STATE OF THE NATIONAL RESEARCH SYSTEM: ISSUES FOR THE NEW ADMINISTRATION

Proposed Remarks by Richard C. Atkinson

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These are challenging times for our country. Because meeting most of those challenges involves the wise use of science and technology, they offer a particular challenge for those of us who currently have stewardship for the national research system. For example:

o All of us were encouraged by the successful conclusion of the treaty between the US and the Soviet Union to remove intermediate-range ballistic missiles from Europe and are hopeful that agreement for a substantial reduction in strategic nuclear weapons can be reached within the next year or two. Yet these trends raise important questions about the future directions of US defense strategy, particularly its technological base.

o A few years ago, most of us were convinced that this country's scientific, technological, and economic preeminence in the world was unchallengeable. Yet despite our superlative scientific capabilities, we face increasingly serious competition not only from Japan and Western Europe, but also from several newly industrialized countries.

Regardless of the outcome of next month's election, the president who takes office in January will have to call on this country's scientific resources to help define and resolve these and other significant national problems - in the fields of agriculture, health, the environment, and space, to give only the most obvious examples. The effectiveness with which science can be used as a public policy tool clearly depends on the strength of the country's scientific resources, and therefore on the continued vitality of the university-based national research system. For that reason, the state that system, including its human resource base, comprises an important set of issues for the new administration.

I'm going to list and describe briefly what I regard as the most troubling of those issues, then comment on the capacity of the White House, as presently organized, to deal effectively with them. Frankly, I think that capacity is inadequate. So I'll conclude by suggesting some options to enable government - and science - to improve the situation.

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There is little doubt that US science today is as vigorous and productive as it has ever been, perhaps even more so. Yet resource constraints are limiting the productivity of our national research system and raising doubts about its productivity can be sustained. For example:

o Despite the fact that several studies conducted during the past eight years attest to the erosion of university research facilities, no solution to that

problem is on the horizon. In fact, estimates of the amount required to restore or replace inadequate facilities range from $2 to $4 billion.

o Individual, disciplinary research is severely underfunded. In 1986, the National Science Foundation was able to support only about 75 percent of those proposals that were in the top-rated categories, as judged by peer review panels. Even successful proposals were funded, on the average, at only 65 percent of their budget requests. The NSF estimated that an additional $800 million, or almost a 50 percent increase in its current budget, would be required simply to support all top rated individual investigator-initiated proposals at adequate levels. An even more substantial increase would be required to provide reasonable support to substantial numbers of new projects, particularly proposed by young faculty.

o Perhaps not surprisingly in view of the difficulty in obtaining research support, decreasing numbers of talented young Americans are pursuing graduate study in science and engineering. Well over half of all graduate students in engineering are foreign born, and the figures for physics, chemistry, and mathematics are comparable. University faculties have become heavily dependent on foreign-born PhDs to maintain their instructional and research programs. With 40 percent of tenured faculty in US universities due to retire by 1995, that trend is bound to continue. No one seriously questions the professional competence of these foreign-born faculty. But relying on a continuous supply of first rate people from abroad to maintain the viability of our research system is hazardous, particularly as working conditions for talented foreign born scientists and engineers continue to improve in their own countries.

Additional federal funds for graduate fellowships and for disciplinary research projects (particularly for young faculty), as well as a coherent nationwide program to arrest the erosion of research facilities, would be excellent investments in the nation's future. But obtaining even a modest fraction of the necessary funds will not be easy.

The Reagan administration's proposed budget for fiscal year 1989 (which began a on October 1) included a total of $64.6 billion for research and development, approximately 25 percent of the controllable part of the federal budget. Despite substantial Congressional support for science, a strong bipartisan consensus to reduce the federal deficit makes it very unlikely that that total can be increased significantly in the foreseeable future.

Of course reallocations within the total for R&D could make additional funds available to support the university-based research system. For example, although defense-related R&D has increased from 50 percent to 70 percent of that total during the past eight years, support for basic research by the Defense Department has not increased substantially. But even marginal readjustments within the total R&D budget or even within the budget of a single agency involve tradeoffs that are often politically difficult.

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During its first few months, every new presidential administration has an opportunity to reexamine the policy assumptions of its predecessor and establish new directions that is unlikely to reoccur. Here are some essential issues associated with the state of the national research system:

o A top priority ought to be to bring more coherence into the construction of at least the research part of the federal budget for R&D. Remarkable as it may seem, budget allocations are not presently made with a view toward optimizing the effectiveness of the overall federal R&D effort. Rather, annual budgets for each of the principal R&D agencies - the Departments of Defense and Energy, NASA, NIH, NSF, and the Department of Agriculture being the six most significant - are established in terms of individual agency priorities in negotiations with six uncoordinated units within the Office of Management and Budget (OMB). Nor are Congressional oversight and appropriations processes any more coherent; no fewer than nine appropriations committees have jurisdiction over separate parts of the total R&D budget. With strong presidential leadership and congressional concurrence, budgets could be devised and implemented with a view toward allocating federal R&D resources to the achievement of overarching, long-range national goals rather to the fulfillment of individual agency missions. Maintaining the vitality of the national research system is, of course, one of the most important of those goals.

o As one result of the uncoordinated federal budget process, several expensive science and technology "megaprojects" have gained presidential approval and have been granted at least some funding by Congress during the past few years. These megaprojects include the Strategic Defense Initiative, the National Aerospace Plane,

the Manned Space Station, and the Superconducting Super Collider. Partisans of another large project which involves mapping and sequencing the entire human genome have also been pushing their case vigorously.

I do not propose to debate the merits of these and other projects. Certainly persuasive arguments have been given by their proponents; otherwise, they could not have gained even provisional presidential and congressional approval. But regardless of their relative merit, it is remarkable that the total cost of pursuing them all or even most of these projects simultaneously seems not to have been considered seriously at the presidential level. An important issue for the new administration should be to establish priorities among competing megaprojects, and, equally if not more important, between support for megaprojects and the broad-based national research system.

o In addition to providing roughly 50 percent of the funds for R&D in the US, the federal government, through its non-budgetary policies, exerts an additional strong influence over the ways science and technology are conducted and used in this country. But formulation and implementation of such policies, including tax, regulatory, patent, and export control policies among others, rarely if ever take into account their likely impacts on R&D. In fact, those impacts are often inconsistent and counterproductive.

For example, a National Research Council study released two years ago estimated that differing interpretations of export control laws by the Departments of Defense and Commerce result in delays in granting export licenses that are costing the US approximately $4 billion per year in lost high technology trade. Ironically those

laws, as presently administered, seem only marginally effective in meeting their objective of denying militarily useful technology to the Soviet Union and its allies.

Tax, regulatory, and patent policies that provide incentives (or disincentives) for industrial investments in R&D have a particularly important bearing on both the strength and effectiveness of the national research system. For obviously the effectiveness with which industry exploits the basic research results of universities requires that it maintain adequate applied research and development capacities. Research undertaken cooperatively by universities and industry can also expedite knowledge transfer, particularly through the movement of people between the two sectors. However, although academic and industrial research interests frequently overlap, universities and industry have distinct goals and missions. For that reason, the new administration needs to understand that federal support for university research cannot and should not be supplanted even in part by industrial support.

o It is often difficult to believe that prior to the late 1940s, federal support for university research was a distinct rarity, and that a small but articulate minority of university scientists vigorously opposed accepting government research funds on the grounds that government support would inevitably lead to government control. Most although perhaps not all of their concerns were answered by means of a federal research system that has managed to preserve the autonomy of academic science.

But despite the fact that their autonomy has been preserved, research universities have become heavily dependent upon federal project support not only for their research programs but for their very existence. Yet the scope of federal

responsibility for the national research system has not been fully and openly discussed since the early 1960s when the President's Science Advisory Committee issued a series of three cogent studies on scientific research and education.

For example, should the federal government assume full responsibility for the state of the university-based infrastructure? During an era of expansion in the 1960s, there were specific federal programs to support the construction of new facilities. But there have never been any federal programs to replace or repair aging university facilities. Should government now assume that responsibility? If so, what budgetary tradeoffs would be necessary? What additional risks to autonomy would be entailed?

As another example, the federal research support system established in the late 1940s was based on relatively small project grants to individual investigators. That mode of support is still the basis of the system, even though the number of investigators applying for grants and the collective costs of their research have grown enormously. But since many first rate proposals are either not funded at all or are funded inadequately, even the most talented scientists may spend inordinate amounts of time writing multiple proposals and otherwise negotiating for funds with multiple federal agencies. Are there more efficient ways to support academic research that would still preserve scientific autonomy?

There are certainly no simple answers to these questions. However, the continued strength of our national research system requires that they be raised and fully

debated. A new administration could demonstrate positive leadership by calling for, and participating in, such debates.

o One of the most vexing issues for the new administration has to do with federal responsibility for science education at all levels, particularly the pre-college levels. I have already referred to the difficulties universities will face in less then ten years in finding sufficient numbers of adequately trained, US born faculty. One reason why relatively small numbers of young Americans elect to pursue rigorous graduate study in science and engineering is that too few of them enter college with sufficient training or motivation to pursue those studies at the undergraduate level!

For at least a decade, a series of studies have decried the sorry state of pre-college education in this country, not only in mathematics and science but in also in English, foreign languages, and social science. Although some improvements have been made thanks largely to vigorous efforts at state and local levels, the situation remains alarming. For example, in science and mathematics achievement tests conducted in 13 countries last year, the best US high school students failed to perform as well as the average students Japan, Europe, and many newly industrialized countries, including Korea.

Because responsibility for public education in this country is diffused among more than 30,000 local school districts, the federal government can only play a catalytic, supporting role in improving education. However, those roles can make a substantial difference, as the history of late 1950s and 1960s illustrates. During

those years, curriculum and laboratory development projects, as well as summer and in service training institutes for science and mathematics teachers, evoked a tremendous response from teachers, students, and parents throughout the country. A few promising efforts along similar lines are being pursued today, several of them supported by the National Science Foundation. These include the curriculum development and teacher training programs at the Lawrence Hall of Science at the University of California, Berkeley. However, those activities are woefully underfunded and their outreach capacity is normally limited to their respective local areas.

While additional financial support for improvements in pre-college education would certainly help, national leadership is an even more pressing need. One veteran observer has referred to the state of precollege education as a genuine national security crisis. At the very least it represents a looming resource crisis for the national research system whose solution will require strong scientific - and presidential - leadership.

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Since issues associated with the state of the national research system transcend the authority of any single federal agency, they can only be adequately addressed and resolved at the level of the White House and Executive Office of the President. Obviously, the fraction of time that a president can devote to these issues is minuscule. The same statement can be made for almost all issues that reach the president. But that does not mean that the president must remain ignorant of important national problems. On the contrary, presidents routinely appoint trusted

advisors who are expected to keep them apprised of problems requiring their attention and intervention, and often delegate explicit authority to assure that their policies are carried out throughout the federal bureaucracy.

Shortly after the Soviet Union launched Sputnik in November 1957, President Eisenhower appointed James Killian of MIT as his science advisor. Science and the nation both benefited from that arrangement, and so Eisenhower's successors continued to make such appointments until early in 1973 when President Nixon abolished the presidential science advisory system.

In 1976, Congress sought to reestablish an effective advisory system by creating an Office of Science and Technology Policy (OSTP) within the Executive Office of the President and designating its director as presidential science advisor. However, the reconstituted system has not functioned as well as Congress and most of the scientific community had hoped. Although both of President Reagan's science advisors seem to have had access to the president's political advisors, neither was ever granted the necessary authority required to deal adequately with fundamental issues affecting the strength and effectiveness of the national research system. As a 1987 report of the General Accounting Office (GAO) noted[1]: ". . we have not seen any evidence under the current administration that the Director of OSTP has enough influence with agency heads to reconcile conflicting views on cross agency issues. . . That would require strong presidential support."

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1. US Science and Engineering Base: A Synthesis of Concerns About Budget and Policy Development. Washington, DC: Government Printing Office. March 1987. (GAO/RCED-87-65).

If the new administration is genuinely concerned about the state of the national research system, then clearly it will have to upgrade the existing presidential science advisory system. Several options for doing so have been suggested:

o An option favored by a substantial number of veteran observers, including several former science advisors, is to establish an independent advisory committee of distinguished scientists with direct responsibility and access to and with the president, on the model of the President's Science Advisory Committee (PSAC) that existed between 1957 and 1973. That committee, which lent strong backing to the science advisor, also provided a direct, two-way communication channel between the president and the best scientific talent in the country.

Although I agree that such an advisory committee could help raise the visibility of the science advisory system, the range and complexity of science-related issues has grown enormously since the heyday of PSAC. For that reason, I question whether the spectrum of expertise that would be required to address today's issues could be accommodated on a functioning committee.

o An option favored by few others, including George Keyworth, President Reagan's first science advisor, would be to create a Department of Science. That department would include, for example, NSF, the National Bureau of Standards, NASA, the general science programs of the Department of Energy, and perhaps several other bureaus such as the National Oceanic and Atmospheric Administration (NOAA) and the US Geological Survey.

One decided advantage to a Department of Science would be that the cabinet status of its secretary would guarantee access for the government's top scientific officer both to the president and his inner political circle, and to high level officials throughout the government whose policy decisions require scientific inputs.

However, there are also serious disadvantages. First, unless a Department of Science included the National Institutes of Health and the principal research bureaus of the Departments of Defense and Agriculture, its secretary would not have the requisite authority to oversee and coordinate the federal research enterprise, or to bring coherence to the federal research budget, unless such authority were delegated by the president. So in that respect he would be in much the same position as the present OSTP director.

Second, trying to combine the operational responsibilities of NASA and NOAA with the intermural research of the National Bureau of Standards and the extramural research support programs of the NSF, for example, would be a formidable administrative task. In fact, it is possible that support for the national research system would suffer in intermural competition with larger operational programs.

o A third option that I favor personally, would be to elevate the science advisor's position to that of a member of the cabinet without portfolio, a status accorded to the director of OMB, for example. This option would have the advantage of giving the government's chief science officer access to the president and cabinet without the additional burden of managing an unwieldy bureaucracy. Moreover, a cabinet rank science advisor who did not have to

compete for funds for his own department would be viewed with less suspicion by the heads of other, more powerful cabinet departments. That would make it politically feasible for the president to delegate authority to the science advisor authority to oversee and coordinate implementation of policies affecting the health and vitality of the national research system throughout the government.

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A number of prestigious organizations, including several scientific societies, have established contact with the staffs of both presidential candidates to present the case for a strong presidential science advisory system. Hopefully, that groundwork will result in visible action by the president-elect between November 8 and January 20.

However, I do not want to leave you with the impression that maintaining the vigor or the national research system is entirely a government responsibility. On the contrary, the current relationship between science and government rests on an implicit contract established in the aftermath of World War II. Reduced to its simplest terms, that contract stipulates that government will support research by university scientists while respecting their autonomy. In exchange, university scientists agreed that they would select and evaluate scientific projects on the basis of scientific merit and establish research priorities consistent with long-range national interests.

That contract has shown serious signs of erosion in the past few years. The most obvious manifestation is the growth of academic pork barrelling. While the frustrations that tempt scientists and university administrators to engage in pork barrelling are understandable, the practice has had a corrosive effect on the merit-based federal support system. It has led to serious questions about the integrity of the scientific community. Largely successful efforts by relatively narrow subgroups within the scientific community to win approval for their own, specialized, and often very expensive projects by taking their case directly to the president have had similar effects.

Unfortunately, science is regarded by some influential people in both the White House and Congress as simply one more special interest group whose demands for resources can be satisfied by means of conventional political horsetrading. For example, there is substantial evidence that appointment of a presidential science advisor was delayed for several months in the Carter and Reagan administrations because the political advisors to both new presidents feared that the scientific community simply wanted to make use of that official as a channel to press their resource claims on the president.

Science and the nation have both been badly served by the perception that we are simply one more special interest group. We will continue to suffer as long there is any substantial truth to that charge. Although the financial needs of the national research system are serious, so are the needs of many other claimants to the federal budget - for housing, education, and community services, for example. We need to

develop realistic means for establishing our own internal priorities. We also need to make it clear that our research efforts aim to support rather than compete with those other legitimate claims.

In the aftermath of World War II and again in the wake of Sputnik, the scientific community was able to convey its vision of the national importance of science to the president, the congress, and the larger public. As a result, science not only received additional financial support but, more important, the moral support of students who shared that vision and decided to devote their careers to its pursuit. If two successive presidents have failed to give adequate status and authority to their science advisors, if far too few young people are selecting scientific careers, part of the problem may be that our own vision has become clouded. The genuine opportunity that presently exists for a fresh look at the national research system by a new administration suggests that this is also an opportune time for all of us to reexamine our own house and take the necessary steps to see that it is put in order.