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Four Years of Reagan Science Policy: Notable Shifts in Priorities

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Summary. Administration priorities for federal support of nondefense research and development emphasize basic research and the concomitant training of students. In 4 years basic research has moved from the smallest to the largest component in nondefense R & D expenditures, and basic research specifically to universities has grown by 26 percent in real terms during that period. New programs for fiscal year 1985 emphasize engineering education and research, as well as improved interactions between universities, federal laboratories, and industry.

The presentation in February 1984 of the President's proposed programs for research and development in fiscal year 1985 marked the fourth R & D budget of the Reagan Administration. From its early days, the Administration had repeatedly stated its intention to develop and implement a new science and technology policy, one developed not so much in response to the needs of the science community as in response to the broader needs of the nation. It also stated its intention to reorder the priorities among the kinds of R & D funded by the government, more clearly delineating the responsibilities of government and the private sector.

Perhaps the most important element of policy that emerged from those reassessments was a renewed—and considerably strengthened—commitment to federal support for basic research. Not only is basic research an essential investment in the nation's long-term welfare, but it is largely a federal responsibility because its benefits are so broadly distributed. Quite simply, basic research is a vital underpinning for our national well-being. There are three reasons for that.

Importance of Basic Research

First, research grants to universities, where the majority of the basic research is done, permit the training of tens of thousands of graduate students under some of the most demanding and stimulating research conditions anywhere. This new talent will be responsible for maintaining American technological leadership in coming years.

Second, strong support for basic research permits U.S. scientists and engineers to challenge intellectual frontiers in the most important fields of science and technology. That provides the new knowledge that drives our economic growth, improves our quality of life, and underlies our national defense.

And third, well-chosen basic research projects can stimulate productive partnerships between scientists and engineers in all sectors of society—partnerships that are increasingly vital to development of new technologies that will keep American industry competitive with improving foreign industries and will speed the application of new knowledge to our increasingly technological defense needs.

What, then, does the 4-year record of R & D programs show? How successful has the Administration been in carrying out its stated objectives, and what have been the implications for science and technology in the United States?

It is possible to get a general answer to the first part of that question by looking at the way in which the Administration allocated R & D resources during those 4 years—and the way the allocations differ from previous patterns.

Funding Trends

The Office of Science and Technology Policy has assembled funding data that include the most recent budget proposals and which are corrected for inflation so that they reveal true purchasing power of R & D funds. The overall trend of nondefense federal R & D obligations (Fig. 1) clearly shows, for the period of 4 years, a strong emphasis on basic research as well as a concomitant reduction of government support for demonstration, development, and applied research projects that are considered to be more appropriate for the private sector. This is consistent with the Administration's stated objective of clarifying public and private sector responsibilities for funding R & D. In particular, substantial reductions were made in energy-related demonstration projects.

The result is that among the three categories of federal funding—basic research, applied research, and development—there has been a marked shift in relative priorities over a relatively short period of time. Basic research has gone from the smallest fraction of nondefense R & D to the largest, with a jump in share from 27 to 38 percent. At the same time, development funding has dropped from a 42 percent share to 27 percent. (Data in Fig. 1 focus on nondefense R & D. Unlike other areas of technology, the government is the sole customer of defense-related R & D; development costs cannot be shifted to the private sector.)

A look at basic research obligations (Fig. 2) shows that federal support for

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basic research for the five largest R & D funding agencies has grown since 1978 (in constant dollars). All five agencies—the National Institutes of Health, the National Science Foundation (NSF), the Department of Energy (DOE), the Department of Defense (DOD), and the National Aeronautics and Space Administration—demonstrate strong and consistent growth in basic research obligations, and in four instances that growth follows level or even declining real budgets in the 4 years preceding 1982.

Figure 3 illustrates how the increases in basic research are affecting universities and colleges. Here the result of the science policy is even more pronounced. Although it is not shown, we could trace a consistent decline in basic research funding for universities back to 1968, and where the data pick up we see that there was essentially no growth from 1979 to 1981. However, from the fiscal 1981 budget to that proposed for 1985, this support for universities grows by 26 percent—again, in real terms. The full impacts of these increases have not yet been felt on the campuses because the actual appropriations lag considerably behind the fiscal year budget proposals. For the most part we are only now beginning to feel the effects of the steeper parts of those curves.

Moreover, the true impacts on universities of federal funding are even greater because so much university research draws on federal investment in special centralized facilities. Substantial amounts of the funds that go to federal and national laboratories actually support university research in physics, astronomy, materials sciences, and space sciences. Thus, as I have been pointing out for as long as I have been in Washington, during the Reagan Administration we have seen the strongest support for basic research in 20 years.

Some highlights of the President's proposed fiscal year 1985 R & D budget are shown in Table 1. Total federal R & D will amount to $53 billion, an increase of 14 percent from 1984. During the 4 years of the Reagan Administration federal funds for R & D have increased by 52 percent. The largest increases for next year, 22 percent, will be for defense R & D, with the next largest component going to basic research. Since 1981 basic research has grown by 55 percent to a new high of $7.9 billion. More than half of that support will go to universities.

As in previous years, we are applying the increases in basic research funds selectively to fields and projects showing strong opportunity and excitement, with high priority continuing to go to support university research. This kind of support is the most important element of the budget in continuing on the path to restoring the health and vitality of our nation's universities.

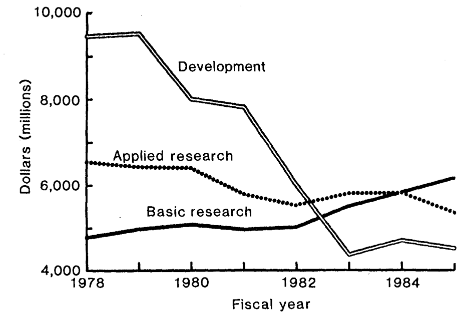

Fig. 1. Federal R & D obligations (nondefense) in constant 1983 dollars. [Source: Office of Science and Technology Policy (from *Special Analysis K: Research and Development, the Budget of the United States Government*, Office of Management and Budget, Washington, D.C., February 1984)]

As I have mentioned, there are three broad goals embodied in our programs for science and technology. These relate to ensuring the continuing supply of bright new technical talent to meet national needs, to selecting the most important and most relevant fields of R & D to pursue and then pursuing them as well as we possibly can, and to stimulating new and productive partnerships that span the range of people and organizations conducting R & D.

To help explain the kinds of specific activities that we are proposing to achieve those goals, I want to describe just a few of the initiatives proposed in fiscal year 1985. Each illustrates our determination to retain U.S. scientific and technical leadership in the fields that we believe are most important.

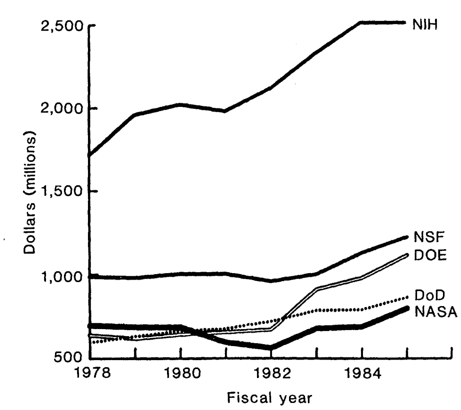

Fig. 2. Basic research obligations in constant 1983 dollars. [Source: Office of Science and Technology Policy (from *Special Analysis K: Research and Development, the Budget of the United States Government*, Office of Management and Budget, Washington, D.C., February 1984)]

The Need for Technical Talent

Without hesitation I would assign highest priority to stimulating and nurturing technical talent. During the past several years I have heard from hundreds of our nation's industrial and university leaders, and almost to a person they echo that priority. Now, especially as the economy has resumed strong growth, industries that depend on technical talent are feeling the pinch. In many of the fast-growing fields—the ones that create new jobs and products for export—there simply are not enough really good people to go around.

We face problems of both numbers and quality. We face problems that threaten to put a brake on the ability of our economy to continue to grow. For instance, in recent years there has been a pervasive and serious shortage of university faculty in engineering, computer sciences, and some of the physical sciences. These shortages have created bottlenecks in our ability to produce the kinds of technical talent most needed by growing U.S. industries.

For that reason I think that one of the really exciting programs approved for fiscal year 1984 was the National Science Foundation's Presidential Young Investigator Awards. This program helps universities attract and retain outstanding young Ph.D.'s who might otherwise pursue nonteaching careers. It does so by generously funding research of faculty near the beginning of their academic careers.

The first 200 awards were made in February 1984, and NSF is preparing to award 200 more in 1985. Each recipient is eligible for 5 years of support at up to $100,000 per year in a combination of federal and industrial funds. It is expected that 200 new investigators will be named each year; resulting after 5 years in a projected continuing total of 1000 active awards. Moreover, this program is flexible and able to respond to obvious shortages. Thus, more than three-quarters of the first awards went to young faculty in engineering and the physical sciences.

Part of the intent of this program is to attract faculty in fields where shortages limit our ability to meet the growing demands by students for training. It is what might be termed a first-order solution to an obvious problem. But there is much more that we can and must do. It is ironic that although the United States has the world's greatest research institutions and the most advanced industrial capacity, we simply have not developed effective linkages between them. We are now intensifying our efforts to do just that.

Both the academic and industrial communities have voiced growing concern about the kind of training we are providing for our engineering undergraduates—the vast majority of whom expect to enter industry. We are in the midst of a revolution in the way engineers work and the way modern industry operates. That revolution is putting potent new computer tools in the hands of the product designer and blurring distinctions between disciplines.

Few universities, however, are able to prepare their students to operate in that new environment. This is not really their fault, but reflects a combination of a lack of modern equipment and overburdened faculty who are struggling just to keep up with teaching demands. We see several hopeful signs that promise to help them overcome those limitations. In particular, industry is helping universities plan for the kinds of working environments that new graduates will enter. At the same time, industry—with virtually no strings attached—is helping many schools directly by funding new programs and providing modern equipment for student use. Certainly, events in the past year suggest the dawning of a new age of enlightenment for engineering education.

The federal government clearly has a key role in this transformation. The nation is going to rely heavily on new generations of engineers for its industrial and economic health. Because of the competitive environment in which U.S. industry must operate, we have to help our universities provide the best training possible.

For the past 6 months the Office of Science and Technology Policy (OSTP), industry groups, the National Academy of Engineering, and NSF have been looking very hard at this problem. We have been looking particularly at the broad areas of design and manufacturing because those are critical processes to master in converting knowledge—which the U.S. research establishment produces in prodigious quantities—into products. What is emerging from this collaboration is a proposal for a new program at NSF in 1985 to create university centers for cross-disciplinary research in engineering.

The intent of such an ambitious program is to develop a body of knowledge to guide engineers in integrating different disciplines to work on problems of both national and industrial importance. At the same time it will help the universities, working closely and continuously

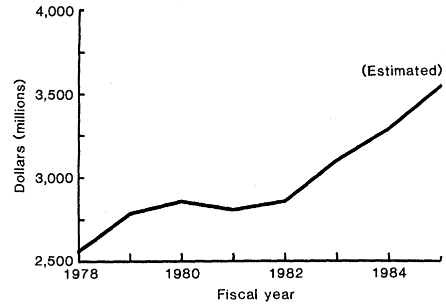

Fig. 3. Basic research obligations to universities and colleges in constant 1983 dollars. [Source: Office of Science and Technology Policy (from *Special Analysis K: Research and Development, the Budget of the United States Government*, Office of Management and Budget, Washington, D.C., 1984)]

with industrial affiliates, take a giant step in how they educate engineers. I believe that in the next few years we are going to see substantial and overdue changes in the way we approach academic engineering and that these centers are only the first of many innovations.

I emphasize that virtually every step being considered for improving the engineering schools is being taken in cooperation with industry. The new federal programs all encourage more productive interaction between industry and the universities—and both should benefit.

One important point is that these engineering centers will continue to require strong disciplinary research programs conducted in parallel in the universities. The hope would be that faculty and students would move freely back and forth between the centers and specific areas of research. Thus, at the same time that the centers are being started, for example, NSF has also requested a 22 percent increase in funds for engineering research. The purpose of that growth is not necessarily to permit more research projects, but to permit the best ones to be more productive by funding larger groups of investigators and by underwriting the purchase of equipment and instrumentation.

Instrumentation and Supercomputers

Because the instrumentation problem underlies virtually all basic research at universities, we have adopted a policy of building support in large part for new instrumentation and equipment directly into project grants. Across all R & D agencies, the federal government expects to provide more than $400 million in 1985 for research instrumentation available for university scientists and engineers. This amount, while substantial, falls far short of the estimated needs. But those needs are the result of an extended period of underinvestment in university research instrumentation, and the problem cannot be solved all at once. Keeping up with new technology must be a continuing process, and we intend to provide these substantial sums of money on a continuing basis.

Our preference for including much of that support as part of actual research grants rather than as separate instrumentation programs is to emphasize that instrumentation is as much a part of modern research as any other expense; to permit instrumentation to be tied closely to highest priority research programs; and to give researchers as much discretion as possible in deciding how best to allocate research funds.

I would include one other specialized kind of equipment in any discussion of development of talent in universities, and that is supercomputers. It is simply imperative for our academic research community—faculty and especially students—to have opportunities to work with state of the art computing tools.

There are three main reasons for emphasizing the importance of these computing tools. One is the direct benefit to frontier research; supercomputers offer the best known way to attack many large-scale science and engineering problems, a way to model complex physical interactions. Second is the opportunity for young scientists and engineers to

Table 1. Federal R & D obligations.

Category	Fiscal year budgets (billions of dollars)					Change (%)	
	1981	1982	1983	1984	1985	1984–1985	1981–1985
Total federal R & D	$35.0	$37.6	$39.5	$46.7	$53.1	14	52
Total defense R & D	$16.5	$20.9	$23.2	$28.1	$34.2	22	107
Basic research							
Total	$ 5.1	$ 5.4	$ 6.4	$ 7.2	$ 7.9	10	55
Agencies supporting life sciences	$ 2.4	$ 2.4	$ 3.0	$ 3.3	$ 3.5	5	46
Agencies supporting physical sciences and engineering	$ 2.7	$ 3.0	$ 3.4	$ 3.9	$ 4.4	14	63

learn what supercomputers can do and to become familiar with them. After all, these people are the ones who will be developing the supercomputer's potential for solving new kinds of problems in the future. And third is the vital contributions that the research community will make to designing and developing the software to make the supercomputers even more useful in the research process.

Both NSF and DOE plan to provide university researchers with more access to supercomputers both by allocating more time to them on supercomputers at national laboratories, such as through DOE's Magnetic Fusion Energy computing network, and by installing new supercomputing facilities dedicated to academic users. NSF also plans to install a class VII supercomputer at the National Center for Atmospheric Research for use by the atmospheric and ocean sciences community.

In parallel efforts, DOE, NSF, and DOD will increase research funds for various areas of computer science and electronics that will be applicable to future generations of supercomputers. We are confident that these varied activities, in conjunction with continued purchase of the most advanced supercomputers for direct government use, will, in turn, provide the market incentives to permit U.S. commercial manufacturers to maintain their technological leadership in this field.

The Pursuit of Excellence

The importance of project support to the vitality of universities and to their ability to train students is evident. But project support is also a primary means of addressing the parallel goal of science policy—the pursuit of excellence. The tried and true method of investigator-initiated, peer-reviewed research grants has produced phenomenal results over the years. The fact that scientists at U.S. institutions won four out of four Nobel Prizes last year reflects on the effectiveness of this kind of system for supporting basic research.

Although there are many, I will offer only one specific example of a 1985 initiative intended to help American scientists continue to pursue excellence. A field of science in which this country has been a world leader and also a field that demands extremely careful—not to mention wise—decisions about future programs is high-energy, or particle physics. The questions the scientists ask are in many ways the most fundamental in nature, and the answers are surely among the hardest to find. Over the years there have been important direct applications of knowledge first derived from this kind of front-line physics research to other areas of science and technology.

But fields like this are important as much for the way they attract and stimulate human intellect as for their specific results. Particle physics, or astrophysics, or molecular biology, or mathematics are stimuli for our broad national strength in science and technology. Of those fields particle physics is the most expensive to pursue today. It is that expense that forces us to make, as I noted, wise decisions about what course we will pursue. It was that expense that led to a fundamental rethinking by the high-energy physics community, last year, of where this country should be going in particle physics.

The result of that introspection was the decision to terminate a major accelerator project that was no longer timely. Instead, the community is now focusing its attention on an entirely new accelerator that would let us take a bold step into new energy regimes. Such a step would permit us to look at truly forefront questions in the structure of matter.

Such a project has strong merit if it can be designed, if it can be built for a reasonable cost, and if it can be built in a reasonable time frame. Those are big "ifs," and I do not believe that anyone can yet tell us whether we can meet those requirements. But we are proposing that in fiscal 1985 we begin the process of trying to find out. To that end, DOE will begin R & D on advanced superconducting particle accelerator concepts.

This would permit us, at some point later in this decade, to decide whether or not to proceed with the next-generation machine, a superconducting supercollider. Questions of how, where, how much, and, perhaps, with whom must be deferred until we have a better handle on the technology. I emphasize that we propose no commitment to proceeding beyond this R & D; construction, should it appear feasible, will have to be decided upon later.

Partnerships with Industry

The third goal of science policy, stimulating partnerships among scientists and engineers in universities, federal laboratories, and industry, reflects the pressing need to improve the transfer and application of new knowledge to national needs, particularly in industry. There has been some real progress in the past few years in improving these interactions, not so much because of anything government has done as much as because of the broad national awareness of the obvious industrial and military challenges from abroad.

Better partnerships are clearly needed in the field of agriculture. There is little question but that we have made only slow progress in bringing the benefits of the modern biotechnology revolution to American agriculture. The result is that we have failed to take the prudent steps necessary to protect the enormous world leadership that we have enjoyed for so long in agriculture.

We have already seen—painfully—how aggressive competitors who adopt new technologies and run with them can make severe inroads into what American industry assumed was a guaranteed market. Automobiles and consumer electronics come most readily to mind. We would hate to have to add agriculture to that list 20 years from now. Fortunately, we have tremendous resources in this country that should enable us to maintain and extend our world lead, but we have to start now to incorporate the fruits of molecular biology and its offshoots into a new field of agricultural biotechnology. To accelerate that process, the Department of Agriculture will greatly expand its competitive grants program in fiscal 1985. This will include a substantial new agricultural biotechnology research effort within that program.

Next year will also be a milestone for another kind of partnership with industry. It stems from the President's decision that the United States should begin work on defining and designing a space station. I would characterize this decision as recognition that we are going to occupy and use space on a larger scale than ever before. We will be simultaneously enlarging our ability to explore space and enlarging the nation's long-term options for creating a new base for industrial activity. It is clear that this activity demands broad involvement of the private sector to identify the highest priority industrial opportunities and to bring industry's expertise to planning systems to be tested and used in space.

At the same time we are committed to maintaining the momentum that we have built up in our very successful programs of research in the space sciences. New programs to start in 1985 include the Upper Atmosphere Research Satellite, the Mars Geoscience–Climatology Orbiter, and the Naval Remote Ocean Sensing Satellite. These join projects already under way, such as the Space Telescope, the Gamma Ray Observatory, the Galileo Jupiter probe, the Venus Radar Mapper, and a variety of Spacelab science programs. The United States has embarked on an incredibly promising and balanced space science program, one that will not be compromised by the manned space efforts but that will, in fact, complement them. We are all aware of the lesson of the impact of the Shuttle program on space sciences in the 1970's—and we are not about to see that happen again.

During the past year we also took important steps toward making better use of the nation's federal laboratories in meeting national needs. In light of the amount of R & D done there—more than one sixth of the total public and private sector R & D—it should be obvious that they should be expected to contribute to our attempts to rejuvenate American industry and universities. In July 1983 David Packard, on behalf of the White House Science Council, presented the results of a yearlong review of the federal laboratories to the President. Following that, the President instructed OSTP and the Office of Management and Budget to lead an interagency effort to work on ways to implement the recommendations. He also asked for a progress report by 1 July 1984.

The Packard panel had concluded that the nation could derive far more benefit from the federal laboratories, and it recommended changes in five major areas to help improve their effectiveness. Briefly, the panel called for clearer missions, for changes in personnel systems to attract and retain top technical talent, for more stable funding and more autonomy for the laboratories in managing their research, and for broader interactions between the laboratories and other public and private sector R & D organizations.

The Administration's plan last year to pioneer a new kind of industry-university-federal laboratory interaction through establishment of a broadly based materials research center at Lawrence Berkeley Laboratory was an early indication of the kinds of actions the panel anticipated. During the past year the plans for the Center for Advanced Materials have benefited from thoughtful review and recommendations from the materials science community, recommendations that are being implemented. The original objectives for the center are unchanged—a place to bring together a range of materials and other scientists from all sectors to work on problems of fundamental importance to future technology.

Leapfrog Technologies

One other example, still in the very early stages, suggests yet another kind of potential for making better use of the federal laboratories. The President's Commission on Industrial Competitiveness, formed about 6 months ago, is a group of mostly private sector leaders who are looking at ways to strengthen U.S. industry. One of the concerns that surfaced early in their discussions was the obvious plight of what are called the basic industries—or the smokestack industries.

One commission member, the chairman of a major steel company, made it clear that the future of his industry in America, which has been losing its competitive advantage to foreign producers, was going to rise or fall in the long term on its ability to achieve substantial increases in productivity through the application of what he calls "leapfrog technology"—a new technological generation in steel manufacturing.

Whether such leapfrog technologies can be developed is an open question. The steel companies, through their research arm, have been working among themselves and with university researchers on just what might be possible and practical. What struck several of the public sector representatives was that the people working the problem were either largely unaware of the kinds of technical expertise in the national laboratories, or they assumed that such expertise was not available to them. In either case, we have taken steps to correct that perception.

The steel industry's problems are important far beyond the industry itself, and not only because of the strategic and economic impacts of a healthy steel industry. In fact, steel is only one of several industries facing similar, almost generic problems. The OSTP has taken this opportunity to serve as a kind of marriage broker between the industry and the federal laboratories, and research directors at the major steel companies have shown great willingness to work together on common problems in R & D. We are determined that their willingness to seek new ways to rejuvenate industrial R & D will be matched by a willingness in the public sector to try to help steelmaking prepare for the 21st century.

It was quickly obvious that these R & D problems being posed by the industry were interesting and important enough to elicit enthusiastic responses from the science community, and it may turn out that the OSTP broker's role will be short-lived. Indeed, it would be disastrous for Washington to become a permanent element in what has to be direct collaboration among working scientists and engineers. The sooner we step out of the process the better.

There is one additional point to emphasize. The initiative for this effort comes from the steel industry—from the people who know the problems and are charged with finding solutions that meet economic tests. For any industry that might benefit from leapfrog technologies, the first step in each case is for the industry itself to define its needs and then to cast a wide net for some new perspectives to apply to recalcitrant problems.

Importance of Consistency

The various examples of new activities in science and technology are intended to convey the directions and emphases in a federal policy that underwent some important changes in 1981. The projects cited are hardly meant to encompass all the important new projects for fiscal year 1985 but rather to illustrate some of the concrete ways in which policy becomes reality.

Above all, I believe that it is critical to be aware of the need for consistency in any policy for science. By their nature, science and technology demand long-term planning and preparation, starting early in the educational process and extending into the maturing of young researchers and their integration into the research, academic, or industrial communities. Major facilities may take a decade to develop and may be used for decades more.

The planning cycles for the world of science and technology are far longer than the turnaround times in the political arena, and one of the most serious detriments to good science is what is called roller-coaster funding. Those of us who accept the responsibility for charting the course for government programs in science and technology must also accept the responsibility for clearly articulating—and sticking to—basic principles for guidance. I see this consistency as a major element of science policy, an element that I hope the Administration, Congress, the science community, and the public will be able to maintain in coming years.