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Michigan State University's College of Natural Science

"The Government-University Research Partnership: Beyond the Endless Frontier . . . ?"

Introduction

Good morning.

I am delighted to be here in Spartan territory to talk about something of vital importance to each of us in this room and to the future of both of our great universities.

One of the unique characteristics 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 certainly has been true of Michigan State University, a pioneer land-grant institution.

Founded in 1855, MSU has a rich history of providing educational opportunities to undergraduates and graduate students of diverse interests, abilities and backgrounds.

The core of the land-grant tradition is the belief that educational opportunities should be available to the widest possible number of people.

It is a tradition that values both the discovery of new knowledge and the development of practical applications of that knowledge.

This unique partnership between universities and the society they serve goes back over two centuries to the Northwest Ordinance, which states:

"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 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 about 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, said when
he testified before Congress:

“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.”

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 of 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 brain power 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.

A frightening sense of crisis is gripping 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. Some 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 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 need to obtain and manage sponsored research funding. Another factor is the disintegration of the notion 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.

My hypothesis is that 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 our 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.

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.

Federal R&D priorities have shifted from defense toward the civilian sector,
reinforcing the trend toward a greater role in total US R&D for
academic performers financed largely by the federal government.

During the decade that ended in 1994,
annual constant dollar increases in R&D performed in universities
exceeded by at least a factor of two the performance growth in all other
settings.

Even as its share of applied research grew, the academic sector remained the largest performer of basic research in the nation, performing about half of US basic research in 1995.

Yet overall growth in US support for R&D has not kept pace with inflation in the 1990s. Federal outlays have been falling in real terms since 1987.

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, appropriations for prisons have now surpassed the funding for higher education and show 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.

America's universities face an additional challenge.

Harold Shapiro, president of Princeton University, has identified what he calls the "1 percent problem" facing those institutions that compete to be the very best in teaching and scholarship.

During the 1980s, the costs of achieving excellence in higher education rose roughly 1 percent per year more rapidly than 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

We have 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 direct services to our society such as through agricultural extension 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 multiple layers of regulations, 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 for most universities.

The same can be said for cost-sharing requirements on federal grants.

There is a certain simplistic rationale behind such requirements – after all, cost-sharing can be viewed as a kind of earnest money proving the sincerity of the institution seeking the grant.

However, cost-sharing can have serious negative implications, since it usually results 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.

Human Resource Development

Yet another source of stress is the total absence of a federal policy on the development of human resources – particularly in the fields of science, mathematics, and engineering.

Although the nation's scientific research has been guided for the past 50 years by the vision and policies articulated in the Vannevar Bush Report, there has been no corresponding, coherent policy for human resource development in science and technology since the 1960s.

Nothing has succeeded earlier federal policies such as the G. I. Bill and the National Defense Education Act.

Instead the nation has been on autopilot, with its human resource development largely occurring as a byproduct of research and development programs rather than through a strategic consideration of national needs.

It is little wonder that the current system tends to replicate itself by producing scientists and engineers trained for increasingly narrow – and increasingly limited – research roles, largely ignoring the broader interests of our best students, the increasing diversity of today's generation of students, and the complex and rapidly broadening roles in our society played by those with science and engineering training.

As pointed out in the recent National Academy and National Science Board studies, there is an urgent need for the Administration to develop both a vision and an associated federal policy aimed at providing the human resources in science and technology necessary to respond to both the contemporary and future needs of the nation.

The goal of such a policy should be to develop broadly educated people with the scientific and technological knowledge and the skills necessary to address the needs of the nation in a rapidly changing world.

This S&T human resources policy should be closely aligned and tightly coordinated with federal policies concerning science and technology, including both fundamental and strategic scientific research, and technology development and deployment.

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.

The "peace dividend" has not provided 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 a successor to the government-university research partnership that 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.

Universities have responded to such national priorities in years past, ranging from national security to health care to agricultural or industrial development.

Indeed, MSU and many of our other land-grant public universities have such strategic research as an important part of their mission.

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 such as 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 I noted earlier, 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 50 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.

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 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 of 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 each detail of its agreements with the
government.

Of course we all need to be concerned about how public funds are spent.

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 experience today.

Unfortunately, even the current 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 productive 50-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 the very moment when it has become most critical for our future.

The Changing Paradigm of the Research University

An even more profound transformation is 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-19th 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.

One frequently hears the primary missions of the university referred to in terms
of teaching, research, and service.

But these roles can also be regarded as simply the 20th century manifestations
of the more fundamental roles of creating, preserving, integrating,
transmitting, and applying knowledge.

While these fundamental roles of the university do not change over time, the particular realization of these roles do change – and change quite dramatically, in fact.

Consider, for example, the role of "teaching," that is, transmitting knowledge.

We generally think of this role in terms of a professor

teaching a class.

Students, in turn, respond by reading assigned texts,

writing papers,

solving problems or performing experiments, and

taking examinations.,

Classroom instruction is a relatively recent form of pedagogy.

Throughout the last millennium, the more common form of learning was

through apprenticeship.

Both the neophyte scholar and craftsman learned by working as

apprentices to a master.

While this type of one-on-one learning still occurs today, in skilled

professions such as medicine and in advanced education programs such

as the Ph.D. dissertation, it is simply too labor-intensive for the mass

educational needs of modern society.

The classroom itself may soon be replaced

by more appropriate and efficient learning experiences.

Such a paradigm shift may be forced upon the faculty by the students themselves.

Today's students are members of the "digital" generation.

They have spent their early lives surrounded by robust, visual, electronic media – Sesame Street, MTV, home computers, video games, cyberspace networks, and virtual reality.

They approach learning as a "plug-and-play" experience, unaccustomed and unwilling to learn sequentially – to read the manual – and rather inclined to plunge in and learn through participation and experimentation.

While this type of learning is far different from the sequential, pyramid approach of the traditional university curriculum, it may be far more effective for this generation, particularly when provided through a media-rich environment.

Faculty members of the 21st century university may well be asked to set aside their roles as teachers and instead be become designers of learning experiences, processes, and environments.

Tomorrow's faculty may have to discard the present style of solitary learning experiences, in which students tend to learn primarily on their own through reading, writing, and problem solving.

Instead, they may be asked to develop collective learning experiences in which students work together and learn together

with the faculty member becoming more of a consultant or a coach than a teacher.

One can easily identify other profound changes occurring in the other roles of the university.

The process of creating new knowledge – of research and scholarship – is also evolving rapidly away from the solitary scholar to teams of scholars, perhaps spread over a number of disciplines.

Is the concept of the disciplinary 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"?

Who needs such specialists when intelligent software agents will soon be available to roam far and wide through robust networks containing the knowledge of the world, instantly and effortlessly extracting whatever a person wishes to know?

So, too, there is increasing pressure to draw research topics more directly from worldly experience rather than from the curiosity of scholars.

Even the nature of knowledge creation is shifting somewhat away from the analysis of what has been to the creation of what has never been –

drawing more on the experience of the artist than upon analytical skills of the scientist.

The preservation of knowledge is one of the most rapidly changing functions of the university.

The computer – or more precisely, the "digital convergence" of various media from print to graphics to sound to sensory experiences through virtual reality – has already moved beyond the printing press in its impact on knowledge.

Throughout the centuries the intellectual focal point of the university has been its library, its collection of written works preserving the knowledge of civilization.

Today such knowledge exists in many forms . . . as text, graphics, sound, algorithms, virtual reality simulations . . . and it exists almost literally in the ether, distributed in digital representations over worldwide networks, accessible by anyone, and certainly not the prerogative of the privileged few in academe.

Finally, it is also clear that societal needs will continue to dictate great changes in how knowledge is applied.

Over the past several decades, universities have been asked to take the lead in applying knowledge across a wide array of activities,

from providing health care, to protecting the environment, from rebuilding our cities to entertaining the public at large (although it is sometimes hard to understand how intercollegiate athletics represents knowledge application).

This abstract definition of the roles of the university has existed throughout the long history of the university and will certainly continue to exist as long as these remarkable social institutions survive.

The particular realization of the fundamental roles of knowledge creation, preservation, integration, transmission, and application will continue to change in profound ways, as they have so often in the past.

The challenge of change, of transformation, is, in part, a necessity simply to sustain our traditional roles in society.

There is an increasing sense among leaders of American higher education and on the part of our various constituencies that the 1990s will represent a period of significant change on the part of our universities if we are to respond to the challenges, opportunities, and responsibilities before us.

A key element will be efforts to provide universities with the capacity to transform themselves into entirely new paradigms that are better able to serve a rapidly changing society and a profoundly changed world.

A World Transformed

Of course these paradigm shifts are being driven
by the ever accelerating pace of change in our society.

We are living in the most extraordinary of times:
the collapse of communism,
the end of the cold war,
the impact of technologies ranging from computers and
telecommunication to biotechnology,
a redefinition of the world economic order, and, of course,
the human population pushing against the very limits of the planet.

Many believe that we are going through a period of change in our civilization
just as momentous as that which occurred in earlier times such as the
Renaissance or the Industrial Revolution – except that while these earlier
transformations took centuries to occur,
the transformations characterizing our times will occur in a decade or
less!

I used to portray the 1990s as the countdown toward a new millennium,
as we find ourselves swept toward a new century by these incredible
forces of change.

The events of the past several years suggest that the 21st century is already
upon us – a decade early!

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 and instead examine the full range of possibilities of the future.

Here we face a particular dilemma.

Both the pace and nature of the changes occurring in our world today have become so rapid and so significant 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.

They are simply incapable of understanding the profound changes characterizing our world, much less responding and adapting in an effective way.

Let me go further.

It may well be that our present institutions, such as universities and government agencies, which have been the traditional structures for intellectual pursuits such as research, could be as obsolete and irrelevant to our future as the American corporation of the 1950s.

We need to explore new social structures

capable of sensing and understanding change,
as well as capable of engaging in the strategic processes
necessary to adapt or control change.

If American higher education is to respond to the challenges, opportunities,
and responsibilities before us,
universities must develop the capacity to transform themselves
into entirely new paradigms
that can serve a rapidly changing society and a changed world.

We must unshackle the constraints that prevent our institutions from
responding to the needs of a rapidly changing society,
remove unnecessary processes and administrative structures,
question existing premises and arrangements, and
challenge, excite, and embolden members of our university communities
to embark on this great adventure.

Our challenge is to provide an environment in which such change
is regarded not as threatening but rather as an exhilarating opportunity
to engage in learning, in all its many forms, to better serve our world.

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 limitations. Presidential and Congressional policy-makers should institute a budget making process which enables them to pay carefully attention to the complex connections and mutual dependencies among US R&D performers and users, to weight the long term consequences of specific funding decisions, and to strategically coordinate federal choices and tradeoff. In order to take advantage of valuable world resources, 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 research 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 explicitly consider the effects of funding decisions on the evolving partnerships between federal agencies and laboratories, industry, universities, and schools in order to broaden 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 specific 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. Although the number of PhDs in S&E has increased since 1985, it has been largely due to foreign born graduates. Today, collectively, European institutions 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 frontiers. 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. It is probably about as safe to assume that the dominant 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 dominant life form on Earth would stem from *Tyrannosaurus Rex*.

John Deutsch: The research university is probably the most endangered species of academic institution over the next decade as the FS&T budget shrinks by perhaps as much as 30%.

There are some obvious responses to this precarious situation:

1. Universities must shift from the public to the private sector for support (...a no-brainer...)

...loss of 30% in FS&T

...corporate support for R&D

...more aggressive marketing of services

...state support --> tuition ("user fees") ("state-related" universities)

Note that this will require a sea-change in university attitudes

2. From “faculty centered” to “student-centered” activities...that is, from “provider-centered” to “customer-market”.
3. 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 1862, it was aimed at establishing programs in agriculture, mining, and the mechanic arts--the forerunner of today's schools of engineering. The industrialization of our nation was the objective and Europe our competitor. 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 defined by Congress. yet, apart from World War II and the Cold War periods' focus on defense as our national priority, Congress has not found it possible to identify, prioritize, and support an agenda of national needs in any sustained fashion. if we cannot work on a national agenda, perhaps we should adopt a regional approach.

A land grant university for the next century could be designed to develop our most important resource, 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 in the region. 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 tradition.

To make this happen will require three substantial culture changes:

i) In our universities, the orientation of faculty effort and the faculty reward system would have to reflect the new institution mission. This is clearly possible, as evidenced by the way that the Bush research paradigm refocused the faculty effort and reward system on research and graduate education following WW II.

ii) While the complexity of our society continues to evolve, while societal problems multiply and public and legislative confidence wanes, we remain committed to the division of knowledge into small compartments overseen by academic politics that offer something for everyone, but less than full value to the student. The attainment of a liberal education remains a romantic notion of the past.

iii) Our society would have to be willing to make accessible quality education, especially in science and technology, at all levels for all students. Ultimately, the attitude of the public toward science and technology would have to change and the connection to the welfare of our nation be firmly established. In short, scientists and engineers are greatly outnumbered by the public at large! As Si Ramo put it, "This is the sentence in which technology advance outstripped social advance. Life on earth...must be regarded as a race, a contest waged on the frontier where advancing technology and society interface."

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.

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.