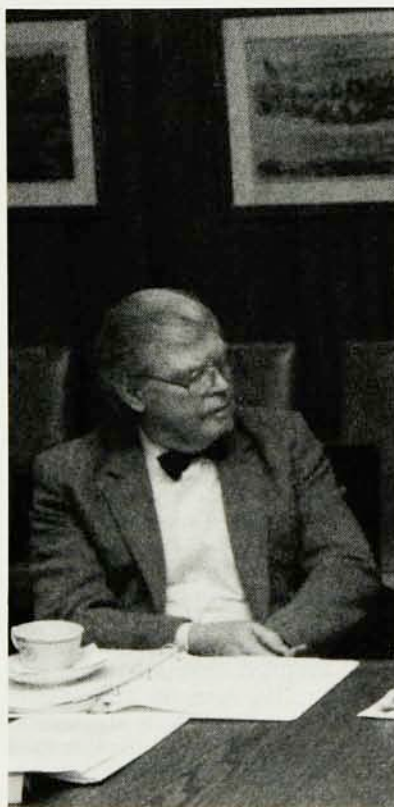


CONVERSATION WITH D. ALLAN BROMLEY ON MAJOR ISSUES IN SCIENCE RESEARCH

In early August, D. Allan Bromley will complete his first year as President Bush's science adviser and director of the Office of Science and Technology Policy. It has been a bitter-sweet period: Bromley has often been at the center of a cyclone of criticism about White House policies on global climate change and government support of new technologies in preproduction stages; he has suffered bumps and bruises from principal investigators whose grants have been curtailed by the National Science Foundation and the National Institutes of Health; he has brought, to his credit, a refreshing openness to science policies by his willingness to speak at public forums and to testify at hearings of Congress; and he also has developed the rudiments of a procedure for setting science and technology priorities in the Federal government by coordinating the program strengths (and weaknesses) of various research agencies with the Office of Management and Budget and the White House. Perhaps the most significant new feature that Bromley has contributed to the R&D scene is a sense of expectation—the promise of improvements for science education and basic research, which have been neglected for years.

Q. The plight is worsening for some of the most prominent and productive physicists, many of whom depend on the National Science Foundation for their research grants. Among these senior investigators there is widespread dismay—in some instances even desperation. And with the number of graduate students and postdocs increasing much faster than the available funds to support them, many are left adrift. If that's not bad enough, there are reports that some are unable to find permanent jobs at universities or in government and in industries. The problem of jobs appears to be a paradox. Until now, demographics and intuition told physicists of a



Bromley: Seeing R&D as it might be.

coming shortage. What are the Administration and its agencies doing to alleviate this panoply of problems during this period of budget restraints? Aren't the prospects grim for individual "small" scientists?

A. There are three points that are important to make: First of all, I think there is a growing recognition in the Administration and in the Congress that we are underinvesting as a nation in our science and technology base and the critical manpower that constitutes part of that—a very vital part of that base. Second, I believe that there is a general recognition that the problem of the support of investigator-initiated research, particularly in the universities, is one to

Throughout the following conversation with Irwin Goodwin, PHYSICS TODAY's Washington editor, Bromley expresses his views on issues associated with the legacy of pain caused by stringent government budgets for R&D and by increasing pressures for greater emphasis on applied research. In this Q&A, Bromley makes at least three points that are bound to have controversial implications: He suggests that grade inflation is beginning to appear in the peer-review process. He indicates that in the future most scientific megaprojects will begin as international partnerships, which will enable foreign scientists and governments to participate in a project's design, in deciding on its site and in its funding, management and operation. He also proposes to stress the precedence of "small science" and individual researchers in the fiscal 1992 budget—a matter of life or death to scientists who depend on government grants.

The conversation took place on 11 June in Bromley's spacious office in a corner of the third floor of the Old Executive Office Building, next to the White House. His office is dominated by a large abstract painting done by Cleve Gray. The Q&A was transcribed and edited by PHYSICS TODAY.

which we have to give very special attention during the coming year—and we will be doing that. The third thing is that I'm surprised at your statement that jobs are less available, because we're just beginning, now, to hit the retirement of the large bump in the age profile that came in during the Sputnik period, and universities that I've talked to are concerned about the very difficult time they're going to have in the future competing for the really outstanding people in teaching and research. There are going to be a lot of faculty openings, so the jobs will be there. Whether, in fact, people are going to want those jobs is uncertain, because it's clear that academic salaries will not be

competitive with industrial salaries. In fact, universities are already worrying about the shortages they're going to face.

Q. Is it possible that there is a lag between the demand that universities foresee happening in five to ten years and the realities of the here and now?

A. There may be a lag.

Q. We've received letters from postdocs who claim there is nothing for them in the academic and industrial worlds.

A. That, I believe, is an overstatement. One can't make a case based on a few anecdotes. What such letters usually mean is there is nothing in the specific subfield that the individual wants. The fact is, however, there are openings. At least people who come to see me on a regular basis tell me that they can't find the physicists to fill the jobs they want filled. There's a mismatch, I'm afraid, between the expectations, on one hand, of people who would like to get established in an academic career quickly and start their own laboratory or program, and the people, particularly in industrial areas, who really want someone to tackle a specific sort of problem that may not be considered very attractive by some candidates.

Q. Job opportunities dried up in aerospace fields in the 1970s and in energy research in the 1980s, and in each instance people fled, influencing students to abandon those fields. The situation was in response to market forces. Since the end of the 1970s, physics has experienced an upturn in graduate students, possibly because of the excitement of new discoveries. Are you saying jobs will be available to physicists when they enter the academic or industrial market?

NASA labs, but in the DOD laboratories, as well as in the laboratories of the defense contractors.

Q. Won't the DOE weapons labs be hit hardest?

A. They may be faced with a problem, but it's one that's been recognized. Admiral [James D.] Watkins [Secretary of Energy] is aggressively trying to develop new missions in which the very real resource that the weapons laboratory scientists and engineers possess can be redirected.

Q. What specifically does he have in mind?

A. One of the things that has been discussed is to ask some of the groups at Los Alamos and Livermore, following on the work that Lowell Wood [of Lawrence Livermore] has already done, to really look at some of the new technologies that might make a significant difference in the economics of our space activities.

Q. Do you mean technologies in the Strategic Defense Initiative?

A. Not SDI, no. Technologies for the space station, the Moon-Mars initiative and the commercialization of space.

Q. Let's return to the paradox I asked about earlier: At the same time that we're encouraging young people to become research scientists, the agencies are turning down grant applications by young people at an increasing rate. A recent analysis by John Crowley of the Association of American Universities shows that two-thirds of the 84 competitive research programs in NSF's five research directorates have decreased below the 1988 level in terms of real dollars. The agencies consistently report greater numbers of proposal approvals, but they are unable to fund many of the highly rated applica-

programs, supercomputing centers and computer networking. Despite the promise of a larger budget each year, overall funding at NSF has not kept pace. At NIH, the agency responded in recent years to the very justified requests from the community to increase the amount and the duration of the average grant. What these changes have done is to create a mortgage payable over three to five years—in other words, obligations that are coming home now—and to make it all the more difficult to fund new proposals. The second thing is that we are seeing here the most concrete evidence for the point I made earlier—that we are underinvesting in our science and technology base. I believe that in fact it would be one of the best investments we could make of taxpayers' dollars to increase funding overall, and that such increased investment not only would make it possible for us to support the ongoing proposals and the research work of people actively engaged at the moment, but also would allow us to maintain that balance of investment in future facilities that are going to be required five or ten years from now to enable those same investigators to reach the frontiers of their science.

Q. How much money would it take?

A. No one can really answer that question because we have a system that is almost insatiable in terms of its ability to absorb funding. What we're seeing now is that in many cases—recognizing the difficulties involved—people who in years past would submit one proposal are now submitting three, four or more proposals and, in that way, distorting the figures. We're also seeing, in some cases, review committees and study groups that only a few years ago would give approval ratings to something between 65% and 70% of the grant applications and now give proposal approval rates of 95% or better. This is not entirely a reflection of an increase in the quality of proposals but a recognition by these groups of the difficulties of getting grants funded and an attempt to tilt the balance toward the investigator. It's well meant, but in the long run it is counterproductive.

Q. Is this practice going to destroy the peer-review system?

A. No, because it's working at the margin. We're not suggesting that bad proposals are funded. But there is a bit of proposal-rating inflation going on.

Q. Something like the phenomenon of grade inflation in schools?

A. Just like grade inflation. It

We are underinvesting as a nation in our science and technology

A. One thing we have to bear in mind is that some 87% of all the scientists who've ever lived and worked in this country are doing it right now. I am concerned that as defense-related activities turn down, there will be some dislocation, because a lot of those industries have hired, over the years, a substantial cadre of physicists. I suspect that some of those physicists will find themselves unemployed.

Q. Mainly in the national labs?

A. In some of the defense laboratories specifically. Not in the DOE and

tions—only one in five grant applications in some subfields, or one in eight or ten in others. This is a frustrating situation. Some young physicists may just give up in such circumstances. You have said that the Administration will come to grips with this next year. How?

A. Several ways. First of all, recognize that one of the reasons for this problem at NSF is that the agency has taken on additional responsibilities in recent years. For example, its portfolio now includes greatly expanded science and mathematics education

doesn't mean that the ones at the bottom of the list are bad at all. It just means that normally they wouldn't have gotten quite so high a grade. I remember when a couple of my very distinguished colleagues at Columbia University were shocked because, after years of being supported by NSF, their grants were terminated. This was done in a very conscious fashion by the director, who felt that if he really meant what he had been saying, the most important thing to do was to support the brightest young people—and if the only way to do that was to cut off support from some people who had been supported by NSF for many years, then he was going to choose that approach. Of course, I have to suspect that sometimes a few truly spectacular candidates are cut out just to make a point.

Q. There are some notorious examples involving outstanding senior scientists who continue to be remarkably productive.

A. Yes, we all know such cases.

Q. Now the budget realities, which squeeze all the research agencies, are worsening this problem. Still, the Administration and its agencies are engaged in promoting more and more costly megascience projects. Is it any wonder that individual investigators are angry and agitated? Many scientists argue that the mammoth projects, as exciting as they are, simply divert funds from small research programs and cause disruptions in government agencies.

A. Two points: First of all, you know as well as I do that in this country the science budget is built from the bottom up. You don't get any megaprojects proposed unless they have a large constituency in the scientific community—a constituency that's sufficiently adept at convincing officials in an agency, in the Office of Management and Budget and in the Congress that what they want done is very much worth doing. One of the problems is that there is no similar constituency for the individual investigator. The time has come, I'm afraid, when these constituencies matter. Until recently we were in the happy position where almost every good idea eventually got funded—perhaps not immediately, but eventually. That certainly is not the case anymore. And it simply is not going to be the case unless the scientific community, broadly, is prepared to recognize that we in the Administration may propose support for science and technology—and I think in the 1991 budget we've done a good job of that—but unless that proposal meets with a favorable response in Con-

gress, we're not going to have the funds. Year after year, President Reagan and now President Bush have been trying to get the NSF onto a budget-doubling trajectory. The doubling request goes through various Congressional committees, all the way to the final appropriations action, where NSF and NASA are head to head with Veterans Affairs and Housing and Urban Development.

budget and on schedule. One of the requirements for that to happen is that no changes be introduced along the way. You can't keep redesigning and rebuilding a project as big and complex as the SSC as you go along.

Q. Isn't it likely that the science megaprojects will have wide support in Congress because, like many military systems and space vehicles, they have constituencies spread across sev-

We're not suggesting that bad proposals are funded, but there is a bit of proposal-rating inflation going on

When you have that situation, you confront politicians with an incredibly difficult choice: Veterans Affairs, representing the past, the commitment to our veterans; Housing and Urban Development, representing the present, the homeless and the needy; and NSF and NASA, representing the future. There aren't many votes in the future. And there is always a feeling, which scientists haven't been fully able to counter, that the future can wait.

Q. For most Congressmen, the future is only two years to the next election. That's a major factor in their decisions.

A. It's a factor.

Q. Large projects are often approved by a scientific advisory committee or a peer group for a specific purpose and at a specific cost. After a year or two many of those projects no longer carry the original purpose or the projected cost. This puts the scientists at odds with the politicians.

A. That's correct. But I think we have to bear in mind that the projects of the past cannot be considered as models for what we're trying to do now. For example, all the major accelerator projects up to the present have been built by physicists. SSC will not be built by physicists—for the very good reason that physicists tend to keep having good ideas as the concept evolves. The designers make changes and the costs keep escalating. Admiral Watkins recognizes that this can't happen to something the size and scope of the SSC. So when he comes in with his "scrubbed" budgets, which contain explanations of the assumptions and estimates on costs and schedules for constructing the project, it will be considered realistic. He has already made it very clear that the construction will be in the hands of people with a track record for bringing in large projects under

eral states—in commercial companies that build the facility and in universities and laboratories where participating scientists work? So the project develops a powerful alliance of industry, politicians, labor unions, business interests and so on. There is evidence that this is happening with the SSC.

A. It is entirely probable that contracts and subcontracts for SSC components will be spread very widely.

Q. The case of the space station is another example of what we're talking about. When it was first approved in 1984, it was an \$8 billion project and its purpose was microgravity research. Now the space station is seen as a loading dock for missions to the Moon and Mars, and its costs are out of control.

A. It's more complex than that, in a sense, because originally space station Freedom was to be, as you say, a laboratory for microgravity experiments. Then it was recognized that if we are going to really have a presence in space, if we're going to commercialize space, we have much to learn about the biological phenomena that astronauts and others will experience in long periods of life in space. So it was assumed that the space station would become the center for evaluating biological effects of long-term weightlessness. Then, thirdly, it is now being proposed as a node in a space transportation system. It is not at all obvious that one particular entity can really appropriately serve the conflicting requirements of those three missions. That's one of the problems: Trying to compromise the requirements of those three quite different missions.

Q. Are we committed to building space station Freedom?

A. The Administration certainly has a commitment in the sense that a number of our foreign collaborators have made major commitments on

their part, and I must say that they would be very upset were we to pull out at this point. In that sense, yes, we are committed to building it. And it is also quite clear that we really do need information about the three different functions. The difficulty that is being experienced is a reflection that the requirements, in many cases, are contradictory or antagonistic. At some point we may have to face the fact that a single system is not the most economical way to achieve the results we need—or want.

Q. Is the Bush Administration committed to building the SSC?

A. The Administration is committed, the Congress is committed, and I think there is no question that both will remain so. I think the only thing that could reverse its prospects would be a major surprise in the total cost of the project. You have to recognize that the costs we've been talking about so far have all been based on a conceptual design study. Admiral Watkins has charged two groups, independent of each other in the Department of Energy, to provide detailed cost estimates of the revised concept put together by particle physicists and accelerator designers. We have to wait and see the numbers that the Admiral has confidence will cover the full cost of the machine. At that point I fully expect the project will go forward, unless the costs have increased far beyond any present expectation. My understanding is that the Admiral expects to have those numbers available for the Congress by the end of summer.

Q. Even so, accurate cost estimates are not likely to be known until a chain of dipole magnets—the DOE says 10 magnets, but others, including you, prefer an array of 25 prototype magnets—is tested under realistic conditions in a section of the tunnel. And that test is still a few years off.

A. There will be two tests: If the cost estimates turn out to be much greater than anyone currently expects, then the SSC could lose substantial support in Congress and in the scientific community. That is clearly one of the break points. Another test is the successful demonstration that the magnets can be built for the machine. I'm quite convinced the project is doable. Expertise to build the magnets now exists in Japan, Italy and West Germany, as well as in this country. I'm quite confident the magnets will be reliable, reproducible and industrially manufacturable. The magnets are not a showstopper.

Q. Are you encouraged about the chances for foreign participation in the SSC project?

A. The exciting development that has occurred recently is that DOE, in its discussions with the Japanese and South Koreans, is approaching collaboration from a different point of view than it has in the past. It's not a question of inviting another country to participate in the design and use of

collaborating nations along with the EC have to decide on moving to the next phase, when we do the detailed engineering design. Thus far, I think it's been successful, in part because each of the collaborators has seen fit to send some of their best people.

Q. Is global collaboration involved

Admiral Watkins is aggressively trying to develop new missions in . . . the weapons laboratories . . . that might make a significant difference in . . . our space activities

our accelerator. It's a question of inviting them to take an equity position in this facility. That has all sorts of implications, as you can imagine, including, if the negotiations work out, accepting the responsibility of sharing the operating costs of the machine on an ongoing basis.

Q. Would that include the management of the accelerator and the associated laboratory?

A. And the management. I think that's an indication of what the future holds for major projects—that we'll start international discussions much, much earlier—before our own decision is made to proceed. And included in those discussions will be questions of creating the design, deciding the site for the machine—that is, which country and which exact location—as well as determining the management structure, how costs will be apportioned and so on.

Q. You're suggesting that scientific facilities in the future, if they're large and expensive, will be truly global—that is, world machines.

A. Absolutely. I think we have reached that stage, and the SSC allows us to break new ground—no pun intended—in establishing a new basis for international collaboration on major scientific projects. Design, construction and operation of these international projects may even require international treaties, with all that this implies.

Q. Is the proposed magnetic fusion machine, known as ITER, for International Tokamak Experimental Reactor, likely to be an example of what you are describing?

A. ITER has been, thus far, a very successful example. It involves a four-way division with the European Community, the Soviet Union, Japan and ourselves. We are now reaching a decision point, where we as a group of

in our Mission to Planet Earth and its many Earth Observing System satellites, which are supposed to provide a continual flow of data about our planet? The Administration and NASA consider this megaproject essential to understanding global climate changes. But the National Research Council, after examining the project, labeled it a turkey. Are we going to do it alone?

A. First of all, I don't think that's really a fair characterization—that it was called a turkey. That was a rather limited study, and I think there were some misunderstandings. But, clearly, from the very outset the intent was not that Mission to Planet Earth would be an all-American activity. The major feature of Mission to Planet Earth is the two polar platforms that would allow us to look at a spot on the Earth's surface with some 14 or 15 instruments simultaneously, depending upon the exact payload distribution. The problem up to now has been that when measurements are taken seriatim the data give you no idea what happened to the air column in between the measurements or to the cloud cover or to a number of other phenomena. The fact that you can make the measurements simultaneously multiplies the usefulness of those data by a factor vastly larger than the number of measurements that you make. Each of those platforms, as now designed, has space for 14 or 15 major instruments, and from the very beginning the assumption has been that although we may provide the platform, the instruments are going to come from Germany, France, Japan, the Soviet Union, the United Kingdom and Canada. It is going to be a truly international activity from which all countries are going to benefit, because, for the first time, this will give

us information on the entire surface of the Earth that will be valuable in ways that we can't even begin to imagine at this point. The fact that each of the participating nations will be able to downlink data and do with it what they will is, I think, critically important.

Q. Related to this, of course, is the vast Global Climate Change program. We seem to be out on a limb—virtually alone, now that [Britain's Prime Minister] Margaret Thatcher has accepted the report of her Meteorological Office calling for action now on chemicals that are adversely affecting the Earth's atmosphere, instead of going along, as she has up to now, with the US position that more study is needed.

A. Well, I'm not so sure. I think that much of this is a reflection of press accounts, both here and abroad, painting the situation as you've just described it. I believe that this country has taken a leadership position. Certainly, in terms of what we are investing in research—\$1 billion in our own Global Change Program—and what we are investing in actually doing concrete things to respond to global change, our responses are larger by at least an order of magnitude than those of any other country in the world. So the argument that the White House is dragging its collective feet on this issue is simply not true. What we are doing, on the one hand, is trying to understand as much as we can about the science and economics that must underlie sound policy formulation. At the same time, we are doing more than anybody else—I emphasize that—to reduce the possible adverse effects of greenhouse global change in the future. I look on our actions as an insurance policy. If you look at the source side of the problem, we're committed to phasing out both the manufacture and use of chlorofluorocarbons by the year 2000. That's well ahead of the requirements of the 1987 Montreal Protocol, both in time and in magnitude. CFCs account for 25% of our greenhouse gas emissions.

The National Energy Strategy, which Admiral Watkins has been instructed by the President to produce by the end of this year, has as its centerpiece the conservation of energy, specifically electrical energy, and that really is the only way we're going to reduce CO₂ emissions, which account for 57% of our total greenhouse gas emissions. So we're on track there to make a major difference. In addition, the clean air legislation will have a major impact on greenhouse gases. The Environmental Defense

Fund, as you probably know, has calculated that just the acid rain part of that legislation would correspond to removing a fifth of our automotive fleet—22 million cars—from the nation's highways over the next ten years. All that is on the source side. On the sink side, the President has proposed that the Department of Agriculture should plant a billion trees a year on private land to soak up 13 million tons of CO₂ per year.

We're also supporting a new \$100 million to \$150 million international fund to help developing nations phase out their use of chemicals that are eroding the Earth's ozone layer. Our contribution is likely to amount to \$20 million to \$25 million as part of a fund to be administered by the World Bank. You know that 54 nations, including the US, have now signed the Montreal Protocol, but many countries, particularly in the developing world, are not party to the agreement to phase out CFCs, and without their participation all other efforts could be frustrated. In addition, we're trying to convince, successfully in some cases, some of our foreign friends to preserve their own tropical forests. That will have a big impact on global warming. But we're doing it primarily to preserve the gene pools in the tropical forests.

We are taking action, we are doing research, but we do not believe that it is appropriate to undertake large mitigation programs until we understand that the programs are going to work and until we understand something about their real cost in terms of our society and our economy. One of the real problems here is that in order to design mitigation or adaptation programs, we need to have some confidence that we can do realistic regional prediction. We don't have that yet, although we can do global predictions.

I want to emphasize another point:

Until recently we were in the happy position where almost every good idea got funded

The working group of the United Nations's Intergovernmental Panel on Climate Change focuses particularly in its policymaking and executive summaries on the anthropogenic greenhouse gases. It doesn't talk about the natural sources and sinks of greenhouse gases that contribute 20 times more than human factors. It doesn't talk about what I think is a very important point—namely, if you

were bright enough to figure out how to modify the natural sources and sinks, which are, as I say, 20 times bigger, then a much smaller percentage change in those could have the same effect as a draconic change in the anthropogenic ones. I think we will need to study this much more than we have so far.

Q. When the Soviets were here for the summit in early June, did they produce any startling ideas as to what we might do collaboratively?

A. I don't think one would say startling. I think the important thing is that they are very enthusiastic about working with us in a great many areas, and I think we made real progress—not only at the summit, but at the US-USSR Joint Commission on Basic Research that met a few weeks prior to the summit. We have ten bilateral agreements now with the Soviets, and every one of these is picking up speed. I expect to see some very effective collaboration over the next several years.

Q. Some of those agreements are renewals of old agreements.

A. Some are renewals, but in almost every case the renewal involves an expansion of scope.

Q. While President Gorbachev and his entourage were in Minneapolis they seemed to accept an idea put forward by Robert Maxwell, the British publishing magnate and former member of Parliament, to establish a technology institute for US and USSR scientists and engineers. Further, there was discussion between Gorbachev and Bush about a US-USSR university, and some institutions, principally Rensselaer Polytechnic Institute and George Mason University, are taking the lead in making this happen. Then there is the agreement to extend and enlarge exchanges of US and Soviet undergraduates. Are such ideas moving forward?

A. I think every one of those is in

fact under way, but they're all under way as private-sector initiatives. I think this is a very important change. That was one of the things made very clear under this latest bilateral on fundamental research. For the first time in one of these US-Soviet bilaterals the program will be developed from the bottom up, rather than from the top down. We're encouraging the kind of initiative that Bob Maxwell

and Minnesota have taken, for instance, in arranging this center. The University of Minnesota, on its own, has organized a theoretical physics institute with private funding and is lining up five Soviet theoreticians to work there. The University of South

Carolina provides another example of

initiative in a joint collaboration for a new Soviet environmental institute to study the pollution of Lake Baikal.

South Carolina certainly will apply to NSF, or other appropriate agencies here, for funding that will allow them to participate. They've already raised a significant fraction of the entry fee of \$500 000 that the Soviets have decided is appropriate for that institute. I think we're going to see much, much more of this private-sector initiative between the two countries that will go a long way toward making cooperation much more normal.

The exciting development... is that DOE has invited Japan and South Korea... to take an equity position in the SSC... We have reached the stage of establishing a new basis for international collaboration in megaprojects

Q. On the subject of public versus private support of R&D, what are the Administration's specific objectives regarding new technologies and industrial competitiveness? DARPA has been involved in this and...

A. Is still very much involved.

Q. ...and there are some good examples in DARPA of the precompetitive generic technologies: VSHIC, par-

allel computers... High-resolution imaging, Sematech and so on.

Q. Indeed, the Pentagon has been generating new technologies for decades by funding light-water reactors for submarines, cargo aircraft, tele-

communications and so forth. What is the future of government support for new technologies?

A. Well, the President gave the most succinct statement of it in his speech on 7 March to the American Electronics Association. He simply said this Administration recognizes its responsibility in supporting the development of generic technologies where you go from the basic discovery up to the point of production and marketing. He looks on that as leveling the playing field for our industrial firms to compete against some of the foreign high-tech companies. So do I. And I think it's an area in which the government has a very important role.

It's an area where we in the Office of Science and Technology Policy are cooperating with the Department of Commerce, the Department of Defense, the Council on Competitiveness and a number of other organizations to try to develop a coherent US

position. We're not attempting to produce an industrial policy. It is a technology policy. And we think it's very important.

Q. Is there something in the works similar to the Agricultural Extension Service for new technology?

A. Yes. To the extent, for example, that we're funding what are really pilot programs—the Advanced Technology Program, the Manufacturing Research Centers—through the Commerce Department. If those are as successful as I think they're going to be, then they will be expanded substantially in the coming years.

Q. Will the National Institute of Standards and Technology—the agency in the Commerce Department that used to be called the National Bureau of Standards—have a greater role in the Administration's technology program?

A. Both of those programs—Advanced Technology and Manufacturing Research Centers—are in NIST, and I would expect that they will be of increased significance.

Q. Is NIST going to become, in effect, a civilian DARPA?

A. No. The reason DARPA has been as successful as it has been, in my view, is because it always had a clearly defined customer, and its decisions were based within that framework. One of the reasons that programs at NIST at the moment are in a pilot stage is because we want to avoid what could otherwise happen to a civilian DARPA—that it could very rapidly turn into a system where the funding decisions were under great pressure from the Congress and from external sources in favor of pet projects. That situation is to be avoided.

GETTING EVEN: DEPARTING NSF DIRECTOR OUSTS EDUCATION HEAD AND REORGANIZES

With only three months to go before he departs at the end of his six-year term as director of the National Science Foundation, Erich Bloch on 31 May deposed the person in the agency who had presided over the reconstruction of science education from the Reagan ruins of the early 1980s. The action removing Bassam Z. Shakhashiri, a chemist on leave to the agency from the University of Wisconsin, was viewed on Capitol Hill and in some education and science circles in Washington as maladroitness, mischievous and mistaken. Even after dozens of members of Congress and leaders in science education complained about the unseating of Shak-

hashiri, Bloch claimed he was too busy to answer directly and sent his legislative aide, Raymond Bye Jr, to calm the ruckus.

At a news conference hurriedly called on 1 June, only hours after *The Washington Post* reported that Shakhashiri had been removed from his post, Bye said Bloch wanted to consolidate many of the agency's education activities and decided to change the program's leadership. "The new directorate will help the foundation respond to the President's challenge to move the US into first place in mathematics and science education," Bloch was quoted as saying in a news release handed out at the meeting

with reporters. Bloch also noted in the statement that NSF's education and other human resources programs now account for more than 20% of the agency's budget. "They are a large and important responsibility."

It hasn't always been so. Shakhashiri arrived at NSF a few months before Bloch in 1984, after the agency's education directorate was virtually dismantled for ideological reasons by the Reagan Administration in 1981. The following year, spending for education was cut to \$16 million, mainly for graduate fellowships. Until the fiscal 1986 budget was prepared by Bloch and Shakhashiri, education programs relied on