Washington Academy of Sciences Capital Science Conference
Luncheon Address
Washington, D.C.
March 20, 2004

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Thank you for inviting me to speak today. In Academy President Marilyn London's letter to me, she explained that one aim of this conference is to showcase the diversity and excellence of scientific research in the National Capital area. "This is of particular importance," she wrote, "because national science policy is made here and this large pan-disciplinary presence facilitates informed policy decisions." I certainly agree. All of the 70 people now assisting in the Office of Science and Technology Policy live in the Capital area, and most of them have been working here as science professionals for years. They link the White House to a network of scientists, engineers, and educators that begins in Washington and extends around the globe. Their expertise and awareness of the technical aspects of policy is essential to the successful execution of the government's business.

I myself grew up in the Capital area, and there is no question that my own attitudes toward science and public service were strongly shaped by the technical resources of this region, which were considerable even a half-century ago. So I thought it would be appropriate for a luncheon address to talk about that experience and, if I could, to draw some lessons from it.

My family moved to suburban Maryland after my father returned from military service at the end of World War II. In 1947 we moved to one of dozens of new communities that sprang up then to accommodate returning veterans – it was called "Woodlawn," just off what is now Route 450 across from the older community of Landover Hills. I entered second grade in a two-room schoolhouse in Lanham, then a rural area with no premonition of the Beltway that would eventually transform it. Along our short street of about two dozen houses lived 45 children with whom I grew and played and learned. I loved my time in the Lanham schoolhouse because I was thrown in with third and fourth graders whose work seemed much more interesting than mine. The next year I moved to the brand new Landover Hills elementary school, and as new schools were built almost yearly thereafter to accommodate the postwar baby boom, I eventually studied in five different schools in five widely different neighborhoods, ending up in Bladensburg High School just outside Washington to the northeast.

In those years we had no air conditioning, and my mother would take us down into the city, sometimes to a movie, but more often to the Smithsonian buildings where the large interior spaces and thick walls provided some respite from the ghastly Washington summer heat. I went from one glass-walled case to another on the upper floor of what is now the Arts and Industries building, pressing buttons to watch the

mechanized exhibits on manufacturing, mining, and machinery. These were intricate scale models of factories and industrial processes that you could watch for hours and literally see for yourself how the whole system worked. On the walls were samples of the tools, materials, and machine components involved, and detailed accounts of the subject. I was always fascinated by working models, and these dusty exhibits held a kind of magic for me. They reinforced a need I had to understand how things work, a need that has sustained my interest in science ever since. I will come back to the importance of museums at the end of my talk.

In 1954, on the advice of a neighbor, my father took me to the industrial exhibit accompanying an Atoms for Peace conference at the Shoreham Hotel. There for the first time I saw the instruments of modern science – gleaming pipes, detectors, complex wiring, and flashing lights. There was also free literature on nuclear reactors, nuclear weapons, and the instruments and theory of nuclear physics. I took home all the brochures and devoured them, and later that year made wooden models of a cyclotron for a 9th grade science project, based on what I had learned. I decided I wanted to become a nuclear physicist. The Atoms for Peace initiative had the same impact on me as the Apollo project did a decade afterward for many other future scientists. We were caught up in the excitement of discovering new things about nature, and using them to benefit all humankind.

It helped to have peers, not many but enough, who were also interested in science and math. The significance of technology in winning the recent war was not lost on us. We were much more aware then than now of nuclear weapons – how they worked, what their capabilities were, and what a difference they made in everything. We were conscious that a threshold had been crossed into a new world in which acts of men and women could disrupt the natural balance. Civil Defense, bomb and fallout shelters, were part of our curriculum in school, and we had not infrequent drills when we marched into basements, and crouched down against the concrete with our history books over our heads. This was the era of the Korean War (1950-53), the build-up of NATO, the appearance of thermonuclear weapons in the U.S. (1952) and soon after in the Soviet Union (1953), and the rise and fall of Senator Joseph R. McCarthy (1950-54).

We who lived in the Capital area did not realize how differently we perceived events of national significance from the rest of the country. It was not until I moved to California a decade later (1963) that I realized that the Capital Area newspapers are unique. In no other region is the news so dominated by the goings-on in Congress, or the personalities in the White House, or the depiction of events against an international background. In Palo Alto during my graduate school years, and later as a young professor in Los Angeles, I was more conscious of the corporate world than of government, even when the American experience in Vietnam went sour and student activism short-circuited academic life on many campuses.

In Washington, politics is in the air. The regionally based organizations that participate in the Washington Academy of Sciences conceive their roles differently simply because they breathe this atmosphere. Public service means national service, and

aims that might be regional in some other city become national in Washington. For a young person who grows up in Washington a career in public service has a different significance, it seems to me, than for others. As we assess the characteristics of our region, we should keep this subliminal force in mind. It is, at best, a force toward patriotism, statesmanship and world leadership. At worst it is a distraction that interferes with the mainstream responsibility every organization has toward its constituencies.

My high school was a regional vocational school with a small academic section, but it had an extraordinary science teacher, Mr. Dale Gerster, recently deceased. It was he who introduced us to the richness of the Capital Area science assets. He himself worked during the summer months at the Naval Research Laboratory, and he took his science classes there on field trips. I remember walking across the platform over the pool of water that moderated and cooled the NRL nuclear research reactor, looking down at the blue glow of Cerenkov radiation that illuminated the depths. (I had a chance to repeat that experience recently at the smaller reactor located across from the NIH campus at the Armed Forces Radiobiology Research Institute.) Because of Mr. Gerster's working relationship with NRL, it was easy for him to keep abreast of recent advances in the broad sweep of science then conducted there. Gerster also took us to the David Taylor Model Basin up the Potomac River from NRL, a laboratory whose measurements using scale models of vessels towed in a long tank were fascinating to a young audience.

Our high school participated in a national program to build and monitor arrays of Geiger counters linked electronically to record coincidence events from cosmic rays. This was also Mr. Gerster's doing. Not only did we learn about cosmic rays and particle physics, we also perceived in the most natural way that science is a global enterprise in which many people must communicate their results to make sense of large scale phenomena. Members of the high school science club wired up the electronics and submitted data in accordance with instructions sent out by the organizers to participating groups. Many analogues of this activity exist today, tied together through the Internet. NASA, in particular, provides excellent web-based school programs. But schools and school districts need to be aware of the opportunities, and they must have teachers who care enough to take advantage of them. We were lucky to have someone who knew and cared.

All our science teachers encouraged us to make science fair projects and compete in the Westinghouse Science Talent Search. The literature I found at the Atoms for Peace exhibit had started me reading everything I could find about quantum mechanics, including several books by George Gamow, then teaching at George Washington University. I decided to try to detect the influence of a magnetic field on the hydrogen spectrum (scientists in the audience will recognize this phenomenon as the Zeeman effect, which is not easy to observe, and indeed the resolution of my spectrometer was too coarse to see it, but I looked anyway). I made a grating spectrometer with an integrated film holder, and a power supply to make the hydrogen glow. But with the primitive glassblowing knowledge we learned in Mr. Gerster's chemistry class, I could not get the electrodes to embed in the glass of the hydrogen discharge tube (you can see that I was making the entire apparatus from scratch). Mr. Gerster directed me to the

University of Maryland chemistry department where an experienced glassblower introduced me to the mysteries of uranium glass, whose coefficient of thermal expansion is the same as tungsten.

The University of Maryland was important for our high school not only as a source of expertise and mentoring, but for its initiative in sponsoring science fairs and other competitions in math and science. I won a second prize, and two other classmates from Bladensburg were in the top five, including first prize, in 1957. John Toll was chairman of the physics department at that time, and I am sure he was an avid supporter, if not the originator, of some of these competitions. My project did not rise to the finalists in the Westinghouse competition, but the judges were kind enough to give me an honorable mention, and because I lived nearby, I was invited to activities in Washington normally enjoyed by the finalists. One of those activities was a lecture by George Gamow in the George Washington University auditorium, not far from the current location of the Office of Science and Technology Policy.

My successes in these and other competitions earned me much attention when it was time to apply for college, and I was lucky enough to receive scholarships to good universities. At Princeton I found that my high school preparation was unusually sound, thanks not only to Mr. Gerster, but also to a small group of teachers in math and science. During the summer preceding my final year at Princeton, I applied for a summer job, again on the advice of a neighbor, to the newly rising NASA Goddard Space Flight Center in Greenbelt. I worked with a small group studying thermal loading of scientific satellites. After graduation, weary from the demanding physics curriculum, and in debt, I worked at Goddard for a year before going on to Stanford to complete my graduate work. While at Goddard, I took graduate courses at the University of Maryland, and managed to pay off my debts. I was supported by a NASA Traineeship throughout my graduate years, and worked at Goddard each summer back in the Capital area.

I attribute my interest in science and my respect for the applications of science to the problems of society to the unusually rich environment of the National Capital region. The Smithsonian, the government laboratories, and the research universities provide resources for talented teachers like Mr. Gerster to draw upon to create a first rate science program with modest investments from school resources. The fact that all this science takes place in the Nation's Capital adds a unique flavor to the technical environment. I do not doubt that my attitude toward public service was strongly shaped by this "Capital area" effect.

One formative experience that I want to mention did *not* take place in the Capital region. In the early 1950's my parents took me to Philadelphia where I visited the Franklin Institute. I was impressed by the difference between the hands-on exhibits there which were clearly designed for instruction, and the collection-oriented or antiquarian style of the exhibits at the Smithsonian. While the natural history offerings of the Smithsonian include good accounts of the underlying science, there still does not appear to be any systematic presentation of the physical sciences. Where can we go in the Capital area to learn about the key laws of electricity and magnetism? Search in vain for

learning tools about the most important 19th and 20th century breakthroughs in physics and chemistry. Neither the Air and Space Museum nor the Museum of American History provides anything like the learning experience in these areas to be found in other major cities. When special exhibits on specific areas of physical science appear, the emphasis is on artifacts and social implications, not on the basic content of the science.

Despite its rich array of laboratories, universities, museums, and organizations, the Capital area is weak in the kind of instructional resource provided by the Franklin Institute in Philadelphia, the Rose Center at the Museum of Natural History in New York, or San Francisco's Exploratorium. Perhaps the public dimension unique to Washington has influenced our notion of museums to dilute presentations on the theoretical underpinnings of science with social aspects that are important but only peripherally related to the underlying science.

I am looking forward very much to the forthcoming inauguration of the Marian Koshland Museum to be operated by the National Academy of Sciences. Advertisements promise a balance in the exhibits between basic science and public policy issues. I hope this new resource will help fill a significant gap in the science offerings available in other Capital area museums.

Thank you for your patience during this somewhat self-centered story about the influence of the technical assets of Washington upon my own attitudes about science and society. The value of institutions makes itself felt indirectly and often over a long period of time. I have benefited in many ways from the rich environment of the Nation's Capital, and I am glad to be here once again, attempting to give back some of the value I have gained over the years. Thank you for giving me this opportunity to do so. Now it is your turn to ask questions.