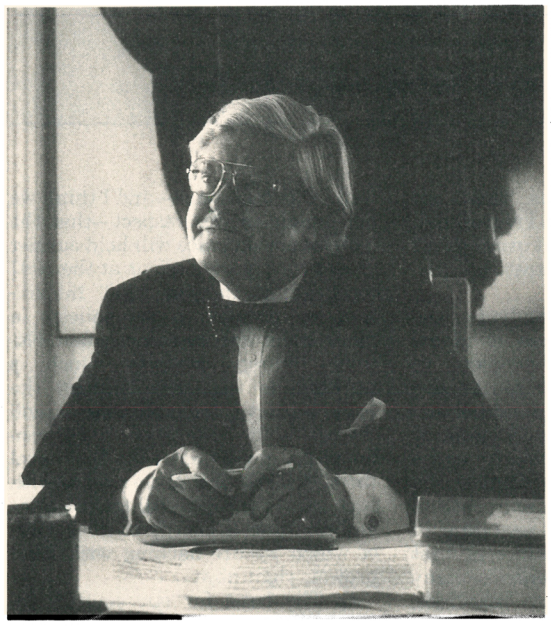
TALK WITH ALLAN BROMLEY: ON LIFE IN THE WHITE HOUSE SCIENCE FAST LANE

In early August, D. Allan Bromley began his third year as President Bush's assistant for science and technology and director of the White House Office of Science and Technology Policy. His arrival was marked by expectations of a revival in the fortunes of research and education. But the times were out of joint. Almost as soon as Bromley moved into his third-floor office in the Old Executive Office Building, next to the White House, he was confronted simultaneously by rising demands for funds and by increasingly tight research budgets. In the following edited conversation with Irwin Goodwin, PHYSICS TODAY*'s Washington editor, on 11 September, Bromley discussed the implications of government funding shortages for research as well as a wider range of subjects, including the need for the Defense Department to support academic research, the state of science in the Soviet Union after the failed coup in August and a new concept for joint US–USSR research ventures.*



IRWIN GOODWIN/PHYSICS TODAY

Bromley: Viewing science research and advanced technology from inside the sanctum.

Q. In your two years as science adviser to the President have you encountered any major surprises—that is, any unexpected or unanticipated events you hadn't figured on?

A. A great many.

Q. Any happy surprises?

A. I think the most striking one is the really outstanding quality of the people who have been willing to join me here in OSTP. And beyond that, the remarkable quality of the people that I have found throughout the Administration and within the Congress. I hadn't expected to find in the government so many people with such dedication and ability. That was very surprising.

Q. Were there any shocks?

A. I probably shouldn't have been shocked by this, but I was—that is, just how long it takes to make anything actually happen in Washington. As distinct from an industrial environment or even a university environment, where, if you are one of the senior people, you make a decision and you expect something to happen on a relatively immediate timetable, in government there are always so many other people involved—and quite properly involved, I might note—in any major new initiative or activity that it takes a very long time to really get everything lined up and in place.

Q. Has Washington been a pleasant or a sad experience so far?

A. On the whole it has been a happy experience professionally. I have found a real reservoir of support and general good will. I would say that the Congress in particular has been very prepared, with a few isolated exceptions, to be extremely helpful and supportive, to listen and to want to listen. We have developed, I think, some excellent dialogues with many of the senior people from both sides of the aisle in both houses.

Q. On occasion, though, you've been taken to task up on Capitol Hill.

A. That's understandable. It would be amazing if a Republican Administration was always in agreement with a Congress dominated by Democrats.

Q. One of the Administration's science policies that has agitated lawmakers is its approach to global climate change—the threat of warmer weather patterns and rising ocean levels caused by increases in "greenhouse" gases. Is there anything you could have done to avert the hostility in political and environmental circles? You have absorbed some of the heat, but most of it has been directed at John Sununu [the President's chief of staff]. What can you tell us about the Administration's apparent lack of action on this volatile issue?

A. The criticism hasn't been fair to John Sununu. He has functioned as a lightning rod, attracting a lot of the

heat away from the rest of us in the Administration. As to what I would have done differently, I think probably the only thing I would say is that we perhaps have not been as successful as we could have been in making clear to the public—and to the world in general—just how much progress the Bush Administration has made not only in understanding global change but also in actually responding with concrete programs and policies that are now reducing our net greenhouse gas emissions. This is not adequately appreciated. I regret that, because if I were doing it over again I would give the Administration's activities more attention.

> 'It doesn't help if the people who should normally be my allies and friends . . . are engaging in genteel cannibalism.'

Q. Well, our understanding of the causes and consequences of global warming isn't nearly complete, so there's time enough for you to give this matter the attention it deserves.

A. It's not over yet, and I intend to give it relatively high priority as we prepare for UNCED, the United Nations Conference on Environment and Development, to be held next June in Rio de Janeiro. The issues at that meeting of some 150 countries, many of them with differing resources, needs, aspirations and priorities, will deal with achieving sustainable economic growth while protecting the global environment and improving the quality of life and human health.

Q. Accounts in the popular and scientific press make it appear that the US stands alone on its position that we need not take any remedial actions before more conclusive research is done on global climate change. By contrast, the European Community and Japan favor adopting firm targets and timetables for stabilizing carbon dioxide emissions—specifically, holding these to 1990 levels in the year 2000.

A. There are countries like the Netherlands, for instance, that have been very outspoken in their desire to focus on targets and timetables for reducing carbon dioxide. We've taken the point of view that, first of all, it's much more important to take specific actions than it is to simply make promises. And much of the international activity I am afraid I would have to characterize as rhetoric rather than reality. In some cases, at least, the people involved really do not know at this point how they are going to meet the targets for which they have been prepared to make commitments. What we want to do, on the other hand, is to put programs in place in an orderly, systematic and flexible way, each one having a substantial impact on reducing our emissions of greenhouse gases and still being defensible on other grounds as well. Our position is—and I think we are unique in this respect—that the policies now in place will hold our net greenhouse gas emissions at the 1987 level through the year 2000. In addition, we propose to put policies in place under the President's new National Energy Strategy—which is working its way now through the Senate—that will enable us to extend the period for holding our net greenhouse gas emissions at the 1987 level through 2030. We would do this with such efforts as clean coal technologies and alternative energy sources, both of which we are backing with R&D projects right now.

Q. The issue for our country involves much more than effects on the planet's environment and on human health. Isn't it largely the economic implications? We would most likely suffer the greatest economic disruptions of all countries if stringent emission limits were now imposed.

A. If we were to make the kind of changes recommended by the European Community, for instance, it would have a major economic impact on several countries. There are a number of reasons why this is particularly true for the US. First of all, our distances are substantially greater than those in the Netherlands, so our transport system would need to find fuels other than the fossil variety. Second, the temperature range between our most northern and our most southern boundaries is much greater than in most countries, so that heating and cooling account for a substantial fraction of our energy supply, and this is reflected in carbon dioxide emissions. And third, one of the largest, if not the largest, user of fossil fuels in the United States is the Defense Department. The fact that for decades we have been carrying a significant defense responsibility for much of the rest of the world tends to be forgotten. It is clear that it is in our interest—and in fact in everyone's interest—to reduce emission of greenhouse gases. We are working on it, but we have not yet been convinced that there is a valid argument that says we should impose heroic economic penalties on our citizens in order to take specific, drastic actions—a heavy carbon tax, for example, or a much higher gasoline tax. In August, the National Academy's Committee on Science, Engineering and Public Policy released a report addressing the question of whether it is possible to adapt to any greenhouse effects. The COSEPUP panel [led by Paul E. Waggoner of the Connecticut Agricultural Experimental Station in New Haven and Jesse Ausubel of Rockefeller University] does not take it for granted that the optimum response is to try to prevent any change from taking place. We can always argue about the details of their conclusions, but it is interesting and refreshing to see the adaptation option to climate warming examined in a scholarly way and advanced by the academy.

Q. You have been spared from criticism by editorial writers and press pundits, but they have attacked the Administration for sponsoring what have come to be known as science megaprojects—space station Freedom, the Superconducting Super Collider and others. Do you chalk up the flak as fair criticism by a free press?

A. The press is fully entitled to say what it wants, but I think it has a responsibility to at least get its facts straight. There is no question but that there is substantial misunderstanding about the megaprojects. That's the way I would put it. It is perhaps most obvious in the case of space station Freedom. A few weeks ago, the Washington representative of The American Physical Society and I found our respective views appearing cheek by jowl in op-ed pieces in *The Washington Post*. As I said in mine, I am completely convinced that there is a misunderstanding about the entire issue. The question has not been—and is not now—a choice between space and science, nor is it between big science and little science. It's a competition between investing in the future on the one hand—and that includes the space station as well as investigator research and all of science and technology—and, on the other hand, building metro lines,

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parking garages and other good things that people want immediately. That's the real question being debated here, and frankly, it bothers me when the scientific community refuses to make common cause with something like the space station.

Q. Are you saying that the argument for the space station is similar to the justification of the Moon landing in 1969—that it should be done, spare no expense, to advance the country's prestige in the world, to promote our aerospace industry and to win the space race against the Soviet Union? Project Apollo was not undertaken for the sake of science.

A. In fact, President Kennedy's science advisory committee advised unanimously against sending astronauts to the Moon. In the present case the President asked me—and the Vice President asked me—to look at the rationale for building space station Freedom. After talking with industrialists in major companies across the country and after talking to representatives of the life sciences, it became quite clear that at this time there is no compelling justification to build the space station for access to zero *g* for microgravity processing or for life science programs. It is easy to argue that we can do better science on the Earth's surface.

Q. But you would not argue against the science community speaking out on this subject? After all, members of Congress as well as you and Frank Press [president of the National Academy of Sciences] have been urging scientists to get engaged in the political process.

A. Yes, that's right. But I think the science community has a responsibility to itself and to the nation to be a little better informed when it speaks out on political matters. The danger that I see is that in casting the space station as a "science versus space" debate, it becomes more difficult to sell to the Congress and to the Administration the need for continuing increases in the overall package of R&D investments in the future. What is happening now is that some scientific groups are trying to shoot down projects proposed by other scientific groups. There are people who are strong supporters of space exploration, and of the space station in particular, who may not intrinsically be strong supporters of science and technology but who have said all along, "It's an investment in the future and therefore I'll buy it." If they find that some scientists are out there gunning for their favorite project, there's a great tendency for them to say, "I'm not too sure why I've been backing these folks in the past, and if this continues it's pretty clear I'm not going to support them in the future." It makes my job more difficult and it makes the support of the whole scientific enterprise more precarious. It should be clear by now that money not spent on the space station, for instance, is very unlikely to be spent on other areas of science.

Q. The fact that science communities are at each other's throats is in large part the result of last year's budget deal made by the Congress and the Administration and the zero-sum game that agreement, the Budget Enforcement Act, left in its wake. Isn't that the reason for the warring factionalism?

A. I don't think so. It's not a zero-sum game. That's very important to recognize. It's zero sum as far as the domestic discretionary account is concerned, but even so we ended up requesting a 13% increase in R&D funding last year. That was done under the budget agreement. What it meant was that the White House found other programs we believed were less important than the programs in science and technology for which we requested increased funding. We had to kill other programs—programs for which there are vigorous and vociferous groups of supporters. It hasn't been a zero-sum game for science and technology. That's my point. I hope to be able to convince people that other things can be sacrificed to continue this growth of investment in science and technology. There is a deep feeling, both in the Administration and in the Congress, that as a nation we are underinvesting in R&D. I can build support on that, but it doesn't help if the people who should normally be my allies and friends in this are engaging in genteel cannibalism.

Q. Don't the spending caps put on at the budget summit limit the number of new starts and the amounts of money available for most R&D accounts in the agencies?

A. I don't really believe that at all. We have a large deficit in this country, and so the days are gone, at least for the foreseeable future, when you can simply go to the chairman of an appropriations committee in the Congress, sell your project and have it added to everything else at the end of the year. The budget agreement, I think most importantly, has now made it even more necessary for people to face up to the need to make priority decisions. But I absolutely do not believe it to be a zero-sum game for science and technology. We demonstrated that in the 1992 budget, and I believe that we will demonstrate it again in 1993.

Q. I'll come back to the priority decisions, but first, on the subject of the budget agreement, there have been suggestions by members of Congress that some money might be transferred from Defense Department accounts into nondefense science—say, to support logistics for the Antarctic program at the National Science Foundation. Is that realistic, given the fences put up around discretionary spending for defense, domestic and foreign aid accounts?

A. No, it's not realistic. As events in the Middle East and the Soviet Union have demonstrated, the world is not yet stabilized to the point where the major fraction of our citizens find it acceptable to reduce our military below what is already planned for the Defense Department. We have programmed a 25% decrease in funding for the Defense Department through 1995. My job, as I see it, is to work with Dick Cheney [Secretary of Defense], Don Atwood [Deputy Defense Secretary] and Victor Reis [Director of Defense Research and Engineering] and others in the Defense Department—and I have talked with them about this in detail—to make sure that as the total defense budget goes down, the fraction of the budget devoted to basic research and to applied research goes up—that is, programs in 6-1, 6-2 and 6-3A accounts. And we want to make sure that DOD funding for the university community goes up. There are several reasons for this: Increased contact with academic research is critically important, I think, because it will

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provide connections between the Defense Department and some of the brightest minds in the country. DOD needs that. It is a dangerous thing if those who are charged with protecting our democracy are uncoupled intellectually from all those particularly bright people who can help our national security. I also believe that research expenditures in the Defense Department need to increase—to protect us against technological surprises, as insurance against being blindsided by anyone. In contrast to the situation in the immediate postwar years, many other countries have developed very sophisticated technologies or have access to these technologies, including nuclear weapons and delivery systems, through third parties. We can't assume that we have the leading edge in every kind of military technology.

Q. Does your remark suggest that you are in favor of the Strategic Defense Initiative?

A. As the President has modified the SDI program, so that it isn't focused on protecting us against a massive ballistic missile strike from the Soviet Union but rather on the possibility of reacting to limited attacks from anywhere on the planet, yes, I support it.

Q. Let's return to the subject of setting scientific priorities, which is a hot topic in government these days. None of the scientific communities has been very successful, with the exception of astronomy, in establishing priorities for its own field. How would you encourage the rest of the research enterprise to do that?

A. I think the simplest way is to point out that the priority decisions are going to be made, and the various communities have a choice: Scientists will either make the priority recommendations themselves and hope the government will find it possible to act on them, or the priority decisions are going to be made by people here in Washington who have much less information and much less immediate ability to make those decisions. The research enterprise may not like the choices that emerge from the Washington process.

Q. The scientific communities themselves, though, are in disarray when it comes to reaching agreement on a rank order for science projects.

A. That's very true. You may recall that back in 1971, I ended up losing a fair number of friends by insisting that in the physics survey we worked on for the National Academy of Sciences we actually address this question of priorities. We actually listed all 160 or so areas of physics according to our best judgment of their priority value. There are still some people who are not terribly friendly as a result of that exercise. In retrospect, the physics survey that I chaired had a substantial impact on the way funding was allocated during the 1970s. The astronomers have been remarkably successful in fighting out among themselves what they wanted, in priority order, and they've gotten something like 60% or 70% of what they asked for. Part of the reason for this is that the astronomers have been able to paint a clear picture of where they were going, what they needed to get there and what they were prepared to sacrifice to secure their top priorities.

Q. There is a belief in some science communities, though, that they shouldn't sacrifice any facility or installation for the sake of new ones.

A. In the best of all worlds, I would agree with those people. Even very old facilities can turn out magnificent work if the people using them are really clever and creative. I had more fun working with the old, nominal 4-MV machine at Chalk River in Canada, to be quite honest about it, than I did with the first of the new forefront tandem Van de Graaff accelerators when we installed it at Chalk River. When we did anything exciting or original with the 4-MV machine, everyone said, "My God, look what they've done with those beat-up old pieces of equipment." And when we did good things with the brand-spanking-new tandem accelerator, everybody said: "Well, what did you expect? Just look at the equipment they've got to work with."

Q. There is a fear, though, that by supporting some of the expensive forefront facilities the government is siphoning money from individual bench scientists, those who, according to conventional wisdom, do the most innovative research.

A. The fear is real, of course, and it is justified in part. Each year, as we work with the Office of Management and Budget and the agencies to put together the President's budget, we go through a balancing process between, on the one hand, supporting today's scientists, engineers and mathematicians doing what they want to do today and, on the other hand, investing in the programs and projects that will take these same people, with their students, to where the frontiers are going to be five and ten years from now. Over the past several years we have tended to let the balance tilt a little bit toward the longer-term investments. So in the 1992 budget we have requested, specifically, a large increase for the National Science Foundation, and this appears to be going through the Congress in good shape. In the past, even when NSF got large increases institutionally, it was frequently the case that the brand-name sciences, such as physics, chemistry, biology and astronomy, ended up getting at most only inflation-level increases because together with the increase NSF got additional missions and areas of responsibility, such as the supercomputing centers and areas of pre-college education. This year, we have explicitly stated that we want a 16% increase down at the level of the basic sciences, so we are doing everything we can to ensure that NSF's university investigators get a substantial increase. We're never going to be able to get rid of all the pain in the research community, no way, because the rate of increase in the number of proposal writers far exceeds any possible increase in our R&D budget. Leon Lederman's proposal to double the science research budget is just not credible in today's fiscal climate. To do that we would have to kill a substantial fraction of the rest of the government's domestic spending. That's not feasible. Within the domestic discretionary budget, science and technology research and development spending makes up about 16% of the total. It's very visible and very vulnerable.

Q. In the last decade there have been significant funding increases for science R&D, but . . .

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A. But it hasn't been equal to the growth in the number of scientists. It's important to recognize that 87% of all the scientists and engineers who have ever lived in the US are alive today, most writing proposals, and fewer than 5% of the taxpayers are, on the same basis, here to pay for them. There is a fundamental disconnect there.

Q. Is this the main cause of the perceived malaise among scientists? There appears to be a lot of despair and disenchantment. Some scientists are even leaving their fields.

A. Yes.

Q. There are scientists who say they are no longer taking risks in their proposals. They're turning in proposals they know the program managers at NSF or DOE will fund. They're not seeking funds for some of the more creative and innovative things because the funding agency doesn't have the money for research where the results are unknown and uncertain.

A. There's no question that some of that is happening, and that's a loss to the entire country, as well to all of science. What it reflects is simply that our funds are limited. We can't do all the good things we'd like to do. But part of the answer, too, is that there is a feedback mechanism, and as young people hear their mentors and the leaders in their fields continually lamenting that the sky is falling—that, as my old Yale colleague Leon Rosenberg has said, "Medical research is burning"—this litany attracts the attention of young scientists. Frankly, I think it is very unproductive. What I keep trying to convince people to do is to talk not about the fact that people aren't getting what they think they should get from the government, but rather about the exciting opportunities out there that have come from the successes of science and technology in the last decade. These opportunities hold high promise of important returns to society. Highly talented people are ready, able and willing to work on these, but cannot for lack of funding. That's an argument that members of Congress—and leaders of private foundations—can respond to. But they don't respond well to arguments that contain vague hints of financial entitlements.

Q. To make room for young scientists to get grants, should we be retiring more older scientists faster, especially those at universities?

A. No! I don't think that age has much to do with creative ability. I have known people in their eighties who were enormously creative, and I know some in their thirties who are not. So I would never be in favor of an arbitrary age-based retirement, but I do think that it would be desirable to have creative early retirement programs both in industry and in academia so that people who find that they really have lost interest in research could, without substantial financial loss and without embarrassment, move into some other field or into another career that might be more exciting and valuable to them, making room, to be sure, for younger professional people.

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Q. Among the controversial science issues before you is NASA's $30 billion Earth Observing System, which is an essential part of a Presidential initiative called Mission to Planet Earth. The question is whether the EOS satellites should be clustered on platforms in space or whether they should be placed separately in space.

A. That question, I think, has been answered once and for all by the Frieman report [from a study headed by Edward Frieman, director of the Scripps Institution of Oceanography, conducted for NASA]. As one would have hoped, in the course of Frieman's deliberations the Department of Defense and the Department of Energy did declassify new technology that can have a substantial impact on EOS. And furthermore, the Defense Department has opened up the Western Test Range [at Point Magu in California], from which we can launch Atlas II's as boosters. The combination of the new pointing and formation flying technologies and the availability, for the first time, of the Western Test Range [for launches into polar orbits] makes it possible for us to think in terms of doing Mission to Planet Earth—a program that I believe is enormously important—without requiring the massive platforms we thought in the past we had to have to achieve simultaneity in our observations with EOS. Frieman's report for Admiral [Richard] Truly [NASA's administrator] is going to be extremely influential. It's going to allow us to do things that we weren't able to do before and to do them at less cost. We all owe Frieman and his panel a huge debt of gratitude.

Q. Another issue is the supercollider. Its critics say it will never be completed without foreign funding. Is that going to happen?

A. Yes, indeed. Just last night I held a meeting to plan our overall government effort to approach foreign governments as potential supporters for the construction of the SSC. I will be visiting Japan in mid-October as chairman of the US side of the US–Japan Joint Commission, and in November President Bush will be in Japan. Even earlier, Will Happer of DOE [its director of research] is taking a group of senior scientists to Japan for discussions with their Japanese colleagues, and in late October Admiral [James D.] Watkins [Secretary of Energy] plans a visit to Japan as well. One of the major items for discussion during each of these trips will be our effort to convince the Japanese not only to buy into the development of detectors, as they are quite prepared to do, but also to become involved in a major way in the construction of the SSC itself. We first proposed this about a year ago [when DOE's Deputy Secretary W. Henson Moore called on Japanese officials in several ministries]. The idea is somewhat novel for science projects: Henson Moore suggested that Japan buy an equity position in the SSC. That would mean that the Japanese would not only be part owner of the SSC but also share the responsibility for supporting the SSC on a continuing basis. Under this agreement they would be represented in the management of the laboratory. This idea is new for us. It moves us in the direction of internationalizing our science megaprojects from now on.

Q. Will you propose the idea of an equity share to the Prime Minister?

A. Last year Henson Moore delivered a letter from President Bush on this matter to the Prime Minister and

the President plans to have further discussions with him in November.

Q. Another country that has been asked to support the SSC is the Soviet Union, or whatever it is to be called now that the empire has broken apart. It is not likely that the republics, in their present state of upheaval, will contribute funds to the SSC project—though there may be a way for physicists to take part in experiments at the detectors. Soviet science is certainly on your agenda for many reasons, isn't it?

A. It is high up there.

Q. Is science collapsing there along with the central authority?

A. No, not science. Fortunately, a year ago we signed an agreement with the Soviets to organize a joint commission on research. I chaired this side of it, and Nikolai Laverov, who at the time was vice president of the Soviet Academy, head of the State Committee for Science and Technology and Deputy Premier, chaired the Soviet side. I was back in Moscow a few weeks before the aborted coup, and we made what I think is a major change in the way we intend to cooperate in science and technology. Up until that time the old Joint Coordinating Committee, of which I've been a US member since 1972, worked from the top down, as most everything did in the Soviet Union. Governments decided, "Here's the amount of money we're going to put into this program; here are the components of the program, and we'll select the people who will be doing the project." Together with Russian science leaders, we have made a very definite switch in the procedure in the last year and a half to a bottom-up, democratic approach. In this procedure we are encouraging individual Soviet scientists to make common cause with their American colleagues, and vice versa, producing joint research proposals. The National Science Foundation has many such proposals at the moment, and Laverov had put together a funding pool of several hundred million rubles so that the Soviet government could begin supporting joint proposals in a way analogous to our NSF.

Q. Would this operate through the Soviet Academy?

A. No, this was to have been done through the State Committee on Science and Technology—Laverov's operation. The Soviet Academy has its own program, operating in cooperation with our National Academy of Sciences. What we did was to establish funding procedures in both countries to support individual investigator activities, as well as institution-to-institution projects. The University of Minnesota, for example, has a number of contacts in the Soviet Union. The University of Miami and the University of North Carolina have similar connections. The University of Washington also has contacted corresponding Soviet institutions in certain specialties and worked out joint programs. As an example of an attractive research opportunity, the bottom of Lake Baikal, the largest freshwater body in the world, contains eight kilometers of undisturbed bottom sediments—vastly more than any other place. Togther, we are jointly probing those sediments and just beginning to get cores. There is a treasure trove of information there about Earth science over a very long period. To take another example: For reasons of tradition, technology and politics, Soviet scientists don't have good computers, but they have done a tremendous amount of excellent work in analytic mathematics and algorithms. Bringing that expertise together with our hardware is going to move scientific and technical computation forward in a major way. This is another area where we both have something significant to contribute. To cite one more example: The Soviets have superpure materials, including silicon, germanium and titanium, typically a factor of 100 purer than any available anywhere else in the world. There are a number of scientific programs where such purity is critically important, and we are beginning to develop specific research proposals and programs that will use these ultrapure materials.

Q. There is some apprehension in this country about the future of science during the reconstruction of the Soviet Union—or whatever it will be eventually called.

A. When we were in the Soviet Union there was no tension between the Soviet Academy and the State Committee. We met with both. In fact, we also met with [Boris] Yeltsin's people in the Russian Republic; we met with people in Kazakhstan; we met with a wide representation of scientists. As you might suspect, scientists tend to be somewhat apolitical in the Soviet Union, as they are here. They tend not to worry so much about who is running the shop as long as they have the facilities they want and the funds to do their research.

Q. Isn't there great uncertainty as to who's in charge of science?

A. There is no question that right at the moment there is uncertainty, and that's bad. One of the uncertainties involves the ultimate fate of the Soviet Academy. It is currently under some attack. Only yesterday I spoke with Yuri Ossipyan [Gorbachev's top science adviser] at some length about this. There are those in the Soviet Union who now feel that the perquisites accorded the academicians in the past are, perhaps, symbolic of the past and should not continue. There are also major questions of ownership of research institutions and facilities in the various republics. Still, the academy is a very important part of the international network of science and technology, and were anything dramatic to happen to it, it would set back substantially the kind of cooperation that is going to be critically important to moving the new confederation of republics—or whatever emerges to replace the Soviet Union—forward in science and technology.

Q. Is the Soviet Academy going to exist in the future?

A. I am quite confident the Soviet Academy will remain in some form and take an important role. There may be a transfer of some influence and power from the central Soviet Academy to the different academies in the republics, but scientific traditions are very strong in the country. Soviet scientists are not going to give up the traditions of the Soviet Academy. It may move closer to the US Academy in terms of conferring prestige on its members and advising the central government, as opposed to actually operating such a large fraction of the research enterprise.

Q. What the union needs is a James Madison or a Thomas Jefferson to put it all together.

A. The country could sure use at least one of them. Right now Ossi-

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pyan is in charge of science, and Yeltsin's senior science adviser, Yuri Ryzhov, can also be expected to play an important role.

Q. Can our science community help stablilize the Soviet science structure?

A. I believe so. I think it's going to happen not so much through any formal delegation of wise men and women, but, simply because there is a network of individual-to-individual and institution-to-institution cooperation already in place, there will naturally be a flow of organizational information that will move in parallel with the science linkages.

Q. Can universities be helpful in this regard?

A. Yes. One of the things that's going on right now is the development of sister-institution arrangements—where an American university and a Soviet university begin to share, on a detailed basis, administrative procedures and bureaucratic skills as well as scientific activity. It's also true that for the first time this fall there are a substantial number of Soviet students in graduate schools here. I know that my own university, Yale, has quite a number of Russian students in its graduate programs for the first time, and that's true across the country. That group, when they go back—and a lot of them, I am told, will go back—will transfer a treasure trove of information about how our system functions.

Q. Mikhail Voloshin of the Institute of Theoretical and Experimental Physics in Moscow, who is also at the University of Minnesota, has expressed deep concern that the scientific heritage of the Soviet Union may be dissipated by the turmoil there.

A. I've spoken to him on the same topic. I also talked to Guriy Marchuk [president of the Soviet Academy] recently, during his tour across the US—he received an honorary degree at the University of Oregon—and I asked him about the loss of scientific traditions and about a possible brain drain to the West. He told me—and he was quite confident about this—that the great majority of Soviet scientists in this country with whom he talked—certainly the established people—all told him that what they had in mind was staying here for a number of years to learn how the system worked, to develop their skills, to become comfortable with the technology and [then] to go back and establish their own schools—something to which the great Soviet scientists have always aspired. They felt that the Russian system gives them the opportunity to do this. Whether it will now or not, I don't know. What may emerge is more of an opportunity to establish schools, like the one identified with Lev Landau in theoretical physics. That's not the American system, of course. What they would like to do is adapt our technology and some of our approaches and to develop great—but highly personal—schools in various scientific fields.

'We are encouraging individual Soviet scientists to make common cause with their American colleagues, and vice versa, producing joint research proposals' to be funded by NSF or the State Committee for Science and Technology.

Q. It's going to require money to purchase the equipment, probably from the West or from Japan, and neither Soviet scientists nor the government has the hard currency for that. The government's primary concern now is how to feed the population in this winter of discontent.

A. That's true. There is clearly going to be a difficult period ahead. But Fred Bernthal [NSF's deputy director], who was with me in the Soviet Union in July, a month before the failed putsch, made it abundantly clear, repeatedly, during the trip that NSF was prepared to receive joint proposals from Americans and Soviets on exactly the same basis as proposals from Americans alone.

Q. Is Congress going to accept that?

A. I think so. The Soviets would reciprocate. Laverov and Ossipyan emphasized to us that their nascent NSF, with the pool of money that they had established, is entirely open to proposals from research groups that consist of Americans and Russians, Ukrainians, Byelorussians or citizens of any of the republics. We emphasized, however, that at this stage in our cooperative development we wanted joint projects; we would not be prepared right now to accept purely Russian proposals at NSF or purely American proposals in Moscow.

Q. Speaking of partnerships in science, there have been suggestions that the US should buy into the Soviet space program. Is that realistic?

A. It's under continuous discussion. It is not as simple as most people think. We learned during the Apollo–Soyuz mission that it is technically difficult and time consuming to mate hardware that is built on entirely different systems and principles. I think we may end up finding ways in which we can cooperate where large systems can be merged at the top of the food chain rather than trying to do things along the way. But it's something that is under continuing discussion, and Dick Truly has good communication with the people who have been in charge of the space program over there. When I was in Leninsky I had a chance to see a large fraction of what they had in the way of space hardware. The new Energia booster, for example, is beyond question a very impressive piece of engineering technology.

Q. Could we buy into the Mir II space station, as some have proposed?

A. We wouldn't want to. The Mir space station does not have what we would consider to be adequate instrumentation. It does not have good information storage or handling capabilities, and it fundamentally is not well suited to doing many of the things that we would like done in a space station. Its technology, after all, is more than a decade old.

Q. Could Mir provide the US with data on the biological effects of space on humans?

A. Unfortunately, the Soviets haven't gotten as much information in that field as we hoped they would. They have also not released all of what they have obtained. One of the things that we have learned only recently is that after extended weightlessness, the cosmonauts experienced some rather serious psychological problems, and those are not yet understood. Although the Soviets have had cosmonauts in orbit for extended periods—and they hold the record for time in spaceflight—they have not, for reasons we don't understand, chosen to make the spectrum of medical measurements that we would certainly want to make. One has to say that Mir is not really a suitable place for many of the things we want to do. The idea that we can rent space in Mir and forget about doing our own studies is not viable for that reason.■