, is it worth the effort? Although few in this audience would question the critical importance of an energetic, productive scientific community, this assumption is so critical to my subsequent remarks that I would like to digress for a moment regarding this point.

Leon Lederman recently suggested five major priorities which face our nation (Fig. 1) (1). These tasks—growth of new industry to increase quality of life, improvement of the general health in a cost-effective manner, elucidation of critical environmental/ecological threats to our future quality of life, development of alternative sources of energy, and enhancement of our culture by expanding our understanding of our universe and the place of humanity in it—are critically dependent upon research and development. There is little doubt that successful pursuit of these tasks will yield enormous economic benefits for our society. One need only look at the broad accomplishments of research and development since World War II to realize the enormous impact which scientific achievement has had on our daily lives (Fig. 2) (1). Such accomplishments lend credence to economist Edwin Mansfield's estimate that scientific research pays off material economic dividends at a rate of ~ 28%, clearly an attractive return by any criteria (2). The opportunities for scientific breakthrough in the next decade are even more staggering. Consider, for example, the list of critical technologies which the U. S. Department of Commerce has estimated will have an economic impact of over $1 trillion dollars by the Year 2000 (Fig. 3) (1). Are we to depend upon others to meet these developmental challenges? Hopefully not. Yet, a number of distressing trends indicate we may not be up to the challenge.

Two years ago Ron Kahn in his Presidential address eloquently established the case for a substantial increase in this nation's investment in science (3). More recently, Leon Lederman has argued compellingly for an immediate doubling of our investment in research to reestablish the dynamic vitality of our scientific enterprise, much as Vannevar Bush successfully argued for a substantial infusion of support for scientific research and development following World War II—ushering in a transient, but highly productive, "Golden Age of Science," which peaked in the mid-60's and has inexorably declined in the last two decades (1). While each of us undoubtedly supports efforts to substantially increase our national investment in research, I am convinced this alone will not solve more basic deficiencies which, unless resolved, will almost certainly cripple the leadership and achievement which is such a proud heritage of our nation's scientific community. I speak of a more fundamental problem rooted in the foundations of our educational system. Symptomatic of the problem is the extraordinary deficit of manpower in science and engineering which is estimated by the National Science Foundation (NSF) to approximate 400,000 BS degrees between now and the Year 2006 (4). Why such a shortfall? It might be argued that this reflects a heightened awareness by high school graduates of the funding inadequacies for scientific pursuits. Available data, however, suggest this is probably not the sole explanation. The problem occurs much earlier as shown in Fig. 4 which depicts the pipeline of students maintaining an interest in natural science or engineering and culminating in the successful pursuit of an advanced degree in science or engineering. These data clearly indicate the disturbingly small proportion of sophomore students in high school (less than 20%) who have an avowed interest in pursuing a career in science or engineering (5). Thus, the greatest fall-off in scientific interest occurs early in high school. Is it any surprise that scientific achievement in our country during these early years of education compares poorly to that of students in other nations? Indeed, in a test of knowledge in biology administered to 12th grade students in 13 countries, our students scored dead last (Fig. 5) (6). The enormity of the problem is further reflected in figures indicating that only 75–80% of high school students take a year of biology and a mere

Received for publication 13 June 1991.

J. Clin. Invest.

0021-9738/91/10/1063/04 $2.00
Volume 88, October 1991, 1063–1066

- Provide for new industry to enhance the quality of life of all our citizens
- Improve general health while containing costs
- Improve our understanding of the major ecological and environmental issues
- Develop alternative sources of energy
- Enhance our culture by expanding our understanding of the universe and our place in it

L. Lederman, 1991

Figure 1. Priority tasks faced by American society. From reference 1.

- Advanced materials
- Superconductors
- Advanced semiconductor devices
- Digital imaging technology
- High-density data storage
- High-performance computing
- Optoelectronics
- Artificial intelligence
- Flexible computer-integrated manufacturing
- Sensor technology
- Biotechnology
- Medical devices & diagnostics

Figure 3. Critical technologies. From reference 1.

15–20% take physics, chemistry, and biology (7). Even worse, taking biology in our present system does not ensure increased knowledge—indeed, a recent test of biology information given to 12,000 American high school students indicated that one-half of students who had not taken biology did as well or better than 40% of students who took the course (8). This is perhaps not surprising in view of the fact that the average student in American elementary schools spends approximately 30 minutes per day in science (9). These figures likely account for Jon Miller's data indicating that only 5% of Americans are scientifically literate. For example, roughly 50% of adults are unaware that it takes a year for the earth to circle the sun (10). Lest anyone regard this as a humorous matter, let me remind you that in 1986 for the first time in our nation's history we experienced a net trade deficit in high technology (11). At present, Japan captures > 50% of the superconductor market and > 90% of the market in dynamic random access memories, a key computer component (11). Moreover, ~ 25% of Ph.D.'s awarded in natural science and engineering in this country in 1986 were awarded to non-U. S. citizens (of whom approximately one-half remain in the U. S.). In the case of engineering, the number of individuals obtaining Ph.D.'s in engineering who hold visas currently exceeds the number of U. S. citizens gaining Ph.D.'s (Fig. 6) (4). Approximately one-half of the patents granted at present are to foreign residents (1). Industry is spending a staggering $24 billion per year to address the problem of technical illiteracy in its work force (12).

At a time when manpower needs are becoming increasingly evident, it is unconscionable that only 3% of all practicing scientists are from minorities. This intolerable disenfranchisement of a sizeable fraction of our society from participating in the scientific enterprise is even more disturbing when one considers statistics which indicate that by the year 2020, 43% of students age 5–17 years will be black and Hispanic, in comparison to 24% in 1982 (Fig. 7) (13). In the face of these facts, one would have to agree with the U. S. Commission on Excellence in Education in its report, *A Nation At Risk,* "If an unfriendly nation had tried to impose on America the mediocre educational performance that exists today, we might have viewed it as an act of war" (14).

Taken together, these disheartening data demand major restructuring of our educational system. We must do a better job of maintaining interest and achieving competence in science if we are to reverse this intolerable decline. Fortunately, our national leadership is beginning to reach the same conclusion. President Bush's commitment to establish our nation as number one in math and science in the world by 2000 is an encouraging first step. The private sector, faced with the expensive task of rehabilitating technological illiteracy of its employees, also shows encouraging signs of supporting this effort. David Kearns, formerly CEO of Xerox, now being considered for the No. 2 position in the Department of Education (under Secretary Lamar Alexander), recently wrote in *The New York Times* in December 1989, that there is currently no higher priority for American business (12).

Where should these efforts be directed? And perhaps more importantly, how can we determine which efforts are worth

- Semiconductors
- Solid state electronics
- Integrated circuits
- Computers
- Nuclear power
- Satellite communications
- Air traffic control
- Microwave telecommunications
- Long-range navigation
- Antibiotics
- Pesticides
- High strength alloys
- Titanium
- High-temperature ceramics
- Fiber reinforced plastics
- Medical diagnostics - CAT, PET, MRI
- Numerically controlled tools
- Powder metallurgy
- Genetic engineering
- Laser surveying, Surgery, Etc.
- X-ray lithography
- Particle-beam therapy
- Optical fibers
- Microprocessor controls
- Robotics
- Superconductivity

Figure 2. Partial list of technologies developed since WWII that are at the forefront of economic growth. From reference 1.

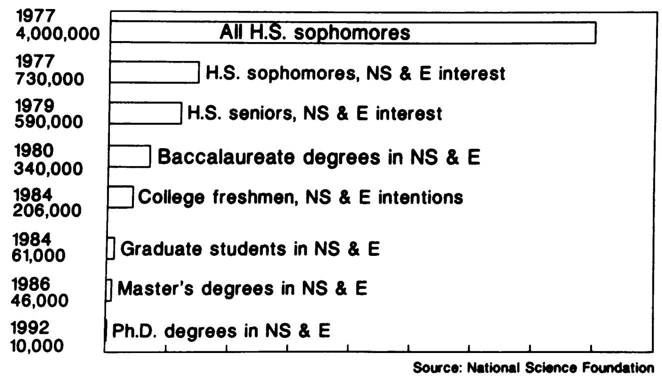

Figure 4. Persistence of natural science and engineering interest from high school (H.S.) through Ph.D. degree. From reference 5.

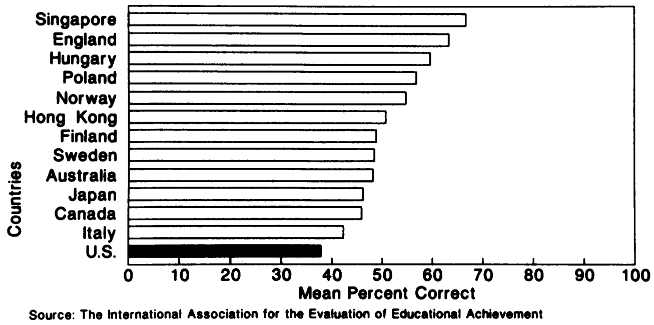

Figure 5. Grade 12 science achievement in 13 countries: biology. From reference 6.

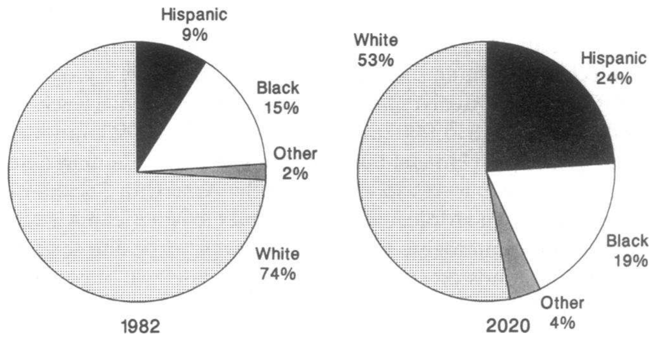

Figure 7. Distribution of students ages 5–17 yr old. From reference 13.

supporting? The marked drop-off in interest and competence in science during elementary and high school years strongly suggests that a major target must be our nation's math and science teachers and the curriculum they teach. Underpaid and underappreciated, it is no wonder that Benjamin Duke, author of *The Japanese School: Lessons in Industrial Growth,* suggested that the vast majority of U. S. high school teachers could not pass the student entrance exam for Tokyo Public Schools in math and science (15). Is it surprising that teaching science isn't considered a highly attractive career when one considers, for example, that in California for an average salary of approximately \$22,000, a high school science teacher may be expected to teach five classes per day, perhaps requiring three different lesson plans. A 60–70-hour work week is not uncommon (16). Inadequate facilities further aggravate the problem. Approximately one-third of 11th grade science teachers have no access to a laboratory but are rather asked to teach from outdated, unexciting, tedious textbooks.

While this all seems very depressing, the fact is that glimmers—indeed, points of light—are beginning to emerge which offer potential solutions to these critical problems. The National Research Council, under the auspices of the National Academy of Science, has recently proposed broad based reforms directed toward development of model curricula, teacher in-service programs, textbook reform, and laboratory exercises (17). Science education programs directed toward these goals are receiving substantial increases in funding from the NSF and Department of Education. As shown in Fig. 8, NSF spending for science education at the graduate, undergraduate, and precollege levels has reversed a long trend of decline and in 1990 approximated that of 1974, still a far cry from the "golden age" which I alluded to previously (18).

The need for more hands-on science exposure in early grades, at a time when our children are being turned off by our current approach, is broadly agreed upon. How can this be accomplished? Bruce Alberts has argued that, "Scientists have to take a lot of the blame for this (crisis in education). There has been no communication between universities and the public." He suggests, "What is required is no less than a revolutionary change in how we recruit people and support our science teachers, as well as an unprecedented role for scientists and science educators in designing and guiding such efforts" (6). Simply put, the buck stops here. Assembled in this auditorium are among our nation's brightest, most productive physician scientists. Despite the many flaws in our educational system, each of us became enamored with the fascination of science, presumably kindled and nurtured by one or more science mentors or teachers. Who could have a better perspective on the value of science education and insights regarding the communication of the excitement of science and its teaching than ourselves? I would submit that each of us needs to contribute more effort toward establishing needed partnerships between aca-

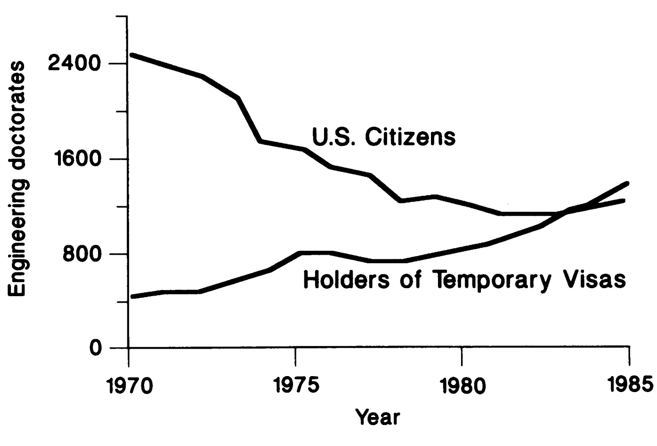

Figure 6. Engineering doctorates awarded to U. S. citizens and to the holders of temporary visas. From reference 4.

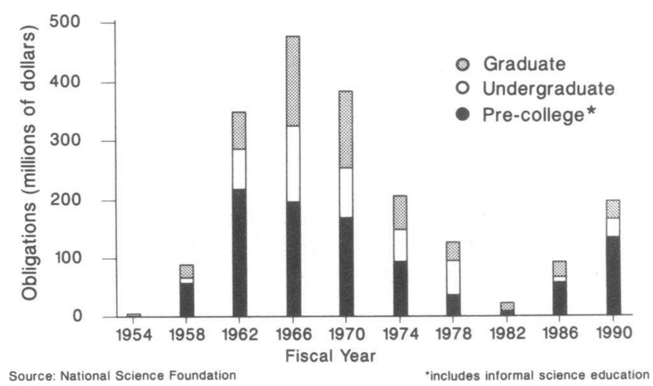

Figure 8. Science and engineering education obligations by level of education (in constant FY 90 dollars). From reference 8.

demic institutions and our nation's precollege science teachers and students. Programs at UCSF, Washington, Minnesota, and Cal Tech are forging such links. Support for Albert's program at UCSF which involves faculty mentorship of science teachers has grown from $15,000 in 1987 to $350,000 in 1990; funding from American Honda has contributed to this remarkable growth (19). Programs sponsored by the American Society of Biochemistry and Molecular Biology and the American Association of Immunologists are directed toward exposing science teachers to hands-on science with the ultimate goal of conveying the excitement of this experience to our nation's children. I am pleased that our organization, under the leadership of Vice President Joel Moss, has just this past year initiated a summer research program for science teachers involving members of our society as mentors. The initial response has been enthusiastic, far exceeding our most optimistic expectations. School systems such as the one in Mesa, AZ, have developed hands-on science kits which cost $5.60 per student per year (20). The private sector is helping: Upjohn has co-sponsored *Science Grasp: It's Elementary,* a program which trains small groups of elementary teachers in weeklong summer workshops and provides grant money so teachers can conduct in-service training programs in their home districts (6). Efforts are being directed toward reaching children at very young ages. Toyota and Georgetown University have launched an early childhood development center so that preschool children can learn about computers. Mandatory naps seem to be the only limiting factor.

Despite the encouraging emergence of a multitude of new initiatives intended to rectify the evident deficiencies in our current approaches to science education, we must be cautious about prematurely embracing any such effort as the ultimate solution. Just as none of us would favor unlimited support of biomedical research efforts in the absence of tangible accomplishment, we should not settle for any lower standards in our support of methods of science education. Resources must be invested for the development of acceptable criteria for measurement of success among these new initiatives. Judgement concerning support for and implementation of new approaches to science education must be based on evidence of effectiveness.

In closing, I refer to a man named Don Herbert, better known as television's Mr. Wizard, who for over three decades has masterfully utilized a hands-on approach to convey the elegance of science to bright-eyed youngsters. Using common household items, he has taught fundamental principles of science to a generation of young people, including I suspect some in this room. I believe he embodies the essence of the philosophy of education stated by Dr. Roger Rowe of the Rancho Santa Fe School in California:

> "Education is . . .
> to be aware of the uniqueness of each individual and to treat that uniqueness with loving concern. To provide each student with the opportunities appropriate to his or her abilities and interests. To encourage each to develop an 'I will, I can' attitude. To help kids go a step above and beyond what they, themselves, or others might expect of them."
>
> —Dr. Roger Rowe,
> Rancho Sante Fe School,
> California

Our goal must be nothing less than to identify, nurture, and reward the Mr. Wizards in our nation's science classrooms. Surely our children, nation, and future prosperity demand nothing less.

Thank you.

Acknowledgments

The author wishes to express his appreciation to several colleagues in the Division of Clinical Immunology and Rheumatology at The University of Alabama at Birmingham for many helpful suggestions: Drs. Mary Ann Accavitti, Gene Ball, Steffen and Renate Gay, Ken Hardy, Louis Heck, and Larry Moreland. I am particularly indebted to Mr. Dennis Watts for his enormous assistance in developing this address and to Ms. Evelyn Rogers for processing this manuscript. Most of all, I wish to extend my appreciation to my wife, Lilliane, and children Benjamin, Anna, Rebecca, and Steven for their endless love, encouragement, and support.

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