Perhaps the unique characteristic of higher education in America is the strong bond between the university and society. Historically our institutions have been shaped by, have drawn their agendas from, and have been responsible to the communities that founded them. This unique partnership goes back over two centuries to that famous passage from the Northwest Ordinance, "Religion, morality, and knowledge being necessary to good government and the happiness of mankind, schools and the means of education shall forever be encouraged." This laid the foundation for one of our nation's most remarkable social inventions, the American research university.

Because they added the activities of research and service to the traditional academic mission of teaching the young, these institutions created a continuing connection between theory and practice. The result has been a powerfully creative engine for progress uniting students and faculty in a collective discovery and transfer of useful knowledge and technology. The American research university, through on-campus scholarship and off-campus extension activities, was first key to the agricultural development of America and then to the transition to an industrial society. WW II provided the incentive for even greater cooperation as the universities became important partners in the war effort, achieving scientific breakthroughs such as nuclear fission and radar. In this period our universities learned valuable lessons in how to develop and transfer knowledge strategically and how to work as full partners with government and industry to address critical national needs.

The seminal report, *Science, the Endless Frontier*, produced by a post-war study group chaired by Vannevar Bush, stressed the importance of this partnership by echoing the spirit of the Northwest Ordinance: "Since health, well-being, and security are proper concerns of government, scientific progress is, and must be, of vital interest to government." The resulting partnership between the federal government and the nation's universities has had an extraordinary impact. It has made America the world's leading source of fundamental scientific knowledge. It has also produced the well-trained scientists and engineers capable of applying this new knowledge. This academic research enterprise has played a critical role in the conduct of more applied, mission-focused research in a host of areas including health care, agriculture, national defense, and economic development.

Yet as important as research universities 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 players 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 Erich Bloch,

former Director of the National Science Foundation stated it in Congressional testimony: "The solution of virtually all the problems with which government is concerned: health, education, 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."

But here we have both some good news and some bad news. First, the good news:

The Good News

The good news is that America's system of higher education is still widely acknowledged to be the strongest and most productive in the world. A couple of years ago a *New York Times* editorial referred to our nation's research universities as the "jewel in the crown" of our national economy. It went on to assert that university research "is the best investment taxpayers can ever make in America's future".

In fact, at a recent session of the National Science Board led by Nobel Laureate Economist Bob Solow, and involving Laura Tyson's economic team, it was noted that in our increasingly knowledge-intensive society, the rate of return of research is rising. More specifically, while the average rate of return on capital investment in the United States today ranges from 10% to 14%, the private rate of return of R&D investment is estimated to be 25% to 30%, and the social rate of return--that is the rate that accrues to society more generally, is estimated to be as high as 50% to 60%--roughly four times the rate for other types of investment.

As a group of 15 leading corporate CEOs led by next year's Woodruff Lecturer, Norm Augustine or Martin Marietta, put it well in a recent letter to Congress:

> "America's leadership position in an ever-increasing globally competitive economy has been fueled by our technological prowess. our universities, and the research programs pursued therein, have played a pivotal role in continually advancing our technical knowledge and know-how. Further they have produced the scientists and engineers who have provided the brainpower that allows American business and industry to operate and compete with nations and cultures throughout the world. The standard of living we enjoy today has, in large part, been made possible by our ingenuity and creativeness and our ability to continually advance and apply technology. Our university system and its research

programs play a central and critical role in advancing this state of knowledge."

The Bad News

If the good news is that our research universities are the strongest in the world--at a time when the benefits from R&D investment have never been higher--the bad news is that the 1990s stand a good chance of being the worst for higher education since the 1930s. There is a frightening sense of crisis at many of our nation's most distinguished campuses.

Our universities are at serious risk on a number of fronts. The signs of stress are everywhere:

1. The breakdown of mutual trust has led to increasingly adversarial relationships between universities and government, including Congress, the administration, and federal agencies, as manifested in recent skirmishes over matters such as indirect cost reimbursement, scientific misconduct, and pressures to restrict the flow of technical information.

2. The skepticism--indeed, hostility--exhibited by the media and government has badly eroded public trust and confidence in the university, as revealed by the recent deluge of attacks on the academy, e.g., those who suggest that "most scholarly activity is 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."

3. Forces upon and within the universities, such as the rapidly escalating costs of research, are pushing toward a rebalancing of missions, away from research and more toward teaching and public service.

4. The morale of academic researchers has deteriorated significantly over the past decade, in part due to the pressures and time-consuming nature of the need to obtain and manage sponsored research funding and the disintegration of a "scholarly community" within the university. In a recent series of campus workshops sponsored jointly by the Government-University-Industry Research Roundtable and the National Science Foundation, a young faculty member described the modern university as "a holding company for research entrepreneurs."

What is going on here? To some degree, we may be seeing evidence of the increasing estrangement of the American public--and their elected

representatives--from science itself. The gap grows even wider between the omnipresent influence of science on modern society and the scientific literacy of the body politic.

We also may be experiencing the same forces of populism that rise from time to time to challenge many other aspects of our society--a widespread distrust of expertise, excellence, and privilege (the Forrest Gump syndrome). Unfortunately, many scientists, universities, and university administrators have made themselves easy targets by their arrogance and elitism.

But something else may be happening. Let me comment on several aspects of the current stresses on the academic research enterprise that may prove of critical importance in the years ahead.

Stresses on the Academic Research Enterprise

The Political-Economic Crisis

Universities are suffering the consequences of the structural flaws of national and state economies, the growing imbalance between revenues and expenditures, that are undermining support for essential institutions as governments struggle to meet short-term demands at the expense of long-term needs. For too long the electorate has had the credo: "Eat dessert first. Life is uncertain. And by the way, just send the bill to the kids later--say in a decade or two." The fact is that education at all levels is feeling the effects of two decades of political failure to invest in our people and infrastructure--in our children's future.

Actually, the writing has been on the wall for almost a decade, since federal outlays for R&D have been falling in real terms since 1987. Today, in Washington, this slogan has been replaced by a new mantra, "Balance the Budget by the year 2000", that is being chanted over and over again as the way to deliverance. While the particular Tao, the path to deliverance, is still uncertain...whether via the Contract with America or Reinventing Government...the endpoint is clear. Discretionary domestic spending, research and education programs, and federal support of the research university, all are at great risk. (For example, basic research is proposed to decline by 30%, with even the National Science Foundation being cut up to 13% ($440 M).) Indeed, leaders both in the federal government as well as in higher education have suggested that the next several months could well determine whether the research university will survive into the next century as a viable paradigm in American higher education.

The states are also in serious trouble. Cost shifting from the federal government through unfunded mandates such as Medicare, ADA, and OSHA, the commitment many states have made to funding K-12 education off-the-top, and massive investments in corrections have undermined their capacity to support higher education. In fact, in many states today, the appropriations for prisons has now surpassed the funding for higher education and shows no signs of slowing. Few, indeed, are those public universities that can expect even inflationary increases in state appropriations in the decade ahead.

As a result, many public and private institutions are facing very serious financial difficulties today. While you read in the national press about the staggering budget deficits faced by relatively affluent institutions like Stanford, Yale, and the University of California, the situation is far more serious in those institutions that do not benefit from massive endowments or generous state support.

There is an additional challenge faced by the best of America's universities. Harold Shapiro, President of Princeton University, has identified what he calls the "l percent problem" facing those institutions that compete to be the very best in teaching and scholarship. The decade of the 1980s experienced a trend in which the costs of achieving excellence in higher education rose roughly 1 percent per year more rapidly that the available resource base. (Some institutions such as Stanford found this mismatch to be 2 percent or higher.) Most studies project that this trend is likely to continue throughout the 1990s, driven in part by the expanding knowledge base and by the cost structures of quality research and teaching. While a given institution may be able to accommodate such an imbalance between costs and revenues over a short period, it is clear that over the long term, the "1 percent problem" will require a significant restructuring of the mission and activities of the university.

The Inability to Comprehend the Modern University

There is another dilemma here, one perhaps best illustrated by the old parable of the blind men each feeling different parts of an elephant and arguing over just what the whole beast looks like. The modern research university is complex and multidimensional. People perceive it in vastly different ways, depending on their vantage point, their needs, and their expectations. Students and parents want high-quality, but low-cost, education. Business and industry seek high-quality products: graduates, research, and services. Patients of our hospitals seek high-quality and compassionate care. Federal, state, and local governments have complex and varied demands that both sustain and constrain

us. And the public itself sometimes seems to have a love-hate relationship with higher education. They take pride in our quality, revel in our athletic accomplishments, but they also harbor deep suspicions about our costs, our integrity, and even our intellectual aspirations and commitments.

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

- improving health care
- national security
- social mobility
- parenting
- big-time show biz (intercollegiate athletics)

It is now asking to us to assume additional roles such as:

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

Unfortunately, most people--and most components of state and federal government--can picture the university "elephant" only in terms of the part they can feel, e.g., research procurement, student financial aid, and political correctness. Few seem to see, understand, or appreciate the entirety of the university.

This is particularly true in Washington, where each element of the federal government attempts to optimize the procurement of the particular products or services they seek from our research universities. There seems to be little recognition that shifting federal priorities, policies, or support aimed at one objective will inevitably have an impact on other roles of our institutions.

Looking at the university from an economist's perspective, one would see as inputs our people--students, faculty, and staff--and our funding--tuition paid by students and families, gifts and income on endowments, and taxpayer dollars from state and federal governments. Our outputs are the value-added through the education of our students, the knowledge produced on our campuses, and through direct services to our society such as through agricultural extension services or teaching hospitals.

The problem is simple: Each stakeholder wants to minimize the input it provides and maximize the output it obtains from universities, but none of the funding contributors is looking at the university as a whole, with diverse missions. More specifically, each party seems to want much more out than it is willing to put in, thereby leveraging other contributors.

Let me illustrate this with two recent examples: Federal efforts to impose artificial limits on the reimbursement of indirect costs on research grants, and the alarming trend to increasing cost-sharing requirements.

Recent efforts to reduce the costs of federally-sponsored research by imposing limits on the rates in indirect cost reimbursement is an example of the type of cost-shifting. While complex to calculate, indirect costs are nevertheless real costs associated with the conduct of federally-sponsored research, and must be paid by someone. Indeed, many of these costs are driven directly by the federal government through layer after layer of regulation, accounting, audits, and policy shifts.

To put it in the bluntest of terms, most institutions have only one recourse to respond to federal efforts to pay less than the full costs of the university research they procure: student tuition and fees. That is, if the federal government decides it wants to reduce federal research expenditures by several hundred million dollars by capping indirect costs, in reality it is asking students and parents to pick up this much of the tab for federal research projects, since this is the only alternative funding source most universities have.

The same can be said for cost-sharing requirements on federal grants. While there is a certain simplistic rationale behind such requirements--after all, cost-sharing can be viewed a kind of earnest money proving the sincerity of the institution seeking the grant--they can have serious negative implications, since they usually result in the diversion of discretionary funds away from educational programs and into federally-sponsored projects.

Both artificial restrictions on indirect cost rates and excessive cost-sharing requirements represent a harmful departure from an important principle characterizing the federal government-university partnership: that the federal government will cover the full costs of the research it procures.

The Real Issue: Shifting Paradigms

Let me suggest that beyond the financial pressures, the cost-shifting trends, human resource concerns, and the difficulties in comprehending and

balancing the many missions of the university, there is yet another important theme that we must consider, and that is change itself. Today we find ourselves in the midst of two simultaneous paradigm shifts: i) in the nature of the government-university research partnership and ii) in the character of the university itself. These shifts are being driven by the extraordinary nature and pace of change in the world today.

Let me consider each, in turn.

The Changing Nature of the Government-University Partnership

A Shift in National Priorities: From Guns to Butter...

For almost half a century, the driving force behind many of the major investments in our national infrastructure has been the concern for national security in the era of the Cold War. The evolution of the research university, the national laboratories, the interstate highway system, our telecommunications systems and airports, the space program, all were stimulated by concerns about the arms race and competing with the Communist Bloc. So too, much of the technology that we take for granted, from semiconductors to jet aircraft, from computers to composite materials, all were spin-offs of the defense industry.

Yet in the wake of the extraordinary events of the last five years--the disintegration of the Soviet Union and Eastern Europe, the reunification of Germany, and the major steps toward peace in the Middle East--the driving force of national security has disappeared, and along with it, much of the motivation for major public investment. Far from a "peace dividend" providing new resources in a post-Cold War world for investment in key areas such as education and research, instead the nation is drifting in search of new driving imperatives. While there are numerous societal concerns such as economic competitiveness, national health care, crime, and K-12 education, none of these has yet assumed an urgency sufficient to set new priorities for public investments.

Further, much of the existing intellectual infrastructure, developed to underpin national defense, is now at risk. The national laboratories are facing massive downsizing and necessarily searching for new missions. The burdens of the massive debts incurred in the buyout-merger mania of the late 1980s have forced corporate America to downsize research and development activities, including the shift of many of America's leading corporate research laboratories such as the Bell Laboratories and the IBM Research Laboratories from long-term research to short-term product development.

Equally serious are signs that the nation is no longer willing to invest in research performed by universities, at least at the same level and with a similar willingness to support understanding-driven basic research. Congress has made it clear that they will insist that universities focus increasingly on applied research, more directly related to national priorities (although many industrial leaders have tried in vain to explain that without "basic" research, there is nothing to "apply"). The federal government has yet to develop an successor to the government-university research partnership which served so well during the Cold War years.

Of course, it is certainly appropriate to seek to support "strategic" research, that is, both basic and applied research that has a high probability of contributing to national goals. And it is also the case that universities have responded to such national priorities in years past, ranging from national security to health care to agricultural or industrial development. Indeed, many of our land-grant public universities have such strategic research as an important part of their mission.

Hence the concern is not the renewed federal interest in strategic research, but rather the way that the federal government is approaching this effort. The American research enterprise triad, research universities, national laboratories, and industrial research laboratories, is generally approached through the institutional structure of Congress, where most committees and therefore budget decisions are organized around specific mission-oriented agencies (e.g., defense, energy, health, environment). While it certainly makes sense to attempt to redirect the entire American research enterprise to focus on new strategic objectives, to do so within a single committee or budget category could lead to a damaging distortion of our research capacity.

A Change from Partnership to Procurement

As we have already noted, the basic structure of the academic research enterprise of the past half century was set out in Bush's study, *Science, the Endless Frontier*, almost fifty years ago. The central theme of the document was that the nation's health, economy, and military security required continual deployment of new scientific knowledge and that the federal government was obligated to ensure basic scientific progress and the production of trained personnel in the national interest. It insisted that federal patronage was essential for the advancement of knowledge. It stressed a corollary principle--that the government had to preserve "freedom of inquiry," to recognize that 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."

Since--at least in the past--the government recognized that it did not have the capacity to manage effectively either the research itself or the universities, the relationship was essentially a partnership, in which the government provided relatively unrestricted grants to support a part of the research on campus, with the hope that "wonderful things would happen." And they did, as evidenced by the quality and impact of academic research.

Unfortunately, in recent years the basic principles of this extraordinarily productive research partnership have begun to unravel, so much so that today this relationship is rapidly changing from a partnership to a procurement process. The government is increasingly shifting from being a partner with the university--a patron of basic research--to becoming a procurer of research, just like other goods and services. In a similar fashion, the university is shifting to the status of a contractor, regarded no differently from other government contractors in the private sector. In a sense, today a grant has become viewed as a contract, subject to all of the regulation, oversight, and accountability of other federal contracts. This view has unleashed on the research university an army of government staff, accountants, and lawyers all claiming as their mission that of making certain that the university meets every detail of its agreements with the government.

To be sure, we must all be concerned about the proper expenditure of public funds. But we also must be concerned about restoring the mutual trust and confidence of a partnership and move away from the adversarial contractor/procurer relationship that we find today.

Unfortunately, even the procurement model may be only a transitional stage, since in recent months there have been signs that the paradigm is continuing to shift still further to the same cost-control--or more correctly, federal cost-shifting--patterns characterizing health care. Can you imagine a system of DRG cost-reimbursement rules for basic research?

Surely the most ominous warning signs for academic research are the erosion, even breakdown, in the extraordinarily productive fifty-year partnership uniting government and universities. Scientists and universities are questioning whether they can depend on the stable and solid relationship they had come to trust and that has paid such enormous dividends in initiative, innovation, and creativity. It is truly perverse that the partnership that has been in large measure

responsible for our long undisputed national prosperity and security should be threatened at very moment when it has become most critical for our future.

The Changing Paradigm of the Research University

There is an even more profound transformation occurring: that involving the paradigm of the research university itself. As one of civilization's most enduring institutions, the university has been extraordinary in its capacity to change and adapt to serve society. Far from being immutable, the university has changed over time and continues to do so today. A simple glance at the remarkable diversity of institutions comprising higher education in America demonstrates this evolution of the species.

The challenges and changes facing higher education in the 1990s are comparable in significance to two other periods of great change for American higher education: the period in the late-nineteenth century, when the comprehensive public university first appeared, and the years following World War II, when the research university evolved to serve the needs of postwar America. Today, many are concerned about the rapidly increasing costs of quality education and research during a period of limited resources, the erosion of public trust and confidence in higher education, and the deterioration in the partnership between the research university and the federal government. However, our institutions will be affected even more profoundly by the powerful changes driving transformations in our society, including the increasing ethnic and cultural diversity of our people; the growing interdependence of nations; and the degree to which knowledge itself has become the key driving force in determining economic prosperity, national security, and social well-being.

Beyond the Endless Frontier

In recent months, there have been strong indications that a new federal R&D policy might be taking shape. First, in a recent report by the National Academy of Sciences, chaired by Frank Press, there was a strong call for a more coherent and strategic budgeting policy for that fraction of the federal budget that expands fundamental knowledge and creates new technology. This amounts to some $35 B to $40 B, distributed among federal laboratories (39%), academic institutions (31%), industry (21%), and other institutions (9%). They proposed that this aggregated federal science and technology budget (FS&T) be identified both by the White House and by Congress to provide a more strategic budgeting process. This would allow selective reductions and increases within and across agencies to reflect changing missions and performance evaluations.

The preface to Science and Engineering Indicators, released every two years by the National Science Board, reinforces and expands this theme in three areas:

1) First, it recommends that R&D priorities be set consistent with new scientific opportunities, post-Cold War national goals, and unavoidable resource limtations. Presidential and Congressional policy-makers should institute a budget making process which enables them to pay carefuly attention to the complex connections and mutual dependencies among US R&D performers and users, to weight the long term consequencies of specific funding decisions, and to strategically coordinate federal choices and tradeoff. In order to take advantage of valuable world resoruces, both material and human, and to share costs, federal policy makers should pursue international S&T cooperation where possible to achieve national and global goals. In establishing strategic goals for federal reserach investments and principles for setting R&D funding priorities, policy-makers should strive for performance at a world level in all major areas of science and engineering and preeminence in a select number of fields.

2) In addressing current and future US workforce training needs, beginning with universal basic science and mathematics literacy and continuing through to the steady renewal and upgrading of US scientific and technological human resource capacities. Federal R&D policies should explcitly consider the effects of funding decisions on the evolving partnerships etween federal agencies and laboraties, industry, universities, and schools in order to breaoden systemic educational reform initiatives designed to meet K-12 students' learning needs in mathematics, science, and technology. Federal R&D policies should explicitly consider the differential effects of agencies' funding decisions on the scope and level of support for undergraduate and graduate education in speciic S&E disciplines.

3) The integration of research and education at US colleges and universities should be strengthened. The combination of training and research in US universities has been a major factor in creating scientific and technical preeminence as well as in providing competent professionals to staff industry and government. It is one of the most effective means of technology transfer, and government allocation criteria in the future should recognize this level of achievement. There are more than 3,600 US institutions of higher education enrolling almost 15 M students, more than double the number enrolled in 1967. Althoiugh the number of PhDs in S&E has increased since 1985, it has been largely due to foreign born

> graduates. Today, collectively, European instituions award 20% more PhDs in S&E than North American universities. Science and engineering is one enterprise and needs to be integrated from K-12 all the way through the research at the frontgiers. Belief in the synergy between research and education which takes place in universities undergirds public confidence in the wisdom of federal investments in academic research. The federal government should strengthen efforts to promote the integration of research and education and support innovative experiments in this area.

Back to the Future...

For the past half-century, the Bush paradigm of federal patronage of investigator-driven research has determined the nature of the research university. Only 125 of the 3,600 institutions of higher education are research universities, but these are just the institutions at most risk as the federal science and technology budget shrinks in the years ahead. Don Langenberg, Chancellor of the University of Maryland goes even further: "It is probably about as safe to assume that the dominate higher education institutions of the 21st century will stem from this small but powerful group of present day institutions as it would have been to assume that today's dominate life form on Earth would stem from Tyrannosaures Rex."

There are some obvious responses to this precarious situation:

1. Clearly universities must shift from the public to the private sector for support to accommodate the erosion in state support. Beyond seeking corporate support for R&D, they will need to more aggressively market educational service and put in place most realistic prices structures (e.g., tuition and fees) that accurate reflect costs.

2. They must also shift rom "faculty centered" to "student-centered" activities...that is, from "provider-centered" to "customer-market".

3. And, finally, there are growing signs that there will be a shift from "elitism" and "excellence" to the provision of cost-competitive, high quality services--from "prestige-driven" to "market-driven" philosophies.

Let me focus a bit on this third issue. It seems clear that a shift is now occurring in public attitudes toward research universities. For the past half-century, the Bush paradigm characterizing the government-university research partnership has been one built upon the concept of relatively unconstrained patronage. That is, the government would provide faculty with the resources to

do the research they felt was important, in the hopes that at some future point, this research would benefit society. Since the quality of the faculty, the programs, and the institution was felt to be the best determinant of long term impact, academic excellence and prestige were valued.

Yet, today the public seems reluctant to make such a long term investment. Rather, it seems interested in seeking short term services from universities, of high quality, to be sure, but with cost as a consideration. In a sense, it seeks low-cost, quality services rather than prestige.

Perhaps rather than moving ahead to a new paradigm, we are in reality returning to the paradigm that dominated the early half of the 20th century...the "land-grant university" model. In fact, perhaps what is needed is to create a contemporary land grant university paradigm.

When the Morrill Act was adopted in 1962, it was aimed at establishing programs in agriculture, mining, and the mechanic arts--the forerunner of today's schools of engineering. That we were successful is obvious. The vast natural resources of our country produced immense wealth for some and a higher standard of living for most. The agricultural experiment stations and cooperative programs were enormously successful. In the last century our universities, particularly land grant institutions, created and applied knowledge, and provided human resources needed to address critical national problems.

A land grant university for the next century could be designed to develop the most important resource for our future--not our natural resources, but rather our human resources, as its top priority. The field stations and cooperative extension programs could be directed to the needs and the development of the people. While traditional professional fields would continue to have major educational and service roles and responsibilities, increasingly, new interdisciplinary fields should be developed to provide the necessary knowledge and associated problem-solving services in the land grant tratdition.

Concluding Remarks

The world and the structure of academic research have changed greatly since Vannevar Bush wrote his report. However the major principles he advanced merit reaffirmation. Now more than ever before the national interest calls for an investment in human and intellectual capital. As Bush so clearly stated it, the government-university partnership is not simply about the procurement of research results. It is also about nurturing and maintaining the human strengths of a great technological nation and sowing the seeds of

innovation that will ultimately bear fruit in new products and processes to fuel our economy and improve our quality of life.

The American public, its government, and its universities should not surrender the long-term advantage of this research partnership because of a short-term loss of direction or 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 re-articulate and revitalize the remarkably successful partnership that has existed between our government, our society, and our research universities over the past four decades.

Indeed, the world--and the structure of R&D--has changed a great deal since Bush wrote his report. But the major principles he advanced in it merit reaffirmation. The long-term national interest still calls for investment in the human and intellectual capital that are essential, ultimately, to national prosperity and security.