PART 1

The 2001 William D. Carey Lecture

In his book *The Two Cultures*, C. P. Snow expressed concern about what he saw as a widening and worrisome chasm of misunderstanding between scientists and intellectuals. This mistrust has not been confined to scientists and intellectuals, but has spread to include the general public as well as many policymakers. One of the most articulate advocates for the need to narrow the gulf between the science and policy cultures has been Neal Lane. In many of his writings and presentations, Lane has expounded on the need for members of the science community to become "civic scientists" in order to reshape and recast the role of scientists and engineers in society.

Widely regarded as a distinguished scientist and educator, Lane has exemplified the "civic scientist" throughout his career in both academia and public service. He served President Clinton as assistant to the President for science and technology and director of the White House Office of Science and Technology Policy, from August 1998 to January 2001. Prior to that, he was director of the National Science Foundation and *ex officio* member of the National Science Board, from October 1993 to August 1998. In his role as educator, Lane has been provost, university professor, and professor of physics, space physics, and astronomy at Rice University, as well as chancellor of the University of Colorado at Colorado Springs.

Lane has written widely on issues in science and technology policy, as well as theoretical atomic and molecular physics. He has received numerous prizes and awards including the AAAS Philip Hauge Abelson Award, and has been a two-time recipient of Rice University's George R. Brown Prize for Superior Teaching. Lane has contributed to public service throughout his career and has participated on review and advisory committees for many scientific and professional organizations and federal and state agencies. He is a fellow of AAAS, the American Physical Society, the American Academy of Arts and Sciences, the Association for Women in Science, and a member of the American Association of Physics Teachers.

In his 2001 William D. Carey Lecture, Lane discusses the challenges the science community will face in the future, specifically concerns over

future of the R&D budgets, and the health of the S&T workforce. Speaking on the importance of science and technology to the economy he says, "I believe it is our task not just to support those who are already fighting for science and technology funding—and they surely need our help—but also to actively seek out those who are passive and often uninformed about the role of science, engineering, and technology in ensuring our national economic health."

The importance of S&T to the economy is not only a matter of increasing funding of R&D programs, but extends to the well-being, scope, and excellence of the workforce. Lane believes that if the U.S. fails to maintain a first-class, technically skilled work force it could "make America a second-rate nation within a generation." He writes, "We must utilize the untapped resources in our population to keep the nation's S&T index at its highest, and ensure our economic prominence for this century and beyond."

Lane closes his cautionary chapter by reminding the S&T community that expectations for science and technology are higher than at any other time in history, and that much is being asked of them. He entreats the community to exhibit more leadership, to change the way science is perceived by students and taught in schools, and finally to turn its attention to social problems. He concludes by reminding us, "In a very real sense, science is an economic, social, and environmental safety net for our global future."

"Talking Turkey: Science, the Economy, and the Community" was presented as the twelfth annual William D. Carey Lecture in Washington, DC, on May 3, 2001. AAAS established the Carey Lecture in honor of Bill Carey on the occasion of his retirement as executive officer of AAAS, a post he held from 1975 until 1987. During his tenure, Carey catalyzed the study of the role of research and development in the federal budget and introduced initiatives that now form much of the landscape of the current AAAS programs, including publication of this *Yearbook*.

The Carey Lectureship recognizes individuals who exemplify Bill Carey's leadership in articulating public policy issues that are engendered by the application of science and technology. Lecturers are selected by a distinguished advisory committee.

1 Talking Turkey: Science, the Economy, and the Community

Neal Lane

This chapter will focus on the scientific community's responsibility for a special brand of leadership in this country. As Will Rogers (a fellow Oklahoman) once said, "If you're ridin' ahead of the herd, take a look back every now and then to make sure it's still there!"

I also borrowed from the vernacular of Will Rogers for the title of this chapter: "Talking Turkey: Science, the Economy, and the Community." I want to discuss some leadership challenges that I believe we face as a community and that we do not quite know how to handle. I will touch on three areas: 1) science, politics, and the budget; 2) the future science and technology (S&T) work force; and 3) the international dimension.

A Stunning Time of Discovery in Science

Science, today, is in top form. This is a stunning time for scientific discovery in almost every field—from dark energy, to a genomic revolution, to molecular computer switches in the world of nanotechnology.

The United States was one of the primary builders of the modern world, a world driven by science and technology. It is chapter and verse of our collective history to recount scientists' knowledge and expertise in helping to win World War II. This led to a new post-war initiative. Under the tutelage of Vannevar Bush, the federal government planned to harness the resources of science for peacetime objectives.

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Now we are competing with many who have succeeded on a similar path or aspire to do so. Prosperity in an increasingly intense global economic environment requires not only being on the frontier in all the important fields but also creating the yet unimagined frontiers. Other nations have succeeded at this, initially by imitation, and later by redefining the playing field with new innovations at the technology forefront. It is a very different world today from that of Vannevar Bush.

Scientist and science historian Jacob Bronowski told us in the 1950s: "The world today is made, it is powered by science." Identifying society as science-based is neither high rhetoric nor casual anecdote; it is fact. Robert Solow, Edward Dennison, Alan Greenspan, Francis Narin, Baruch Lev, and an increasing list of economic scholars have shown us the fundamental change in macroeconomic drivers. Science and technology make a powerful cocktail that fuels roughly half of our economic growth. Other nations of the world have taken note of this fact, and they have not been idle.

But, It Is Politics as Usual

And yet, in the recent presidential campaigns and the heated public debate about the 2002 budget blueprint, it has been politics as usual, and science and technology were peripheral. This was not true in science policy circles, but those circles do not always intersect with the bigger beltway of budget topics. Those topics, amply covered by the media, range from the size of the projected budget surplus to protection of the Social Security Trust Fund, from the continued viability of Medicare to the appropriate size of a tax reduction. They also include defense spending, prescription drug benefits, education initiatives, and how to pay down the national debt.

Only in our small—and still seemingly separate—community of science and engineering, and those congressional committees (and subcommittees) with S&T jurisdiction, along with the trade media, has there been much talk about science. Yet it so clear to us that science is the powerful engine that drives the economic and technological underpinnings for everything on the list of national goals.

From early economics we were indoctrinated with the dogma of land, labor, and capital. We will always require capital, and today we desperately need a highly educated and technologically skilled labor force. "Land" has been replaced by the landscape of knowledge and information. Those same two critical components, capital and labor, must now

create economic growth and increased productivity through the landscape of science, engineering, technology, and innovation. One could be cryptic and say that research and development (R&D) powers the nation's economic engine. One could be even more cryptic and quote Allan Bromley in his op-ed in *The New York Times* in March, "No science, no surplus. It's that simple."

But, as we know well, science is about much more than economics. For example, we care about our health and that of our families. The government-funded human genome project was a bold undertaking, at least at the time of its formation. In parallel, the effort of Craig Venter and his private company, Celera Genomics, was a bold step in the private sector. Both groups recently published their respective versions of the first draft sequence of the human genome, which is 90 percent complete. We were humbled to learn that we humans have only 30,000 genes, far fewer than we had thought (even the worm has 20,000). Sequencing the human genome opens up a whole new world of biomedical research and potential new medical miracles of diagnostics, prevention, and treatment. It would not have been possible without the enormous advances we have made in microelectronics and computing over the years. Moreover, none of this would have been possible without substantial federal investments in basic research in physics, chemistry, mathematics, biology, and many other fields of science and engineering, particularly in universities. This is a point Harold Varmus, the distinguished former director of the National Institutes of Health, has made so effectively over the years.

But here is the puzzle. If this is so straightforward, such simple logic, why is not every Member of Congress and the Administration making this fundamental connection? Why are we hearing even from our friends on the Hill that we have to do a better job of justifying these research budgets, that our arguments just sound like "more is better"?

I have heard a multitude of budget issues discussed and dissected by policymakers and the media. But the connection of this budget or any other budget to the health of science and engineering in the nation is like the hippopotamus in the living room. It is bigger than life, but many still choose to deny its presence, or connection. The reality that technological innovation accounts for roughly half of the nation's economic growth is often ignored even though it has enormous implications for America's future. Do the politicians not believe such statements, or do they simply not care, because it is not something the people back home seem concerned about?

The Challenge Is Ours

This dilemma is not new. But the science and engineering community must take the lead in solving it. The rhetoric and rationale can change quickly in Washington. Sometimes, what you heard six months ago bears no resemblance to today's debate. But, as the English writer Aldous Huxley said, "Facts do not cease to exist because they are ignored."

We have said for a long time that science is bipartisan and has considerable public appeal. Science has loyal advocates, even champions, in both parties. And science does not really have adversaries, at least very few. But simply being bipartisan and popular with the public does not mean it is of vital interest to the constituents back home. Too many voters have still not made the connection between science and the prosperity of contemporary society. Too many still do not understand the simple logic of "no science, no surplus!"

I strongly believe that our community—the researchers themselves, the professional societies, and the CEOs of universities and companies that depend on new technology—will have to become much more engaged in the political process. We tend to believe that the obvious importance of our work and the demonstrated benefits it brings to society speak for themselves. It is my experience that they do not. We have a good story to tell, but the story has to be told. Moreover, it has to be sold. That is the political process, and it applies to federally funded science and technology just as it does to everything else taxpayers pay for. We need a tactical side to our approach to the White House, Congress, and the many organizations that thread their influence through the nation's capitol. This approach needs to complement the longer-term strategy, which is also very important, of engaging in a dialogue with the general public about science and technology.

Gro Harlem Brundtland, former Prime Minister of Norway, said in 1991, "For science to make maximum impact on society it must interact with politics, with democratic debate, and it must be geared toward defined needs. It is the responsibility of scientists to take an active part in the shaping and directing of our common future. To make full use of human knowledge, we need better interplay between science, politics, and public opinion." That sounds a lot like "civic science" to me.

I believe it is our task not just to support those who are already fighting for science and technology funding—and they surely need our help—but also to actively seek out those who are passive and often uninformed about the role of science, engineering, and technology in ensuring our

national economic health. Many policymakers and a significant segment of the population still do not get it. We know from surveys that the public thinks well of science; however, that does not mean they grasp the fact that our economic future depends on it, that the quality of their children's lives depend on it, that politicians should be elected or not, depending on their support of science and technology, and that "more actually is better!" Many still think of science as something that just happens, or worse still, a "gee whiz" luxury. We need to convince all of them that science is a hard-nosed necessity that should not be taken for granted.

I do not underestimate the fine and forceful work during the Clinton Administration of the science and engineering community, corporate leaders, coalitions, and nonprofit organizations who made the case for a more balanced, and therefore, more productive R&D portfolio. Their arguments were sound and their impact was substantial. They helped immensely to get the ball rolling in the right direction.

It does matter that science has good friends and no genuine enemies. But that does not erase the fact that too many just do not understand its fundamental role in the new economy.

It does matter that S&T is nonpartisan. However, that has not been sufficient to prevent the steep downward trend of federal R&D investment in science and technology. It continues to be a smaller and slimmer part of the whole (public and private) of R&D funding in the nation. This trend is particularly troubling in light of Francis Narin's bibliometric studies of patent citations, which show that government-supported science is a critical fount for industrial innovation. As economists learn more about science and technology, it would probably be good if scientists were more conversant with economics. I am not suggesting that the somewhat mysterious notion of knowledge capital is crystal clear to anybody. But what goes in one side and dramatically transforms and enhances what comes out on the other side, deserves studied attention. That is the kind of economic argument the average citizen can understand. And, we will have to help tell that story.

Also, it does matter that we have good collaboration with those who know the importance of science. But it does not make up for our avoidance of those who are oblivious to the contributions that science, engineering, and technology make. Perhaps we have been assuming someone else would do that. But I am not sure who that someone else would be.

The science and technology community has to lead this educational process. This is not a short-term effort. It is not about one budget cycle, or

even four. It is instead a cultural change for us, a new way to understand ourselves and our leadership role in society. The status quo is not good enough. Something has to change, if in fact we expect others to understand in a more comprehensive way the importance of science and technology, and if we are to begin to share some of the concerns we have about U.S. science and technology. Will Rogers comes to mind again. He said, "Even if you're on the right track, you will get run over if you just sit there."

The Future S&T Work Force

If there is anything that could make America a second-rate nation within a generation, it is the failure to provide for a first-class, technically skilled work force.

Do the American people really understand how much our economy has relied on talented men and women from other parts of the world who came to this country and added strength to our science and technology base? Their work fueled the innovation, productivity gains, and long period of economic growth we have all become accustomed to. Over the past decade, importing larger numbers of the finest minds from abroad may have seemed like a good idea to address a shortage of high-tech workers, but it was not a long-term strategy. Now, these talented men and women are returning home in greater numbers. Furthermore, the recent episodes of alleged spying at our weapons labs, during which outrageous exaggerations were made by Members of Congress and the press, has done serious damage to the nation's reputation around the world as a place of fairness, openness, freedom, and opportunity. We must continue to welcome the brightest and best to our shores, as this nation has always done. Indeed, that is what has made this country great. But, we have to grow the best intellectual crop we can on our own soil with education and training. This means raising the standards here at home, not only for high-tech workers but also for the work force in general.

In fact, the distinction between these two categories is diminishing. Daily existence grows ever more dependent on technology and the ability to maintain it. In short, the entire American work force needs to become a high-tech work force.

The Bureau of Labor Statistics indicates that over the next ten years the growth rate of minorities in the labor force will be more than three times the overall growth rate. Clearly, we need to increase the repre-

sentation of women and minorities in the science and engineering work force. For whatever reasons, white males have dominated the field for too long. *The New York Times* reporter, James Glanz, wrote in an April 1, 2001 article on global human resources, "As the global competition for the world's most precious commodity heats up, the United States could come to regret its neglect of native-born minorities and the educational system that develops their talents and provides them with skills."[1]

Representation of women and minorities is improving in many professions, but progress has been disappointing in the science and engineering work force. We must utilize the untapped resources in our population to keep the nation's S&T index at its highest, and ensure our economic prominence for this century and beyond. If pitifully few high school graduates know anything about science, mathematics, and technology, then this situation is not going to change.

How do we encourage more boys and girls, in all communities, to study science and mathematics? We have recognized for some time now that the best way to teach science is through the process of inquiry. That is why young boys and girls are attracted to science, at least until they get to school, where many find "inquiry" to be a foreign concept. That is also why not-so-young men and women choose research careers in science and engineering—inquiry is what research is all about.

Agencies, such as the National Science Foundation, continue to emphasize the importance of inquiry-based education at all levels and the integration of research and education in universities and colleges, encouraging institutions to build more research experience into the undergraduate curriculum. Research is about imagination, risk-taking, and complex problem solving.

Like no other activity, research provides the full range of experience and skills needed for successful and fulfilling lives and careers—discovery, imagination, excitement, creativity, discipline, dedication, design, analysis, synthesis, assessment, problem definition, and problem-solving, not to mention computing, electronics, and mechanical skills, and sometimes even plumbing. A person with those skills listed on his or her resume would be an asset to any organization that believes innovation is important.

There is something else wrong with our traditional approach to science education. One reason we see a pervasive disconnect between science and prosperity among the public is the absence of any kind of

historical context for science in our general education. We provide science courses, many of them excellent, and want all students to take them, but we do not connect science to the historical progress of the nation. The history courses do not do this either. The pivotal role that scientists played in World War II became the catalyst for major public funding of science in America. From that early action a critical chapter in American history has unfolded, but it has meager mention in American history textbooks. And, we do not read much about it in science textbooks either.

Many outstanding science students in our high schools do not know the origins and evolution of this significant force in our history and in today's society. So, it should not be surprising that most of our graduating science Ph.D.s have little notion of the total value of what they have learned and the diversity of careers available to them, perhaps even public service.

Stephen Jay Gould affirms this when he says, "…science cannot be separated if only because the primary motor of social reorganization throughout human history, from the advent of agriculture to the acme of modern industry, has been fueled by applied scientific knowledge."[2]

We owe it to America's future to ensure that science is taught in a way that recognizes how young people actually learn, and that science is finally able to take its rightful place in the history of our nation and of our world.

International Imperative

Finally, it is worth emphasizing that science has been an international exercise from the start. However, as the world has continued to shrink, to become more intimately connected through sophisticated systems of transportation and communication, the swift globalization of knowledge has created a web with the potential to draw nations and cultures together and to share benefits in a more equitable manner. The benefits that accrue from scientific knowledge are perhaps the most valuable and are, in principle at least, the most democratic.

Former Secretary of State, Madeleine Albright, expressed it more eloquently in a speech at the 2000 American Association for the Advancement of Science (AAAS) Annual Meeting. She said, "I want to forge a truly active partnership with the science and technology community. Science, perhaps even more than diplomacy, carries with it the hopes of

people everywhere who seek a future better than the past." That is a very strong statement, especially coming from a Secretary of State. It should lift our spirits and motivate us to work to make that better future come as soon as possible.

Bruce Alberts, president of the National Academy of Sciences, has been active in a similar realm. In 1995, through his efforts, an Inter Academy Panel was formed—a group of 80 world academies of science. A major goal of this initiative was to "increase the visibility and policy-making role of scientists everywhere."

All nations deal with common challenges—educating the young, ensuring safe water, protecting land for raising crops, fighting disease, promoting the safety of their populations in the wake of natural disasters, and many more. Nations must design their solutions to fit their social, cultural, economic, and geographic constraints. But a shared body of scientific knowledge can form the beginning of those many and varied solutions. History has shown that scientific communication can remain strong even when diplomatic relations have become severely strained.

At the 2000 National Academy of Sciences Annual Meeting, Alberts said, "It is not enough to recognize that every nation today needs its own scientific capacity—both to address local issues and to access the vast resources of world science. This science capacity also needs to be organized in a way that gives it a powerful voice—both with the public and with national policymakers. …In the 21st century, science and scientists will be judged on how well they help solve local and world problems, not only on how well they generate new knowledge."

Conclusion

I hope to convey three principal messages. First, we in the science, engineering, and technical community will need to exhibit more leadership and become much more involved with the public. We must become much more active in the political fray, telling the true story of the importance of science and technology to the economy and to our lives. We must sell science and technology in the din of competition for the attention of both the public and the politicians.

Second, we will need to take a much more active role in ensuring that the nation has the science and technology work force it needs for the

next century. That means changing the way science is perceived by young people and taught in our schools.

Third, scientists all over the world will be asked to turn their attention more to social problems. That will be true in this country just as it will in the rest of the developed and developing nations across the globe. Since we share many of the same problems, it stands to reason that we should solve them together. In a very real sense, science is an economic, social, and environmental safety net for our global future.

In 1998, I gave a speech at the 23rd AAAS Colloquium on Science and Technology Policy in which I talked about "civic scientists." What I am suggesting now is just another large step in that same direction.

Expectations for science and technology, many of them yet unspoken, are perhaps higher than at any time in our history. Much is being asked of the S&T community, and time is short. Our answer might be: "That's too much to ask!" But I believe that is an answer we cannot afford to give.

At the beginning of this chapter, I quoted Will Rogers on the subject of leadership, where he said, "If you're ridin' ahead of the herd, take a look back every now and then to make sure it's still there!" I am suggesting that as we, the S&T community, look back over our shoulders—it seems the herd is not all there. We have got a lot of strays to round up. And, it is time we got started.

Endnotes

1. Glanz, James. "Ideas & Trends; Trolling for Brains in International Waters." *The New York Times*, April 1, 2001.
2. Gould, Stephen J. "The Great Asymmetry." *Science* v279 (February 6, 1998): 812-813.