



A Presentation by

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Some Reflections  
on the Future  
of the American  
Academic  
Research  
Enterprise

Sigma Xi  
Science Education Lecture  
Series  
January 21, 1992





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## Introduction

When I was asked to provide a title for this talk by the Michigan Chapter of Sigma Xi, I was still serving as Chair of the National Science Board's standing Committee on Education and Human Resources. Therefore, it was natural to select the topic of science and mathematics education. However, late last fall I was elected Chair of the National Science Board. Since I now have to worry about the totality of American science, I have decided to exercise a presidential prerogative and broaden my topic to that of "Some Reflections on the Future of the American Academic Research Enterprise." As you will see later in my remarks, perhaps a more appropriate title would be "Jumping from Bush to Bush . . ."

It is important to note here the significance of each word in the phrase "academic research enterprise." In the United States the universities play the central role in basic research. Furthermore, our research structure is indeed an enterprise because it relies on the entrepreneurial efforts of individual investigators to seek the support for their activities.

## GUIR Report

Late last fall the Government-University-Industry Research Roundtable released a draft of the second phase of its studies on "The Future of the Academic Research Enterprise." The principal conclusions of this report seemed to hit very appropriate themes:

1. Principal investigators, university administrators, and agency officials need to assess changes occurring within the research enterprise.

2. Universities and research sponsors need to take immediate concrete actions to respond to changes, to set overall research priorities, to clarify respective responsibilities for funding research, to upgrade organization and management strategies, to adapt to societal change (e.g., demographics, values), and to improve science and engineering education, particularly at the undergraduate level.
3. All with a stake in academic research—including political, corporate, and public interest sectors—should think more strategically about the options for the future of the research enterprise.

Consistent with these themes, then, I would like to share with you my own present thinking on the future of the American academic research enterprise.

## The Warning Signs

There are many signs that the American academic research enterprise is under considerable strain these days:

1. We see an increasingly adversarial relationship between the university and various government bodies, including Congress, the administration, and federal agencies.
2. A good example of this is the tragic battle over indirect-cost reimbursement. While the University of Michigan has escaped relatively lightly in the eruption of university bashing over the indirect-cost issue that has been orchestrated from Washington, other institutions have not fared so well. For example, Stanford has already lost a president and is facing serious budget difficulties because of the unilateral decision of the federal

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government to cancel its earlier contractual agreements. More recently, Stanford faces a federal audit report that may claim as much as \$350 million in overpayments. MIT, too, is at serious risk with over \$22 million of claimed overpayments identified by federal audits and threatened further by devastating reductions in indirect cost rates.

3. Charges of scientific fraud and misconduct continue to abound—perhaps the most famous being those characterizing the MIT laboratory directed by David Baltimore. Indeed, some Congressional staff are pushing for criminal indictments of university scientists.
4. There continues to be an intensification of the efforts of the federal government to shift research costs to academic institutions. While this was a clear trend appearing during the 1980s, it has now become a pronounced objective of major federal agencies for the 1990s, with the National Institutes of Health taking a lead in the cost shifting effort.
5. Earmarking has become, in effect, the “new federal facilities” program. We see increasing effort for individuals and institutions to bypass the peer review process and obtain federal funding through political earmarking. Indeed, last year it was estimated that over \$490 million was obtained through such pork barrel activities—roughly the magnitude recommended by the Packard Bromley Report for a major new federal research facilities program!
6. The skepticism exhibited by the media and government bodies, particularly Congress, has evolved into actual

hostility toward higher education.

7. This has triggered an erosion of public trust and confidence in the university at a moment in history when these institutions are playing an even more critical role in our society. A good example of this is the wide range of criticisms of the very nature of contemporary scholarship, such as those in the book, *Profscam*: "Most scholarly activities are either the sterile product of requirements imposed by Philistine administrators or a form of private pleasure that selfish professors enjoy at the expense of their students."
8. There are serious questions now arising within the universities themselves as to whether there needs to be a rebalancing of missions, away from research and more toward teaching and service.
9. There is little doubt that a serious deterioration has occurred in the morale of academic researchers, driven by the pressures and time-consuming nature of their efforts to obtain and manage sponsored research funding and the absence of a "scholarly community" within the university.
10. There continue to be concerns about the degree to which results of the research conducted by American universities become available to foreign competitors. This is most commonly heard in the question, "Why should we fund American universities to do research which benefits our competitors?" So too, there continues to be a debate about the number of foreign students studying in critical areas of science and engineering in American universities.



11. The rapidly escalating costs of conducting cutting-edge research, particularly in laboratory science, is forcing a re-examination of institutional priorities at a time when the resources available to most institutions are increasingly constrained.

What is going on here? To some degree, we may be seeing evidence of the increasing estrangement of the American public—and their elective representatives—from science itself. As the gap between the impact of science on modern society and the scientific literacy of the body politic widens, the fear of science may be driving much of this hostility as a way to “control” it, to keep science in its place.

So too, we may be experiencing the same forces of populism that surface from time to time to challenge many other aspects of our society, as manifested in a widespread distrust of expertise, excellence, and privilege. It is worth noting that those universities which have borne much of the brunt of the tax from Washington have been some of the finest and most important in America. However, it is also important to note that many scientists and universities have made themselves easy targets by their arrogance and elitism.

While both a fear of science and a new populist outbreak may be driving many of these new strains on the academic research enterprise, I believe that something else even more profound may be happening.

## Paradigm Shifts

In my view, the major difficulties and challenges faced by the academic research enterprise today are arising because we are in the midst of three simultaneous paradigm shifts:

1. Changes in the relationship between the federal government and the research university.
2. Changes in the nature of the research university.
3. Changes in the role of the faculty themselves.

These changes are being driven by the extraordinary nature and pace of change in the world today. To understand these shifts in the academic research paradigm, let's begin by recalling "the good old days of academic research."

### The American Research Partnership

The basic structure of the academic research enterprise of the past half century was set out in the seminal study, "Science, the Endless Frontier," chaired by Vannevar Bush, President of MIT, shortly after the end of World War II. The central theme of this report was that the nation's health, prosperity, and military security would continually require deployment of new scientific knowledge. It, therefore, suggested that the federal government had an obligation to ensure basic scientific progress in the production of trained manpower. The Bush report insisted upon the principle of federal patronage for the advancement of science. But it furthermore stressed a corollary principle: that the government should preserve "freedom of inquiry" since scientific progress results from "the free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for explanation of the unknown."

Unlike many other nations, the United States chose the university as the most appropriate institution for the conduct of basic research. This

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was in part because of the belief that there is a synergistic effect between research and education. Such federal support would serve the dual purpose of accomplishing research and educating students who would comprise the next generation of scholars. But there was a more pragmatic reason. Research at universities generally costs far less than it would in other sectors of society.

Since the government recognized that it did not have the capacity to manage effectively either the research itself or the universities, the relationship was established as a partnership in which the government provided relatively unrestricted grants to support a component of research on the campuses, with the hope that “wonderful things would happen”—which, indeed, they did. Further, the funds for such research provided by the federal government, were deployed according to competitive process based on peer review, with the belief that this process would channel dollars to the best researchers.

The success of this research partnership has been truly extraordinary. America’s research universities have done an astonishing job of transferring their knowledge to society-at-large. Beyond question, the research performed on our campuses has improved, prolonged, enriched, protected, and comforted human life.

For example, over the last four decades on the University of Michigan campus we have developed: the science of nonlinear optics, fiber optics technology, the bubble chamber, the positron microscope, the clinical trials for the Salk vaccine, the artificial knee joint, the use of radioactive iodine treatment for thyroid disorders, the heart-lung machine, the theory and application of holography, synthetic aperture radar, the ruby laser, multi-spectral scanning, gene therapy, genetic medicine, bacterial bioremediation of petroleum and PCBs, neurally connected hearing aides, acoustic cancer therapy, microscopic bio and chemical sensors, methods for econometric, sociological, and political surveys, the structures of



organizational science, the technology of highway safety, and the broad-based sciences necessary for the understanding of the Great Lakes.

The remarkable institution of the American research university has been widely admired around the world. It represents a significant source of U.S. exports. It has demonstrated a remarkable capacity to adapt successfully to society's many new needs. It has remained the most important source of both new science and new cultural understandings regarding how humankind relates to both its past and its future.

From this perspective then, as we approach the end of the twentieth century, we should celebrate the many extraordinary achievements of American's research universities. Yet, something quite different appears to be happening.

### The Transition from Partnership to Procurement

In recent years we have seen the unravelling of the research partnership that served this nation so well over the years. Today this relationship is changing rapidly from a partnership to a procurement process. That is, the government is increasingly shifting from being a partner with the university, a patron of basic research, to becoming a procurer of research, just as it would procure other goods and services. The university is being forced to shift to the status of the contractor, no different from that of other government contractors in the private sector.

In a sense a grant today is becoming increasingly viewed as a contract, subject to all of the regulation, oversight, and accountability of other federal contracts. This perspective has unleashed on a research university an army of government staff, accountants, and lawyers, all claiming as their mission the task of making certain that the university meets every detail of its agreements with the government. So too have entered the politicians, some with legitimate

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concern about the expenditure of public funds, but others with more opportunistic and political objectives on their minds.

The partnership characterizing the past several decades as articulated in the Vannevar Bush vision is being replaced by a relationship in which trust has been subsumed by an adversarial negotiation process. Clearly, this shift has been driven in part by a serious erosion of public confidence and trust, undermined in part by the media seeking cheap headlines, and by politicians with personal political agendas. In part it has been undermined as well by the haplessness of academic leaders in articulating the importance of the research enterprise. But the shift has also been driven by a dramatic change in the public's perception of the need for fundamental research. No longer is research justified by the post-World War II imperatives of national security, the confrontation of dreaded diseases such as polio and cancer, or the challenge of the space race. Today our concerns have shifted to issues such as economic competitiveness, K-12 education, and the costs of health care. While these issues are certainly as imperative as concerns of defense and space, it is somewhat more difficult to articulate the role of basic research in addressing them.

## The Changing Paradigm of the Research University

The academy faces a great many challenges these days. There are those challenges specific to higher education such as the erosion in public support at the state and federal levels, the change in the federal research partnership, the tendency to assign still further missions to the university—even as we view it in a one-dimensional way, and the erosion in public trust and confidence. Then too, there are those more sweeping challenges characterizing our society-at-large, such as the changes in demographics, the internationalization of our society, the growing importance of knowledge as a strategic commodity, and the degree to which mankind is beginning

to push up against the constraints of the planet itself. So too, there are a series of challenges of a more abstract nature, such as the challenge to rationalism ("post-modernist" thought), the increasing interdisciplinary nature of the problems that face us, and the changing modes of teaching and scholarship itself. All of these are driving changes in the nature of the university.

But there is an even more profound transformation occurring. The triad mission of the university as we know it today—teaching, research, and service—was shaped by the needs of an America of the past. Today our nation and the world are changing at an ever-accelerating pace. Hence, many now question whether our present concept of the research university, developed largely to serve a homogeneous, domestic, industrial society of the twentieth century, must also evolve rapidly if we are to serve the highly pluralistic, knowledge-intensive world nation that will be the United States of the twenty-first century.

The winds of change are blowing today, stirring the cauldron of higher education to create a new model for the university of the future. Put another way, perhaps the decade ahead is a time for "re-inventing" the American university. But will a gradual evolution of our traditional paradigm be sufficient? Or will the challenges ahead force a more dramatic, indeed revolutionary shift, in the paradigm of the contemporary research university?

## The Changing Role of the Faculty

Today we find an interesting paradox. Roland Schmitt has observed that an analysis of research funding during the 1980s reveals that real R&D support has been increasing at rates comparable to the 1960s, at roughly 6 percent per year. Yet the attitudes of the scientists themselves suggest a belief that there is serious underfunding. For example, in 1976, 63 percent of those surveyed thought funding was adequate; in 1990, only 11



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percent believed this.

To examine this in more detail the National Science Foundation arranged workshops of principal investigators at all levels, from beginning to experienced, to discuss these themes. Some of the comments drawn from these meetings are interesting. Many scientists now view the universities as "holding companies for research entrepreneurs." There seems to be little identification or loyalty to the institution, but rather a view that research is conducted by individuals operating in a free market sense. We seem to have lost the institution-building philosophy of past research support. Investigators in their research are moving farther from their institutions and from their teaching and education function.

So too, it was their sense that junior faculty are thrown far too early into the dog-eat-dog competitive world of sponsored research. Further, it was all too easy for mature scientists to lose funding and fall out of this competitive environment. The synergy between education and research seems to have disappeared.

## A World Transformed

Of course, these paradigm shifts are being driven by the extraordinary pace of change in our society. Few could have predicted that over the last several years communism would be rejected around the world or that the Berlin Wall would crumble and Germany would be unified, or that the Soviet Union itself would disintegrate from the forces of freedom and nationalism.

Yet these changes are just the tip of the iceberg. The world about us is undergoing massive change at a pace that continues to accelerate. Indeed, many believe that our society is going through a process of transformation just as profound as those which have occurred in earlier times such as the Renaissance and Industrial Revolution—except that while these earlier transformations took centuries to occur, the

transformation characterizing our time will occur in a decade or less.

I used to portray the 1990s as the count-down toward a new millennium, as we found ourselves swept toward a new century by these incredible forces of change, but the events of the past year suggest that the twenty-first century is already upon us, and a decade early.

Are we ready for it? Are we prepared to face a world whose economy, culture, and polity are driven by the explosion of knowledge itself? In this spirit let me consider several particular challenges to the academic research enterprise.

## A Holistic View of the University

A modern research university is complex and multi-dimensional. In many ways it suffers from a plight illustrated by the old parable of the elephant being felt by the blind men, who argued over just what the beast looked like from touching only a small part of it.

People perceive the university today in vastly different ways, depending upon their vantage point, their needs, and their expectations. Students and parents are concerned both with the quality and the cost of education. Business and industry seek high-quality products, our graduates, research, and service. The patients of our hospitals seek quality and compassionate care. Federal, state, and local governments have complex and varied agendas which can both sustain and constrain us. And the public itself seems to have a love-hate relationship with higher education. They take pride in our quality and revel in our athletic accomplishments, but they also harbor deep suspicions about our costs, our integrity, and even our intellectual aspirations and commitments.

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Beyond the classical triad of teaching, research, and service, society has assigned to the university over the past several decades an array of other roles:

- health care
- parenting (or in the immortal words of Lord Rugby, “converting savages into gentlemen”)
- social mobility
- big-time show biz (intercollegiate athletics)
- national security

Yet today it is asking us to assume additional roles such as:

- revitalizing K-12 education
- securing economic competitiveness
- rebuilding our cities
- improving race relations in America

Unfortunately, most folks—and most agencies of the federal government—picture the university “elephant” only in terms of the part they can feel—for research procurement, student financial aid, even political correctness. Few in Washington seem to see, understand, or appreciate the entity of the university. And no one seems to understand or care that shifting federal priorities, policies, or support aimed at one objective or area will inevitably have an impact on other roles of the university. For example, it is clear that excessive cost-sharing requirements or inadequate reimbursement of research costs will inevitably cause fund shifting from other functions of the university such as education or public service.

## Manpower Issues

Research is an intensely people-dependent activity. No matter how much funding we have, no matter how fine our facilities, no matter how effective our organizations—if we do not have great people going into these fields, we will



not have great research.

For the past decade the National Science Board has been attempting to assess scientific and technical manpower needs of our nation. It is our belief that we will indeed face serious shortages at both baccalaureate and doctorate levels in the years ahead. In fact, most universities can tell you that the manpower crisis is already upon us in many fields—although many folks in Washington continue to argue about the fringes, e.g., debating “short falls” versus “shortages,” questioning the assumptions in various manpower projections, while the universities and corporate America suffer and the clouds continue to build on the horizon. There are many factors that suggest that our country will indeed experience such a shortage and must begin immediately to design and implement policies that will mitigate its effects, including the declining number of college-age citizens, the declining fraction of students majoring in science and engineering, the surge of faculty and industrial retirements in the 1990s, and the probable growth of the needs of the industrial sector for advanced training.

Beyond the question of numbers is the question of quality itself. We have to face the fact that our best talents—our smartest students—are simply not attracted to research or academic careers these days. Instead, they are attracted to careers in business, law, politics—to wealth, power, and fame, and not to intellectual excitement.

As I suggested earlier, it just isn't much fun to be a faculty member these days, and our students have sensed this. Clearly, today's faculty feel stressed out, overloaded from the rigors of grantsmanship, paperwork, committee assignments, review panels, oversight strains—with precious little time for teaching and research, much less thinking. We need to address these manpower challenges, or we can forget about the rest of the research agenda.

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## Big Think vs. Small Think

The American research enterprise in general and the research university in particular place most emphasis on "small think," on increasing specialization, intellectual fragmentation, and disciplinary compartmentalization. Indeed, even so-called multi-cross-disciplinary efforts are, in reality, achieved by gluing together a bunch of specialists with funding, facilities, and organizational structures.

Yet it is my sense that the most exciting and important problems today require a broader view. They require the "big think" of individuals with unusual intellectual span, rather than the "small think" of the specialist. Further, it does not appear that our present public policies and political structures are capable of the strategic thinking, the "big think," necessary to keep America's research enterprise healthy and moving ahead. Instead, our public leaders, like so many of our private leaders, have become obsessed with quarter-to-quarter, election-to-election time horizons.

## A Comment About Process

Today we generally operate with a traditional decision process characterized by consensus-building, inclusiveness, dealing with broad-based constituencies, and engaging in joint planning. Yet I fear the world may be moving simply too fast to allow such considerations.

Perhaps we need to shift to new approaches in which strategic thinking and action occur simultaneously. It may be that our "ready, aim, fire" sequential approach will bog down in a world of change, become more of a "ready, aim . . . " approach. Perhaps we need to consider approaches characterized by more parallelism such as a "do it, then fix it if necessary" approach more capable of tracking the pace of change.

## Is It Time to Break the Mold?

This time of great change, of shifting paradigms, provides the context in which we must consider the changing nature of the academic research enterprise itself. We must take great care not to simply extrapolate the past. Instead, we must examine the full range of possibilities for the future.

But here we face a particular dilemma: both the pace and the nature of the changes occurring in our world today have become so rapid and so profound that our present social structures—in government, education, the private sector—are having increasing difficulty in even sensing the changes (although they certainly feel their consequences), much less understanding them sufficiently to allow institutions to respond and adapt.

Let me go further. I worry that our present institutions, such as universities and government agencies, which have been the traditional structures for intellectual pursuits such as research, may turn out to be as obsolete and irrelevant to our future as the American corporation in the 1950s. We need to explore new social structures capable of sensing and understanding change and capable, as well, of engaging in the strategic processes necessary to adapt and control change.

### Example One

Since the business of the academic research enterprise is knowledge, let me suggest that the impact that extraordinary advances in information could have—likely will have—profound implications. Technology such as computers, networks, HDTV, ubiquitous computing, knowbots, and other advances may well invalidate most of the current assumptions and thinking about the future nature of the research enterprise.

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For example, will the university of the twenty-first century be localized in space and time, or will it be a meta-structure involving people throughout their lives wherever they may be on this planet, or beyond? Is the concept of the specialist really necessary—or even relevant—in a future in which the most interesting and significant problems will require “big think” rather than “small think,” where intelligent software agents can roam far and wide through robust computer networks containing the knowledge of the world and instantly and effortlessly extract what a person wishes to know.

Will lifestyles in the academy (and elsewhere) become increasingly nomadic, with people living and traveling where they wish, taking their work and their social relationships with them?

In the spirit of these questions, perhaps we should pay far more attention to evolving new structures such as “co-laboratories” in which scholars collaborate worldwide through robust networks, rather than old-fashioned structures, such as research universities, federal research laboratories, research projects, centers, and institutes. There is a possible implication here. If information technology will indeed allow—perhaps even require—new paradigms for research organizations, should we not place a far higher priority on linking together our scientists and engineers, not to mention linking them with the rest of the world? This would seem to be a modest investment compared to other megaprojects such as the superconducting supercollider and the space station. Further, without investigating the impact of this technology-based infrastructure first, we may find ourselves making massive investments in research structures of the past.

## Example Two

While I am raising concerns about obsolete structures in academe, perhaps I should also raise a question about the role and even the existence of the federal research laboratory system. Currently, we have over 700 such laboratories, accounting for over one-third of federal R&D expenditures, \$21 billion a year.

These laboratories seem increasingly to suffer from "the marching army" syndrome in which federal facilities originally designed for highly specific roles, such as atomic energy development, defense research, or manned space flight, have acquired a momentum and a constituency quite independent of these original roles. Many of these laboratories are now thrashing about, seeking to find other missions to justify their massive public investment. But in the process, they are trampling other sectors such as education and industry. Perhaps it is time that some of these sacred cows be taken to market.

## Some Other Examples

Perhaps we need to try some experiments and examine far different models of the research enterprise. For example, we have long allowed private contractors to retain so-called IR&D funds to allow them to conduct independent research and thereby better prepare themselves to respond to future federal contracts. Perhaps we should also allow academic institutions to sequester a part of federal payments for such independent research.

A second idea is to recognize that since megaprojects such as the space station and superconducting supercollider utilize significant human resources, perhaps these projects should be "taxed" to support the development of these human resources.

Third, perhaps we should experiment more with block grants to institutions that would give them more flexibility over the support of academic research.

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## The Growing Importance of the Research University

For much of history, the university was a protected enclave respected well enough but mostly unnoticed and allowed to go about its business unchallenged and largely unfettered. What a contrast today when the university finds itself considered a key social, economic, political, and cultural institution. Today, the modern research university plays a central role.

Yet as important as these institutions are today in our everyday lives, it seems increasingly clear that in the future, they will play an even more critical role as they become the key player in providing the knowledge resources—knowledge itself and the educated citizens capable of applying it wisely—necessary for our prosperity, security, and social well-being. As we rapidly evolve into a post-industrial society in which the key strategic resource necessary for prosperity and social well-being becomes knowledge itself, our future will depend to an ever-increasing extent on new discoveries, expert knowledge, and highly trained people.

Erich Bloch, former director of the National Science Foundation, put it well in testimony to Congress, “The solution of virtually all of the problems with which government is concerned: health, education, the environment, energy, urban development, international relationships, space, economic competitiveness, and defense and national security, all depend on creating new knowledge—and hence upon the health of America’s research universities.”

The challenges of our age are immense:

- global change, the understanding of man’s impact on our planet
- the disparity in wealth, between rich and poor, between developed and



underdeveloped nations, between the northern and southern hemisphere

- the obsolescence of existing social structures, governments, corporations, universities, cities, states, nations
- specific U.S. challenges, such as the restructuring of K-12 education, economic competitiveness, the cost and availability of quality health care, drugs, and crime.

It is clear that universities, the people and knowledge they produce, will be key to meeting these challenges. But note that these particular challenges represent solutions to our present situation.

What about the great frontiers of the twenty-first century?

- understanding our universe, life, our existence
- using powerful new tools such as molecular biology and information technology to create a new future
- enabling mankind to break the bounds of our planet and begin the colonization of our solar system and perhaps even the stars beyond
- the creation of new materials, atom by atom, of artificial intelligence, of new life forms.

These, too, should be—must be—part of the mission of our research universities.

## Concluding Remarks

The world and the structure of academic research have changed a great deal since Vannevar Bush wrote his report. But the major principles he

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advanced merit reaffirmation. The national interest still calls for an investment in human and intellectual capital. Science still operates best in an environment of freedom.

Throughout this nation we see a shift away from fundamental research in many sectors. For example, the increasing pressures on industrial research laboratories to support competitiveness have shifted the focus of great national assets such as Bell Laboratories, the IBM Research Laboratories, and the General Motors Research Laboratory to far more implied work. There is a real question about the future of the government laboratories, particularly those with DOD missions. Hence, universities are rapidly becoming the last stronghold of basic research. If our research universities don't perform it, no one else in our nation will.

But we must remember that the government-university partnership isn't simply about the procurement of research results. It also concerns nurturing and maintaining the human capital of a great technological nation.

The American public, its government, its universities should not surrender the long-term advantage of this research partnership because of a short-term loss of confidence. At a time when many of society's other institutions do not seem to be working well, the research university is a true success story. We simply must get that message across to the American public. We must redouble our efforts to articulate and preserve the remarkable partnership that has existed between our government—our society—and our research universities over the past four decades.

Our future depends on it!

