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Gary D. Krenz, Editor
Proceedings of the 1996 Jerome B. Wiesner Symposium
The Future of the Government/University Partnership
Gary D. Krenz, Editor

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Proceedings of the 1996 Jerome B. Wiesner Symposium

The Future of the Government/University Partnership

University of Michigan, Ann Arbor
Horace H. Rackham Building
February 26, 1996

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The 1996 Jerome B. Wiesner Symposium and Proceedings were made possible by the generous assistance of the Ford Motor Company
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The Jerome B. Wiesner Symposium sought to accomplish two goals: 1) to honor the memory of Jerome B. Wiesner, distinguished alumnus of the University of Michigan, leader of higher education, and a key architect of the nation’s research policy; and 2) to help carry forward a highlevel, multi-sector, bipartisan dialogue on the future of the government/university partnership in research.

The organizers of the Wiesner Symposium wish to acknowledge a number of individuals and institutions who made the Symposium possible, and its success a reality.

With respect to the first of the goals mentioned above, we wish to thank the members of the family of the late Jerome B. Wiesner, who so graciously agreed to allow us to use his name for this new annual event at the University. We hope that the Symposium has served, and will serve, to honor the memory of Jerome Wiesner.

We wish also to thank James J. Duderstadt, President of the University of Michigan: his suggestion a couple of years ago that the University try to do something to honor Jerome Wiesner led ultimately to the creation of this Symposium.

With respect to the second of the aforementioned goals, we note that the Symposium builds directly upon the ongoing effort of the research vice presidents of the Committee on Institutional Cooperation—the Big Ten universities plus the University of Chicago—to engender a national discussion of the basic “principles of partnership” that should guide universities and the federal government.

In particular, thanks goes to our colleagues on the Steering Committee for the CIC effort: Robert Galvin, Chair of the Executive Committee, Motorola, Inc.; John Mctague, Vice President, Technical Affairs, Ford Motor Company; Gene Mazenko, Associate Provost, University of Chicago; Homer Pearce, Vice President for Cancer Research,
Eli Lilly; Luis Proenza, Vice President for Research, Purdue University; David Shirley, Senior Vice President for Research and Dean of Graduate Studies, Pennsylvania State University; David Skorton, Vice President for Research, University of Iowa; Dick Stoddard, Director of Federal Relations, Ohio State University; and Roger Clark, Director, Committee on Institutional Cooperation. Thanks also goes to the presidents and provosts of the CIC, who originally authorized the effort as a CIC activity.

The Big Ten universities elected to co-sponsor, with the University of Michigan, this inaugural Jerome Wiesner Symposium—and we are very appreciative of their support. Without their co-sponsorship, and the commitment to dialogue that it represents, the event would certainly not have been as successful as it was.

The Ford Motor Company contributed generously to defraying the costs of the Symposium.

We would like to thank all of the many individuals from government, industry, and academe—too many to name—who took the time from their busy schedules to review and comment on various drafts of the “principles of partnership.” Their efforts helped advance the discussion, we believe, to a point where a successful Symposium was possible.

We thank Congressman Vernon Ehlers and Congresswoman Lynn Rivers for their co-chairing of the Symposium.

Finally, we thank the chairs of the various sessions: John McTague, Robert Galvin, David Skorton, and Ed Hayes, for their particular preparations, which certainly made each of their sessions a great success.

Homer A. Neal
University of Michigan
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**Introductory Essays**

Executive Summary of the Symposium

“Focusing on the Future”
by Homer A. Neal
Executive Summary

The first annual Jerome B. Wiesner Symposium, held at the University of Michigan on February 24, 1996, brought together leaders of academe, industry, and government to discuss the future relationship between government and universities: their respective responsibilities, and respective expectations for each other, in contributing via research and education to the national good.

The Symposium, named in honor of one of the University's most distinguished alumni, was devoted to The Future of the Government/University Partnership. The inaugural Symposium was co-sponsored by the universities of the Big Ten, and grew out of a year-long effort to develop a multi-sectored, bipartisan understanding of the basic framework of responsibilities for the research system (see “Focusing on the Future,” page xviii).

The Symposium sought to carry forward a discussion of the principles that underlie the government/university partnership for research and education (see Appendix E), and it was organized around the basic themes developed in those principles. Many of the participants in the Symposium had already contributed to the development of this draft through prior discussion and correspondence; essentially all Symposium participants received the draft in advance of the Symposium. What follows is a brief summary of the Symposium discussion.

Opening Session

Homer A. Neal convened the Symposium, and offered in his opening remarks a metaphor for the purpose of the day's activities: with respect to science policy, the nation is like the passengers and crew of a ship, sailing toward a distant land of promise; until recently, the maps and charts provided by Vannevar Bush in his seminal report, Science: The Endless Frontier, have served to guide our voyage. But now, we have
entered into uncharted waters, and we need to assemble as a group of “all hands”—crew and passengers—to help chart our future directions (pp. 40-41). “We remember Vannevar Bush’ words, but we do not quite know what they mean in this new regime. Hopefully, our symposium today will help extend our charts and bring us closer to our desired destination.” (p. 41).

The honorary co-chairs for the Symposium, Vernon Ehlers and Lynn Rivers, picked up on the theme of outcomes to be hoped for from the Symposium. Ehlers spoke of the need for the “development of a new model for the relationship between the federal government and the universities” (p. 43). He pointed to the issue of basic research versus applied research—the danger posed by inadequate or misleading distinctions, and the opportunity to better define the government’s appropriate role with respect to the spectrum of research activity. Ehlers also broached a key issue, which he would return to in later remarks, and which, indeed, might be seen as one of the critical themes of the Symposium: science as a mode of inquiry as well as being a body of knowledge (p. 44). To the detriment of science education, he noted, universities have focused too much on the latter and not enough on the former.

Lynn Rivers urged that the assembled company engage in a non-partisan discussion, but noted that partisan issues cannot be ignored altogether. She suggested that there were several issues that needed to be dealt with: the unfortunate emergence of “junk science” in Congress; the need for the nation to be willing to invest in research and development; the nation’s goals with respect to defense and economic competitiveness, and the role of research in helping to meet those goals; and the scope of inquiry that ought to be supported, and by whom (pp. 45-46).

**Keynote Session**

James Duderstadt introduced the keynote session by focusing on the tremendous value that the nation would stand to gain by investing in research generally, and university-based research in particular, but noting that there are at least four signs of stress on the nation’s system of
research universities (p. 51). These include: 1) a breakdown of mutual trust between universities and the government; 2) the erosion of public confidence in universities, in part spurred by increased skepticism in the treatment of universities in the news media; 3) rapidly escalating costs of research; and 4) decline in morale of academic researchers, due in part to the increased difficulties associated with obtaining sponsorship for research.

Charles Vest wove together in his talk the two overarching themes for the day’s gathering—namely, honoring Jerry Wiesner and discussing the future of the government/university partnership. In a wide-ranging talk, he presented Jerry Wiesner as the embodiment of just the sort of open, honest, and thoughtful approach that we need in this new time of “crisis” in national science and technology policy. “We need to ask,” he said, “what would Jerry do?”

The dangers and opportunities that we face in “a world of change” (pp. 58-59) are manifold: “It is a time of change and it is a time for change” (p. 58). The government/university partnership has, he noted, gone through several watersheds in its history: the establishment of the land-grant colleges, which helped spur regional and national agricultural and industrial development (p. 59); the invention of the modern research university in and following World War II, when military and then national security “necessity drove new meldings of the professions, and new understandings about the relationship between the deepest of sciences and the most practical of applications” (p. 60); and the new era, in which “fundamental change seems to be demanded, but its nature is unclear” (p. 61).

At the crux of our current situation, Vest places the threats to our national “innovation system” (p. 61). The innovation system, a “loose coupling” of government, academe, and industry devoted to the creation, dissemination and implementation of new knowledge, is articulated into three tiers of research and development activity:

1) the bottom or long-term tier of fundamental science and engineering research, predominantly carried out at universities;
2) the mid-term, middle tier of research on “commercial or societal application—let us say, between two and five years” out.
This research, he notes, “contains much of what economists term the social return on our R&D investments” (p. 62); and
3) the short-term, top tier of product and application development, usually within a time-horizon of a year or two.

This system is now in danger of disintegrating, precisely because the middle tier is gravely threatened: once the province of industrial research, it is no longer adequately supported either by industry or by the federal government (p. 63). In industry’s necessary refocusing on bringing products to market in an efficient and effective manner, the investment in development of the precompetitive technological base has declined precipitously. As a result, collaborations between industry and universities have been damaged. Consequently, there is a widening gap in the middle of the innovation system, which threatens to leave fundamental research altogether unused, untransformed, and unapplied, and which could result in the top tier eventually grinding to a halt, as the precompetitive base erodes.

We need now to deal with the resulting research gap in a creative manner that really moves the nation forward.

First, he said, we must understand the implications of our level of investment in research and development. At present, only 0.5 percent of the Gross Domestic Product is being invested by the federal government in research and development activities that generate new knowledge and technology. Moreover, this level of investment will likely decrease in constant dollars, if most deficit-reduction projections are borne out in practice over the next few years. Our situation contrasts sharply with that of Japan, which is currently investing approximately 2.8 percent of its GDP in research and development, and which has set as a goal the doubling of its investment in R&D by the year 2000 (p. 65).

What must we do, then, to seize the opportunity at this danger point? We must, Vest says, attend to the overall policy environment (pp. 66-68):
1) We must avoid simplistic categorizations of research into, e.g., basic and applied. Such categorizations are not reflective of the realities in contemporary research and scholarship, and their usage is detrimental to policy discussions.
2) We must not fail to recognize that the funding of research and higher education is an investment that yields extremely high rates of social return—in some estimates, as high as 50 percent (p. 67).

3) We must avoid the egregious separation of education and research.

4) We must avoid driving wedges between public and private institutions, as we endeavor to revitalize the research partnership (p. 68).

What positive steps should be taken—or, as Vest says, how do we “build bridges between ideas and institutions to create entirely new paradigms to meet the times and the nation's need”? (p. 68) What the research community can and must do is open itself in fresh ways to a genuine dialogue with the broader society. “If we expect the federal government and the American people to support us, we must pay more attention to the things that concern them.” The academic and scientific communities must advocate their cause: “Though we must not blindly advocate our cause...we must advocate it” (p. 70). “Let us be teachers,” he says—but also, “let us be partners.” And this notion of partnership captures the other side of the dialogue: we must listen, and in listening create partnerships in our research and educational activities—with industry, with the government, with national laboratories, with the public. “Our value to the national economy stems from our willingness to explore the unknown, unravel mysteries and satisfy human curiosity. We cannot deprive the next generation of the opportunity to contribute to this process.” (p. 72)

The University in National Science and Technology Policy

The next session was devoted to a series of historical reflections on universities and the federal government, from the perspective of four former presidential science advisors—representing the Johnson, Ford, Reagan, and Bush Administrations—as well as the current associate director for science in the White House.

John McTague suggested that discussion about the role of the fed-
eral government in research policy is misdirected: the primary discussion must be about the goals that the nation hopes to achieve through an investment in research. If agreement on the goals can be attained, the definition of roles will quickly fall into place. (pp. 81-82).

Donald Hornig cautioned against panic and overreaction: “we are back to problems that have not changed as much as much as we would like to think when we say that we are now in a crisis” (p. 83). He did, however, point to a major problem on the horizon, namely, that the system simply could not continue to grow forever, and at some point would reach a fundamental limit of growth. This was a concern, he noted, even in the 1960s— but it is only now that we are actually beginning to reach what might be a fundamental limit (p. 86).

Guy Steever, also noting that concerns about levels of funding are not new, stressed the importance of communicating effectively with members of Congress: “We had to fight for our funding; we did our best to build bridges to Congress....One of the biggest jobs that you have in facing the future is to ensure that building that connection to Congress is done well” (p. 89).

Allan Bromley recalled a key strategic accomplishment of the Bush Administration in the area of science policy— the development of a two-tiered budget. Most of the research budget, he noted, is developed from the “bottom up,” by investigators working through particular agencies. “What we introduced was the idea that, on top of that structure, would come half-a-dozen...areas selected by the President, to which the President would give special personal support from the bully pulpit of the Presidency”(pp. 91-92). Bromley also noted that the federal government ought to pay the full costs of the research that it funds— a topic that received attention throughout the day’s proceedings.

Ernest Moniz maintained that the Clinton Administration is committed to the investment in research, but suggested that in order to make that investment strategy pay off, universities needed to improve undergraduate education in science and technology, and ensure broad access to university education by qualified students. “This is arguably the core issue for our socially dynamic society in the next century” (p. 97).
This session, parallel to the first two sections of the “principles of partnership,” was devoted to an examination of the goals that the nation would hope to achieve through the investment in research.

Vern Ehlers advised that the scientific and academic communities must come to terms with the fact that the federal government simply no longer has a “money tree” for support of scientific research (p. 109). New sources of funding for research must be developed at the state level, in international collaboration, and in partnership with industry. Ehlers also spoke of the importance of uniting education and research: the future of both scientific research and higher education depends on engaging students and the public in science as a “mode of inquiry” and not simply as a body of received knowledge (p. 108).

Kumar Patel addressed the critical issues of knowledge conversion and technology transfer, noting that universities must become much more active partners with industry, and especially with small-to-medium-sized companies that are most likely to market new technologies. The traditional forms of knowledge conversion—releasing educated students into the workforce, and relying upon “chance encounters between the creators and the users”—are no longer adequate (p. 112). Universities must build a “feedback loop” into their interactions with industry, if they are to bridge the mid-term research gap that Vest had discussed.

Anne Petersen pointed to the importance of better integrating undergraduate education and research in the future partnership: “In the partnership of the past 50 years, the balance has been increasingly on the side of research. The partnership of the future requires a realignment” (pp. 115-116). Research universities have much value to bring to undergraduate education, and NSF, she said, has developed several approaches to helping “stimulate the dynamic interplay between research and education”—including a soon-to-be-announced award to recognize innovation in combining research and education (p. 118).

Lynn Rivers discussed the framework for national decisions regard-
ing the investment in research and higher education, in an era of con-
strained resources. The government might learn a lesson from observ-
ing how a cash-strapped family makes investment decisions: they do
not cut across-the-board; they prioritize, and after accounting for ne-
cessities, they put aside savings for future values like education. The
nation also, she said, should look into the more distant future as it
budgets, and make “intellectual currency” a high priority: “If we allow
our intellectual reserves...to drop, the costs will be devastating to us as a
nation” (pp. 120-121).

**Inputs: Responsible Allocation and Stewardship of Resources**

This session, parallel to the third and fourth sections of the “prin-
ciples,” dealt with the responsibilities that universities and the govern-
ment have for the management of the nation’s investment in research.

**David Skorton** spoke on the necessary, and potentially creative, ten-
sion that exists between a primary goal of science, which is progress, and
a primary goal of law or government, which is the assurance of due and
equitable process (p. 137). In our democratic society, as we revitalize the
government/university partnership, we must give appropriate attention
to each of these goals. Skorton suggests two operating principles that
ought to guide the partnership: 1) “prudence and cooperation among
all participants in utilization of the national investment in R & D,” and
2) “continuous improvement in administration of resources by all mem-
ers of the partnership” (p. 139).

**David Auston** provided the assembly with an overview of the re-
cently released report of the National Academy of Sciences, Allocating
Federal Funds for Science and Technology (the so-called “Press Report,”
because the committee that produced it was chaired by Frank Press). A
key set of recommendations in this report call for the establishment of a
new Federal Science and Technology Budget process, whereby non-de-
defense, knowledge-and-technology-generating research funds (a figure
that comes to about $35 billion) would be identified as a single entity
and treated as such throughout the budgeting process (as opposed to
the current process, in which the nation’s R & D investment is calcu-
lated "after the fact" of appropriations) (pp. 143-144). The new FS&T budget is contrasted with current R&D calculations (totaling about $70 billion), which typically include defense-production kinds of programs (pp. 144-148). As Auston pointed out in discussion, the thrust of this proposal was to provide a coherent and cohesive entity that could be advocated for: "It currently is not possible for the President to advocate effectively for science and technology funding as such; our proposal seeks to change that" (pp. 167-168).

The FS&T proposal generated extensive and intensive exchanges in the discussion period following the panel presentation. Some argued that the proposal would effectively reduce the base of funds available for non-defense science and technology programs, a point perhaps best expressed by Allan Bromley: if we set the base level at "$35 billion [as the proposal would suggest], then we have essentially set ourselves back about 50%" (p. 160). Others criticized the proposal on philosophical grounds, suggesting that there is a sound rationale for having the R&D budget priorities driven by the goals of the diverse agencies, rather than treated as a single entity. In the words of Donald Hornig: science and technology are not "national goals in themselves...[they are] adjunct to all sorts of national goals" (p. 168).

In his talk, Tom Weimer treated the new political dynamics in the Congress, and in the House Science Committee particularly. The critical change, he said, is not the change in party leadership of the Congress, but the change from an old guard to a new guard. Sixty percent of the House Science Committee have been in office for less than three years, and this makes it difficult to engage in discussion, because it generally takes about six years for members to understand the full range of science and technology policy issues (p. 152). There is a need, therefore, to convince the new members that funding of research is indeed a national investment, and not just a cost—but do not be surprised, he said, if you find the members "compelling you to come up with arguments as to why you believe that to be true" (p. 154).

John Yochelson closed the panel presentations by discussing elements for a forthcoming report from the Council on Competitiveness, on the need for more partnerships within the nation's research system.
It is absolutely essential for the national good, he said, for various players within the "innovation system"—universities, industry, and national labs—to form partnerships around particular problems and interests, rather than to commit "fratricide" against each other in a scramble for scarce resources (p. 156). The partners must break down artificial barriers within the system, and the federal government, he noted, can play a facilitating role in the establishment of partnerships.

CLOSING SESSION

In an insightful and highly effective summary of the day’s discussion, Neal Pings wove together many of the themes of the conference, and added a couple of his own. Although no one had much discussed national defense as a rationale for research funding, he said, we must not forget that the defense need has not entirely disappeared—and that, indeed, the need for technologically sophisticated military preparedness is growing (p. 177). He also noted that another constraint on university budgets and on research funding will tighten within a few years, due to changes in the retirement rates: fewer faculty will be leaving the system, at the same time that federal funds for research are declining (p. 178). Pings did not see much prospect for other sources—state, industrial, or university—to make up for the decline in federal funds.

Ed Hayes followed Pings with discussion of next steps. We need to be active in making the case for the investment in science, he said, despite the fact that “in the present political environment, where sound bites and political rhetoric often carry the day, it is very difficult for thoughtful people to explain the strong case for support of science and technology” (p. 182). As one possible course of action, he suggested that an effort be made to have a science plank inserted into the political party platforms. His suggestion was generally supported by the assembly, although it was proposed that a more visible and fruitful tack might be to try to have a question on science policy raised in one or more of the presidential debates.
CONCLUDING OBSERVATIONS: THE SYMPOSIUM AND THE PRINCIPLES OF PARTNERSHIP

The Wiesner Symposium, we noted at the beginning of this summary, was built upon an effort to define a common understanding of the responsibilities and expectations for government and the universities. This effort had reached the stage of development of a draft set of principles, which, as was noted above, may be found in Appendix E. It was our intent and our hope that discussion in the Symposium would inform development of a new draft of the principles, which could in turn be presented in various venues for further discussion. I would like to reflect in closing on some of the key themes—new themes or new emphases, as it were—that we might collectively consider building into a new version of the principles, as a result of the Symposium. These include:

• placing greater emphasis on the notion of research as the conduct of inquiry rather than as the creation of knowledge. In a complex, rapidly changing world, the notion of inquiry can have great force as an organizing principle, and it cuts across many distinctions: it captures the sense of universities as social institutions that are engaged in an activity that can be helpful to others. At the same time, inquiry makes reference to the eternal values that scholarship and science seek to embody, and that universities seek to safeguard: it is not just any questioning, but a questioning according to norms that have been established as valid on the basis of free and open discourse and collective experience. In this view, the primary function of universities might be to develop, standardize, and sustain the conduct of inquiry. Universities provide the environment in which modes of inquiry are refined, tested, applied, and taught—in an atmosphere of open discourse. Universities, as communities dedicated to the value of inquiry, thereby sustain the nation’s ability to conduct inquiry.

• placing greater emphasis on the notion of the investment in research. The return on this investment is great, as Vest and oth-
ers noted. Moreover, the notion of investment is doubly obli-gating: the government is responsible to the American people to make wise investments, and there can be few investments wiser than the investment in research; universities owe it to the American people to ensure that the return on investment is as great as it can be— they must share resources, cut costs, and provide more in the way of undergraduate education than they have in the past.

• introducing, explicitly, the three-tiered structure of the nation's “innovation system,” and the respective responsibilities of government, the universities, and industry in each of the tiers. We might note here that although Vest's discussion of the innovation system tended to focus on the manufacturing industry, the concept might have broader applicability. In the service industry, and for that matter in areas of social service, public health, and even in artistic and cultural development, one can imagine the potential usefulness of a tripartite structure for conceptualizing the flow of knowledge and understanding among the various sectors of society. Universities are being called upon to play a greater role in the “middle tier” in many ways: through technology transfer, through community service; through academic outreach. To what degree can they do that—collectively, not necessarily individually—without sacrificing the “eternal values” mentioned above, or their absolutely essential characteristic of sustaining free and open academic discourse?

These and other issues developed within the Symposium will, we hope, be brought to bear on the further discussion of principles, as we all work toward the appropriate, mutual understanding needed for a “changing world.”

Gary Krenz
University of Michigan
Thank you. I have been asked to speak with you today about the view from academic institutions on policy contexts for R&D activity in the upcoming year. Needless to say, it is impossible to give a definitive statement of the view from academic institutions, because there are of course many views within academe. Nonetheless, I believe that I can say with some confidence that there is widespread concern among faculty throughout many of our institutions, about the current state of national science and technology policy and about what the future will hold. There is also widespread concern among our students about the future, and ample anecdotal evidence that many students' career decisions are being influenced by the current trends in the budget. I am sure that many faculty and university administrators could join me in giving actual examples of very bright students who have decided not to pursue careers in academic research, because they fear that they will have little chance of obtaining funding for their research. Although there are those who would counsel us not to worry about the “out years” of the federal budget, because it is difficult to predict outcomes so far ahead, those of us in academic institutions know that we cannot readily urge our students to do this: they are making career choices now, and they can only see the budget projections as indicating increased risks associated with careers in scientific research. This situation does not bode well for the future of science or academe.

However, rather than go into more detail about these concerns—since for the most part we all know them full well—what I would like

This essay is based on remarks delivered by Homer A. Neal at the 1996 AAAS Policy Colloquium in Washington, D.C., April 17, 1996.
to do instead is step one level above the original charge. I want to invite you into an effort that has been initiated by some of us in academic institutions to generate, through extensive discussion with key policy makers, a consensus view of the responsibilities and expectations for research and development in this country—not just in FY97, but into the future as well.

**Goal: To Develop a Policy Consensus**

In brief, we are, collectively, faced with a situation in which: the world has changed; the rationale for government support of science and technology research cannot take quite the same form that it did during the Cold War; the government faces new fiscal constraints; and consequently, both universities and the government must adjust their ways of operating. What is the basic framework upon which decisions about R&D funding in the fiscal years ahead should be made? What are the general principles that should guide us as a nation as we formulate our research policies and make our decisions regarding research?

We know that one principle currently being employed, both within Congress and within the Executive Branch, is the goal of balancing the budget. That may well be a laudable goal—one to which we, as scientists and academics, ought to contribute our fair share. But what are the other principles that would truly ground a rational assessment of the value of research to the nation, and ground an understanding of what the investment in research is to provide for the country? What are the principles that would permit Congress and the Executive Branch to make the decisions that need to be made in a knowledgeable fashion? Whereas in the past there was broad, bipartisan, and multisected agreement on the goals the nation was trying to achieve by means of its investment in research, we are concerned now that this broad agreement no longer exists. Consequently, we fear that decisions are being made, in essence, without sufficient understanding or agreement—and in such a situation, the principle of a balanced budget will hold sway in an overly simplistic manner, leading perhaps even to severe damage to our nation’s system of research and development.
The effort that I mentioned above, therefore, has been aimed precisely at trying to recreate a broadly shared understanding of the investment in research. And here I would point out that I mean an understanding shared not just across party lines, but across sectors of society as well. Those of us from academic institutions who have been involved in this effort understand that our goal is not only one of conveying the value of research; our goal must also be to understand better how to increase the value of research to the nation in the new era that we have entered.

This effort reached an important stage about six weeks ago, when we held at the University of Michigan the first annual Jerome B. Wiesner Symposium—an event named in honor of one of the University's most distinguished alumni. In addition to honoring Jerry Wiesner, this Symposium sought to engage leaders from the legislative and executive branches of government, industry and academe in an analysis of the options for the future of the federal government/university partnership.

Now, I have said that we are seeking to develop a consensus view, and I should say something about who we are. The Symposium grew out of an ongoing effort, initiated by the senior research officers of the universities of the Committee on Institutional Cooperation (also known as the CIC, this includes the Big Ten universities plus the University of Chicago), to develop a set of principles that would define the respective responsibilities of the government and universities, and their expectations for each other, and help chart a course for the decades ahead.

We have entered a period of government downsizing, and as I noted above, it is our concern that decisions about funding and, by extension, priorities, are being considered, discussed and made in the absence of a mutually accepted understanding of the responsibilities of and expectations for the government and research universities. For many years, the principles articulated in 1945 by Vannevar Bush in Science: The Endless Frontier have guided us; but for the past several years, perhaps even longer, that paradigm has not been as relevant as it once was. There is a need to replace those former constructs with ideas or principles that are relevant to the time we are in and the times we will be in
In effect, this discussion has already been going on for a number of years and in a number of venues. Three successive presidential administrations—those of Reagan, Bush, and Clinton—have issued reports on the essential importance of the nation’s investment in research, and cited the importance of research universities in that investment strategy. The recent report by the National Academy of Sciences on Allocating Federal Resources for Science and Technology (also known as the “Press Report”), likewise stresses the importance of the investment in research and of university-based research in particular. In recent years, several conferences across the nation—some sponsored by universities, some sponsored by professional societies such as AAAS, some sponsored by the government—have dealt with the partnership of government and the universities, directly or indirectly, in whole or in some aspect. The President’s Council of Advisors on Science and Technology has issued a set of principles that it believes ought to guide the government’s policies in science; the House Science Committee under Chairman Walker has released principles that it has used to guide its deliberations on specific authorization bills.

Without either endorsing or discounting the views or recommendations advanced in any of these venues, we can say that they indicate a tremendous intellectual effort devoted to issues of principle and policy. Much progress has been made. What has not developed, however, is a multi-sectored, nonpartisan consensus—in part, because few have systematically sought to create it. That has, however, been one of the goals of the CIC effort I mentioned: to carry out a conscientiously bipartisan discussion, focused in such a way as to create the possibility for consensus. This has been our approach to rewriting and revitalizing the ideas that guided U.S. science policy and the growth of the American research university from the 1940s through the end of the Cold War.

The issues that we have tried to wrestle with are various, but let me try to give you some sense of where we are trying to articulate agree-
ments on principle, just by listing a few:

- Applied Research vs. Basic Research: is the distinction valid for purposes of policy?
- Technology transfer: what are universities' responsibilities?
- Public understanding: how can the importance of research be conveyed to the public?
- Understanding the public: how can universities be more attuned to the public's needs and interests?
- Optimizing use of resources: can universities better share resources and radically cut costs?
- Research and education: how can research universities capitalize on their research strengths to enhance undergraduate education?

History of the CIC Effort

Now, I would like to tell you a little more about the process that we have followed. In the fall of 1994, the senior research officers of the Committee on Institutional Cooperation conceived the idea of a national "summit" meeting on the future of the government/university research partnership—a meeting that would bring together leaders from academia, government, and industry, to discuss and develop a new "compact" for the partnership. The "compact" is envisioned as a statement of the fundamental expectations that the public—through the instrument of government—should have for the nation's research universities, and what the research universities needed from the government in order to meet those expectations.

Three members of industry joined our effort at an early stage, Bob Galvin of Motorola, John McTague of Ford, and Homer Pearce of Eli Lilly. Bob Galvin circulated material among the so-called "Augustine group"—the CEOs who last year published an open letter to Congress in the Washington Post. Several, including Augustine, endorsed our effort; several commented at some length upon the draft of the principles.

Throughout the preparation of several drafts of the "principles,"
meetings, discussions, or correspondence took place with a large number of individuals, including:

in Congress: Representatives Robert Walker, George Brown, Vernon Ehlers, Steve Schiff, Pete Geren, Bob Livingston, and Lynn Rivers; Senator Tom Harkin; and staff for Senator Mark Hatfield and Representative John Murtha.

in the Executive Branch: M.R.C. Greenwood, John Gibbons, Cathy Woteki, Ernie Moniz, Neal Lane, Anne Petersen, Martha Krebs, and Harold Varmus.

We received encouragement from all of these individuals, and others--and we continued to revise our draft “principles of partnership” on the basis of input that we received.

The Function of a Policy Framework

But, one might ask, why try to develop principles at all? Are not the problems that we face really much more immediate and concrete than can be addressed in a sufficient way by a set of general propositions? The answer to that question must of course be, yes! No abstract framework, in and of itself, will provide automatic answers to specific problems. But it does not follow that we should, therefore, dispense with the discussion of that framework. It is in that discussion that we begin to understand more fully what it is that we expect of each other, and what we really take our respective responsibilities to be. If we can elaborate those reciprocal expectations and those responsibilities, we might lessen the tendency to continually retread the same ground in discussions of concrete issues and plans.

I cannot stress enough how important it is for us to engage in this process. We all know that we have entered a new era. We have lamented that fact; we have tried to understand its meaning; sometimes we have even railed against it. It remains true. We are at a crossroads, and the decisions that we make now will affect the future of the nation. Can we imagine ourselves a nation dependent upon others for scientific and scholarly insights and expertise? Can we imagine ourselves a nation in which we are no longer able to effectively pass on to new genera-
tions the skills of inquiry needed to confront a new world? It could happen, if we are not careful to preserve the gains that we have made. Conversely, can we imagine ourselves a nation that, though still strong in research, falls short in its efforts to prepare new generations for life in an increasingly complex world? A nation where science is seen as remote from and irrelevant to the living concerns of most citizens? That, too, could happen, if we do not use our resources wisely and attend carefully to our mission.

We must all become stewards of the system of research and education that we have inherited. That system is not immutable— and for that matter, it is not perfect. It must be nurtured and developed. Several decades ago, individuals like Vannevar Bush and Jerry Wiesner created the framework for this system, in response to the problems of their day, but also with a vision of the future. We must emulate them, but we cannot repeat their decisions. Our solutions cannot be precisely their solutions. The world has changed. We have changed. So, we must all work together to determine who and what it is that we are to become: we must address our problems today, but we must do so with an eye to the future. And here I would add, we cannot do this alone: we must be engaged with the public whom we are all trying to serve.

I believe that documents like the “principles” drafted by the CIC vice presidents can be tools to help focus our dialogue about these overarching issues— and I invite you all to use the draft of principles to help further the discussion. Although the effort springs from this group of midwestern institutions, it was never conceived as having a midwestern focus: the issues that we want to address are national issues, and the consensus that we want to facilitate would be a national consensus. To achieve that goal, we clearly need the assistance of individuals, institutions and organizations from outside of the midwest. In this regard, the Wiesner Symposium was an excellent step forward: it was a genuinely national conference.

It has been my vision that organizations such as the CIC would examine the principles, refine them, and then ultimately endorse them. We certainly have not yet reached the point of endorsement, within the CIC or even at any particular institution. The principles are still open
to significant, even radical, revision. I encourage you to examine them and to think about them. Take them to your home organizations and institutions, discuss them, and send us your comments.

THE DRAFT PRINCIPLES OF PARTNERSHIP

The draft principles [Appendix E] are grouped into four thematic areas: 1) Research and Scholarship in Support of the Nation’s Well-Being; 2) Education for the Next Century; 3) Responsible Allocation and Utilization of Resources; 4) Stewardship of the Public Trust. Each section begins with a broad vision statement, which is followed by more specific goal statements, and each of these in turn is explicated through some more specific statements—though still not down to the level of measurable objectives. Time does not permit me to go into detail, and I do not want to recite here what you can in fact read in the text. I will simply say a few words about the issues that we have tried to deal with within each thematic area.

1. Research and Scholarship in Support of the Nation’s Well-Being
   Here we seek to define the ways in which research and scholarship do and should contribute to meeting national needs—through contributing to our public fund of knowledge and understanding, through inquiry into a wide range of issues in partnership with others, and so on. What is it that we are trying to accomplish as a nation via research and scholarship, and how do we achieve it? What interest does the government have in supporting research, and what should be the parameters of that support?

2. Education for the Next Century
   The improvement of education at all levels is a key to the nation’s future. What can universities do to enhance education within our own institutions? What are our responsibilities to assist K-12 education in improving—and what is the extent of our material interest in doing that? To what degree is educational improvement an issue of partnership between universities and the federal govern-
ment, and what innovative forms should the partnership take?

3. Responsible Allocation and Utilization of Resources
   Resources in the future will be more constrained than they have been in the past. Yet, the government's investment in research yields great returns to society. How do we ensure that that investment is sustained at levels that will continue to yield those returns? And how do we in our universities ensure that the return is optimal: that we have reduced waste to the minimum, that we are sharing resources whenever we can and competing when we must?

4. Stewardship of the Public Trust
   No statement of the framework for universities and the government would be complete without recognition of the importance of the integrity of our activities. Some of the problems that we face today in terms of public appreciation of our contributions stem from some highly publicized allegations of fraud and misconduct. Although such cases are relatively rare, we must as a community forthrightly take responsibility for them.

   The Wiesner Symposium was designed around these themes, and with an eye to advancing the discussion about them.

   Time also precludes me from going into detail about the Symposium; I urge you to have a look at the Proceedings themselves.

EXTENDING THE DIALOGUE

What I would like to do is suggest a range of activities that we might consider taking, as a means of advancing the dialogue.

First, I urge you to examine the drafts of the principles, and the Proceedings of the Wiesner Symposium. Take them to your universities, to your laboratories, to your organizations. Discuss them and debate them. In what ways do they capture your beliefs about what it is that we as a nation seek to accomplish through our universities and
through our research? In what ways do they fall short? Send us your comments. I would not expect us all initially to agree—but there is no reason in principle to think that we cannot come to some agreement, stated in some way.

I suggest that we need to be even more open and adventurous in our thinking—although what I am about to suggest would be considered by some to be naive rather than adventurous. It is important, if we are to engage in a national discussion, that we find ways to move well beyond the limits of our own academic and scientific communities. There are various ways to do this, and I propose, for example, that we call for Congressional hearings or establishment of a joint Presidential/Congressional Commission on the government/university research partnership and on the future of national research policy—perhaps even using some version of the “principles” as a reference point.

Now as I say, some would see this as a dangerous move—a move in which we were ceding control of the discussion to others. I suggest, however, that we really have nothing to lose, and much to gain. Congressional hearings are likely to occur at any rate, and it would be wise for us to be proactive rather than reactive. Moreover, I believe that we do not really have anything to fear from hearings. We believe that we have a strong case. If we believe in it, we can make it—as Chuck Vest said in Ann Arbor a few weeks ago, we cannot make it blindly, but we certainly can make it. There are certainly enough deep thinkers and interested individuals in Congress and the Administration to believe that we would have a genuine opportunity to make it. And, indeed, our case is based on the premise that we do not represent a special interest, seeking government assistance, but rather that we represent a common interest—a point well made by Rad Bylerly at the Wiesner Symposium. We believe that the investment in research is important to the health and well-being of the nation—that it is genuinely in the national interest to sustain its research capability. If that is what we believe, we have both the right and the responsibility to act accordingly, and I can think of no better way to do that than to make known that we are prepared to engage in the discussion, in full public view.
But let me be more specific: in the spirit on constructing a truly broad, bipartisan, national dialogue, I propose

1) that the Administration and the Congress establish a bipartisan joint commission to examine and develop a statement of the nation’s long-term research philosophy. I propose as well that this Commission make use of the draft of the “Principles of Partnership,” and similar documents, in its deliberations. The Commission would be representative of the various groups of “stakeholders” in the research and development system: universities, national laboratories, industry, the funding agencies, the public, and even Congress itself. It would be charged with producing a report on the appropriate framework for the national investment in research. In any case, the critical element here would be the joint, bipartisan character of the action that authorizes the Commission: this is what potentially would distinguish this discussion of research policy from those that have preceded it.

2) that following completion of the Commission’s report, Congress and the Administration jointly sponsor a national “summit” meeting to discuss the report. This summit, like that originally envisioned by the CIC Senior Research Officers, would bring together representatives of Congress, the Executive Branch, academe, and industry.

3) that following the summit, the appropriate Congressional committees convene hearings on ways to implement elements of the report. The time is right, I believe, for just such a sequence of events. I note here that PCAST has recently recommended that the White House sponsor a conference on science and technology. That would be an excellent step forward—but I would suggest that the approach that the CIC has been working on, and the one outlined above, has the added advantage of maintaining a bipartisan, two-branch foundation. I also note that the Council on Competitiveness, in its recent report “Endless Frontier, Limited Resources” also calls for a national dialogue on partnerships; I propose that we consider the above as a valid way of constructing that dialogue.

If we are serious about engaging in dialogue, we must somehow
elevate the discussion— and this is a possible route to doing that. We who are members of the academic and research communities must have faith that we can and will be heard— but we must know that we will assuredly not be heard if we do not speak more directly to the nation and to our government. If we fail to try, we have only ourselves to blame for not being understood.

I urge us, then, to be bold in our thinking and bold in our actions. We must have intelligent faith in our cause, and we must also have faith that through genuine dialogue with the people, through the vehicle of government, we can help achieve what is best for our nation.
The 1996 Jerome B. Wiesner Symposium

The Future of the Government/University Partnership

Jerome B. Wiesner
The 1996 Jerome B. Wiesner Symposium
The Future of the Government/University Partnership

photo courtesy of the Massachusetts Institute of Technology

Jerome B. Wiesner
Jerome B. Wiesner (1915-1994) was one of the University of Michigan's most distinguished alumni (BS '37, MS '38, Ph.D. '50, D.Sc. '62). His contributions to higher education, scientific and technological research, and national policy in the areas of science and technology have been unsurpassed.

Born in Detroit in 1915, Jerry Wiesner grew up in the city of Dearborn and entered the University of Michigan in 1933, where he majored in electrical engineering. He received his Bachelor of Science degree in 1937 and entered the graduate program in engineering, completing his M.S. in 1938. In 1937, he also became Associate Director of the University's radio station, a position that allowed him to experiment with new sound recording techniques. Among other accomplishments in that position, he engineered a live state-of-the-art broadcast of a lecture given by Archibald MacLeish, then Librarian of Congress. In 1940 Wiesner joined the Library of Congress as Chief Engineer of the Acoustics and Recording Lab. In 1940 he also married Laya, whom he had met at Michigan; they eventually had four children.

In 1942, Jerome Wiesner joined the staff of the MIT Radiation Laboratory; he moved to Los Alamos Scientific Lab in 1945. In 1946, he became assistant professor at the Massachusetts Institute of Technology. In the meantime, he continued work toward his doctoral degree, and in 1950 he received that degree from the University of Michigan, with a thesis titled 'Pre-ignition Phenomena in Gas Switching Tubes and Related Rectifier Burnout Problems.'

Jerry rose quickly through the ranks at MIT. He directed the Electronics Lab from 1952 to 1961 and was named Head of the Department of Electrical Engineering in 1959. During this period he was also increasingly active in issues of science and education policy. In 1954, he served on a panel chaired by James Killian that made a study for President Eisenhower on national defense against surprise attack. In 1957, he was a member of the Gaither Panel, which studied the means to defend large civilian populations against nuclear attack.

In 1961, Wiesner accepted President John F. Kennedy's invitation to serve as Special Assistant for Science and Technology and director of the Office of Science and Technology Policy. During this period of rapid growth in the nation's science research infrastructure, Wiesner was key in the creation and refinement of a national framework for the investment in science and technology research and development. With
his background in nuclear weaponry and defense systems, he was also a key figure in the work that led to the first Nuclear Test Ban Treaty.

In 1964, Wiesner returned to MIT as Dean of Science and in 1966 he became Provost. He was a steadying force on the campus during a period of considerable Professor and Emeritus President). Throughout this period, he continued to be an active and valuable contributor to national science and technology policy formation, and was a member and chair of the Technological Advisory Commission of the Office of Technology Assessment from 1974 to 1981. He also became more and more deeply involved in discussions of nuclear arms reductions and was a driving force in the Pugwash conferences.

Jerry Wiesner received numerous honors during his lifetime. He was a member of the National Academy of Sciences and the National Academy of Engineering, and he held honorary degrees from the Polytechnic Institute of Brooklyn, the University of Michigan, Lowell Technological Institute, the University of Massachusetts, Brandeis University, Lehigh University, Northwestern University, and Rensselaer Polytechnic Institute. His greatest honor, however, may be in the memories of the numerous individuals—ranging from students to world leaders—whose lives he touched and influenced with his wit, care, compassion and intellect.
For me, as for so many others in this room and throughout the world, Jerry's influence on our lives was immense. But history will remember Jerry for the institutions he built, the public interest battles he fought, the testimony he gave, the books and articles he wrote. All of this effort was out of his concern for the millions he never met, whose lives were endangered by the threat of high technology warfare, or whose subsistence was marginal, and therefore whose potential as humans might never be realized. He was determined in his pursuit of a vision of what could be, if reason and good sense prevailed. He did this as a scientist and engineer, as a White House official, as a great university builder, as a foundation trustee, as a polemicist, as a citizen of the world.

Jerry's life spanned the scientific-technological revolution that created terrible weapons of destruction while at the same time opening the possibility of ending hunger, curing disease, and creating wealth and better lives for people everywhere. He understood that human betterment could never be achieved unless the enormous resources wasted on unnecessary military expenditures, without "coherent and reasoned requirements" (his words) would end. Advice to a new President Clinton about this funding imbalance was the theme of his talk at the National Academy of Sciences three years ago, when he received the Public Welfare Medal, the Academy's highest award. Jerry was not shy about giving advice to Presidents, Prime Ministers, CEOs, public figures, faculty, students, anyone he could enlist in sharing his vision of a secure and better life for people everywhere.

In 1981, the National Academy of Sciences launched its Committee on International Security and Arms Control with Jerry as a founding member. This unpublicized CISAC, as it is called, may well be one of the most important initiatives of the academy in its 130-year history. CISAC engaged a counterpart committee of the Soviet Academy of Sciences in arms control discussions. It trained a cadre of Soviet scientists in methods of analyzing military systems. These Russians later became advisers to
Gorbachev and Yeltsin. I am certain that Jerry's vision of what real security means was imparted to these influential Russians. Historians will write that CISAC and its Russian counterpart, working privately and without publicity, showed both governments how major reductions in nuclear weapons could be achieved without reducing their security.

I first met Jerry in 1961 when he invited me, then a 37-year-old Caltech professor, to serve on President Kennedy's Science Advisory Committee. It is not surprising that the Wiesner PSAC had its problems with the rest of the White House staff. Nevertheless, it has never since been matched in any administration in the degree of its influence and access, and the willingness of its members to work on PSAC matters despite full time jobs running companies and laboratories. This was in no small measure because of Jerry's inspirational qualities and the sense that our efforts made a difference.

Jerry involved PSAC members in education, space, health, military budgets, arms control, economic growth, international cooperation, and much more. And not just in doing studies but in active engagement with cabinet officers and agency heads. On PSAC, I was engaged in the internal government debates about the wisdom of pursuing a nuclear test ban. I remember Jerry's being called out of a PSAC meeting we were having, and his elation when he returned and passed me a note saying that President Kennedy had just given the go-ahead to pursue a test-ban treaty.

In 1965, Jerry flew to California and convinced me to leave Caltech and come to MIT. He put it this way: "You really should leave the best department in the country and come here and build a better one. I will give you the resources you need." What he did in my field he also worked for physics, chemistry, and biology. And raising the quality of science to the highest level, to match what was achieved in engineering, is but part of Jerry's legacy to MIT.

It may be easier to show concern for millions of people without touching any one of them, than to become involved with the personal lives of those in a small community. But not so here. Jerry and Laya were partners in their compassion and involvement in a highly personal way with people throughout MIT. They were gracious hosts; they wanted to know how things were going; they were always available to share in moments of happiness and to really help out in bad times.

The Press family experienced this expression of loving concern, and we are grateful. I daresay that many were touched in the same way by the Wiesners.

Adopted from a presentation at MIT
12/2/94
The 1996 Jerome B. Wiesner Symposium

The Future of the Government/University Partnership

Proceedings
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**Opening Session**

- Homer A. Neal
- Vernon J. Ehlers
- Lynn N. Rivers
I would like to welcome you to this, the inaugural Jerome Wiesner Symposium on National Science Policy.

There are two principal and overlapping reasons for the symposium today. First, we want to honor the memory of one of the University of Michigan's most distinguished alumni, Jerome Wiesner, who served as science advisor to President Kennedy, and as President of MIT.

Second, we wish to engage leaders from legislative and executive branches of government, industry and academe in an analysis of the options for the future of the federal government/university partnership.

The overlap in the two goals for this symposium is obvious, in that nothing would likely have been more pressing in the thoughts of Jerome Wiesner at this time than the question of the future of this partnership.

The issues we will be discussing today are not just local issues—indeed they affect the nation and the world. Thus, we are particularly pleased that the symposium is being cosponsored by all of the Big Ten Universities, and that we have participation in the program by academic leaders from other top universities well beyond our region, including MIT, UCLA, and Rice University. A few words would be in order about the cosponsoring institutions. Their sponsorship goes far beyond that of allowing their names to be used in the program. For over a year now, the vice presidents for research for these Big Ten Universities have been working hard to ensure that the global aspects of the partnership between the federal government and universities are discussed and examined, as we reorient ourselves for the new world we now face. In short, we seek a clearer understanding regarding what the nation expects of us and what we will need from the nation to achieve our joint aspirations.
Over a year ago this group of vice presidents, augmented by three leaders of industry—Bob Galvin of Motorola, John McTague of Ford Motor Company, and Homer Pearce of Eli Lilly—set to work on a set of principles that might govern such a partnership. Input was received from many members of Congress and their staffs, from the Executive Office of the President, and from several others in academe and industry.

This process, which also included a meeting between several of our vice presidents for research and several members of the House Science Committee in its hearing room, was extremely valuable to us. It helped us reflect on what our future role should be, and to highlight those areas on which future discussions needed to focus.

Some of the issues have been sharply posed: should there be a partnership at all, some have asked. Should universities be more active or less active in technology transfer? Should research universities be more attentive to undergraduate education, perhaps at the expense of their research programs—or less focused on that area of their missions? Should we more aggressively pursue applied research, or leave that for ultimate resolution by industry and the government laboratories?

On first reading, many of us will make an immediate leap to our favorite answer to these deceptive questions, but I can assure you that the answers are not trivial.

In *Science: The Endless Frontier*, written in 1945, Vannevar Bush noted, “Science can be effective in the national welfare only as a member of a team, whether the conditions be peace or war, but without scientific progress, no amount of achievement in other directions can insure our health, prosperity and security as a nation in the modern world.” He goes on to state that publicly and privately supported colleges and universities and endowed research institutes must furnish both the new scientific knowledge and the trained research workers. These institutions are uniquely qualified by tradition and by their special characteristics to carry on basic research. A nation which depends upon others for its new basic scientific knowledge will be slow in its industrial progress and weak in its competitive position in world trade.
There are those who claim that the compact articulated by Vannevar Bush has outlived its usefulness and that modern times require a new compact. I believe that many of his points still hold true but need further interpretation and extension.

As we all know, analogies stretched too far can be dangerous, but with that point made, let me suggest that we are on a ship that departed from a port in the early 1950s, where the maps, charts, accumulated knowledge, and national resources were piled on board. We were told that if we held true to a certain course, we would likely find another land that would be much freer of disease and poverty, where we would have fewer concerns about our security, and where the overall quality of life would be much higher.

Our ship has sailed true, and it has passed through several major storms, represented by hot wars where our troops were actually deployed, through periods of good and bad economic times, and most recently through the Cold War. We have emerged from these storms intact, with our national will still vibrant, with our sights still set on the promised land, but with our on-board resources apparently diminished, and with an increased debate as to how to best deploy the remaining resources, to have the best chance for reaching our ultimate destination.

Many note that R&D has helped us get through past storms, but ask if we still need to use as much of our on board resources in this way, since there are no huge new storms on the horizon. Some suggest that we could get by with fewer navigators, chart makers, meteorologists, those working on better glue to hold the boards together, or ways of navigating when the stars are not visible. Others note that if we wait until the clouds—whose origins are currently unknown—come into sight, it will be too late to develop a response and we might all perish.

We should remind ourselves that this odyssey is taking place in an environment where every four years there is an opportunity for a wholesale change in the leadership of the vessel, complete with a new captain and a new first officer who may want to make a major course change, and perhaps even turn around and head back to the port we left almost fifty years ago.
That this complex vessel seems actually to more or less work is a real testament to our nation, and gives us full confidence that we will eventually reach our collective goal.

But today we want to assemble as a group of “all hands” to discuss where we are, what our course setting should now be, and how we should organize ourselves for the next portion of our journey.

The maps given us by Vannevar Bush have done a good job of getting us through the rough water so far, but they have become less detailed as we have emerged from the Cold War region. We have conquered polio, we have invented lasers for eye surgery, we have traveled to the moon. We found out about DNA structure, perhaps found all the quarks, and so on.

We remember Vannevar Bush’s words, but we do not quite know what they mean in this new regime. Hopefully, our symposium today will help extend our charts and bring us closer to our desired destination.

Now, let me say a few words about the organization of the program designed to achieve these goals.

First we will hear from Chuck Vest, a former colleague here and President of MIT. He will share with us some of his reflections on Jerry Wiesner and his views of what the challenges are that lie ahead.

Then a panel that consists of science advisors from the Johnson, Ford, Reagan and Bush administrations, and the current associate director of OSTP for Science. We will hear from them, their views of the historical nature of the federal government/university partnership, and recommendations for future actions.

The next panel, to be chaired by Bob Galvin, Chair of Motorola, will focus on what the nation should expect from the partnership—that is, when the partnership is working smoothly, what are the outputs that should derive from it?

The following panel this afternoon will discuss the resource and stewardship issues related to the partnership. In short, what will be needed to make the partnership work? That session will be headed by David Skorton, Vice President for Research, University of Iowa, and the person who has served as co-chair with me in the CIC (Committee
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... initiated effort that led to the development of the principles and the idea that an event of this type was needed.

I might also mention that in David's remarks, he will note that the scope of the concerns of the Big Ten vice presidents extends beyond that of the sciences, even though by sheer volume of dollars, any discussion of the federal government/university partnership will only seem to focus on the sciences and engineering. But indeed our obligations go much further than that.

Finally, a summary of the day's activities will be given by Ed Hayes, Vice President for Research, Ohio State University, and Neal Pings, President of the Association of American Universities.

In closing, I should say a word or two about whether this effort is to be seen as an end or a beginning of a process to educate the public and its leaders about the issues facing research universities. Speaking for myself, I would like for this to be one step in a continuous effort of education, first of ourselves and then of others. Our vice president colleagues will decide on our collective actions following this symposium. There will be proceedings of this event produced immediately after the symposium. It is our hope that the Big Ten Universities, and others, will disseminate these proceedings and the principles on their campuses and to their legislative delegations. Several of us may set up meetings with key legislators, with the White House, and with leaders in industry to summarize the most important points made today. We will consider at the end of the day suggesting to the Big Ten presidents that they convene, perhaps with other presidents, one or more high-level meetings in Washington to review the issues raised in our discussions here today—meetings with President Clinton, Speaker Gingrich, Majority Leader Dole, and with those responsible for overseeing the development of the respective party platforms.

I am fully aware of the virtues of modesty and the importance of not overstating one's case, but I do not believe I am violating either of these considerations by saying that what we are dealing with today may be at the very heart of the prosperity and welfare of this nation in the decades to come.

Now, at this stage I would like to turn to the honorary co-chairs of this event, Lynn Rivers and Vernon Ehlers.
It is good to be back on a campus, although things have certainly changed. I would have appreciated having a podium like this when I was teaching at Berkeley. This lectern is a veritable fortress; it even appears to be bulletproof.

I want not only to thank you for the kind introduction, Homer, but also congratulate you on being named Interim President of the University of Michigan, and furthermore congratulate you for your wisdom in declining the presidency. You deserve commendation for both!

I also commend you, Dr. Neal, for your work in launching the Committee on Institutional Cooperation's effort, which is the forerunner of this symposium and which was instrumental in asking some very important questions about the future of federal science policy and the relationship of the federal government to university research.

Those questions are important, they deserve good answers, and I hope those good answers will be forthcoming in part from this symposium and also from the federal government.

I must say that I came here to learn and not to expound, and I hope that I will benefit from this conference. I was asked by Homer to list some of my hoped-for outcomes from this conference, and I will run through just a few of those. I hope first of all that this will be the launching pad for development of a new model for the relationship between the federal government and the universities. We also need a new model for federal government science policy per se, and I will amplify upon that in my later comments. We need a better definition and understanding of the government's role in basic research and so-called applied research. I believe the Congress needs guidance on the funding
of what has come to be called "mega-science," the major projects that are likely to become international in scope in the future.

We need to have a better understanding of the distinction between basic and applied research, and perhaps our discussion today will lead to that better understanding—and above all lead eventually to a better policy defining the role of the federal government in assisting fundamental science or basic science, applied science, technology transfer and all of the related research and development.

Something else I would like to see developed by this conference, which I have not heard discussed nationally at all, is the federal-government/state-government relationship vis-a-vis science policy. The states have been innocent bystanders, by and large, in the entire area of scientific research and science policy. I think that given the current mood of the country to devolve government responsibilities back to the states and communities, we should be involved in a discussion of the federal/state relationship as it relates to support of research and science.

I hope that out of the discussion here we also will develop additional means, better means, for the transfer of scientific knowledge, and the results of scientific research, from the universities and federally sponsored research, into the factories and the shops. I will discuss that in more detail in my comments later.

We also—and this is a very important issue—need a better transfer from the university research community to what I call the K-16 education regime. Notice, not K-12, but K-16. There is not sufficient transfer from the scientific community to the undergraduate level. We, as a result, have graduates of our universities and colleges who are leaving without any grasp of science as a mode of inquiry, let alone science as a body of knowledge.

With those thoughts, and in order to try to get you back on schedule, I conclude my comments here.
Lynn N. Rivers
Member, U.S. House of Representatives
Michigan 13th District

Good morning. I am very pleased to be back in the bosom of the university that nurtured me and as an alumna, I am very proud to welcome you to my university. As a policy maker, I am pleased to support this important inquiry into the future of government and university partnerships. As a person who values learning, I am humbled by the company. I salute you for taking the time and energy, and for applying your considerable intellect to these questions that we are going to deal with.

After the first year of the 104th Congress, I am particularly happy to be here today, serving as co-chair with Representative Vernon Ehlers. For those of you who have perhaps been on a different planet and have not noticed the partisanship that is currently ripping the House of Representatives and the Senate apart, it has been a very, very difficult year, and one that has not often found areas where the two parties could agree, let alone work together. I, however, have found Vern Ehlers always to be a strong voice of thoughtfulness, of cooperation and of compassion, and I have been pleased each and every time that I have had an opportunity to work with him. So I am very happy that both sides of the aisle are represented as we move forward in this important discussion.

But our inquiry today should not be political. It need not be partisan. But I do not think that we can ignore some of the political dynamics that are at work in our country right now. First, I would note the resurgence of so-called "junk science" and the fact that it is increasingly gaining an ear in Washington and affecting decisions that are being made. It is an important issue for this community to address.

Second, the issue of funding in general needs to be discussed, and I happen to think that the current proposals on funding for education
and research are short sighted and not appropriate to where we want to go as a nation.

Third, we need clarity on our role in the world in terms of economic competitiveness, as well as defense. What can we do for ourselves? What must we do for ourselves? Where must we go as we operate as a global neighbor in a new world?

And then lastly, we have to consider where we want our country to go and how we are going to shape our academic and financial prosperity for the future. Questions such as how much inquiry and what kind of inquiry we are going to allow in the future have tremendous implications for all of us—-not only for the future of our universities, but for the future of our nation and, ultimately, for our future as a species.

These are important issues that we must grapple with, and once we have made decisions, once we have begun to understand the importance of what is being done in this area, it is then incumbent upon us to take that message to the larger community. We must not simply talk among ourselves, but must make sure that the importance and the value of the work being done in university communities today impacts on everyday people and the future of everyday families.

This message must be carried across this country and must reenergize a commitment to science, to research, and to a technological future.
Keynote Session

James J. Duderstadt
Introductory Remarks

Charles M. Vest
“Not What We Think: What We Haven't Thought Of”

Discussion
Welcome to Michigan.

One of the hats I wear that Homer did not mention, but that I would like to put on for a moment, is that of the current Chair of the Board of the Big Ten Conference. This is important because when university presidents in the Big Ten get together in Chicago, we deal with a wide range of issues—although you might think that all we do is argue about whether the Rose Bowl should go into the bowl alliance.

In reality, we are first and foremost a collection of academic institutions committed to serving this nation and the world. This particular conference is the result of several years of effort to build a closer strategic alliance among Big Ten institutions. Our work spans a number of different areas; for example, several years ago we made a commitment to merge our twelve library systems into one library with 58 million volumes. We also are extensively involved in world-wide outreach, and are now putting together an Erasmian-type program that would allow students on one campus—in a transparent fashion—to take instruction on other campuses. Today's conference, the result of over a year of planning by the Big Ten vice presidents for research, is an opportunity to talk about the future of the research university and its relationship with the federal government.

Fortuitously, our conference overlaps with the inaugural lecture in honor of Jerome Wiesner, one of the University of Michigan's most distinguished alumni and president of the Massachusetts Institute of Technology from 1971 to 1980.

Dr. Wiesner held four degrees from the University of Michigan. A science and technology adviser to Presidents John F. Kennedy and
Lyndon Johnson, his contributions to higher education, research, and national policy in the areas of science and technology are unsurpassed. He had an enormous impact on the nation's science research infrastructure and a particular impact on issues involving nuclear disarmament, the nuclear test ban treaty, and nuclear arms reduction.

I should also point out a little known fact—when Jerry Wiesner was a student at Michigan before the war, he was an engineer for the campus radio station. He had a colleague some of you may have heard of—the principal broadcaster on that radio station—Mike Wallace. Fortunately for us, Jerry Wiesner went in another direction, but he and Mike remained close friends.

Members of Dr. Wiesner's family were unable to be with us today, but I would like to read a letter from his widow, Laya Wiesner, addressed to members of the Jerome B. Wiesner Symposium:

I would like to thank you for the symposium you have established in the name of my husband, Jerome Wiesner. He would have been particularly honored to have the University of Michigan, his alma mater, remember him and acknowledge his contributions in the area of science and public policy in this way.

I know the special place his years at Michigan held in his memory. I am sorry it is not possible for any members of my family to attend this year's symposium, but we would like to extend greetings and thanks to those who joined together to take part in these proceedings.

I feel a special pride, as I know he would have, that so many people from so many areas of the scientific and public policy communities have come together to take part in this important symposium. On behalf of my entire family, I would like to thank you again and hope that we can join you in the future.

Jerry received numerous honors during his lifetime, including honorary degrees from the Polytechnic Institute of Brooklyn, the Lowell Technological Institute, the University of Massachusetts, Brandeis University, Northwestern University, and of course, the University of Michigan. He was a member of the National Academy of Sciences and the National Academy of Engineering.

Three years ago, in my role as Chair of the National Science Board,
I had the pleasure of presenting him with the Vannevar Bush Award, the nation’s highest award for scientific leadership and statesmanship.

Roughly half a century ago, Science: The Endless Frontier, the seminal report produced by the post-war study group chaired by Vannevar Bush, stressed the importance of the partnership between this nation’s research universities and the federal government 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 during the last half of the twentieth century has had an extraordinary impact. It has made America the world’s leading source of fundamental scientific knowledge. It has 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.

As important as this relationship has been in the past half century, it seems increasingly clear that it will play an even more critical role as we move into a knowledge-intensive future. Research universities will 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.

One of my colleagues, Erich Bloch, stated it well in Congressional testimony when he was Director of the National Science Foundation: “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.”

America’s system of higher education is widely acknowledged to be the strongest and most productive in the world. A couple of years ago, The New York Times asserted that university research “is the best investment taxpayers can ever make in America’s future.”

At a recent session of the National Science Board led by Nobel Lau-
create 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 percent to 14 percent, the private rate of return of R&D investment is estimated to be 25 percent to 30 percent, and the social rate of return—that is the rate that accrues to society more generally, is estimated to be as high as 50 percent to 60 percent—roughly four times the rate for other types of investment.

Unfortunately, despite their enormous success, our nation's research universities now are at serious risk on a number of fronts. The signs of stress are everywhere:

1) A breakdown of mutual trust has led to increasingly adversarial relationships between universities and government.
2) Skepticism—indeed even hostility—exhibited by the media and government has badly eroded public trust and confidence in the university.
3) Internal and external forces, including the rapidly escalating costs of research, are pushing toward a rebalancing of university missions, away from research and more toward teaching and public service.
4) The morale of academic researchers has declined, in part, due to the pressures and time-consuming nature of the need to obtain and manage sponsored-research funding.

The world and the structure of academic research have changed greatly since Vannevar Bush wrote his report. But the major principles advanced in that report merit reaffirmation. Now, perhaps more than ever, the national interest calls for an investment in human and intellectual capital. As Bush so clearly stated, the government/university partnership is not simply about the procurement of research results. It is about nurturing and maintaining the human strengths of a great technological nation and sowing the seeds of innovation that will ultimately bear fruit—new products and processes that will 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 particularly well, the research university is a true success story. That is a message we simply must get across to the American public.

I believe—and I think most of you in this room agree—that 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 half century.

With us today is Ernie Moniz, Associate Director for Science in the Office of Science and Technology Policy, who has a letter from President Clinton to read to us.

ERNEST MONIZ: Thanks, Jim. Jack Gibbons sends his regrets that he could not be here today, but he did want me to read this letter from President Clinton.

Warm greetings to everyone gathered at the University of Michigan for the inaugural Jerome B. Wiesner Symposium.

As educator, scientist, national policymaker, and private citizen, Jerome Wiesner consistently exemplified the finest attributes of the scientific spirit. His work at MIT and within the Kennedy Administration helped to advance science and engineering in our nation and to advocate peaceful uses of technology in the interest of a safer, more secure world. Dr. Wiesner’s achievements remind us that scientists play a vital role in addressing the domestic and international challenges that confront us.

In this age of global competition and revolutionary technology progress, our national science policy is becoming increasingly important to our success. I commend the organizers and participants of the Wiesner symposium for addressing key issues involving that policy and for focusing on the future of America’s vital university/government partnership.

Your efforts will help us to forge bold strategies for the next century of scientific achievement, making this annual symposium a fitting tribute to the life and accomplishments of Jerry Wiesner.

Best wishes for the event,

Bill Clinton
JAMES J. DUDERSTADT: It is now my pleasure to introduce to you the first lecture in the Jerome Wiesner series, which will be given by Dr. Charles Vest, fifteenth President of the Massachusetts Institute of Technology.

Chuck, like Jerry Wiesner, earned his graduate degrees from the University of Michigan. His undergraduate degree was from West Virginia University. His research interests are in the thermal sciences, the engineering application of lasers, and coherent optics.

Chuck has received numerous honors, including being named a Fellow in the American Academy of Arts and Sciences. He currently serves as President of the National Consortium for Graduate Degrees for Minorities in Engineering and Science, and on the board of directors of a number of business and civic groups.

Chuck has been a forceful spokesman on behalf of the research university during his years at MIT. He is a true leader, and we are delighted to have him return to the University of Michigan. We look forward to his comments as he addresses the topic, “Not What We Think, What We Haven’t Thought Of.”

Dr. Charles Vest.
It really is quite wonderful to be back at Michigan. In 1990, Becky and I left after 27 years, to continue the great adventure of our life in new roles at MIT. We had arrived here in 1963, driving in the then-obligatory graduate-student Volkswagen Beetle. In two weeks, we had graduated from college, married, honeymooned and enrolled in the Horace H. Rackham School of Graduate Studies. Little did I know that Michigan would become the core of my professional and personal life for nearly three decades. Still less did I suspect that on the basis of the education, life experience, and opportunity that Michigan would afford me, I would someday have the privilege of becoming the President of MIT.

I am extremely honored to be asked to give this lecture at the first Jerome B. Wiesner Symposium. This symposium is devoted to exploring a topic about which I am passionately concerned. It is dedicated to a man I revered, a man who five decades ago also took his Michigan education and trekked to Cambridge to build a career at MIT.

As we begin this symposium, you need to know something of this man. Because in searching for answers to the problems that perplex us today, we can do no better than to reflect on his life, which ended in 1994—all too soon.

The New York Times columnist Anthony Lewis said at Jerry's memorial service, “There are any number of intelligent people in the world. There was only one in my experience who combined a brilliant intellect with the modesty, the humor, the patience, the humanity and the commitment to bring reason to an often stubbornly irrational world. That was Jerry Wiesner.”
Reflections on Jerry Wiesner

If I could say one thing to sum up Jerry Wiesner's life, it is that his was a life remarkably well lived. His was a life that drew deeply on science and engineering, but also demonstrated a profound humanistic impulse, educational leadership, artistic sensibility, and statecraft of the highest order.

Although Jerry's life took form from—and gave form to—MIT, his life and career are an example to us all:

- Over the course of his career he helped shape fields, departments, schools, and the Institute itself. And he extended this reach to corporations, foundations, and community organizations, through service on their boards.
- As a scientist and electrical engineer, he promoted the growth of the humanities, the arts, and the social sciences in our midst.
- He co-founded the Media Laboratory to explore the outer reaches of human and societal implications of emerging information technologies.
- He led us in bringing women and minorities into the academy.
- He reveled in discourse with everyone—students, trustees, staff, faculty, alumni and alumnae, artists, corporate leaders, politicians and poets—and he delighted in bringing people from these different worlds together. In the 1970s it was Jerry who convened an informal and impassioned dialogue among government officials and student protesters. And he maintained an international perspective and world view in all that he did. Indeed, Jerry Wiesner was a citizen of the world.
- He was science advisor to two U.S. presidents.
- During the Cold War, he was a guiding light of the Pugwash Conference and movement that sustained discussion across national and political boundaries.
- He worked tirelessly to awaken the world to the nightmare of nuclear standoff.

Yet throughout his life on the world stage, he lived quietly and simply with his beloved wife Laya in Watertown, Massachusetts and on
Martha's Vineyard.

Through it all: he spoke his mind. Listen to what—in part—America's great poet, Archibald MacLeish, said of Jerry.

A good man! Look at him there against the time!
He saunters around to his place in the world's weather,
lights his pipe and hitches his pants,
talks back to accepted opinion.
Congressional Committees hear him say:
"Not what you think: what you haven't thought of."
He addresses Presidents. He says:
"Governments even now still have to govern:
no one is going to invent a self-governing holocaust."
The Pentagon receives his views:
"Science" he says, "is no substitute for thought.
Miracle drugs perhaps: not miracle wars."
Advisor to Presidents, the papers call him.
Advisor, I say, to the young.
It's the young who need competent friends, bold companions,
honest men who will not run out,
won't write off mankind, sell up the country,
quit the venture, jibe the ship.

How does this life relate to a seminar on the future of the American research university, and the role of the federal government?
We—all of us—must nurture, support, and build our institutions for the future...as Jerry did. We must keep alive the joy, excitement, beauty, rationality, and creativity of science and technology, deeply understood...as Jerry did.
Yet we must understand the power and potential of science and technology to provide the means for harm as well as for great good. In other words, we must never cease to consider the context in which the powers of science and technology are applied. And we must strive to integrate the understandings of humanists and artists with those of sci-
entists, engineers, managers, architects, planners and social scientists...as Jerry did.

We must strengthen America's great research universities. We must shape them, change them, steer them...so that future generations will benefit as greatly from them as did the generations that came before. We must not, as MacLeish says, "sell up the country, quit the venture, [or] jibe the ship."

We need to ask, what would Wiesner do?

A World Of Change

Jerry came to MIT during World War II--at the beginning of the second of the great watersheds in the development of our nation's universities, a time that lead to the forging of a common vision and sense of partnership between the nation's universities and the federal government. The first watershed, of course, was at the time of the Morrill Land Grant Act in 1862. We are now at the third great watershed--a time when the value of higher education and research to the nation is being questioned. That is why we are here today--to take stock of where we are and where we need to go.

As research universities, who we are, what we do, and how we do it are changing very rapidly. It is a time of change and it is a time for change. The accessible base of science is expanding, bringing new possibilities, flexibilities, and techniques to engineering. Just scan last September's issue of Scientific American, which is devoted to key technologies for the twenty-first century. You will find things there like wireless networks, all-optical networks, intelligent software, high-speed rail, new spacecraft concepts, gene therapy, artificial organs, self-assembling materials, microscopic machinery, high-temperature superconductivity, industrial ecology, sustainable agriculture, and the information economy. We really are in for a very exciting time.

But this is not the whole story. We inhabit a world with rapidly expanding populations everywhere, a threatened physical environment, and a set of nations in societies with disparate cultural values. Economically, we now compete against every other country and company.
Corporations are continually merging and dividing, employment is in flux. Intellectually, disciplines are increasingly irrelevant. And in all of this—thanks to the power of information technology—distance and time are becoming compressed at an astonishing rate.

In such a world, we succeed by our wits rather than by our power or our natural resources. Social, political, economic, and environmental factors appear likely to dominate over technical matters, as we have traditionally defined them.

This is the world that research universities have shaped and that we serve. Our role—once clearly defined in the public mind, and strongly supported by the public and government alike—is now neither understood nor as appreciated as it once was.

This country emerged from the Second World War confident that we had the strength and the vision to create a vibrant future. We had trust in each other and in our institutions. Universities benefited from the confidence placed in us by the government and the public.

Today, our value is questioned by those who look at the cost of education and the cost of research, and look at these enterprises as just that—costs, rather than as investments in the future.

Of course, to some extent, this reflects a general mistrust of institutions and concern about the future that is prevalent throughout the populace. Such attitudes notwithstanding, we are, indeed, at a watershed point in our history.

Fundamental History and the Issues

The first watershed event I alluded to—the passage of the Morrill Land Grant Act—resulted over time in the development of first-rate universities in states all across America. The charter of MIT, which is a Land Grant institution, reflects the spirit of those times. At a period of rapid industrialization in this country, MIT was established to aid “the advancement, development and practical application of science in connection with arts, agriculture, manufactures and commerce.” Universities were encouraged to interact with industry, and until World War II this was a central driving force in engineering and in much of science.
During World War II military necessity drove new meldings of the professions, and new understandings about the relationship between the deepest of sciences and the most practical of applications. The Manhattan Project at Los Alamos and the Metallurgical Laboratory of the University of Chicago unleashed the energy that had been locked since the beginning of time in the nuclei of atoms. This changed the nature of our world forever. And in the process, we learned that basic science, when combined with industrial and engineering knowledge, and organized on an unprecedented scale, was capable of accomplishing astounding feats.

At MIT during this same period, scientists and engineers were brought together at the Radiation Laboratory for the purpose of developing radar, a recent British invention, into deployable, military hardware. They succeeded, and in so doing changed forever the nature of engineering, and indirectly, of engineering education. A strong scientific base now undergirded practical engineering, and mathematical analysis came to the fore. During this same period work at Harvard, the University of Pennsylvania, Illinois, MIT, and elsewhere laid the groundwork for the development of modern computing.

Also, during the war years, extraordinary organizational changes at unheard of levels of government/industry partnership, resulted in the development of manufacturing systems with a scale and production rate that were previously unheard of. Parenthetically, this production rate was made possible in large measure by a massive entry of women into the nation's industrial work force.

So, World War II was a time of unprecedented transformation and accomplishment in U.S. scientific, engineering and industrial sectors. University faculty and administrators, and in some cases universities as institutions, were at the core of these accomplishments.

The subsequent history of science and technology policy is well known to all of you, so I will not review it in detail. Its central feature, however, has been the realization of Vannevar Bush's vision, developed by a committee in about nine months in 1945, when President Roosevelt asked how the lessons of wartime innovation and production might be applied in peacetime. The question Roosevelt put to them was, how
could science be applied to enhance the health and welfare of the American people.

The answer was set forth in the seminal report *Science: The Endless Frontier*. The main principles in this report were that the federal government had a responsibility to foster and fund scientific research and that universities should conduct most of the scientific research, thereby combining the functions of education and research. Now, undergirding these recommendations was a faith--a faith that fundamental scientific knowledge, developed and disseminated by faculty and students, would diffuse into industry and inevitably advance the health, quality of life, and economic vitality of America.

These two watershed events, the Morrill Act and the mobilization of the scientific and engineering communities during the Second World War, shaped both our university system, and its relations to the federal government and to industry. There have been many other factors, especially the rise of academic medicine, but these two were the major sea changes. Both were stimulated by tectonic shifts in the national and world scene.

Since 1945, America's innovation system, and especially the federal/university partnership, have succeeded far more than anyone could have predicted. Each of you knows this modern history well.

Now, fifty years after the Bush report, we find ourselves facing constrained budgets, and a distinct lessening of faith in the current system to provide for the nation's future. Fundamental change seems to be demanded, but its nature is unclear. As Karen Arenson titled a recent editorial in *Technology Review*, “Out With the Old, In With...What?”

I do not have the answer to that question, but I would like to discuss the framework within which we might contemplate it.

**A Disintegrating Innovation System**

As we enter this era, we find that our highly successful national innovation system is threatened. Indeed, it is in danger of disintegrating. What do I mean by our innovation system? I mean government, industrial, and academic institutions working in at least a loosely coupled manner
to produce new scientific and technological knowledge, recognize its relevance to public and commercial good, translate some of it into industrial practice, and prepare people to develop, implement, and market it.

Here is what I observe today. We have a three-tiered system of R&D:

- Its foundation is fundamental scientific and technical research—research that has a long time horizon for possible commercial or societal application. This work is predominately carried out in research universities.
- The top tier is R&D that is aimed at, and indeed increasingly integrated into, production of commercial products—work that is likely to result in a new or an improved product within a year or two. This kind of R&D is almost exclusively conducted in industry.
- The middle layer is R&D with the mid-range time horizon for commercial or societal application—let us say, between two and five years on average. This mid-range research, conducted in the past largely in industrial settings, has been the source of a large amount of America's innovation. The knowledge developed in such precompetitive research, and disseminated through the normal channels of conferences and publications, provides a shared technology base that is drawn upon by industry and academia alike. Such research contains much of what economists term the social return on our R&D investments.

For nearly fifty years, these three levels worked as a system that paid great dividends to our society. Why do I say this system is disintegrating? Here is why:

- The bottom layer of fundamental, long-range, largely university-based research is strong, but it is increasingly under financial duress.
- The top layer of short-time-horizon R&D is spinning along rather nicely—for the moment. Industry has been forced by the realities of intense global competition to concentrate on product and process improvement and the reduction of prod-
uct cycle times. These changes have been absolutely necessary, and they have been effective. Still, this “upper layer” of short-time-horizon industrial R&D is locally optimized— for the most part, it improves only the situation of each company or a small group of cooperating companies.

- Now, what about the middle layer? Because of industry’s necessary investment in building things better, faster, and cheaper, mid-range research is disappearing from industrial research laboratories. In fact, many of the laboratories themselves have disappeared. Useful couplings between academia and industry that existed in this layer have been badly damaged.

What is the result? The result is that the innovation system is in danger of coming apart. The bottom layer of university-based, long-range research is chunking along, despite wear, tear, and rusting bearings. The top layer is spinning fast, on freshly oiled bearings, but it is using up all of its stored energy for short-term optimization, and is not investing sufficiently in the future. As a result, contributions to the “middle layer” by industry are rapidly diminishing, and the upward flow from universities is rather random and less productive than it might be.

This description is oversimplified, but it gives the essence of our situation. Admittedly, this image of the national innovation system is most accurate for mature manufacturing-based industries. It is less accurate for younger, fast-paced industries like biotechnology, where the path between fundamental scientific research and commercialization is very short. But in general, while the recent reorientation of industrial R&D has gotten many of our companies back into strong, competitive positions, and created value for stockholders, I fear for the longer range health of our industries.

Thus we have more than just our universities and their relation to the federal government to worry about.
THE LEVEL OF INVESTMENT

Before turning to matters pertaining specifically to universities, let us examine the state of our national investment in R&D.

In 1993 the U.S. invested 2.7 percent of its Gross Domestic Product (GDP) in R&D. This includes investment by both industry and government. Just two years ago the White House Office of Science and Technology Policy's report, Science In the National Interest, suggested that investing three percent of the GDP in research and development would be an appropriate national goal. By next year, it appears that the national investment in R&D will drop to 2.2 percent of our GDP.

The federal government currently invests about $70 billion annually in R&D. Close inspection of these budgets, however, discloses that only about $35-to-$40 billion funds anything that this audience would consider research or development. This is only 2.3 percent of the federal budget, and it is only a little more than .05 percent of our GDP. The remainder is largely for objectives such as testing of weapons systems. If all these numbers are a bit confusing, the "bottom line" is that the federal government devotes only two or three percent of its outlays to real scientific and engineering research and development.

The likely future of U.S. R&D funding is not attractive. The budgetary turmoil in Washington makes prognostication difficult, but here are a few facts. The current Congressional budget resolution, as analyzed by the AAAS, is headed toward a 30-to-35-percent decrease in real dollars by FY 2002, almost uniformly across agencies. The Administration's budget projections also show nearly as serious reductions.

Examination of the immediate state of affairs looks slightly less troublesome. The Department of Defense, through the past three administrations, has worked hard to keep R&D investments constant in current dollars, despite the dramatic declines in manpower and procurement. But it is dropping nonetheless. The National Institutes of Health, unlike most components of the budget, are funded for the entire fiscal year and will actually receive a 5.6 percent increase over FY95. (This is due to strong leadership by Congressman John Porter of Illi-
nois and Senator Mark Hatfield.) The National Science Foundation likely will receive an increase of one-to-two percent, i.e. a slight decline in real dollars. Congressman Vernon Ehlers of Michigan is leading an attempt to stabilize NSF’s appropriation for the entire fiscal year—a very important leadership action if the federal budget is not adopted by March 15.

Other leaders in Congress, such as Bob Walker, Chairman of the House Science Committee, and George Brown, its ranking minority member, have fought to extend the erosion of support for fundamental research. But we cannot be complacent. What will happen in the years ahead is the issue. We are very likely to seek serious deterioration in federal investment in R&D.

Industrial spending on R&D, currently about $102 billion annually, is also on the decline. Indeed it has not grown in real terms for seven years.

Now, let us contrast our situation to that in Japan. Japan currently invests about 2.8 percent of its GDP in research and development, which is almost exclusively non-defense R&D. Japan, a much smaller nation, spends essentially as many absolute dollars in non-defense R&D as does the U.S. While we in the U.S. are moving toward a distinct R&D funding decline, the Japanese are operating under a law calling for a doubling of their investment in R&D by the year 2000. Now it appears that this goal will not be fully met by 2000, but the Japanese science and technology budget is increasing by about ten percent per year, despite the fact that the rest of their budget is flat.

Furthermore, Japan is moving aggressively to build its infrastructure for scientific research. It is reforming its system of funding university research and providing for 10,000 new doctoral and postdoctoral fellowships. It is planning to sell bonds to support a system of new centers of research excellence. Japan is moving very aggressively. We should remember this as we look to the future of our own R&D system.
RENEWING THE NATIONAL INVESTMENT IN RESEARCH AND EDUCATION

Maintaining a sound level of national investment is a primary matter, but the overall policy environment is also important. As we evolve our national science policy, there are a number of principles that we should hold to, and a number of pitfalls that we should avoid.

Indeed, I fear that we are stumbling into several policy pitfalls. I will note four that are of particular concern to me. They are:

• Categorization of research,
• Failure to recognize research and advanced education as an investment,
• Separation of research and education, and
• Driving wedges between public and private institutions.

First, categorization of research: During the past three years, far too much of the science policy debate in Washington has been dominated by classifying R&D programs as "strategic" or "basic" or "applied." This has caused unnecessary pendulum swings in several agencies, and has unnecessarily invited ideology and partisanship into the debate. In addition, the categorization of research in this way ignores the reality of how modern industry integrates science, engineering, management, process, and production. Such a perspective mitigates against clear, long-term thinking. We need to get this behind us.

Closely related to this is another concern. Many decision makers, and much of the interested public, appear to have a reasonably clear understanding of the importance and the mission of the National Science Foundation and the National Institutes of Health. There is far less understanding of the role of the mission agencies. They are very important participants and supporters of research and education in a wide range of areas. Department of Defense support of university research has been the predominant factor in the development of computing, networking, and modern telecommunications. The Department of Energy supports most of the basic atomic and nuclear physics in the U.S., especially that requiring large-scale facilities. NASA, Transportation, and Commerce are all essential parts of the equation. Indeed, the mis-
sion agencies provide around 70 percent of all of the federal funding of
research in America's engineering schools.

The "Press Report," i.e. the report of the National Academy's Com-
mittee on Criteria for Federal Support of Research and Development,
recommends that the President annually prepare a Federal Science and
Technology Budget that displays the support of science and technology
across all federal agencies. Such an analysis, though difficult, would
give a far truer picture of the nation's investment in science and tech-
nology, and of the role of the mission agencies in these endeavors.

The second policy pitfall the nation must avoid is a failure to recog-
nize research in advanced education as an investment. Expenditures on
R & D are increasingly viewed as simple costs. They must be recognized
as investments--investments that pay extraordinary rates of return, both
financially and socially. This is not an abstract concept; it is an impor-
tant, if often overlooked, fact. For the moment, let me simply point to
a recent review and analysis by Joe Stiglitz, the Chairman of the Coun-
cil of Economic Advisors.

Stiglitz reviews several recent econometric studies. They indicate
private rates of return, i.e. return to the company supporting the R & D,
on the order of 25 percent. The social rate of return, i.e. the return to all
who utilize the knowledge generated, is around 50 percent, and many
investigators suggest a much higher rate of return. These are astounding
numbers that reflect a great and underappreciated return to the Ameri-
can public.

An important aspect of return on our national investment in uni-
versity research occurs by attracting private capital to develop inven-
tions that we have patented. At MIT, we carefully analyzed what our
patented technologies have added to the economy. We then conserva-
tively extrapolated across all university patents in the country, and con-
cluded that the licensing of university inventions adds more than $20
billion and 150,000 jobs to the economy every year. It is hard to argue
that the funding of research is a drain on the national budget!

The third policy pitfall is one that concerns me very deeply, and
that is the separation of education and research. It is the tendency, in
tight financial times, to create an environment that pushes research and education apart at the very time that they need to be increasingly integrated. It is short sighted and dangerous.

What are the indicators of this? Federal sponsors, through a variety of mechanisms, originating both in the Congress and in the Executive Branch, are retreating from paying the full costs of the research they sponsor. This forces universities to shift the unreimbursed costs to their only other sources of revenue--tuition, gifts and endowment income, and state support. These resources generally should be devoted directly to our teaching program and environment.

The failure to meet full costs, and the application of arbitrary caps to cost-of-education allowances, tuition reimbursements, and reimbursement of indirect costs creates a situation in which it becomes more attractive for faculty to hire postdoctoral scholars or junior research scientists than to support graduate students. This trend, though understandable, should be arrested and reversed.

The final policy pitfall I worry about is a manifestation of the Law of Unintended Consequences--and that is the specter of driving wedges between the public and private research universities. We simply must not allow this to happen. Some of the financial and policy issues, especially those associated with cost reimbursement, look a little different in detail from the perspective of the public and the private institution. But we have much more in common than we have differences.

We must work together, as we are today, and not allow ourselves to develop conflicts that are counterproductive, especially when viewed in the long run. The ecology of American higher education, with its great variety of institutions, has made us the greatest system in the world. We need to be vigilant to keep it this way.

**Toward Some Solutions**

Now, what about solutions? I did not promise to delineate new policies, but I did promise to talk about the framework for our discussion. This is the kind of challenge that Jerry Wiesner would have rel-
ished: how to build bridges between ideas and institutions to create entirely new paradigms to meet the times and the nation's need.

Where then, should we—the universities—begin? There are some things we must avoid, and some things we must do. Let me begin with three dangers that we have to avoid. They are:

- Throwing out what is good,
- Smugness and complacency, and
- Looking back too much and forward not enough.

First, do not throw out what is good. You may wonder why I would even suggest such a thing...that we may be in danger of abandoning the principles and mechanisms that have built the world's premiere system of higher education and research. But if we just think about it, there are pressures edging us towards doing just that. We must resist those pressures. Difficult financial times, for example, must not force us to abandon the integration of teaching and research. Indeed, these activities need to become even better integrated and more mutually reinforcing. We must be learning communities in the deepest sense. And we must not abandon the American ideal of making our best institutions accessible to all who have the intellectual capability and the drive to benefit from them. Education must come first.

Second, do not fall prey to smugness or complacency. The excellence that we have attained does not imply that we do not need to change. Our own worst enemy is smugness and complacency. We have been guilty of both. The world does not owe us a living. We must be willing to explain what we do, why we do it, and why it is important to the future. We must honestly and continually assess what we do and how well we do it. We need to work effectively to reduce our costs while retaining institutional and educational excellence. We need to humanize our learning environments. Our institutions must evolve rapidly in new directions to meet the needs of the century ahead. “Send the money and leave us alone” is not, and should not be, an acceptable message to Washington. Yet, I have heard it many times.

Finally, stop looking to the past instead of the future. We cannot justify the investment of federal funds in 1996 on the fact that we won the
war in 1945. We need to look to the future, conceive of improvements in our role in the national innovation system, utilize the very technologies that we have developed to improve learning both inside and outside our campuses. We need to work aggressively to prepare our students for the international, globally integrated, environmentally challenged world they are entering. We need to tailor new degree structures and new educational formats to the needs of a new age.

We need to think carefully about what Congressman George Brown has told us—-that if we expect the federal government and the public to support us, we must turn more of our attention to the issues that most concern them—-issues like poverty and crime and economic distress. Are there new things that we can do to solve these problems? I do not know, but I do know that we need to think hard about it and not presuppose the answer.

What else can we—or should we—be doing? I would suggest two arenas in which we must be more active: advocating our cause and building partnerships.

Let me say a few words about advocacy. Though we must not blindly advocate our cause...we must advocate it. We need to tell our story on editorial pages, in the television news, in public lectures, in the most popular of magazines, in local political gatherings. The future has no political constituency. We must become that constituency. We must raise the level of the debate. We must show our relevance to society, and especially to the lives and quality of life of future generations. We do not need to engage in hyperbole because we have a strong, defensible case. But we do need to make it. Let us be teachers and partners.

Indeed, partnerships will be the key to success. Our national innovation system must be just that—a system. Government, industry, and academia must be in greater discourse and partnership to attain our goals. We are great economic engines in the near term through our R&D activities. We can be even greater economic engines in the long run through improved education of our students.

We are not listening enough to what industrial leaders are saying about the qualities they desire in our graduates. They are not listening enough to our concerns about the deterioration of mid-range research
and the shared technological knowledge base. Our discourse regarding the roles and future of our national laboratories has been far too defensive and far too unimaginative.

This is a time for experimentation, for the development of new paradigms. My belief is that many of these will involve imaginative new partnerships across all three sectors.

Let me be a bit parochial and give three examples of some fledgling new partnerships that MIT is involved with.

First, we have recently established an Alliance for Global Sustainability, jointly with the ETH in Zurich, the University of Tokyo, and several global corporations. Our goal is to advance the concepts, science base, enabling technologies, and policies necessary for the vastly greater efficiencies and reduction of environmental damage that the future demands. Many of the initial activities of the Alliance emphasize work associated with industrial development and energy utilization in China. The base of environmental and sustainability research in all three of the universities remains dominantly funded by our national governments, but the Alliance leverages and builds on this base, and extends its range of influence and relevance.

A second example is the Lean Aircraft Initiative, a partnership involving the U.S. Air Force, 19 aerospace-related corporations, two major labor unions, and several U.S. universities. We are engaged in a massive study of manufacturing in the aircraft industry to identify the means to dramatically lower the cost of high-quality production of aircraft. It is a highly unusual style of research and has radically changed the careers of a few of our faculty.

Finally, I would note the "Things That Think" initiative of our Media Laboratory. This initiative is being carried out through a consortium of industries ranging from appliance manufacturers to telecommunication companies to theme park developers. It is an imaginative exploration of building intelligence and digital communication into a myriad of objects—from vacuum cleaners that can tell the difference between a gum wrapper and a $20 bill to personal newspapers that prescreen and deliver the world's news to you each morning.

Every other major university has new partnerships of this kind that are emerging. We need to accelerate them.
It is also my belief and experience that many of the most imaginative and important new partnerships that will emerge will largely be aimed at achieving educational goals, rather than being isolated research activities. This, of course, is a larger topic in and of itself that we should explore together.

IN CONCLUSION

In closing, I want to state that we must not lose sight of the fact that despite the extremely important role that the federal/university partnership has in meeting the challenges of the world as it is, our deepest value as universities lies more in what we do not know than what we do know. Our utilitarian value to society is considerable, and I celebrate that. But ultimately it is the unraveling of mysteries and the satisfaction of human curiosity that will provide the keys to the future.

There is an infinity of important things to discover, understand, and apply. We, as a nation, cannot lose our will to continue this great adventure. We cannot deprive the next generation of its opportunity to contribute to this advance. And we certainly cannot afford to fail to invest in the very activities that will provide for the future: for the quality of its life, the vitality of its economy, and the purity of its environment.

There is so much to be discovered and understand: how we learn, remember, and communicate; what the relationship is between thought and speech; how to convert solar energy into practical, cost-efficient fuels; how viruses form their elegant, geometric structure from common protein building blocks; how living cells interact with non-living materials; what aspects of weather and climate are predictable; why different nations' economies grow at much different rates; what effect the explosion of networked electronic communications will have on nation-states; what is the origin of the universe.

Such questions remind us that our value to practical concerns such as health, economic productivity, and national security accrues ultimately from our enthusiasm and our readiness to explore the truly unknown.

In other words, to echo Jerry Wiesner, “It's not what you think, it's what you haven't thought of that's important.”

Thank you very much.
Discussion

HOMER NEAL: Well, thank you very much, Chuck, for doing such an excellent job explaining the issues that this symposium will be dealing with. Are there any questions?

AUDIENCE MEMBER: I have been trying to push the issue of investment in talking to politicians, and what I get back is the statement, “Everybody wants to be seen as an investment.” The infrastructure, everything that the government spends money on, would like to be treated as an investment: infrastructure, welfare, investing in the children. And it gets to be a very tricky issue to try to segregate it, as I tried to. If investment is good and expenditure is bad, you are going to find everybody claiming that their special interest is investment. Have you found any way of getting around that?

CHARLES VEST: Well, I do not know whether I have gotten around it. I understand what you are saying, and I guess, being an engineer, I believe that the best approach is to try to demonstrate these things in sound quantitative terms. Over the past few years, there have begun to be a number of studies that make that case very clearly.

More important, in terms of public and federal recognition of what this means, I think it is infinitely more effective if this story and these statements are not made by those of us in the university community, but by others. It is more productive when we hear, as we often do, from people like John McTague and other leaders of industry who are willing to sit down with people in Congress or in local forums, to talk about what investment in research means to the growth of industry in this country.
So, I agree that many sectors use the word “investment,” but I think universities have an absolutely sound, quantitative story to tell in terms of private capital attracted, in terms of job creation, and so forth, that justifies our use of the term.

And I have found, over these past five years, in trying to tell the story of American higher education, that the single best tool that I have had has been a study that was done independently by the Bank of Boston in 1989. This study showed the number of companies and jobs that had been spun out of MIT in one way or another, and it is absolutely astounding. We could show that, at that time, there were on the order of 300,000 people in Massachusetts companies that had been started by our faculty and recent graduates. Those kinds of facts grab people, they hit home locally, and I think they demonstrate that funding for research is an investment.

AUDIENCE MEMBER: I believe you hit on two items that seem critical in today’s world. One is the governmental attitude, the other is industry’s attitude. Going to the industrial side, what seems to have changed so dramatically, as you mentioned, is that there is a much shorter-term perspective to it, and that has an impact on our research establishment, on job opportunities for our students, on where research is done, etcetera. Japan seems to have a totally different attitude. So my question is, what is going on in Japan and in Japanese industry that allows that country and its industries to see things so differently from the shorter-term perspective that we seem to be taking?

CHARLES VEST: There are undoubtedly people on the panels today who can speak with deeper knowledge than I on these issues, but let me make a couple of brief comments in reply. First, I want to emphasize something I said, which is that my perspective is not one of, “Let’s say bad things about U.S. industry and its R&D policies.” Industry has largely done things over the past five or six years that it has had to do. It has done them well, and our economy, such as it is, is in much better shape than it would have been if industry had not taken these steps. Still, the changes have made companies more inward-looking.
I can only repeat what everybody in the room knows, which is that our current penchant to look almost exclusively for the fastest possible rise in stock prices and so forth, driven by the so-called value investors, is causing trouble in the long run. About a year ago, that remarkable colleague of ours, Norm Augustine, the CEO of Lockheed-Martin, told me a story. He said that two or three years before, Martin had developed a very careful strategic plan, and had decided to make a very major increase in its investment in research, and particularly in research with a much longer time horizon. They thought the case was absolutely sound and beautiful. They went to New York, made the presentation to the Wall Street analysts, and their stock dropped something like 25 points, and it took two years to recover. Those are the pressures that any real business person has trouble dealing with.

Now Japan—what can I say? I think that there are a few important characteristics. First, we are talking about a nation that has, in a fairly strategic way, been pulling itself up from the ashes of the Second World War. It has a traditional culture that is somewhat more focused and disciplined than ours. Until recently, Japan has not been a good world citizen, in my view, in terms of its investment in basic research. This is a fairly new activity for them, but boy, are they going at it aggressively.

I think these differences in time horizons are built into the political system, built into the attitude, but in the long run, believe me, I would prefer the U.S. system, as long as we keep it a little closer to being on course.

DAVID GOLDSHTON: Chuck, at meetings like this, usually when people talk about long, mid-term, and shorter term research, the point is that it is the longer term research that is the most threatened and that has lost its industrial constituency, and that all the pressures seen within the university from both industrial and federal funding, are more towards mid-term research for things that industry can see a return on. There is an incentive to do that research because of the desire to patent. Government policy is really uneven, focusing on targeted or strategic research—although those words are used more quietly now than they had been in the last couple of years. Do you have any comment on
that? To what degree do you think that the alternative to the view you advanced—the view that at this time it is the longer-term research that is more threatened—is an accurate concern? For example, do we need to be concerned that in industry research is usually discussed in terms of, “Where is the next transistor coming from?”

CHARLES VEST: By the way, for those of you who think there are not people in Washington who understand what is going on, there is a great counterexample.

David, I chose in my remarks to emphasize what I call mid-term research for a couple of reasons. First, I have found over the years that what most people in industry mean when they say long-term research is what I think of as mid-range research, and we have not been talking nearly as much about it in the dialogue recently. We have been talking about the basic research and applied research as if there were a clear boundary between the two. So, I wanted to give a little emphasis to the fact that there is a continuum, and I do think it is that mid-range of research that, for the most part, industries have backed away from.

The second reason I chose to amplify it a bit is that, while we have lots of arguments back and forth about appropriate levels of investment, and appropriate sets of policies, I think there is generally still a very strong bipartisan belief that the funding of truly fundamental science research, and perhaps truly fundamental engineering research, is a legitimate role of the federal government. I think that is why NSF and NIH continue to be a bit better understood than the other agencies.

I think that we have not talked enough about this mid-range research, however. As I think about the entire R&D system in the country, that is a part we really need to worry about more, even as we are trying to continue to build a strong case for the truly fundamental work.

JOHN YOCHELSON: Chuck, one of the many structural shifts that may bear on the resources going into R&D would be the shift away from manufacturing towards services, which has been ongoing during the 50-year span that you have described. I wondered if you could share with us—wearing your MIT hat—whether you feel that the ser-
vice industries understand and are receptive to the need for R&D and university partnerships, as much as the manufacturing sector, which has been so heavily engaged in R&D?

CHARLES VEST: Thanks, John. Two things. First, I almost hesitate to give you this figure, because it astounds me every time I repeat it, but it is true. About 85 percent of our undergraduates leave with degrees in either science or engineering. And yet, of those companies who came to MIT on recruiting visits, 45 percent were from the service industry or the software industry (predominantly the service industry: financial services, Wall Street, management consultant services, and so forth). A decade ago the figure was under ten percent.

This a big shift. The service industries, as all of you know from your own institutions, are learning really to love quick, quantitative young men and women, regardless of their backgrounds, whether it is mechanical engineering, biology, physics, or what have you.

At MIT, our interactions with the financial services industries—with service industries in general—are just beginning to grow. It is an absolutely different experience to try to talk about the support of research or building of endowment or fellowships in those industries, despite the tremendous contributions that we have made to the fields of financial engineering and so forth, going clear back to the development of the Black/Scholes algorithms for pricing futures.

The service industry does not have the same sense of commitment that I believe the manufacturing-based industry had in the period in which it was clearly in the ascendancy. It is a big argument that we have to make. Part of the problem is that many of the service institutions are partnerships, and the sort of corporate funding and thinking is very different than it is in the manufacturing sector. A major challenge for MIT, and for most research universities, is how to engage the service industries in these discussions. It is going to demand a very significant cultural change and change of attitude; we really have to get them to see their responsibility for helping to develop the scientific fields, if they want to utilize the knowledge and the graduates that are produced.
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**The University in National Science and Technology Policy**

John P. McTague  
Donald F. Hornig  
H. Guyford Stever  
D. Allan Bromley  
Ernest J. Moniz

Discussion
We have a very unusual collection of individuals here, almost unprecedented. Allan Bromley reminded me when I asked him if there have ever been such an assembly of former and present science advisors, and he said the last time he could recall was back in 1981 when Jerry Wiesner assembled such a group at MIT.

So I think it is particularly appropriate that it is happening today in connection with the Wiesner Symposium.

The credentials of the individuals on this panel are so distinguished that we have a choice, and that is to spend the next hour reading their accomplishments, or listening to them speak. I have chosen to listen to them, rather than to extol their virtues. So there will not be extensive introductions.

What we will do is have brief remarks and perhaps reminiscences from each of these individuals in historic order, working from the earliest days up to the present, where we have a coverage of national service—a continuous coverage now, of over half-a-century. After we do that, we will hopefully have time to engage in a dialogue.

Now, having set out the general rule, I will immediately violate it and, although, by natural sequence—since I served in the Reagan Administration, I should be in the middle of this group—rather than having me pop up and down, I will start off and make the first remarks, and then we will go to Don Hornig.

I came to Ford from the White House almost ten years ago now. And when I first came, I got a standard question from almost everybody in Michigan, and that is, “How does it feel to be at an institution like Ford, compared to being in the government?” My immediate re-
response to that was, “Well, they are both very large organizations, and large organizations tend to have many problems in common, the biggest of which is communication. But the biggest difference between Ford, or any other industrial organization, and the government, is that in an industrial organization the desired outcome is agreed on by every member of the organization.”

You can go to a worker on the line or go to the chairman’s office and ask what the purpose of the company is, and they will tell you what the purpose of the company is. It is to build good automobiles at a profit, so that the organization can sustain itself, and its stockholders can be rewarded.

But if you go to government, and you ask any of thousands of people what the purpose is, they will all know the purpose of government, but no two of them will agree on what the actual purpose is.

So the debate in government is always on what is its purpose.

The result of that often is, as Chuck was saying, that you get involved in issues of categorization. Should the government be involved in this activity or should it not be involved in this activity? Should it be involved in this one instead? I was pleased to see that Congresswoman Rivers did not fall into that trap. What she talked about were the desired national outcomes, not the desired role of the federal government.

If you immediately leap into the middle—which happens usually when there are new people in the Congress or the Executive Branch (the same thing happened in the early eighties, by the way, in the beginning of the Reagan Administration)—the debate immediately focuses on what is or is not the purpose of the government, as opposed to what are the desired national outcomes.

If you focus on national outcomes—as Congresswoman Rivers mentioned, things like national security, health and prosperity for today and tomorrow—you tend to try to look at how the system as a whole can reach proper conclusions, and how people can work together.

Chuck mentioned at the beginning of his talk the Morrill Land Grant Act of a century-and-a-third ago, which focused on the development and practical application of science in connection with the arts, agriculture, et cetera. Note that right from the beginning the univer-
The university/government partnership was aimed at development and practical application. If you look at the agricultural industry in the United States, it is perhaps still the single most successful industry globally that we have. That is because the nation as a whole decided what the outcomes should be: an extremely strong agricultural industry based on very good research and on partnership all the way down the line—partnership, as Congressman Ehlers mentioned, which also involved the state and local levels.

If you look at the other great successes, the same conclusion applies: in World War II, for instance, we clearly knew what outcomes for the nation were desired.

Once you know what the outcomes are and you have focused on them, you can find a way to integrate the broad array of national resources, government, universities and industries toward the desired outcome. You do not necessarily debate: is this the role of universities? is it basic or is it applied research? is this the role of industry or is this the role of government? You try experiments to see what works toward attaining the large-scale national goals.

So it seems to me that the important thing is to get back, once again, to the issue of debating not what is the role of government, but what are the national outcomes we desire, and to use all the institutions we have in partnership toward reaching those goals.

I think that is something that is achievable, because it has been achieved in the past.
It is a pleasure to be here at a symposium honoring Jerry. He was my immediate predecessor and his creativity, his energy, permeated the Office in the White House and lasted for a long time after he left. I had his image before me all the time.

Now that era has passed, but we are back to problems that have not changed as much as we would like to think when we say that we are now in a crisis. Before World War II there was nothing to discuss. There was no cooperation. The universities and basic research were funded by the states, by foundations, from their internal resources such as tuition and endowments, and by industry. Industry then played a much heavier role in supporting basic science in universities. In many ways I think the recent retreat of industry from basic research is a consequence of the success we have had in getting federal support for basic research in universities.

After World War II, first the Office of Naval Research, and then the Atomic Energy Commission, the NIH, and NSF began supporting not only research but graduate education in the universities. All of them had the sense from their practical experience during the war that research and graduate education should be deeply linked.

What happened was remarkable. By the early 1950s the federal government had become the principal patron of university research, and by 1966 74 percent of all university research and development was federally supported. That fraction, incidentally, has stayed more or less constant ever since. Conversely, by 1966 half of all the federal spending on basic research was in universities, and it has grown since then.
So by the mid 1960s it was clear that the question was no longer one of interaction between the federal government and the universities and their research laboratories, but rather a question of real partnership—which I do not think can be dissolved now. By the time I became involved, which was when I joined President Eisenhower's Science Advisory Committee in 1960, this partnership between the public and private universities and the federal government was falling pretty rapidly into place. The main scientific and technological focus at that time was the Cold War, weapon systems, and the space program, but those who looked at the future of the country, such as the President's Science Advisory Committee (PSAC, as it was called), realized how much we were dependent on the universities and on basic research. Right off, in 1959, one of the very first reports from the new PSAC—it was founded after Sputnik in 1957—was entitled, "Education for the Age of Science." The PSAC took off from there. I will not go further into any of these historical details, but we all felt very strongly at that time that graduate education and fundamental research were the responsibility of the federal government. We did not distinguish particularly between basic and applied research. Our feeling was that the two interacted and fed each other at all stages. We also did not talk much about technology transfer in the modern sense. Our conviction basically was that it was the people who came out of the universities who were the fundamental transfer agents. The movement of educated people was the most important thing.

We did also, though, believe very much in the pluralism that said that all the mission agencies should in their way support fundamental research, rather than being part of an overall national plan. They should all support fundamental research in the areas required for their missions, because this ties the scientific enterprise to the variety of goals of the federal government.

Such a position was formalized in 1965 when President Johnson stated in a memorandum to the department and agency heads, "that research supported to further missions should be administered not only with a view to producing specific results, but also with a view to strengthening academic institutions and increasing the number of institutions
capable of performing research of the highest quality.” I think I would still stand by that statement.

The list of concerns was startlingly similar to those we have today. One of our great efforts was to support the NSF and gain funds for basic research. It was not much easier then than it is now to convince Congressmen and everyone else that research which had no obvious tie to public policy or public goals was worth supporting. Still, there was some success. From 1963 to 1968 the expenditure for fundamental research rose by 60 percent in constant dollars. That is a growth rate of 12 percent per year. Contrary to many visions of what the “Golden Past” was like, it was a struggle every inch of the way to get those funds. If you doubt me, I suggest you talk to David Robinson, who is here, and who worked valiantly with the Bureau of the Budget and all the agencies involved, to achieve that kind of growth rate.

I do want to point out that we have been through our present dilemma before. By 1970 the picture had changed. After that great growth in the 1960s, expenditures dropped and remained essentially flat until 1981. I commend to all of you in this regard the book by Smith and Carlesky, *The State of Academic Science*, which was written in 1976. It examined the problems that arose from what was perceived as a public and government for which science and universities had lost their allure. The situation they describe quite accurately anticipated what we are talking about today. Well, we came out of that earlier difficulty. Problems are never completely solved; they only recur, and so now we are back with a similar situation.

I want to leave you with one final thought, though, because I think there may be a real change ahead that we are going to have to worry about.

Even in the earliest days under PSAC, we worried about the fact that if we were successful and things kept on growing at 10 or 12 percent per year, at some point before everyone in the country worked in a research organization there was going to have to be a leveling off of the growth rate. At some point we would have to arrive at growth roughly parallel to the growth of the gross domestic product. That concern is still valid today. And the point is that when that happens, it will pro-
duce very great changes. The magnitude of the whole research enterprise may simply have to follow the budget. If the budget levels, the research enterprise may level, not only in the short term, but permanently.

But what happens if you drop from growth to a level situation, a steady state, is that the throughput, the numbers of ins and outs, the numbers of new graduate students, the numbers of new faculty, the number of—well, the number of everything—drops dramatically. For example, if you replace a 10 percent per year growth rate by a steady state, then (assuming five percent per year ordinary attrition) the number of people entering and leaving the system would drop from 15 percent per year to five percent per year, a factor of three.

We are now moving in that direction—but not yet drastically. But when a significant movement in that direction occurs we will be faced with qualitative as well as quantitative changes. The whole mode by which we teach undergraduates, using the labor now provided by post docs and graduate students, will have to change.

So I recommend to all of you that you think very deeply beyond simply persuading the government that we need more money, which we do. We must think more deeply about the consequences for ourselves and the way things will be done in the system when we reach a fundamental limit to the growth capacity.
I am honored to be part of this University of Michigan celebration of the great life of Jerome Wiesner.

In ways I pity the University of Michigan in the future, for I doubt that it will ever get a Jerome Wiesner Symposium Speech to match what we have already heard from Charles Vest. Perhaps you out just to repeat this one every year to introduce the discussion.

I have a great fondness for this region of the country and this University. In the mid-thirties I worked two summers in the River Rouge plant of the Ford Motor Company, which helped me to pay for my undergraduate education at Colgate University. And, as some of you heard recently, this campus houses the Gerald Ford Presidential Library in which my life’s papers are archived.

When I appear in the middle of a large program as I do here, I make a standard statement that I accept all and rejoice in all of the wise remarks made before, and I ignore all the unwise ones. In this particular case, however, the remarks have all been so wise that it makes it difficult to follow. But I will on the basis, as Congressman Ehlers noted, that much of the best came from the World War II generation which includes Jerry, Don Hornig and me.

I met and worked on radar development with Jerry in World War II at the MIT Radiation Laboratory. There in our formative work years we were part of a team of university-based professors and young graduates working on a common and urgent practical goal of applying science and engineering to winning the War. I base my remarks pertaining to universities and national policy in part on those wartime experiences in the National Defense Research Committee/Office of Scientific
Research and Development organization led by Vannevar Bush, on which he based his report, *Science: The Endless Frontier*.

After the War, Jerry and I joined the MIT faculty, he in electrical engineering and I in aeronautics and astronautics. The federal government funding for research, so vital for graduate education was not immediately available from not-yet-established agencies like the National Science Foundation, hence much of university research depended still on military-oriented programs. One of Jerry's greatest immediate contributions was to help form and lead the Research Laboratory for Electronics, MIT's peacetime follow-on to the Radiation Laboratory, which was sponsored and funded by units of the Navy, the Air Force and the Army. Jerry's own work was on over-the-horizon radar, which included both basic work and applied work, the latter because it was to be used in the emerging air defense system for the North American Continent. My work in aeronautics and astronautics was similarly based on the RadLab experience but additionally on the work I did for Dr. Bush in London and on the Continent on rocketry and guided missiles as that age was being started.

In the fifties, even though government agencies that supported non-military research, both old ones like the National Institute of Health and new ones like the National Science Foundation and the Atomic Energy Agency, were growing in their share of support for university-based research, the military remained strong as the Soviet Union developed in series the atom bomb, the hydrogen bomb, intercontinental missiles, and spacecraft. So the universities continued to be involved in military-related research. It was a pattern that was difficult to stop as long as there was a Cold War. In fact, there developed a sense of a "golden age," because one could get support for any good idea, or so we thought. Since then it has steadily grown more difficult, for many reasons which will be discussed today.

As I progressed from researcher and teacher to associate dean, to department head, to president, I got many different views of the government funding of academic research and teaching. When I decided that it was better to give than to receive, I took the Directorship of the National Science Foundation. There my most frequent office visitors
were researchers and teachers, deans, department heads, and presidents. I tried to learn and to be helpful. One of the first things I learned was to be very careful concerning the significance of statistics. For example, I must disagree with a previous speaker on the significance of the drop in R&D funding from over 3% to 2.3% of the gross national product. That occurred because the National Aeronautics and Space Administration had completed the installation of its immense infrastructure and purchased all the needed rockets for the trips to the moon, and not because there was any immediate disaffection with the support of research. That came a little later, but never succeeded in causing any serious setback until recently, although the question of how much is enough became louder rather steadily.

I arrived in Washington just at the time the funding had hit 2.3% of GNP, and we worked for my five years to get it to level off and to start upward, but was a difficult job, as a previous speaker has pointed out. Don Hornig has just said that things have not changed as much as we think. I agree with him for many of the big issues of today were also our big issues. We had to fight for our funding; we did our best to build bridges to Congress. We were always glad to have some of the old timers in Congress to help us—those with experience who slowly but surely had developed a very good understanding of science and technology, even though they were not scientists. One of the biggest jobs that you have in facing the future is to ensure that building that connection to Congress is done well, because some of the newcomers badly need that connection. Some indeed are reaching out, and I am convinced you can succeed.

Jerry and I were fellow members of the Carnegie Commission on Science, Technology and Government which studies many of the issues of interest to you today. One of the studies which I chaired produced a report, *Enabling the Future: Matching Science and Technology to Societal Goals*. Almost a decade ago we came to the conclusion that, contrary to the opinion of some doubters, there were many well understood goals of society. Our founding fathers include some in the Constitution. Some goals have overlapping features with others and some seem to be in conflict. Nevertheless, we identified about a dozen major goal-areas
in which science and technology play an important role, including national defense, transportation, education, health, social welfare, personal security, and so on.

We recognized that the science and technology base was important in the pursuit of all these goals. Universities, together with industry and government, have a great responsibility in establishing that science and technology base, maintaining it and strengthening it through research and education. We recognized another important goal which was to ensure a strong industrial activity, another area where universities and industry must work together.

Let me close by reiterating the strength of our universities’ case. We must work on presenting it well. In that presentation, I wish to remind you present leaders that you must be more optimistic and positive in your presentations. I do not believe that things will be as bad as many predict. In fact, there are many approaches to our problems where progress is being made. Chuck Vest made an important point in recommending a strong, positive thrust. If you do, there will be many of us cheering you on. Thank you.
It is a great privilege to be here this morning. In contrast to the prior speakers, by the time I got to Washington, there was one major change that had already occurred. In the early days, there really were no scientists or engineers in Washington at all, and I remember—from the early PCAST—that Ed Pursell told me that he spent much of his time going around Washington explaining to people why it was that satellites did not fall straight toward the center of the earth. Newton's laws had not penetrated Washington. Most of the people in PSAC at the time were physicists. But by the time I got there, there were about eight different scientific species. The fact is that almost every Congressional committee, every committee for each member of the Congress and all of the agencies, now have very competent scientists. And for that reason, we focused on somewhat different things. In particular, I want to go back to Jerry Wiesner, because it was Wiesner who, more than anyone else, recognized the true power of having active research in each of the more than 20 agencies of the federal government, that were charged with specific mission responsibilities relating to science and technology.

Of course, if you have more than 20 agencies all supporting research and development, you have an enormous potential need for coordination. One of the things that I am most proud about in the Bush Administration is the fact that, working with President Bush, we agreed that we should try for a two-tiered budget structure. As is unique to the United States, most of the research budget was built from the bottom up on the basis of proposals submitted by individual scientists, engineers, mathematicians, or small groups thereof. What we introduced was the idea that, on top of that structure, would come half-a-dozen, let
us say, areas selected by the President, to which the President would give special personal support from the bully pulpit of the Presidency.

And because these were Presidential initiatives, we were able, each year, to get from the Congress increases of between 16 and 40 percent. This, of course, made an enormous difference in what we could do for the universities and for the research community.

We also spent a lot of our time making it socially acceptable for the federal government actually to work with the private sector on the development of generic technologies, because the rationale for supporting generic technologies is precisely that already admitted for fundamental research. Out of this effort came the CRADAs, consortia, the Advanced Technology Program, and a whole series of programs where the federal government worked not only with the private sector, but also jointly in cooperation with the private sector and with the universities. This, I think, was an important new development and one that is being built on today.

Let me then turn to what did we not do. Probably the most important thing was simply to provide a new vision for research and development for the United States—how it should be structured, how it should be utilized—to replace Vannevar Bush’s 1945 vision. He wrote his report at a breakpoint in our history; we too were at a breakpoint in our history with the collapse of the Cold War.

There are three pillars underlying U.S. science and technology enterprise: the 150 research universities among the 3,000 colleges and universities, the 726 federal laboratories, and the roughly 16,000 industrial laboratories. We completed a study of the university/federal government interface. That was published by the President in December of 1992 but was lost, largely. I urge those of you who are interested in the university relationship with the federal government to look at that report. It was put together by a blue ribbon committee chaired by Dave Packard and Harold Shapiro, an engineer and an economist, and it has, I think, some very important recommendations. First, it strongly recommends that the federal government really begin paying the total cost of the research it sponsors at universities. Second, it emphasizes that wrenching and difficult decisions are inevitable in our future. And
it comes down with what I think is an excellent statement of what our goals should be, namely, this: In those fields of research in which our work does not define the frontiers, we should be working close enough to those frontiers to be able to exploit new discoveries, whenever and wherever made, without delay.

There are some half dozen other recommendations that I will not mention now for lack of time.

It would be only fair to mention a couple of other things that I would have liked to have done. First, we edged around the whole question of the world population problem, and never brought it directly to the President or to the Congress. If I had to do it over again, I would most assuredly do this, because I think that it is one of the most important problems that we now face. We simply decided that it was not politically feasible or timely.

And, lastly, we did not make optimum use of PCAST. When we organized PCAST, it was the first time in 20 years that there had been a group of citizens who reported directly to the President and met regularly with the President, so that he got advice and comments, unfiltered by any bureaucracy, but directly from the shoulder. We originally asked the PCAST members to serve for one week out of each month, and every member of the group agreed to do that. But because we did not organize ourselves adequately, they did not do anything like that amount of work. I believe that they would have done so if asked and given specific problems. They would have made a more major contribution to the entire scientific and technical life of this country, had we challenged them adequately.
It is indeed a pleasure to be a part of this symposium. I have a somewhat different perspective on Jerry, since I joined MIT in the 70s, when Jerry was past his direct government service and was president of MIT. All of the descriptions of Jerry’s attributes from President Clinton’s letter to President Vest’s remarks have not yet touched on two things which influenced me a lot as a young faculty member. One was Jerry as a dreamer—that was a very clear characteristic of Jerry which really energized young people. And second, right from the beginning, it was very clear that he urged and expected the MIT faculty to view public service as a basic part of the job. This is a message deserving re-emphasis today to our nation’s faculties.

I am also very privileged to be on this panel with individuals who have served so many presidents of both parties. We have heard that in fact bipartisan support for basic science has been characteristic over many decades. Of course, election years can do strange things, even among friends. Allan Bromley, President Bush’s science advisor and a fellow nuclear physicist, just recently invited me to lunch to discuss science policy, and promptly directed a ripe tomato at me. Just part of the job.

Among the club of nuclear physicists, I would also like to acknowledge Congressman Ehlers’ very strong efforts for science in the Congress.

There is no doubt that there are many stresses confronting universities, from the uncertainties of research funding to a variety of new educational challenges, to administrative regulatory issues, to a new set of responsibilities—perhaps not fully defined—to society in the next century. Let me just try to summarize very briefly our current
Administration's views with regard to the university/government partnership.

First, at the most general level, there is no doubt that the future health of the universities, where research and education come into contact (and occasionally clash), is something which must be nurtured by the government.

Second, energetic reciprocal action on the part of universities in defining and meeting their new responsibilities to society is something on which we expect to have a very vigorous dialogue.

The rationale for this position is not very complicated. As the President said in his State of the Union Address, “We live in an age of possibility. A hundred years ago, we moved from farm to factory. Now we move to an age of technology, information, and global competition.” That reality drives an investment agenda with a strong emphasis on research and education. Research and education are two sides of the knowledge coin. Knowledge is the key resource of the next century. Thus, knowledge institutions—schools, colleges and universities—will more and more become critical elements in society's collective prosperity and health, as well as in each individual's prosperity and health.

Consequently, we have mutual responsibilities, a) to nurture the university system; and, b) to look to universities to provide leadership in terms of defining very important social responsibilities and transformations.

With that general backdrop, it is now important, of course, to look at various specific areas. Let me briefly go over some of the areas of stress and make a few comments.

1) Research funding. Clearly, there is a very deep concern about the coming years. There is no doubt that most parties have agreed that a balanced budget is important. A balanced budget will constrain domestic discretionary spending. And it does not take too much arithmetic to figure out that in scenarios of, for example, a constant-dollar budget, you in effect lose 15-25 percent in spending power over the next five-to-seven years.

Right now we are taking the one-year-at-a-time approach to the budget. In the new Administration budget proposed for fiscal year
1997, the bellwethers of university support, NIH and NSF, are proposed for real budget increases (i.e., beyond inflation). In this constrained environment, this is indicative of the Administration’s commitment to try to support basic research at universities. That does not lessen in any way the point that mission agencies have a very strong and important role in supporting basic research and university-based research in particular. Key programs at DOE (high-energy, nuclear, and fusion science, for example) are up. NASA space science missions are sustained. Peer-reviewed research at USDA and EPA are proposed for major increases. And basic research at DOD is maintained. All told, the budget proposed sustains the promise of university research in difficult times.

2) Research and Health Care Reform. The issues are not just those of the funds available for grants; there are other stresses which we must be aware of. For example, the future of biomedical research and education in academic health centers is an area of great concern. There is no doubt of a bipartisan commitment to preserving those institutions. But as we carry on discussion of health care reform, both in the government and in the private sector — with rapid managed-care growth, for example—we need to make sure these important research institutions come through this period in a healthy way. They are critical for research, education, and care of society’s most vulnerable members. New funding mechanisms or new regulatory approaches, or both, will be needed in the new world of health care.

That points, in fact, to a responsibility of the community. A coalition of academia, of industry, of governors, and of concerned citizens, must speak for the future and must keep that future vision in the foreground as the Administration and Congress try to deal with very difficult and challenging short-term issues. Otherwise, the urgent will indeed overtake the important.

3) Education. In education, there are, again, many new challenges. I was very pleased to hear Congressman Ehlers refer to something I had planned to remark on myself. We hear a lot about science standards in K-12 education, and this is a very important issue. On the other hand, to this audience I would stress, as he did, that we have to take a look as
well at what universities are doing in terms of science standards. We are producing individuals who will be the intellectual leaders of society but who may not have the knowledge of science, mathematics, and technology needed in the age of possibility. These are issues which universities and the faculties, I think, must face head on.

Outreach is another. Allan Bromley mentioned 150 research universities, which are indeed critical to our future. But the talent in our young people, through high school and into college, is distributed broadly across the country. What can research universities do to foster that talent? What is their role in helping look for that talent, and bringing those young people into science and technology? Do research universities have an advantage in using research to energize education at all levels? How do we promote that, and thereby help enlarge the pipeline for future scientists and engineers?

But the big issue in education, in my opinion, is the question of access. Given the central role of universities in defining both society’s and individuals’ opportunities, given the increasing correlation between knowledge disparities and income disparities and social disparities, it is the responsibility of all of us to maintain and increase access to education for everyone. The President has certainly taken this as a very serious challenge, with a number of innovative programs and proposals. The universities are equally responsible at many levels, including the key one of cost containment, to make college and university as available as possible. This is arguably the core issue for our socially dynamic society in the next century.

4) Administration and Regulation of Research. There are also stresses in the areas of administration and regulation—the business of allowing universities to do their jobs. There are internal issues (streamlining, reinvention, cost containment), and there are also government/university relationships. I think this is not the time to go through the indirect cost saga, which continues on. For example, there will be a new Circular A-21 shortly, followed by more proposals and negotiations. What I would like to urge here is that, as those discussions move on, it is critical to maintain a professional dialogue between universities and the Administration. We should understand that we do have largely common
goals, but that there are business issues to be negotiated. Accountability is important not only for the government sponsors of university research but also for the universities. It is one element of sustaining, and perhaps repairing, the stature of our major research universities in the public's eye.

5) Partnerships. Finally, the area of partnership: the university community has the responsibility to help think through new approaches. We have heard a fair amount about industry/university connections, and this is indeed very important. Let me not touch on that, but amplify something which Chuck Vest mentioned briefly: we also have a very important national laboratory system. It is a very large system, itself under great stress, a system which is responsible for advancing many of the missions of our agencies. This would not be a time to drive a wedge between those systems—that is, the university and national lab systems—as perhaps there is some danger of doing in this time of downsizing. Rather, in my view, we must find much more creative ways for universities to help advance the missions of these laboratories, perhaps at the same time helping themselves. Following the advice of the great philosopher, Willy Sutton: the labs might be an excellent place for universities to do some of their research.

In conclusion, the knowledge business is clearly about the future. Investments in the future are especially dependent upon trust and upon a degree of optimism. Perhaps the most important partnership that the government and university can engage in right now is to develop and foster that vision of an optimistic future.
JOHN McTAGUE: I have checked with Dr. Neal and he says we have about ten minutes for open dialogue. So I will open this to any questions or comments from the floor.

AUDIENCE MEMBER: Yes. I have a question relating to the issue of research and education, and I refer to a number of speakers who say they disdain the dichotomy between the two, and that we need to view them, as we all know, as an integrated entity. At the same time, we ask the federal government to come forward and cover the full cost of research, and yet, from the educational perspective, we know that graduate tuition is really not a meaningful quantity in covering the cost of the educational component. If we are to view these two entities as an integrated whole, or in the university as our goal, both for advancing research and education at the same time, can we really expect the federal government to “cover” the costs of research in universities?

D. ALLAN BROMLEY: The answer briefly is, yes. And to go on from that, I think the important thing to recognize is that there is substantial truth in some of the recent press reports that universities are not being anywhere nearly fully compensated for the costs incurred during federal research being carried out on their campus.

That research cost has to be made up from somewhere—from endowment, from tuition, from gifts—and I think a great many of us, as was noted earlier, would agree that those particular sources should best be used for other-than-research activities on the campus.
We have to do a much better job, in my opinion, than we have ever done before in making the case that, in fact, the federal government is still getting a marvelous bargain if it pays something at least much more closely approaching the total cost. We should remind ourselves that this is the way we started out back in 1946—with the intention that, the federal government was going to pay effectively the total cost of the research it sponsored.

JOHN McTAGUE: Anyone else want to comment? Any other questions, comments?

ALAN KRISCH: On the same subject, certainly it would be good if the government could pay more of the cost, but it seems that one of the things that has changed in the 32 years I have been in this business, is the real cost has gone up, because the bureaucracy has gone up enormously. I occasionally complain about this to some of the people in Homer’s shop. They show me a stack of papers this thick, including a statement signed by lawyers that we did not lobby or hire any lobbyists to get this contract. It seems to me that a good thing to do would be to try to get the research universities to work together to decrease some of these unreasonable regulations. And it is something that exists in all of our society. The most striking example that I know of, is in 1990, a bunch of tiger teams descended on the DOE labs and basically shut them down for a year. And it seems to me that it is not a science issue per se, but it is an important issue. Maybe we should try to do something about it.

D. ALLAN BROMLEY: Inject some common sense.

JOHN McTAGUE: I think that has a lot to do with what I was advising earlier that we do, which is focus on outcomes. If you really focus on outcomes, you then find ways that make systems work.

For a long time in DOE was focused very much on internal procedures, and no one was worried about outcomes. I think there have been some encouraging actions in the past year-and-a-half; for example,
at several of the national laboratories there is now an experiment called, “necessary and sufficient” with respect to environment, safety and health rules. The lab asks, “Well, what is it that we are trying to do, what safety are we trying to guarantee?” And then, “Is there a simpler way than the government rules for doing it? Can we use commercial best practice? Can we use state regulations? Instead of the arcane DOE regulations?” So there have been several things along that line that have occurred.

In the academic/government relationship, of course, there have been some experiments with A-21. Now, unfortunately they were only experiments, and they have not gone further. In any case, focusing more on where we are partners, as opposed to who could possibly violate a rule, would certainly make our system more efficient. It takes a lot of courage on the part of people in the government, though, to do that, because they get punished for things that go wrong and they do not get rewarded for things that go right.

DONALD HORNIG: In this context I cannot help but note, while we are straightening out government bureaucracy, that in the last 20 years university bureaucracies have grown three or four times in magnitude, too. So we might begin at home.

ERNEST MONIZ: Let me reinforce John’s point. I think there is, actually, a fair amount of progress and some promising directions. John mentioned a few of them.

There are others. Some recent FDA reforms, for example, in biologics have been a big help to industry. There are some not-yet-quite-finished packages—things that sound simple, like lab waste disposal, for example—but where universities are finding growing impact on indirect cost growth.

Unfortunately, it just takes time. But there is a commitment to address the problem, in consultation with universities.

AUDIENCE MEMBER: Since most of you, have, at least at some time, worked in circumstances where the President and the Congres-
sional domination were in opposite parties, how important do you think the bully pulpit of the President is, was, and can be?

D. ALLAN BROMLEY: Certainly in the cases in which I was involved it was extraordinarily important. The fact that we had a President who was prepared to stand up and give his personal support to specific areas, as I said, was reflected, for example, in annual Congressional appropriations representing increases from 16 to 40 percent. That is not insignificant.

H. GUYFORD STEVER: I would like to comment, since during all of my time in government we had a split government. Fortunately, I was defending basic research, and both parties seemed to have a pretty good position on that. But there were certain exceptions. For our education budget, new developments in education, the administrations were always against it and the Congress was always for it, and so we fixed a reasonable number and knew that the OMB would knock it down and that the Congress would knock it up and so we would come out with a reasonable program. We played this game in several different areas. But I have to say that this really shows the importance of wise people in the Congress. We always had enough real leaders in both parties in both houses of Congress with whom we could talk to and get things readjusted. For example, every year we got a five-to-ten percent cut by Senator Proxmire, and we knew exactly what senators we needed to go to to make sure that did not go through. He was not against basic research or anything, he just wanted to make us more efficient. Well, after many, many years at the NSF we had gotten about as efficient as we could get. In fact, we were lower than any of the regular foundations in the amount of overhead that we had. I think NSF has that proud position today.

JOHN McTAGUE: I think we have time for one last question.

AUDIENCE MEMBER: One of the things that seems to be happening is a rebalancing between the kind of public decisions made by na-
tional elites versus the more distributed elites—the counties, the communities, the state level. I think science has benefited enormously from decisions made by the national elites. I would like some speculation on the kinds of changes that might occur if, in fact, science decisions start being made more by this so-called, “distributed elite” structure.

ERNEST MONIZ: Well, I will go back to one of the issues that Congressman Ehlers raised, and that is a newly energized attempt to try to coordinate better federal and state policies in science and technology.

As you may know, there was a recent report from a committee chaired by Governors Celeste and Thornburgh. There is now a working group chaired by Mary Good, that is trying to implement a variety of initiatives. For example, in my part of the OSTP shop, we are looking at intersecting with the states in a variety of food, health and safety areas: data collection, data transmission, data linking, research agendas. This effort would be, I think, of great local interest, and yet one which has great national importance.

The second comment I would make is—following up some of the things that Chuck Vest said when he alluded to the Bank of Boston study—that research universities are perhaps not as well recognized in their locales as they should be as major engines of economic growth, cultural development, et cetera. I think the university has to do a much better job, frankly, in working at the local level and having an attitude that we are part of a local society. That attitude has not always been foremost.

D. ALLAN BROMLEY: One of the areas that is intermediate, where I think we are going to see the result of cooperation between the federal and the local levels has to do with the use of the new standards in education: standards for what students should be expected to know at the ends of grade four, grade eight and grade 12, in mathematics and the various sciences.

It is important to recognize that this is in no way a national curriculum, but, by the same token, it is going to be extraordinarily difficult for school districts and states not to use these standards—because of
peer pressure—and I think that this is going to make a significant difference.

Very little happened after the 1983 “Nation At Risk” report, until only the third summit in the history of the nation, where the President assembled all the governors together in the fall of 1989, and among other things they agreed that we should produce these objective standards.

JOHN McTAGUE: And Don Hornig has the last word.

DONALD HORNIG: I have a question. Chuck Vest mentioned K-12 and K-16 education as something we might contribute to. I am curious about the fact that not once in any of these proceedings has anyone, including me, mentioned our schools of education. We all have them, but where do they fit in; what might they contribute to this dialogue?

JOHN McTAGUE: Well, this has certainly been a historic occasion. As Allan noted, the last time this happened was in 1981. And doing my quick mathematics, this panel will reconvene in the year 2011. Thank you.
The 1996 Jerome B. Wiesner Symposium

The Future of the Government/University Partnership

**Outputs:**

Research and Education for the 21st Century

Robert Galvin, chair
Vernon J. Ehlers
Kumar N. Patel
Anne C. Petersen
Lynn N. Rivers

Discussion
I am in a bit of a dilemma because—and this may occur to other speakers as well—a dilemma because Chuck Vest gave my speech. He gave it at somewhat greater length and in greater detail than I had intended, and certainly far better than I could, but nevertheless he covered most of the points I wanted to make. So I have been reviewing my proposed comments, and I will pass over quickly the things he covered and emphasize the things that he did not.

I will also tell you that I will be addressing this issue from the perspective of a Congressman who was previously a scientist, rather than from the point of view of a scientist who happens to be a Congressman. The reason for that is a very unfortunate fact of life in Washington: Congressmen do not have time to think. That means my speech will be given without having given it much thought. If I were speaking as a scientist, these comments would be very carefully thought out and structured.

It seems to me, first of all, that we as a nation have gone through three different eras of scientific research, and you have heard some reference to those earlier today. There is the pre-1940 era, characterized by investigator-driven research, very little federal involvement, and funding provided at very low levels, primarily by foundations and industry.

The post-1940—or I should say, the 1940 to 1990 era—included a great deal of federal involvement, with the majority of the funding coming from the federal government, provided through a plethora of agencies of the federal government: funding from many different sources, so that, even today, it is difficult at times to determine the total federal research effort of the United States.

Notice, I ended that era in 1990; I believe in 1990 we entered a new era. Allan Bromley already referred to this. All partisan politics aside, I
do regret that Allan was not able to continue the programs that he and
the Bush Administration started, but, unfortunately, with a change of
administration, that came to a halt and we have a different emphasis
now. I think some of the things that were started then—this is prob-
ably a good argument for one eight-year term for presidents, rather
than two four-year terms—some of the things that were started then
were seminal, and could have led to a major federal policy change, but
it simply has not happened to this point. And let me emphasize that
that is not meant to be a partisan comment, but a compliment to Allan
and the work he did.

I would say that since 1990, the emphasis in federal research policy
has been shifting more toward applied research and technology trans-
fer, and toward “strategic research,” which is a euphemism coined by
someone in the Senate. So we find ourselves in a new era, and I think
we have a great need to define, rather clearly, the science policy for the
future. At the moment I suspect we are adrift. We certainly do not
have a national agreement on research policy and, worst of all, some of
the science and technology effort has become politicized—particularly
issues such as the Applied Technology Program, which has fallen on
hard times under the current Congress because it is perceived to be a
political program. Time prevents me from getting into details, but that
is an example of what can happen if one is not careful.

I plan to spend a few minutes discussing the university role as I
perceive it in science and science policy; the federal role; the state role;
and then I will make a few closing comments.

It seems to me the role of the university as it has been traditionally
defined is the diligent pursuit and acquisition of new knowledge and
new concepts—and I would put the emphasis on concepts when we are
dealing with science. The acquisition of knowledge is always impor-
tant, but science involves more than that; it involves development and
pursuit of new concepts, new ideas, new approaches, and new modes of
thought as well.

The second major role for universities is the communication of these
new concepts and that new knowledge to students and the public at all
levels. I believe this is extremely important in the sciences, and I alluded
to it in my earlier comments. I would also like to pick up on the com-
ment made in the last panel in regard to university departments of edu-
cation, because I feel very strongly about that issue. In fact, I devoted a
good deal of my professional life to education at all levels, at consider-
able risk to my professional career, and in fact, perhaps, to the detri-
ment of my political career. But I seem to have some talent for teach-
ing, and it seemed to me, if one is to break the cycle of scientific igno-
rance and illiteracy in this nation, one should start with the elementary
schools. So I became involved in teaching science to future elementary
school teachers. That involved a considerable amount of research on
my part into educational practices, theories and philosophy, and re-
sulted in attempts to integrate that into my science teaching.

I developed a lab-centered course for future elementary school teach-
ers in which the laboratory materials were all taken from existing el-
ementary and high school science programs, and I spent a good deal of
effort trying to educate these future teachers. This was an eye-opening
experience for me, and it illustrated to me the magnitude of the prob-
lem we deal with today. The reason I am emphasizing this, is that I
suspect we are going to have great difficulty maintaining our standards
of scientific research, and our dedication to scientific research, over the
next 30-to-50 years, if we do not do a better job of educating the pub-
lic.

I think it is extremely important— and this is my third point— to
involve the students and the public in science as a mode of inquiry, rather
than as a body of knowledge. I believe that distinction is absolutely cru-
cial, because most members of the public regard science as a body of
knowledge and not as a mode of inquiry, and I think the distinctive
part of our endeavor is our investigation of the universe using particular
modes of inquiry. The whole concept and use of models, for instance,
is totally unknown to most members of the public. That includes those
I referred to as the K-16 range: including undergraduates in most uni-
versities and colleges.

I think a role model for much of what we should do is Michael
Faraday, who was, of course, from the pre-1940 era; but I want to point
out that even then, a good share of his research was funded by a federal
government, namely the United Kingdom. For years and years Faraday maintained his research efforts by doing work testing oatmeal for the navy, to insure that it would not go bad onboard the ships. But also, Faraday spent a great deal of his effort educating the public, with Friday evening lectures that were widely attended and very popular—as popular as concerts are today. We have lost that contact between the scientific community and the public. I believe we should model ourselves after Faraday.

I also believe we need aggressive transfer of knowledge from the university to scientists and engineers outside the academic realm—the so-called “technology transfer.” One of the panelists, I think it may have been Guy Stever, said that in the early days technology transfer consisted of sending graduate students out into industry after they received their degrees. That is not a bad model. We seem to have lost some of that today, and some of the interest in serving the non-academic world.

The final role I see for the universities is to serve the economic needs of society and industry: in other words, to have an eye on what needs to be done in research to further or to provide the economic base for the future, even if it may be two to five decades in the future.

With respect to the federal role, the most important thing I can say is to emphasize that we no longer have a money tree in the federal government, and we all have to recognize that. The financial needs are very pressing. So the federal role, as I see it, is support of research which is not “economically feasible.” We do not have time to define that, but I will be happy to discuss it with any of you.

We have to insure that the needs of science and industry are met, and that is another important federal role—again, the so-called “technology transfer” issue. I believe it is important to establish, with the aid of the scientific community, a comprehensive national science policy that is well articulated and popularly understood and supported.

Additionally, something new that is needed is to create concrete mechanisms for development of international mega-science projects. Only with international cooperation are we going to be able to complete projects such as the SSC, the ITER fusion project, and so forth.
My next point concerns the state role, a role that virtually does not exist at this time. In fact, I will differ from some of the panelists in the previous panel: I think we are going to have to require greater state participation in research efforts, rather than greater federal funding. The money is simply not there at the federal level, and will not be there. I think states should identify what is important to them as government entities. Each particular state should decide what research should be supported, and should be willing to put their resources into it, rather than depending on the federal government to support all of it. I believe we also have to work to develop a federal-state relationship on research efforts.

We need new models, new ideas, new approaches. And for that, I will turn back to an old model, which I believe has worked remarkably well, and was the very first area of scientific research in our nation: it was primarily agriculture, through the land-grant universities. The land-grant system has been incredibly successful, largely due to the cooperative extension service. I find it amazing that at Michigan State University, when research is done on a particular agricultural problem, and a discovery is made, within a year or two the farmers in the Michigan fields are using the knowledge that was developed in the laboratories at MSU. We do not have anything approaching that in other areas of research, and I find that extremely frustrating.

I believe energy efficiency is one of the most important national issues facing us in the long term, and yet the energy-efficiency discoveries, or energy research in general at the universities, takes 15-to-20 years to filter into the building industry. We need more cooperative extension services in all areas, not just agriculture, to result in immediate transfer of knowledge and information from the laboratory onto the workbench and into practice.

And as a result of these new models of interaction between the scientific community and society as a whole, I believe we will develop increased support for science, and I hope that any future science policy we develop will recognize that, as well as the need for fundamental basic research. Thank you, very much.
C. Kumar N. Patel  
Vice President, Research Programs  
University of California at Los Angeles

It is a pleasure to be here and I want to thank the organizers of this conference for inviting me to share my thoughts with you today. Before I start, let me do something which normally people do not do, which is to bite the hand that feeds them. I am surprised to note the lack of young people in this room. I wish there had been young faculty members in the audience and on the panels, because it is they who are going to be affected with the kind of discussions we engage in and decisions we make here. I am sure this will not be the last meeting of this kind. Therefore, next time around let us make sure that we will have more young people who will participate and contribute to ways in which we need to fix the system, which appears to be in some disarray.

Before I turn to the question of outcomes, please allow me to give you my views on the present. One of the ways by which I can paraphrase what has happened to the system of higher education and academic research is to note that we have lost our traditional constituency, which both appreciated and supported research at universities. And there is no better way of summarizing our angst than by quoting ex-Governor Kean of New Jersey; he once said, “Here is the reality plain and simple: our ivory tower is under siege. People are questioning our mission and who we are. They claim we cost too much, spend carelessly, teach poorly, plan myopically, and when we are questioned we act defensively.”

This is where we are. But my task is not to comment on the external situation, since this is a session designed to look at outcomes, and so I am going to look at the university research as a process through which measurable outcomes may emerge. Some of the outcomes have already
been identified by Congressman Vern Ehlers and earlier speakers. The outcomes fall principally into four categories, although there may be more that one could discuss. First is education, second is wealth creation and job creation, third is health, and fourth is national security. These categories are not new; they have been around with us for a very long period of time; but the relative importance of the four has changed in the last five years.

Educated and trained students clearly are and will continue to be the most important outputs of the university. However, I will disagree with some of the earlier speakers, and state that students are not and have not been very good mechanisms for technology transfer. I will return to the question of technology transfer a little bit later.

Other outcomes of universities in education are creation of knowledge and dissemination of knowledge. With respect to wealth creation and job creation, additional descriptors of these outcomes include creation of intellectual property and technology, and technology deployment and conversion.

Let me return to my assertion that educated and trained students are far from being ideal mechanisms for technology transfer. Here I am disagreeing with many of my colleagues. My disagreement stems from the fact that the system that we have has run as an open-loop system. We neither receive nor do we rely on feedback from the employers to find out how well we do, or whether we do well at all. Training and education are good ways of providing potential employers a reasonably well-educated body of individuals who still have to be trained before they can become contributing partners in whatever jobs they have. Yes, they do bring education with them, but they rarely carry much in the way of technology.

Technology transfer heretofore has relied on what I call “chance encounters between the creators and the users.” Another way of saying the same is that we delight in tossing over the transom an esoteric publication, hoping that somebody will pick it up and that something good will come of it. As a matter of fact, in the last 30 or 40 years a lot of good has come from this method, and it has been the principal mode of technology transfer. Unfortunately, as was pointed out by President
Vest earlier, that intermediate term research, going from two to five years out of technology conversion period is rapidly disappearing from industries. And therefore, a conceptual and fundamental advance is rarely picked up. Throwing the publication over the transom is not an effective way of transferring technology.

The relationships between government and university and industry and university have been largely characterized by patronship rather than partnership. Partnership is a relationship in which there is an active dialogue, not only in terms of processes, but also in terms of outcomes. We need to increase that kind of interaction with both government and industry to become true contributors in one of the outcomes which I had mentioned, the creation of wealth and jobs.

One of the many noticeable aspects of technology transfer or technology conversion is that, more often than not, universities have had a very good relationship with large industries because they have people who look like us, who could be faculty members, and who speak the same language we do. The most unfortunate aspect of this is that when one transfers technology or new knowledge to industry it results in wealth creation, but it also results in a decrease in the number of jobs, because that is the way by which industries become more efficient in their present business enterprises and therefore become more successful at the bottom line level. On the other hand, a substantial number of new jobs are created in small and medium sized companies, because they are more likely to pick up new concepts and come up with new products and new services in a timely manner. Netscape is a prime example. Even though, overnight, it has become a billion-dollar industry it started as a small industry.

Technology transfer to small-to-medium sized companies clearly is something on which universities will be measured in the coming years. At UCLA we have identified this as one of the principal issues that we want to deal with. A month-and-a-half from now, we will have the first industry/university conference that focuses principally on industries with revenues under $200 million. We find that there is a very large number of such industries. Some of them employ perhaps no more than half-a-dozen PhDs in a variety of fields, and these individuals are supposed to
be jacks-of-all-trades. I was speaking to a CEO of one of these industries, trying to learn if universities had done a good job of educating the students they hire. His answer was, “Yes, I think for the first job they come here to do, you do a fairly good job; but for their second and third jobs universities by-and-large do a less than adequate job.” He would like to see that one of the six PhDs on his payroll would become the CEO of the company some years hence. He says, “My problem is, none of these six know diddly-squat about economics, they know even less about management, and even less about how to interact with people.”

So, there is a message here that while educated and trained students are carriers of knowledge, they do not satisfy the full panoply of needs of our industrial customers.

Let me close, then, by saying that what we need is a way by which we can close the loop and establish objective measures of the outcomes that we have described. Nobody disagrees with what the outcomes are. The question is, who is going to determine how well we are doing? I will end by paraphrasing Jerry Wiesner: Our task today does not stop with the questions that we have asked. I hope this is a time when we start asking questions that we have been afraid to ask so far.
I am honored to be part of a symposium in honor of Jerome Wiesner. I was privileged to know Jerry as a board member when I was with the MacArthur Foundation in its early days. The subject of the government/university partnership is an appropriate emphasis for the first Wiesner Symposium and an important one for us all.

It is a real pleasure to be here among so many friends and colleagues. I especially valued working with the CIC research vice presidents when I was at the University of Minnesota. I continue to draw from relationships with many people here and enjoy working with you from my current role at NSF. The draft principles from this group represent an outstanding effort toward the new government/university partnership needed for the 21st century.

A successful government/university partnership will be critical in the 21st century, to expand our ability to explore the frontiers of knowledge, and to link that exploration, where feasible and appropriate, to the problems and needs of society. Equally essential to this partnership is an emphasis on excellence in science, mathematics, engineering, and technology education for all Americans. It is a tremendous benefit to the nation to educate students—and especially future scientists and engineers—in the institutions where new knowledge is created.

Progress on a national level requires that we simultaneously produce knowledge and ideas, as well as the people who can apply them. This is why the focus of this session is so appropriate. The output of our joint endeavor must be both research and education in a balance that provides ultimate benefit to the nation. In the partnership of the
past 50 years, the balance has been increasingly on the side of research. The partnership of the future requires a realignment.

I want to focus, this morning, on the interplay between research and education, which is something that will require more and more of our attention as we face budgetary challenges and new social expectations for both universities and government. We at NSF feel strongly that we must emphasize the strengths of the research university as a locus for the federal research investment, because research in the educational context has proven so effective for the nation. At the same time, we want the federal research investment to enhance the educational capabilities of universities, not to detract from them.

It is a relief to have a thoughtful forum for this discussion. When the issue of research and education is raised in the media, the end result is rarely productive or completely accurate. The dominant images too often portray research and teaching in conflict, suggesting that they are mutually exclusive activities. Lately, it seems that once or twice each year, a firestorm of controversy ignites around this issue.

A year ago it was CBS’s “60 Minutes” that suggested that educational experiences in large universities were being undercut by too much attention to research. And, just last month, an article in the Chicago Tribune suggested that tuition dollars are often used inappropriately to supplement research at major universities. The Tribune, to its credit, corrected inaccuracies in the article and even issued an editorial several days later affirming the value of learning in the research university. Nevertheless, the residual image in the public mind is that research is incompatible with teaching—and that research and education are competing forces. We seldom hear about the fruitful interplay between research and teaching, and the ways that research and education reinforce each other.

If times were different, we might have the luxury of indulging or ignoring these misguided ideas. Today, we do not have that luxury. More importantly, ignoring them would be a real missed opportunity. There are, of course, many reasons to strengthen the ties between education and research. One of the most compelling reasons is to reinforce to the American people their complementary contributions. This con-
nection to society is crucial, because it has an impact on the public support for science.

Public support for science profoundly influences the level of resources committed to sustain the government/university partnership. Let me use an example I know well, the NSF budget. Right now, NSF is operating under the most recent of several continuing resolutions, which ends on March 15th. None of us knows for sure what the final Fiscal Year 96 budget will look like. Fortunately, though, broad-based fundamental science has some strong supporters on both sides of the aisle in Congress. Two of those supporters are here on this panel.

Representative Ehlers has taken a strong stance in support of science in the halls of Congress—and he is living proof that Congress would be well served by having a higher ratio of scientists to lawyers. His letter to the House Appropriations Committee Chair and to our Appropriations Subcommittee Chair urging funding for NSF for the remainder of FY96, has sent an important message to both parties. One of the 89 members who signed his letter was representative Lynn Rivers—another friend of science in Congress. Thank you, Representatives Ehlers and Rivers, for bringing this positive message about the importance of science to your colleagues on Capitol Hill.

While we hope to emerge from this year's budget battles in a position of relative strength—that is, without dramatic cuts—we need to keep an eye on the longer-term funding environment. Many of you know that AAAS has projected that in the current balanced budget scenario, non-defense R&D might decrease by one-third in real terms by the year 2002. The question many of us are asking is: can we reduce the federal investment in non-defense R&D by one-third and still be a world leader in the 21st Century?

The possibility of constrained resources and the need to enhance public support for science prompted me to revisit the roots of NSF's support for colleges and universities. In shaping a vision for NSF at its creation, Vannevar Bush wrote, “We must strengthen the centers of basic research....It is only the colleges and universities and a few research institutes that devote most of their research efforts to expanding the frontiers of knowledge.”
Vannevar Bush recognized the benefits of conducting the search for new knowledge in an environment of learning. The synergistic contributions of research and education remain a defining part of the NSF mission—and have been at the core of the success of science in the United States for the last 50 years. But if the public believes that federally supported research detracts from the educational function of universities, we all lose. Reinforcing the effective interplay between research and education is part of the solution to maintaining the world leadership of American colleges and universities and to upholding world leadership of American science.

At NSF, we are continually seeking new ways to stimulate the dynamic interplay between research and education, and we are working on a broad set of efforts, many of them experimental in nature. A cornerstone of our efforts is the CAREER program for beginning faculty that supports both their research and their involvement in education. One awardee, for example, studies new ways to use computer programming to improve engineering education and helps students use computers just as practicing engineers do—for problems solving, team coordination, and modeling.

Throughout NSF we aim increasingly to enrich research and education together. Some of you may be familiar with our recent effort aimed at comprehensive reform of undergraduate science, engineering, and technology education. We are pleased to see that about one-third of the proposals came from research universities, and many of the proposals focused on the entire undergraduate student body. Our approach in this, as in all of our educational programs, is on science as a mode of inquiry.

Today I am pleased to announce that you will soon see a new initiative by NSF to identify and enhance successful activities in research and education. Our Fiscal Year 1997 budget proposal contains an exciting new plan to recognize academic institutions that have outstanding efforts combining research and education. In determining how NSF can best enhance the integration of research and education in higher education, we thought the best place to start would be to find out what institutions are already doing.
Our plans benefited from the Baldrige Awards of the Department of Commerce. The Baldrige Awards have generated visibility for the best practices in industry today. Bob Galvin could say more about them, because Motorola was the first recipient. These awards set the standard for competitive excellence in business. We hope that our awards would do the same for colleges and universities by recognizing institutions that creatively and successfully link education and research, and by asking them to work with other institutions for effective change.

We hope that all institutions of higher education will be inspired by the competition generated by this initiative. The initiative will also help NSF to best identify how best to proceed with future efforts. We at NSF understand our responsibility to be an effective partner to foster productive change in research universities, and we welcome all suggestions for how best to do this.

At the core of our efforts is an understanding that colleges and universities will increasingly play a leadership role in the future as centers of knowledge and lifelong learning. The most successful institutions will understand research and education as two sides of the same process. The poet William Butler Yeats wrote, “education is not the filling of the pail, but the lighting of the fire.” At NSF we are looking for new ways to work with universities to light the fire of inquiry and discovery that is at the heart of both research and education. We look forward to working with you to provide leadership into the next century.

Thank you.
I am going to do what Representative Ehlers did and talk just for a minute about the perspective with which I come to this process, because I think no one comes to public policy with a completely blank slate. We bring our own package of experiences with us. I have approached the whole issue of setting public policy from the perspective of someone who has spent most of her adult life advocating for children. I was on the local school board here for almost nine years. I was involved in a variety of community-service organizations and groups that help children. You cannot be involved with children without becoming concerned about what will happen in the future.

I was a mom at a very early age. My husband and I got married literally the day after high school. I was 18, he was 17, and we had two babies by the time we were 21. Because the opportunity of attending a public university with help from federal funds was available to me, my life is very different than one might have expected. When I approach public policy issues I always have an eye to making sure that those doors of opportunity are kept open for others as well.

But also, as a member of Congress, I have learned that we are in a situation where we have limited resources and changing dynamics. As I tried to think through this question of where we need to go as a nation, I came up with goals, some of which are borrowed from other places. I will not acknowledge exactly where they came from, but nobody will sue me for copyright violations, I hope.

1) Leadership in science and technology. As we look at this issue, the first thing we certainly should discuss—and I hope we could agree on—is the need to maintain leadership in the acquisition of scientific
knowledge. As a nation, we must be in the forefront of the intellectual work that goes on in science. One of the things that we have to do within that goal is to define science. I talked earlier about the “junk science” that I see coming to Congress. I do not want to spend a lot of time on it today, but I am terrifically concerned about proposals that we are now seeing in Washington that would allow members of a peer review council to be remunerated by bodies that have a financial interest in the outcomes of the deliberation. We are seeing people whose Congressional testimony or writings are relied upon for evidence, but who are not credentialed in the areas in which they are speaking, or who publish their work only in non-peer reviewed journals. This is a big problem, and it is important that we keep an eye on it.

Similarly, we must look more closely at how we handle competition for what are going to be reduced dollars. One of my fears is that, as the federal budget declines, it becomes increasingly difficult for members to deliver various things to their districts that we can just call, for the sake of argument, “pork.” We might see a retreat from the kind of merit competition that we have come to expect. We might see efforts to promote programs that will allow for a more even distribution of resources across the country, but not necessarily on the basis of excellence. This is an issue that will have to be addressed as we move into the new era.

Not only whom we will fund is an issue, but also what we will fund. What kind of inquiry are we going to fund as a nation—and who is going to decide among alternatives? Who is going to do the long-term planning? Who will define the targeted outcomes?

2) Connecting Research and National Goals. The second thing that we must do is to stress the connections between research and national goals and interests; Chuck Vest did a fabulous job of discussing that issue.

People often suggest to me that the government should run its budget the way a family does. I think that is true. One of the things that families do when they become cash-strapped, when the credit cards are too full, when they cannot make their payments, is to sit down at the kitchen table and decide what their priorities are. They may very well
say, we do not need to go out to dinner every Friday night, but we must pay for the piano lessons or we must pay for the braces.

Well, there are items in our national budget that we must pay for, and we should have a discussion to clarify what they are. The investment in research should be up near the top of the list. To put it in terms of the family: families who say they will save whatever is left at the end of the month usually have no savings at all; it is only the families who set money aside on a regular basis and make savings a budgetary priority who actually gather dollars over time. It is the same with intellectual "currency." We must have a plan to make it a priority.

If we look at our global competition, we see that other countries are making research a priority. Someone once said, "knowledge is power," and that is true. Our competitors, particularly Germany and Japan, understand that, and they are investing more in terms of real dollars and in percentage of GDP in research, than we are.

3) Creating Partnerships. The third thing that I think we must examine is how to create partnerships that will promote investments in fundamental science and engineering. Often we hear arguments that if something is worth doing, the market will take care of it. If there is research that we no longer want to fund federally and this research is of value, the argument goes, the private sector will step in and pick up the costs. One of the flaws in that argument— not in all cases, but in many cases— is that it is based upon a fundamental misperception of what is happening in the private sector. Someone spoke earlier about Bell Labs; Bell Labs does not exist in the same way that it did years ago. The private sector has not been willing to invest to the same degree in long-term funding as it has in the past, and we must deal in the realities of today's world rather than hearkening back and pining for a time that no longer exists.

The claim that applied research essentially falls into the category of "corporate welfare" and needs to be eliminated is made without any real analysis of what value comes to the larger community from the work that is done under many industrial research arrangements. It is difficult to determine the difference between applied and basic research, because sometimes they look very much alike.
4) Producing the finest scientists and engineers. The fourth goal that we must have is to produce the finest scientists and engineers. This is important for several reasons. One is simply our defense industry: it is very frightening when you look at technologies important to defense systems--like flat panel display--and find that we do not have the capability in this country to produce such items. We have allowed development and production of technology that we use in our basic defense to be moved overseas, and it is important that we reverse this trend.

We must raise a similar concern when we discuss eliminating or severely cutting areas of federal support for research: will it entail the elimination of areas of inquiry or areas of teaching? Are we going thereby to eliminate departments within universities? Or, are we going to have them spread out across the country that in certain areas of inquiry, there will not be a large enough mass of people at any given spot to support one another? I fear that we will lose important areas of inquiry, information, and educational programs altogether. Then, how will we develop and maintain our intellectual infrastructure if we do not have a national research and education system that will sustain a strong, world-class cadre of scientists and engineers?

We cannot ignore these issues and simply say, well, the money is not there. As the saying goes, "If you think education is expensive, try ignorance." If we allow our intellectual reserves in this country to drop, the costs will be devastating to us as a nation.

5) Raising the level of scientific and technological literacy. Lastly, we need to raise the level of scientific and technological literacy of the entire country, of all Americans. There is value in having a strong national intellect. And, the more scientifically literate we are, the more we will want to continue support for educational initiatives in general. Anne Petersen just mentioned that there are people who fear that research at universities somehow operates to the detriment of the teaching program. Well, having attended this university, I certainly never felt that way; quite the contrary. But when you actually look at the number of people who are able to attend research universities relative to the entire population, there are not that many of us out there carrying the word.
So it is important that science activities be spread across the entire nation and have real impact for real people.

In terms of funding the programs to meet these goals for university-based science and science education, some today are arguing for much greater decentralization. I understand the arguments, but frankly, I am very concerned: many of these programs have been funded nationally because states were not willing to make the investment in science in higher education. Moreover, my experience from serving in the state legislature, on the Higher Education Committee, is that it is much easier to make cuts at the state level than at the federal level—and sometimes much more necessary, because there are different dynamics driving the decisions at the federal level. I am concerned that not all states would approach funding of university science with enthusiasm. Not all states would be willing to fund science and higher education to the degree that we would hope. Frankly, scientific research and higher education have national implications—implications, for instance, for our national security. They affect our country's future direction and development, and to say that the best way to handle national needs is to devolve the funding and the responsibility to a level other than the national one, is not a position that I would support. That does not mean that I do not think there are ways to encourage states to become more active in support of research and higher education; but I would be very concerned if we were to let this responsibility slip from the national level, because I fear that our overall commitment to research and education would decline, much to our detriment as a country.

Thank you.
ROBERT GALVIN: As with the earlier panel, this is a remarkable cadre of associates. It is now your meeting, ladies and gentlemen. What are the subjects that you would like to have this group further comment on and/or comments that you would like to make?

DAVID SKORTON: I wanted to follow up on Representative Rivers’ comments about state contributions to research. I agree with Representative Ehlers that there needs to be a more decided, more declarative, partnership between state and federal governments, but I just want to make sure that we all remember the contributions that states are already making in public research universities.

I may have this number wrong, but the last time I looked, in the aggregate the states were contributing about $35 billion a year to higher education. We need to remember that in most of the public research universities, most of the buildings are shared-use buildings, and this infrastructure is largely built by the states. Even in public research universities that receive less than half of their revenue from the state, which is the case for virtually all around this table, those moneys would be very hard to replace in terms of faculty salaries. So I think that if the federal government does abdicate any substantial part of its role in the research enterprise, that role will not be picked up effectively by states or the private sector.

The other point I wanted to make, alluded to earlier by Homer in his introductory remarks, is that the nature of the conference today, as we planned it, was to focus on the natural sciences. Understandably, we have all been very concerned about the budget picture now, and the projections for the next six years, but I must say that after all of the understandable hand-ringing, the agencies that really were savaged the worst this year were the National Endowment for the Humanities, and
the National Endowment for the Arts. In terms of quality of life issues and societal problems, it will be important not to forget the social sciences, humanities, and arts. The 40-percent-or-so cut in real dollars to the National Endowment for the Humanities this year is potentially a very, very severe change in our ability to deal with research in history and some aspects of political science. It has been estimated that approximately 70 percent of all research in humanities in this country is supported directly or by so-called "recycled" dollars from the National Endowment for the Humanities. So particularly as it represents a relatively small part of the national research and development pie, it would be important at least to get on the record concerns that some of us have about these endowments. Thank you.

ROBERT GALVIN: Thank you. Congressman Ehlers.

VERNON EHLERS: First, on the latter issue that has been raised, that is a very difficult issue with the current Congress. You would be surprised at how hard some of us had to fight to keep the NEH cut as small as it is, and I suspect Congresswoman Rivers and I were on the same side on that one. There is an entire historical aspect to the issue, which we do not have time to get into at this conference.

In regard to state support, the point I was trying to raise was not just the need for state support, which I would still be happy to defend. But also it is a matter of reality. If you are going to put all your eggs in the federal basket, you are going to go down. I do not want to sound too pessimistic, but just as Allan Bromley mentioned about population issues during the previous panel, all you have to do is perform the arithmetic. It is not even advanced math; it is simple arithmetic. The implications of population growth are impressive.

It is the same with the budget. It is simple arithmetic. Look at how much money is committed to Social Security, how much is committed to Medicare, and to other so-called entitlement programs. Look at what the revenues are. Recognize that the American public is in an anti-tax mood, pure and simple, and particularly about sending money to the federal government.
You do the arithmetic and you see there is not going to be much left for discretionary domestic spending. The percentage is going to get lower and lower in the years ahead.

Look at our meager efforts to address the problem this year in Congress. Take, for example, our attempts to rein in some of the costs of Medicare, and the political brouhaha that emerged out of that, including the deliberate political frightening of the elderly community, and observe their response. You can see how difficult it is going to be to address some of the entitlements and reduce spending.

Assume a constant revenue stream, in terms of percentage of taxation—which I think is a good political assumption for at least a decade—and then look at the growing commitments out there for the entitlements. There is not going to be much federal money for discretionary spending, including research.

If you do not develop avenues to get more state money—when the states, in fact, are in better financial condition than the federal government—you are going to lock yourself into a barrel that is going to be very hard to get out of.

ROBERT GALVIN: Let us move, if we can, to some additional subjects. Sir?

JON VEIGEL: I think to put the most optimistic spin on it, we are all here because we are experiencing the creative tension that is inherent in this cusp of science. If we look to the past, it is my belief that society has been willing for science to be fairly self-defined and self-judged, providing two factors were true. First, our national discretionary resources were large enough to forestall the need to make forced choices between equally attractive alternatives. Second, society saw that the benefits of science exceeded its financial and its environmental and other kinds of costs.

That first factor is certainly no longer true, and I think the second is being challenged. I think that for the future we need to pick up on one of the points that was brought up this morning and add to it two more, and let them become the metrics by which society is going to judge us.
One is that we are, in fact, shifting publicly from a view of science as an investment to science as an expense, and that has been explored already this morning. The two points that I do not think we have brought up yet are the movement, at least in research on university campuses and in national laboratories, from the very pleasant situation of having cost-plus contracts, to now being held to fixed-price contracts, very much analogous to industry.

Second, we are moving in society from an automatic assumption that education and research yield value-added outcomes, value-added products, to the point of view, at least in part, that education and research are commodities. Now that we have 20 percent of this country holding bachelor's degrees, I assert that bachelor's degrees are a commodity. Not always, not everywhere, not every person, but certainly more of a commodity, like gravel and rice, than a value-added product that is specifically designed, perhaps, to train that CEO in Los Angeles that we heard mentioned [by Dr. Patel].

I think we have got to start dealing with the reality that science is being judged in ways that it has never been judged before, and we cannot be as self-indulgent as we have been to think only in terms of our wants, our own needs and our own perceptions of what ought to be the metrics by which we are judged.

ROBERT GALVIN: Thank you. Ladies and gentlemen. Lynn?

LYNN RIVERS: One of the first things that you learn when you become a candidate for office is that if you let other people define you, you lose. But if you do your work and get out your information to define yourself, you win.

Part of what I was trying to say is that the five issues that I was laying out have to do with how science is perceived in this country. I think that there are some mistakes currently in the thinking of many people. There is a view in Congress — and I certainly would except Representative Ehlers — but to some extent there is a certain anti-intellectualism that is being expressed in Congress. There are people who see the academic community as a collection of slackers who are operat-
ing at the public’s expense. They see education in general as a cost instead of an investment. That is not going to change. The afternoon talk shows are not going to change that. The newspapers are not going to change that. It is people from the education and science community who have to change that.

If your feeling is, “Well, I work hard all day and I come home and have things to write and things to read and I do not have time,” then you will allow the support that science has gained over the years to continue to erode.

So I think it comes back to everyone in this room. How are we going to change the perception of research and development in this country? How are we going to help everyday Americans understand the benefit to themselves and to their children?

If we do not have a plan, we are in trouble, and so we had better come up with a plan.

ROBERT GALVIN: Thank you. Sir?

DAVID GOLDSSTONE: I am a little bit concerned about what I find at most of these meetings, which is that within short order the tone of paranoia becomes almost overwhelming. There is a feeling that everything is fine inside and that all the problems are outside. That how on earth did the public ever get this perception that research and education were unrelated? Well, it happened because they sent their students to research universities and found out in a lot of cases that their education was adversely affected because of the nature of research and because NSF had—and Neal Lane and Anne Petersen have done yeoman’s work to try to reverse this—but over the years that federal funding had unintentionally created almost nothing but disincentives for focus on education.

In fact, when NSF tried some years ago just to reinstate the requirement that research applications state what graduate students would be supported and what the education would be out of that grant, just the simple statement, that took years to actually get through the White House and be approved. And that was only to go back to what had
been a long-standing assumption about the nature of research in education.

If the assumption is that the only problems that universities face are external perceptions that are based on a mere souring of the public, the situation is going to become much worse than it is now.

Now we are at a pivotal moment, in which there is a chance to adjust, despite the attack on funding. In general, science funding has actually done remarkably well. There is no political scientist, I think, who would have predicted, given the political atmosphere, that science funding would have been spared in this round of budget cutting the way that it has been.

Science agencies in general have actually done fairly well. I think there is a moment here for us to correct some of the internal problems, before things get much more severe. But I am concerned that if all we do is view the situation as a result of the public getting nasty, the public not understanding that science is good, we will miss a tremendous opportunity. We need to remember that the single event in human history that most made the public concerned about science was the explosion of the atomic bomb, which also assured the greatest increase in federal science support that we have seen. So these things have always run in tandem. To see the current situation as a new problem of baseless public suspicion, I think, is something that is going to lead us down the wrong path.

I just throw out one other historical footnote. The Morrill Act has been talked about a lot today. The Morrill Act only passed because during the Civil War, the southern states that had opposed it for decades were not there to vote it down. So, there is a long history of having to overcome opposition of various sorts. I suspect that that is not an approach we would want rely on to pass legislation now. Though, as a New Yorker, I sometimes wonder. But I just throw that in to indicate that the idea that there are obstacles to overcome is not exactly unique to our time.

ROBERT GALVIN: Thank you. Other comments from the floor?
MARTIN APPLE: We have let the Congress this year define what the federal government will be, and it has done it by a series of budget projections, and Congress and the White House working together in whatever format they have, have created a future in which by the year 2002 or 2003 the federal government will be supporting the healthiest gerontocracy in the world's history by means of a strong defense department. The rest of the budget will have been balanced on one-sixth of the budget. Now, if we accept that premise, we need to begin to work from there. But I do not want to accept that premise.

I would like to accept the premise that, in fact, we can define outcomes. We can decide that K-12 learners should graduate knowing how to think. That is a very big change from what we have now.

We can decide that they are to be numerate and science literate. That is a big change from now. We can define how that can be done, but we are not yet doing it.

We need to have some vision and goals that we can coalesce around, that the universities can grab onto and build on.

Now, this group here is part of the process. This is not to say that we are simply sitting here ringing our hands; we are learning. This is how we go about learning. We make mistakes. David, please understand, the mistakes that we make result in better understanding. That is what we do here. This is part of how we grow and develop. We are now recognizing that, even though it is taking external forces to do it for us.

I think we have taken a great deal of leadership so far in redefining and beginning to reinvent, and this is just one of the outcomes, namely that we are discussing this right now.

So I do not think we should say that we are either to blame or not to blame. I think the essence is, where do we go from here, and how do we get there?

ROBERT GALVIN: Just some observations. We have approximately two or three minutes. At the center of the audience, sir?
DAVID SINGER: I am David Singer, a political scientist from the University of Michigan.

I like very much what I am hearing this morning, and I particularly wanted to endorse Congresswoman Rivers’ notion about encouraging the public to think in a more positive and friendly way about what we do. In the university I am quite struck by our tendency not to bring our research into the classroom. My own preference is to make it a constant issue, but over and over I hear the same attitude that says, these students are not interested in scientific method, these students are not interested in research, they just want to be trained and sent out to get jobs—even though, as you pointed out, that is not a hot way to learn.

In that connection, I would like to ask Anne Petersen, what the prognosis is for funding the social sciences?

We heard this morning that more and more students are coming out of schools and going into the service sector. Now, I would argue that all the technology in the world is not going to make these people perform very well in the service sector. What can we do about the social sciences?

ANNE PETERSEN: I agree with you that that is one of the knowledge bases that needs to be brought to bear on the service sector. I think this is another area in which we have a lot of work to do. There is massive misunderstanding of what the social sciences do and what their contribution can be as fundamental sciences. I am convinced of the goal right now and I really would urge everybody in universities to see this as a challenge that we should step up to.

There have been several calls this morning, for example, about the importance to the American people of addressing some of the problems that confront us. If we do not have a strong science base in some of these fields, we will not be able to do that. The National Science Foundation certainly is continuing our support of those fields, but it is a very, very small pot of money that we have. And we support a big percent of the research that is being done in some of the social sciences.

ROBERT GALVIN: Sir?
HARRY MORRISON: Harry Morrison from Purdue.

The land-grant universities, which are represented here under the Morrill Act, I think are an appropriate place to say that we are addressing many of these problems.

For example, in our own university, we have taken the model of the Agriculture Extension Agent and applied it in the School of Science, K through 12. We have science extensions going out into the schools throughout the state of Indiana.

We are also doing similar things with the technology assistance program, out of our technology and engineering school.

I think one of the problems we have is that we are all doing small things, and there are not enough opportunities for good models to be developed nationally and adopted nationally.

I think we could find many very successful programs out there, but I am not sure that we are doing a good job of realizing that they are there.

ROBERT GALVIN: One final comment or question from the audience and then we will be obliged to conclude.

There is another hand in the audience, and, sir, would you please identify yourself?

PAUL CARSON: I am Paul Carson in the Basic Science Division of the Radiology Department here at the University of Michigan.

I was struck by the difference between Lynn Rivers' statement that we do have to set priorities, which most of us would like to believe, and the statement by Representative Ehlers that the money is not going to be there for discretionary spending.

Now, I wonder if we could not and should not back away from the politics and from trying to undertake major ideological changes, and work with what has worked in the past, which is a reasonable balance of the federal budget now, and say, let us just cut equally across the board. I think science could live with a five percent cut, as could any of the so-called non-discretionary programs.
If we do that as a starting point, then, in the evolutionary process which is the hallmark of our form of government, we can work at fine tuning.

ROBERT GALVIN: I am going to presume the prerogative of the chair with a very, very brief concluding comment.

Jim Cronin had lunch with me one day—your most distinguished scientist in cosmic rays—and when he had completed explaining his next experiment, he leaned forward humbly and he said, "Bob, even if we are a success, I do not know what good it will do." And I said, "Jim, it's time for lunch, let's just walk to the window of my office," which looked down on a very large industrial campus, and I said, "Jim, you see those 6,000 cars parked out there, you know why they're there? It's because of Faraday, Maxwell, et al., and some day whatever you and your fellow scientists unravel in the elements of nature, will be applied, jobs will be accomplished, discretionary income will be earned, society will advance." He knew that.

You are on the right side of the angels and you are not alone. You must engage us in industry. We must engage you. Your government partners are sitting here and talking with you.

Those of you who are representing the research universities have a great story to tell, but you have to tell your story better, and you have got to do your work better than you have done in the past. All of this can get better.

The quality principles can be applied to what you are doing. You can improve your cycle times. You can improve your productivities and you can do all the other things that were represented here.

Finally, you and we have to get the story out. Science has a great story to tell. I think we have got to determine to sell it as others here on this panel have represented, and I can assure you there are other constituencies that are ready to ally themselves with you.

Ladies and gentlemen, this brings this panel to a close.
Inputs: Responsible Allocation and Stewardship of Resources

David Skorton
David H. Auston
R. Thomas Weimer
John N. Yochelson

Discussion
Welcome to the third panel session in our symposium. In this session, we will discuss some issues related to responsible allocation and stewardship of the precious public resources put into civilian research and development, particularly those resources allocated to universities. As you are aware, allocation of science and technology funds has been among the most hotly debated public policy questions in the current Congress. I will begin the session with a review of some general issues and specific actions that might be considered by universities and the federal government to improve the allocation and stewardship of these moneys.

How should the government/university/industry partnership plan, manage and monitor the public investment in research and development? These issues must be considered in terms of the large number of parties participating in the civilian science and technology endeavor in our country. The majority of fundamental scientific research is initiated and conducted by individual scientists in laboratories scattered throughout hundreds of universities and other institutions across the country. These scientists and laboratories have traditionally been aggregated into research groups and departments within individual universities. Increasingly, though, universities are sharing resources by developing interuniversity regional consortia, one example of which is the Committee on Institutional Cooperation (CIC), comprised of the Big 10 Universities and the University of Chicago.

National professional, scientific and technological organizations play a key role in the research enterprise by developing consensus statements and standards and by interacting with state and federal governments on behalf of science and technology. State governments play an enormous
role in supplying much of the infrastructure for public research universities and, in selected areas, in the direct funding of research. The bulk of the public investment in science and technology research at universities, however, is made by the federal government, which spends in excess of $15 billion annually on such allocations.

In this era of so-called big science, particularly in the physical sciences and in major biological science endeavors such as the Human Genome Project, international consortia are becoming increasingly important. Finally, the role of industrial research and development laboratories is critical, particularly in the current global economic circumstances that demand efficient and effective utilization of industrial research resources.

In evaluating general issues related to allocation of resources and management of research, it may be helpful to consider the intersection of science and law as described by Steven Goldberg in his thought-provoking book, Culture Clash: Law and Science in America, published in 1994. Goldberg reminds us that a key goal of science is progress, based on self-initiated efforts of individual scientists. In contrast, a key goal of law or government is process: in our context, developing fair and consistent procedures to ensure broad access to federal research funds and adherence to generally accepted standards of research conduct. There is a normal, healthy tension that exists between science and government: scientists want unfettered access to funding to pursue promising ideas as they wish with minimal governmental regulatory interference. On the other hand, government strives for fairness and consistency of access and the development and enforcement of regulations based on its perception of the public good. An effective government/university partnership must make the best of this intersection and capitalize on this healthy tension.

In thinking about this tension between science and government, it is useful to recognize the portions of the funding allocation process that are under the control of government and those that are under the control of the scientific community. Governmental authority for science and technology allocation includes determining the amounts to be allocated to specific agencies and general directions for the use of these...
funds. The establishment of regulatory agencies and determination of their mandates also is the authority of the federal government as are the laws and guidelines related to intellectual property rights and procedures. Other aspects of resource allocation and management are under the control of the scientific community. Scientists define precisely what might be done in a given field and even recommend an order of priority in that field through systematic review and debate among experts. Later in the process, scientists review and evaluate the purpose, methods and results of this research before it can have wide dissemination to the scientific and general public.

An important feature of the intersection between science and government that raises serious questions is the set of research regulations with which universities and other research institutions must comply in order to be eligible to receive federal funding. Is this regulation needed? Does the public distrust the science establishment? Does the science community deserve trust?

In discussions of regulation of the conduct of research by individual scientists, questions of academic freedom often arise. In his 1982 book, Beyond the Ivory Tower: Social Responsibilities of the Modern University, Derek Bok asks whether traditional principles of academic freedom fit the contemporary realities of science. He reminds us that scientific research is no longer the exclusive preserve of solitary investigators pursuing their own ideas. To the contrary, modern science requires a huge public investment in personnel and infrastructure. Along with this investment comes accountability to the public in the form of governmental regulation. Yet this regulation need not be seen as impinging on academic freedom. Traditional academic freedom concepts deal in part with protection of the right of the individual to express unpopular ideas without fear of reprisal in the place of employment. These ideas can be met by other ideas in open debate to determine the most convincing and cogent. On the other hand, inadequate, unsafe or intrusive methods can create dangers that cannot easily be countered except by prohibiting the methods themselves, according to Bok. Certainly, this represents another important point of balance between scientific entrepreneurialism and governmental regulation.
A final general issue, which is important to recognize in any discussion of stewardship of public research resources, is the ethical conduct of research. Many current areas of public interest and concern fall within the purview of research ethics, including scientific integrity, training of students and others in the ethical conduct of research, research utilizing humans and animal subjects, the process of peer review in both funding and publication, questions regarding the determination of authorship and ownership, conflicts of interest and commitment, management of intellectual property, a host of issues related to genetic research and the potential of gene therapy, the methods of estimation and use of so-called indirect cost allocations, and finally, considerations related to private sector support of and influence on research. A robust, effective set of principles related to stewardship of resources must consider these and other ethical issues.

I would like to turn now from these general considerations to some specific issues that need to be considered for the future of the government/university/industry partnership in science and technology. Two of the operating principles that should govern the partnership are: (1) prudence and cooperation among all participants in utilization of the national R&D investment, and (2) continuous improvement in administration of resources by all members of the partnership.

What are the responsibilities of the universities regarding these operating principles? First, universities will need to recognize that each campus cannot be all-inclusive in its research efforts; we need to focus on local areas of greatest expertise and to reallocate funds to these areas of strength. Regional consortia need to more aggressively devise schemes to share resources among the universities in each consortium. A good example in the CIC is the increasing sharing of library and other information resources via modern telecommunications technology. University administration needs to improve its efficiency and effectiveness to keep indirect costs of research at the lowest level consonant with effective management. Peer review processes need to be continuously reexamined and strengthened, both in funding and in publication. The state of the university research infrastructure is of considerable concern. Universities bear an important responsibility to maintain this infrastruc-
ture by such mechanisms as judicious sharing of research facilities between investigative and instructional users as well as development of shared core facilities to obviate unnecessary duplication of expensive equipment. In this regard, a new era of more open sharing of the resources represented by our national laboratories may permit a substantial increase in the availability of some resources in selected science areas. Importantly, universities must exert increasing efforts to respond to public concerns and needs. Even the most basic scientists must recognize the linkage of allocation of basic research money to the national economy. Ethical concerns also must be recognized and dealt with efficiently and effectively by the scientific community. Finally, although the emphasis of this talk and this conference is on the natural sciences, we must be cognizant and supportive of funding for scholarship in the social sciences, arts, and humanities.

What are the responsibilities of the federal government in the allocation and stewardship of resources? At stake in responsible allocation of resources is not so much the amount of funds directed at specific problems or phenomena, but the methods used to arrive at the decisions on funding. These methods ought to be explicit, repeatable and capable of adapting to change, much like science itself. Some specific concerns with which the federal government needs to deal include a perceived lack of predictability of year-to-year funding, especially for large complex projects, a good example of which is the late superconducting supercollider project. Sudden changes in funding also cause enormous damage to ongoing graduate education linked to the research in question. There also appears to be a lack of recognition by some in the federal government and the public of the impressive, positive economic impact of science. Research allocations should be viewed as investments, ones that require sustained input for optimal dividends. Finally, as I stated earlier, funding for scholarship in the social sciences, arts and humanities is critical and must be given a high priority because of their impact upon the overall quality of life for the citizens of the United States.

In administration and management of research funds allocated to universities, the federal government should consider ways to reduce dis-
incentives to research for individual scientists. For example, in regulatory compliance, more “just in time” approaches to compliance might be explored. For example, since the majority of grant applications to federal agencies are not funded on any given cycle, compliance with animal and human subject approval procedures might be postponed until it is clear that a particular application will be funded. More debate on industrial research and development policy is important since the partnership between industrial and university laboratories will likely become a more important part of the landscape, particularly in the biological sciences. Finally, further consideration needs to be given to the equitable sharing of total costs of research among universities, state governments and the federal government.

In summary, in 1996, we find ourselves at a crossroads in the partnership among the federal government, the universities and industrial research and development laboratories. Sustained attention to the intersection of science and government should lead to a more robust and predictable research and development strategic plan that can continue to maintain this country’s leadership in civilian research and development. We stand ready to participate in this process.
Homer asked me to give you a summary briefing of the report that was released by the National Research Council last November entitled, “Allocating Federal Funds for Science and Technology.” To give you a complete briefing would require more time than I have available today. However, I would like to give you an overview of the report, with a specific emphasis on those issues that relate to the methodology for allocating federal funds for research and development.

This effort arose from a request that came directly from Congress, specifically from Senators Hatfield and Harkin. Hatfield at that time was Chair of the Senate Appropriations Committee. He came to the Academies and asked them to undertake a study of this type. The Senate provided some lubrication in the form of $750,000 to undertake what is really an awesome task, namely, to advise the federal government on the allocation of federal funding of some $70 billion a year of research and development expenditures.

From the perspective of investment management, that is a very low investment management fee. One would expect to pay Solomon Brothers or Lehman Brothers a lot more than $750,000 to provide advice on how to should spend $70 billion - just another illustration of the fact that scientists can be bought cheaply.

There were three elements to the charge to the study group [Figure A]. First, is to develop criteria for allocating federal funds for research and development, and in particular to specify a process by which those criteria may be implemented.

Second, to examine the appropriate balance among the providers of research and development, specifically government laboratories, universities and the industrial sector.
Figure A - Background of the Committee

Origin is a FY 1995 Senate Appropriations Committee request to:

- Consider the criteria that should be used in judging the appropriate allocation of funds to R&D activities.
- Examine the appropriate balance among the different types of institutions that conduct such research.
- Look at the means of assuring continued objectivity in the allocation process.

T hird, to look at issues relating to the continued objectivity and the integrity of the allocation process.

The committee were drawn from government laboratories, universities and the industrial sector [Figure L]. It was chaired by Frank Press, former President of the National Academy of Sciences. Guy Stever, with us here today, also participated in the study.

An important issue that occupied much of the committee’s time, was the question of what constitutes “research and development”. While federal R&D spending totals are typically stated as approximately $70 billion per year, almost half of that figure is expended on production, maintenance, advanced testing, and up-grading of large-scale weapons and space systems at DoD, DoE, and NASA. While these have clear national importance, they are neither long term investments in new knowledge nor investments in creating new applications. The commit-

Figure B - The Federal Budget for Science and Technology

- The federal science and technology budget is $35 to $40B, not $70B.
- This FS&T budget supports creation of new knowledge and technologies.
- Excludes testing and evaluation—important but based on existing technologies rather than creation of new knowledge and technology.
Figure C - The Federal Science and Technology (FS&T) Budget

- Offers a unitary view of federal investments in new knowledge and technologies.
- Not artificially balkanized into agencies and programs.
- No distinction between basic and applied research.

The committee chose to postulate a Federal Science and Technology Budget (FS&T), which is a smaller figure, somewhere between $35 and $40 billion [Figure B] that specifically excludes these items. The FS&T budget more closely related to the generation of new knowledge, rather than the development and application of existing knowledge.

The first advantage of this approach is that it offers a unitary view of federal investments in new knowledge and technology [Figure C]. The FS&T budget provides a mechanism for following the budget for science and technology in a unified manner from the early stages of...
development of the federal budget in the Executive Branch through the very intricate negotiation and approval stages in the legislative branches. This allows one to ask whether the total spending on FS&T is appropriate and, more important, it provides a framework for trade-offs and reallocations within the FS&T budget as it moves through the various stages of the budget development and approval process. Such trade-offs within the FS&T budget would be used to meet new national needs, to reflect evaluations of quality, and to recognize fiscal stringency where appropriate - all with the intent to preserve and strengthen the world-class standing of American science and technology.

By contrast, the current R&D budget is an accounting of total spending on R&D and is essentially a derived number that is presented as a summation at the end of the budget process. It is never considered as an integrated whole during the development of the President’s budget or given an overall review by the Congress.

Figure D illustrates the distinction between the current R&D budget concept, and the proposed FS&T budget concept. If one looks first at the pie chart that labeled federal R&D, we see that defense is the...
single, biggest piece, at 55 percent; general science is a very small component, at four percent; health science is 16 percent. The FS&T budget that we are proposing provides a different perspective. In this budget, defense occupies only 27 percent of the allocations; health, about 28 percent; general sciences, 7 percent.

One can also look at the allocations to the different agencies in terms of this budget [Figure E]. In the current R&D budget, Health and Human Services accounts for about 16 percent; NASA, 13 percent;
DOD, 9 percent; NSF only three percent [Figure E-1]. In the FS&T budget, NSF is five percent, DOD is now 22 percent. [Figure E-2].

If we look at the distribution of the R&D budget among performers, industry receives the lion’s share, 45 percent [Figure F]. (These are FY94 figures. They have changed appreciably in the past fiscal year, largely due to changes in defense contracting.) Universities and colleges receive 17 percent of that total of $70 billion. Under the FS&T budget, universities and colleges would be counted at 31 percent; federal intramural laboratories at 29 percent; and industry at 21 percent. Federally Funded Research and Development Centers (FFRDCs) would receive about 10 percent.

The trends in funding are also interesting if one looks at them in this framework, and this may account for some of the guarded optimism that I heard expressed this morning. Figure G compares the total R&D spending with the smaller FS&T budget, in terms of both current dollars and in terms of constant. Both in terms of a current and constant dollars, the FS&T funding is not doing too badly. In recent

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**Figure H - Using the FS&T Concept**

- R&D budget is now a number tallied at the end, not a tool to guide decisions.
- FS&T linked to judging S&T opportunities and R&D needs for national goals.
- U.S. preeminence in some fields, at world levels and “poised to pounce” in others.
- FS&T tethered to a process to check interdependencies among fields and agencies.
- President offers a comprehensive FS&T budget.
- Departments and agencies allocate their FS&T funds against criteria used by the White House and the Congress.
- Congressional review of FS&T needs before disaggregation for congressional appropriations.
- Monitor FS&T budget in Executive Branch (OMB & OSTP) and Congress (CBO).
years, it has leveled off at about 19 percent, as Figure G clearly shows, but as a percentage of the total spending, it has actually been growing.

Now, why make the proposed change? It is more than just accounting; there is a process that the Committee recommends go with it [Figure H]. Currently, the R&D budget, is tallied after the long process of budgeting has been concluded; it does not help guide the budget process. With the FS&T budget, we propose that from the early stages of development of the budget within OMB, during which time the negotiations with the agencies are being undertaken, and more importantly, at the time that the budget is sent to Congress, it be widely understood that the government is dealing with a single, science and technology allocation. It should also be understood that there would be some provision for setting priorities, and invariably reallocating, among the various agencies, programs, and sectors.

We do not have time to examine the specific criteria that the Committee proposed for priority-setting, other than to say that we favor the recommendations of the COSEPUP Report, published by the Academy about three years ago. We recommend a two-tiered set of criteria: 1) that the US should strive to achieve a level of excellence comparable to the world level in all fields, and that in a small subset of those fields, it should aim to be preeminent; 2) that the Federal Science and Technology budget should be fettered to a process to assess interdependencies among the fields, and among the agencies—meaning in simple language, that some reallocation would be expected.

The budget process proposed would involve the President, OMB, the OSTP science advisors, the President's Council of Advisors on Science and Technology, and peer evaluations throughout the scientific community, all working together to develop and offer a comprehensive federal science and technology budget. This budget would represent from the outset a well-defined entity, and it would be tested in terms of its ability to meet national goals through the relative balance of allocations among different sectors of research providers. The departments and agencies would allocate their FS&T funds using broad criteria set by the White House and Congress. Moreover, Congress would review the FS&T before it is disaggregated into the Congressional appropriation-
Figure I - Principles to Guide FS&T Investments

- Competitive merit review preferred for awards.
- Support projects and people, not institutions.
- Continually review programs, using external advisors where possible.
- Pursue international cooperation, especially for large facilities.
- Don’t establish new laboratories unless necessary; sunset newly created institutes.

Under the present system, the budget goes to Congress and is split into 13 pieces, and distributed among the separate committees. In doing so, the research component is spread among those separate committees, and is generally weighed against non-research programs.

This proposal would require a much larger role for OMB, OSTP, and the Congressional Budget Office in monitoring the science and technology budget as an entity.

Some of the guiding principles for this process that the Committee recommends have already been mentioned, but let me go over them [Figure I].

First, we strongly recommend that merit review be the preferred basis for making awards to performers.

Second, we recommend that where possible people and projects be supported, not institutions. This recommendation seeks to avoid the creation of entitlements. Institutions that have been receiving funding for a number of years, perhaps decades, and for which the missions may no longer be fulfilled, should not necessarily continue to receive funding.

Third, we recommend continual review, using external advisors where possible.

Fourth, as others today have mentioned, we need to pursue international cooperation, especially where large facilities are necessary for the performance of research.
The proposed system would require a stronger hand for the Office of Science and Technology Policy, and OMB, as well as new roles for the Congressional Budget Office and the Congressional committees [Figure J]. It would continue to distribute funding among agencies, retaining the current pluralistic system. The Committee spent a great deal of time discussing the possibility of the establishment of a Department of Science and decided that it would not be necessary to accomplish the goals that we outlined.

**Figure J - Organization of FS&T**

- Stronger hand for OSTP and OMB.
- New role for CBO and congressional budget process.
- Retain R&D within agencies that need it, resulting in a pluralistic system.
- FS&T budget accomplishes more than a Department of Science.

Fifth, we recommend that a sunset clause be required whenever a new lab is established. There should be an established goal and target date for the particular project completion, and it should be understood that funding would not go beyond that date.

_N.B._: Figures D, E, F, and G are reprinted with permission from _Allocating Federal Funds for Science and Technology_. Copyright 1995 by the National Academy of Sciences. Courtesy of the National Academy Press, Washington, D.C. Please see Appendix D for further details.
I had put together a set of notes to use in this presentation and, having just re-read them and realized I will be reiterating things that have been said at least twice, and in some cases six times today, I thought that I might shift gears and try a little different approach. Rather than addressing the parameters of an effective, efficient and responsible government/university partnership, I might try instead to talk a little bit about one of those partners, which is the Congress, and make some general statements about how I think it might react over time.

I want to commend the University of Michigan and the Big Ten for undertaking this Symposium, because I think that it is extremely timely. As long as you regard what we are all engaged in as a process that is likely to require years, and not just a few more months, I think that you will find it a very healthy and useful exercise.

Let me state that I served on the staff of the Science Committee back in the mid 80s and had the opportunity to observe about four Congresses then, and the debates on science and technology policy in that timeframe. I then left for six years, worked in the Executive Branch and the private sector, and just returned to Congress last January.

I give you this background because the snapshots I have from the mid-to-late eighties of the debates within the Science Committee, and my observations of the debates within the past year, provide some real contrasts. I am going to draw some conclusions which I certainly hope will not offend the two members of the committee who are here. If they do, just whack me up alongside the head and I will stop.

The ideological and party leadership changes and agendas in this Congress, the 104th Congress, have been widely, and I think mostly
accurately, reported—at least as they relate to science and technology and public policy. I believe that the membership of this Congress, having heard the voters' clarion call to balance the budget and downsize government, adopt as their overarching goal to put in place a framework to achieve those ends. There has been a rich debate on how to do that, but most members certainly seem to agree that balancing the budget and downsizing government would result in expanded opportunity and economic growth.

However, there are other factors operating in this Congress that have received less attention, but which I think have major ramifications. First we have a very young House Science Committee. There are 50 members of Congress on this Committee. Twenty-two are currently freshman, nine are sophomores. So, over 60 percent of the Committee has engaged in the debates over science and technology policy for less than three years.

Now, here I would point out that new science committee members generally—and I think that Dr. Ehlers is certainly a unique exception, as is Ms. Rivers, with her background in education, is also—but most of the new science committee members do not come to the Congress immediately prepared for fully engaging in debates over science policy. This is not a new dynamic, it was this way in the mid eighties. The difference is that we have such a large number of new members at this time. Typically, in the Congressional changes in the mid 80s, we saw eight-to-ten new members come to the committee in each new Congress. Now, as I said, we have 22 new members in this Congress alone.

So what is really different today is that we have a majority voting block of new members. My observation is that generally, depending on the experience that new members bring to the committee, it takes anywhere from one to three Congresses for a member to achieve sufficient familiarity to engage independently in science policy debates. Obviously members gain expertise in specific issues fairly rapidly, but if you take the whole gamut of civilian science policy from space through energy through basic research, it generally takes several Congresses before someone is comfortable in independently engaging in a debate.
Now, obviously a change in Congressional party leadership could shift the debate away from some of the current issues, such as the emphasis on basic research at the expense of technology development, and toward a more pro-industrial policy.

But what do the dynamics suggest for longer range planning? If you look at the influx of new members, what we are really seeing in the Congress, in the House in particular, is a generational transition. Clearly the House is leading this changeover, in part because of its shorter election cycle. The changeover began in earnest, I think, two elections ago. It is likely to be final in two more elections. The Senate, because of its slower election cycle, is lagging. However, if you look at the 13 announced retirements this year in the U.S. Senate, you see that dramatic changes are in store for that body next year.

I would not be surprised, even after this generational transition has occurred, to continue to see a higher turnover rate than in the past. This is due to many things. The volatility of the electorate is one, but we also in many states now have state term limits, which will change the dynamics within those states among people who are interested in running for federal office. Federal term limits were held unconstitutional, but there are many states with valid laws relating to their own elected offices.

All of these things argue, then, that we are right in the middle of a generational transition, from post-World War II or the World War II generation members, to members who generally were born during the Baby Boomer era.

I would like to make a personal observation here from watching the committee operate this year. If you will afford me a wildlife analogy: there is a young bull versus old bull dynamic that sometimes goes under-reported or unreported, but which I see operating in the Committee. I will cite just one example here, because it is the vote in the Committee that first highlighted this dynamic to me; I mean the vote on the Department of Energy authorization bill last April, when the Committee voted to kill the advanced gas reactor. Now, that particular reactor had been supported by the Committee in a bipartisan fashion for over ten years. In last year's vote, it was killed by about eight votes. My
recolleciton is that all but one of the newer members voted to kill the reactor, and almost all of the senior members— that is, three terms or more— voted to save the reactor. It was not a partisan vote, it was a younger members versus older member vote. I do not need to go into the debate; I simply note that several of us who were watching observed the dynamic.

This argues for the point made earlier today that there is need for an effort to approach the new members, and in particular, to convince them of the merits of the federal investment in research and development— and convince them that federal spending in research and development is an investment. That is not a view that many of the members simply accept. If you begin to engage some of the newer members in discussions on this issue, you may find them really challenging your assumptions, and compelling you to come up with arguments as to why you believe that to be true. I know of no single white paper or single discussion or even symposium, such as this one today, that will necessarily persuade some of these newer members that that is the truth.

I heard, for example, a member of the Appropriations Committee just last month state that he thought every dollar they appropriated was an investment. So, you will have to show why federal spending in science and technology, in your view, differs from federal spending for other programs that might be better characterized as under-funded annuities.

I know Neal Lane has spoken at some length and for some time about the need for scientists to get involved in the political process. I have recently heard him use the term “citizen scientists,” to talk about the need to get all of those who are practicing within the community to become involved. It clearly is a multi-year effort that is going to be required, as I said, because of the ongoing nature of the change in Congress. You cannot simply talk to the members of the 104th Congress about these issues, and then sit back, hoping that the 105th Congress will be different and the 106th and so on.

I would, again, commend you for having symposia such as this that are beginning to look at very much how that partnership has, perhaps, unraveled, but perhaps have now best be put back together. Thank you.
I much appreciate the opportunity to share with you some highlights of a forthcoming report by the Council on Competitiveness which compliments this timely CIC initiative.

As some of you may know, the Council on Competitiveness is a nonprofit organization in Washington that brings together leaders from universities, from industry, and from labor. We are particularly known for our work in technology, with an executive committee that includes Chuck Vest from MIT and Tom Everhart from Cal Tech. The Council's Distinguished Fellow, Erich Bloch, is known to many around the table.

Our effort to take a broad look at the challenges facing the U.S. R&D enterprise began about a year and a half ago. The project was co-chaired by Frank Rhodes, now President Emeritus of Cornell, and by Gary Tooker, CEO of Motorola. We involved over 70 people in this study from the three R&D stakeholders: industry, universities and the federal government.

I would like to recognize my colleague, David Goldston, presently working with Congressman Boehlert, who did the lion's share of the initial work on this project. I have only been at the Council since December 1995, and I have been quite involved in the closure and final drafting of the report. It is my pleasure to share with you some of the thinking behind our effort.

We approached partnerships not so much as an object of study as the CIC has, but as part of the solution to the range of challenges facing the U.S. R&D enterprise.

We examined university-government-industry partnerships in all of their diverse combinations. In doing so, we did not try to rank
them. We did not try to suggest that any were more valuable than others. Indeed, as we looked at a range of six industry sectors—aircraft, automotive, chemical, electronics, information technologies, and pharmaceuticals—we illustrated the kinds of partnerships that could be developed, but we did not do the kind of work that CIC has done. In this respect, our effort ends where yours begins, with a great deal of overlap.

Let me highlight the three challenges to which partnerships are an important and timely response. The first challenge is the resource constraint. As Chuck Vest and Representative Ehlers have pointed out here this morning, the Council's judgment is that the resource constraint on R&D is not cyclical but structural. I might just add that our sense is that the constraint is not limited to federal resources or industrial priorities. It also reflects the increasingly international character of R&D and the fact that global demands to invest in the future will continue to affect R&D allocations.

Our sense is that partnerships, broadly defined, represent an important way to leverage resources, and that they could help all of the components of the R&D enterprise to think smarter rather than richer—because that is what the challenge is going to be.

The second challenge that we think partnerships could address is the challenge of changing the culture, the operating processes, of the three stakeholders in the R&D enterprise. We believe that working together will help break down the barriers that we identified in companies, in the government, and in universities. A good example close to home is the partnership for the new generation of vehicles that has brought the Big 3 auto-makers, national labs, and research universities together in ways that would have been unheard of a decade ago.

The third challenge that we feel partnerships could address is to contain fratricide among the stakeholders in the U.S. R&D enterprise. Many of us around the table have been quietly taken aside by someone from a university or from industry and have been told, for instance, "Those national labs are just a mess, they should be taking the hit." Or alternatively, we have heard from others who say, "Gee, it is the universities; they simply have not been subjected to the kind of discipline that industry has." Or, we have heard other complain that industry is driv-
ing the relationship with the universities off kilter. Our sense is that this kind of competition, at this historic moment, is not very helpful and that it would probably exacerbate the polarization alluded to earlier in the day with respect to the correct role of the federal government in research and development.

To meet the challenges I have sketched, the Council report develops guidelines not just for government but for universities and industry as well. For our purposes today, I would just like to touch on five of the guidelines for government. While they will not come as a great surprise to you, I think they are important, and we hope to do something about them.

First, we urge the federal government to meet its obligation to support civilian research, as both of the members of Congress here emphasized in their remarks. An action group, including Chuck Vest and other Council members, will meet with Senator Hatfield, Chairman of the Appropriations Committee, in about two weeks to help lay the groundwork for making that case. We feel that is an important point for a group like ours to make.

Second, we argue that the federal government should play a constructive role in fostering partnerships broadly. This involves thinking about the government as a participant in partnerships, as well as providing access to federally funded research.

Third, we feel that it is important to look at the business environment within which R&D is conducted. In this respect, I must note that some of today's conversation has been a touch narrower than I had hoped would be the case. We have today defined resources heavily in terms of Congressional budget allocations, not in terms of the way in which our tax system or our regulatory system might affect resources, their allocation and the behavior of those who are involved in R&D. It should be a goal of federal policy to create an environment in which the private sector can assume the funding role for the maximum amount of R&D possible.

Fourth, we suggest that it is extremely important to refocus federal research to meet the missions of the national labs. We must look systematically and with urgency at what they are doing and at their pro-
ductivity. The goal should not be to single them out, but to put them through the same rigorous analysis and assessment that industry has been going through and that universities are beginning to go through as well.

Finally, we believe that it is extremely important for the federal government to continue supporting research universities as it has in the past. While there is some comfort in the continuity of that role, our work suggests that the federal support for R&D conducted at universities has declined over the last 15 years, this is not something that we feel very good about.

In conclusion, and in respect to the piece of our report that I have reviewed for you, we do not feel that these issues are yet being handled correctly. We do not feel that the kind of consensus that we would like to see with respect to the federal role in the R&D enterprise has yet been achieved.

We do hope very much that our effort will provide, as yours will provide, Dave and Homer, the beginning of a national dialogue—one that will involve the key decision-makers from both political parties as well as the key R&D stakeholders. We simply must deal with these difficult, long-term issues, on the basis of more consensus than we have now.

Thanks very much.
Discussion

DAVID SKORTON: Thanks very much, John, not only for being on the panel but for being willing to share the report ahead of time, at least that part of it.

Well, if I am correct, we have about a half hour, plenty of time for conversation, so anyone either around the "U" shaped table or in the audience, now is your chance to jump in and let us hear your comments.

D. ALLAN BROMLEY: Well, reasonable people can differ. I understand full well that the defense department likes the recommended budget changes that David Auston has told us about. But there are a lot of people, including myself, who think that the change to a federal science and technology budget would be a fundamental mistake. The reason is that a number of administrations have worked very hard over the past decade or so to build up the total R&D budget in the United States to the current $70-to-$75-billion level. During the entire period, through at least three, and perhaps four, administrations, we have worked systematically to change the ratio of military to civilian expenditure within that total budget. We have done it successfully.

In my experience, I have never known any time when you gave away a large fraction of an investment in the future and in any sense were able to retain it as an investment in the future. So quite frankly, this proposed budget scheme looks to me like a marvelous way to reduce the total funding capacity.

I have every confidence that we can, in fact, continue the transfer from military to civilian expenditure within the present $73-odd-bil-
lion research and development category. But if we arbitrarily say, well, that is really not important, it is really only $35 billion, then we have essentially set ourselves back about 50 percent, and we start working with a $35 billion overall budget. This seems to me not a terribly wise move.

DAVID AUSTON: I agree Allan, reasonable people can differ. Let me acknowledge that the very question you raise was one that the Committee looked into in some depth. In fact, there was a concern that we might in some sense be saying to the federal government, we do not need as much, only $35 billion instead of $70 billion. On the other hand, let me just mention some of the arguments in favor of this approach. First, we felt that in terms of advocacy for science and technology funding, and the strength of the supporting arguments, it was important to have a definition of science and technology that was based exclusively on developing new knowledge in science and technology.

Second, do not believe that defining a budget for federal investments in fundamental science and technology in any way lessens the opportunities to shift funds from one category to another within the total federal budget. Simply because the committee saw the 6.1 to 6.3 categories as part of the federal science and technology base does not deny shifting funds from 6.4 to 6.7, or from any other budget category, to support fundamental science and technology R&D. The reality is that science and technology funding competes not against the total R&D budget, but rather primarily against funds for activities outside research; for example, defense S&T competes against procurement of weapons systems as well as salaries and housing for the armed forces; NOAA must compete against funding of the FBI; NSF against HUD and the VA; and so on.

D. ALLAN BROMLEY: May I ask a further question? I have the suspicion that some members of your Committee thought that they were gaining a possible advantage by chopping the total down to 35 billion, because they could then argue that we were down at the funding level, or below the level, of Japan or Germany. But quite frankly, I
have never seen the slightest evidence that anyone in the Congress, with minor exceptions, cares at all about that ratio.

DAVID AUSTON: The thrust of the Committee's recommendation, as I said, Allan, was to bring focus to the research and development budget process, so that apples were compared with apples and we were not comparing apples with oranges. Guy may want to add to that; since he was involved in the discussion.

H. GUYFORD STEVER: We were asked to find ways of making judgments between and amongst the various R&D programs. The smaller budget component, which we called the federal S&T, grouped together similar things, things that, in fact, you could put quality judgments on via peer review and other forms of review.

Much that is in the other part of the R&D budget—the non S&T part—is very important. We were not against it, we have to see it. We were only trying to point out that the judgments about projects there, such as the testing and the evaluation of technologies, or the procurement of the best units, was not part of the new knowledge base. It was using old technology in weapons systems and so on. That is why we separated the budget into two parts. Having done that, we began to ask questions analyzing these figures against various scenarios—for instance, if somebody, a booster, or exactly the opposite finally came down on the side of the other with respect to funding.

D. ALLAN BROMLEY: As I have said, reasonable people will differ and will continue to differ until such time as we see what happens.

DAVID AUSTON: We have been, as you might expect, keeping tally of correspondence, and also there have been any number of hearings that the Committee has had with members of Congress, with the agency heads, and with the scientific community. Generally, the concept of a federal science and technology budget and the process that we have recommended to guide its development and approval—that element of the report has generally met with fairly strong positive reaction.
There are some other elements that we report that, as we expected, have been very strongly criticized, but the FS&T budget has generally been fairly well received.

D. Allan Bromley: I would anticipate that that would be the case in discussion with a purely scientific audience. With an audience that spends a lot of its time trying to negotiate budgets with Congress, it might be different.

David Auston: Actually Representative Walker himself was quite favorably impressed with the concept.

D. Allan Bromley: Exactly.

David Skorton: Representative Ehlers.

Vernon Ehlers: Thank you. I had not intended to get into this argument when I raised my hand, but I will make just one comment on it—in fact all my comments will be under the general heading, “Let’s remember we are working in a political atmosphere.” Much of the discussion here has been about science policy per se, and about relationships with the Congress, without taking due account of the fact that Congress is a political body and that the President is a political person.

On this last argument I have to reluctantly cast my lot with Allan Bromley, because my heart says, in a sense, that we should go the other way, but my head—my political head—says it is dangerous.

The proposed Department of Science, I thought, was a good idea, in the sense of unifying science policy-setting, unifying operation, and perhaps introducing efficiencies in the scientific enterprise. It might still be a good idea. The one political downside, which is probably a large enough danger that we should be very cautious about a Department of Science, is that it exposes—to the glaring light of day and TV cameras—how much money is going into various efforts. It makes
science a very inviting target. Do you remember the Proxmire Golden Fleece Awards?

My concern, from my understanding of the proposal outlined by David Auston, is that it seems to have the downside of making everything readily targetable, without the upside of a unified science policy. And so I would say, let us proceed very cautiously on that.

Along that same line, I appreciated Tom's comments and his emphasis here. As we had the questions and the comments from the panel just before lunch, it was clear to me that some here are not familiar with the political arena, or are trying to avoid the fact that we are engaged in a political process. And I am not saying any of this to be derogatory about the political arena. But you have to start with the assumption that most members of Congress, if not all, would like to be reelected. And if you want to be reelected, you may sit around the table and decide what the priorities are—but if in that process you do not take account of issues affecting reelection, you will not get very far.

If the members of Congress could simply sit down and talk about the budget and set priorities, I suspect they would probably reduce the cost of living adjustments for Social Security and for federal retirees, both civilian and military, and so forth. If the Congress in fact did that, you would have a new Congress two years later that would reverse the changes, and you would not have really gained anything other than to have a totally new Congress.

Those are simply some of the realities we live with, and that is the background for my comments that spending is going to be very tight for the next decade unless public attitudes change. Just look at the tremendous ruckus about our attempts to improve the efficiency of Medicare—not even cutting it, just reducing the rate of growth by introducing efficiencies into the system. It has been demagogued to death for months. And frankly the Republicans are losing the battle on that one, even though it would be a minor reduction in spending. Allan has been through these kinds of things before: struggling with a minor cut across the board, which is really insignificant compared to some of the things that have to be done.
On the Science Committee, it was partially the old versus the new, as Tom suggested. But the most striking thing to me about discussions on that committee was that at times I felt there were only a few of us who were interested purely in the advancement of science or in doing what was right for science. Now that is not to indict my fellow members of the Committee, but rather to substantiate my first premise, that members would like to be reelected. Most everyone on that Committee is there by virtue of their interest in a major research facility in their district.

I have one colleague, for example, who would love to cut the federal budget in half, but he is on the Science Committee to protect and support a major federal facility in his district, and is not willing to cut one dime from that facility. Most of the Committee is that way. That is why the gas reactor was killed: it did not have a constituency on the Committee.

One of the bigger battles that I fought this year—it was not big in terms of dollars, but I think big in terms of importance—occurred when a proposal came from the Energy and Environment Subcommittee to eliminate some $28 million for nuclear physics accelerator research. Several things happened. I immediately fought it, brought it to a vote in the subcommittee, and gave all the logical, cogent reasons for reversing the action recommended by the staff. I thought I had the votes, and I thought I had the subcommittee with me, but we took the vote and I lost. Why? Because almost everyone who voted against me did so for one simple reason: they were afraid that money going to nuclear physics accelerators would take funds away from the facility in their district. The only way I managed to save the accelerators was by getting Chairman Bob Walker on my side, and having him go to the appropriations committee to raise the total amount of money available for the Science Committee, and then using that extra money to resurrect the accelerators.

So it was startling to me when I lost that first vote. Logic did not prevail. There is an even more startling aspect to it that gets back to Tom’s comment about, “Everyone has to get active, involved and organized.” During that period of several days, while all these accelerators
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Discussion

were destined for extinction, I received three telephone calls from the physics community. One of them was from Charles Vest, and I appreciated that; it was very helpful. Three calls out of that huge physics constituency out there. After I managed to save the accelerators, I got one call thanking me. Once again, from President Vest.

Now compare that to the phone calls that we would get for almost any other area of the budget. If we had cut $28 million from Social Security, or almost any other area of the budget, there would have been hundreds of phone calls, not three. So I think that you have to recognize that if the science community wants to be heard, it has to be organized, it has to be aware. You certainly have the Internet alert system: who uses the Internet more than the scientific community? But the community has to organize using this network, improve its capacity for action, and get on the phone very, very quickly when matters arise.

Finally, I would like to comment on the dangers of fratricide among the universities. I am glad to say that, regardless of how you may feel about Republicans or Democrats, and regardless of how you may feel personally about this issue, I think it is a real plus that we have virtually gotten rid of earmarking scientific research funds in this Congress. At the state level, when I was on the higher education appropriations subcommittee, I watched for years as universities knifed each other in the back for funds, to the detriment of all the universities. The collective effect was simply bad, and that sort of infighting for any kind of funds, state or federal, is damaging.

Thank you very much. I am sorry to go on at such length, but I just wanted to get back to some of the realities that I face every day.

AL TEICH: As long as we are being reasonable people, differing about the Academy's report, let me put in my two cents. I think there is a more important and more fundamental problem even, than the question of whether or not you include the testing and evaluation activities in the budget. After all, that is only $35 billion—not such a big deal.

But I have three other concerns about the idea of the federal science and technology budget that I would like to raise and ask for comments on.
First, I think it would set up a zero-sum game, where one does not exist now, and that would be detrimental to the science community. Second, I think it would confuse means and ends in the relation between research and national goals. And third, I think it is inconsistent with the way government works.

To return to the first point: starting out with a federal science and technology budget from the beginning, would mean that we would decide, presumably, on a total amount for science and technology each year. The tradeoffs would be internal to this FS&T budget, which means that if people within the community wanted the 5.7 percent increase for NIH that they got this year, that money would have to come out of NSF or NASA or some other agency, rather than out of other parts of the Labor-Health and Human Services appropriations bill, as it does in the current system. While it is not nearly as neat and tidy to have the messy system of confusing appropriations tradeoffs that we have today, it works to the advantage of the science community in most respects.

Second, the argument was made that, by setting up this FS&T system, we would allow science budgeting to be more effectively linked to national goals. I think just the opposite would be the case, because by making the tradeoffs internal to science, you would reduce the ability to make tradeoffs with regard to the goals that those pieces of science serve. So again to look at the NIH budget: under the current system, you trade off budgets for health research against other means of achieving health as a national goal. But, under the FS&T system, you would be trading it off against other things that have in common only the name research or the fact that they are done by scientists and engineers in laboratories—for example, particle physics, space, or ecology. So, it seems to me, we would be getting farther away from the idea of linking science to national goals than getting closer to it.

Finally, I believe that the proposed change is just inconsistent with the way government operates. There was a statement on one of the viewgraphs that the proposal would get around the “artificial Balkanization” of government agencies. Let me say that what is one person’s artificial Balkanization, is another person’s rational administra-
The government operates by addressing goals through various administrative agencies. That is a system that has evolved over many, many years, and while it certainly can be improved upon, it somehow is necessary to the function of government. This “Balkanization” is really a division of labor. To propose a system that would try to do without that is really pie-in-the-sky. So, I am interested in the reaction to those observations.

DAVID AUSTON: I can see I have a hard sell here. Let me take the issues one at a time. Actually, your first point, I think, is very similar to your third point, about the issue of whether this sets up a zero-sum circumstance. I do not believe it does. The rationale for the recommendation is twofold: first, to define a more meaningful conceptualization of federal spending in this area, so that it can be linked more closely, in total as well as independently, to national needs. That, in no way, implies that there should be a cap. It was anticipated that this process would enable—both at an early stage, and at later stages—an assessment of whether the level of expenditure is appropriate and sufficient.

I will mention in this connection that the Committee rejected the notion that federal spending on science and technology should be linked directly to gross domestic products—e.g., whether the current figure, running around 2.3 to 2.5 percent, should be raised to three percent. The committee decided to reject that approach, because it felt that that would carry with it an element of entitlement, and it would not be an effective advocacy strategy. But there is nothing in the proposal and the recommendation that says that a cap should be applied.

Now, I know your rebuttal is that political realities may argue otherwise. Currently the process, particularly in Congress, involves competition within the various agency budgets. The R&D funds—a piece of the discretionary spending of the federal government—is competing with items that have heavy agendas, substantial political clout, such as social welfare issues, or issues related to other elements of national needs. In that arena, science and technology do not fare well. So, I beg to disagree with your conclusions. I think that the process we are recom-
mending is sound: it gives the President and the Administration the opportunity, in proposing a budget for science and technology, to stand behind it and advocate for it. It currently is not possible for the President to advocate effectively for science and technology funding as such; our proposal seeks to change that.

DAVID SKORTON: Dr. Hornig.

DONALD HORNIG: Well, I am sorry, Professor, but I disagree. I think Al presented his case very eloquently. I would have said it a little differently, but my point is parallel.

I do not see research and development, or science and technology, as national goals in themselves. I think that is part of our problem; we cannot crystallize a national effort around those words.

Science and technology are an adjunct to all sorts of national goals. There is a part which I guess exists for itself, and that is what we principally support through the National Science Foundation. But almost all of the other research and development funding is tied to major national goals. Those might be defense; they might be health; they might be education. Then the question is, “Where should the budget tradeoffs be made?”

The concept of a unified science budget implies that we are going to have a debate over where a research dollar or an S&T dollar should be allocated within the science budget. I think the real question, both politically and in reality, is, which one of these other national goals, of which there are dozens, do I want to achieve? Do I want to put more money into research, science and technology, or do I want to create more hospital beds, or you name it? I think that our current pluralistic scheme is really a quite legitimate way for a democracy to pursue its business.

DAVID SKORTON: Mr. Yochelson.

JOHN YOCHELSON: I just would like to chime in by suggesting that the tradeoffs are not purely domestic. The nation’s international
standing in research and development is a fundamental issue. Fifteen, twenty or twenty-five years ago, it might not have seemed necessary to raise this issue, but it seems a very compelling issue today to the Council on Competitiveness. It will be increasingly compelling as the years pass along. We have to define our goals in an international, rather than a purely domestic, context of tradeoffs.

DONALD HORNIG: I think that point is very well taken, except that the international programs are dealt with segment by segment. All the international arrangements that I know of are segmented one way or another, and we never really stake out our national science and technology position against anyone else’s.

H. GUYFORD STEVER: That is one of the worst parts of the situation, that our international efforts are handled segment by segment. We have these fiefdoms with the leaders going abroad for nice trips, and making this agreement and that agreement. They are very ineffective, and I would like to see a much more concentrated effort to get our science and technology into the international arena.

D. ALLAN BROMLEY: But that requires that our State Department set up an American desk.

DAVID GOLDSTON: A couple of comments. One, I also want to agree with Al Teich’s comments. The one place in the government where there is now an effort actually to look at spending in general by function is the budget resolution, which has been pretty woefully ineffective because of the way it has been broken down by appropriation.

And the way that has evolved really underscores the point that Al is making. There is one function, function 250—general science—which covers DOE Labs, NSF and NASA; the other parts of the science budget are located in the functions that are attached to the particular goals that the science is serving. So, NIH is in Health, and Defense is within Defense, and so on. It is not that nobody has ever thought of changing this budget structure before. Each time it has been tried, the things
that have come out really underscore the kinds of principles that Al discussed.

Just the fact that we feel the need to break out the $35 billion from the $70 billion is the same issue. Our feeling is, well, you cannot say we do not have enough science and technology, if you are comparing apples and oranges. But nobody worries about, do we have enough science and technology per se. The concerns arise field by field. For the same reason that $70 billion does not work to map the funding, $35 billion does not work either. That is not really the way the issues are raised.

This brings up an underlying point: it is never clear to me in these exercises what problem it is that is supposed to be solved. If the problem is that science and technology somehow are under-funded, I am not sure that is true. If the problem is that it does not seem to get the kind of political prestige that other areas get, that the President does not get out often enough and say, “Science and technology is important,” that seems to be more an issue of pride than a practical issue.

And as Congressman Ehlers pointed out, there is a certain degree to which being in the shadows has worked to science's advantage. I have always felt that the Department of Science would immediately result in a cut for the budget for R&D, because no one knows that there is that much money floating around there right now.

I sometimes think that these budget exercises are a solution in search of a problem, and I am not really sure what the problem is, other than wounded pride that more people call about social security than about science cuts.

Vernon Ehlers: Just two quick sentences. First of all, I am going to have to leave because I have to meet this evening, as Ernest does, with some people from CERN to talk about international science. Before I leave I want to thank Homer for all of his hard work, not only in setting this up, but also on the effort that he had set up earlier. I certainly appreciate his work.

My second comment is related to the comments that were made about international science. I have proposed, only partially in jest, that since the space station is now a matter of international diplomacy rather
than simply a scientific project, that the funding for the space station should come out of the State Department budget.

At this point I have not received a great deal of support.

DAVID SKORTON: Thanks a lot for your participation, too. We have time for just a couple more comments.

H. GUYFORD STEVER: Well, I would like to say some more about why the idea of an FS&T budget came up. The committee was asked very specifically for ways to judge between and amongst science areas, and to find logical ways of making those judgments. We felt that the groupings of the FS&T budget identified areas in which judgments of quality could be made. Such judgment certainly cannot be made in the other part of the R&D budget; in that part, judgments are made on the basis of whether you want to buy ten or five weapons systems, and they do not have anything to do with the science and technology base.

DAVID SKORTON: There was one other question over here.

RADFORD BYERLY: I will try to be very quick. I just reviewed a book called, “Can Democracies Fly in Space?” The thesis of this book is that we should reorganize the government for the convenience of NASA, so that it can build large space stations and things like that.

It sounds pretty ridiculous when it is put that way, but I get a feeling that that is what is being argued for here: that you want to have a science special interest. You know, one man’s Balkanization is another man’s rational allocation of responsibilities.

I am worried about our saying or appearing to say that we are a special interest, but the proposed unified budget would make it very natural to slip into that perspective. Then, we are right in there with the tobacco lobby and we will be stuck, because if you call yourself a special interest, everybody else will be happy to agree you are a special interest. It seems to me that if we told our story differently—not just better, but very differently—we could say with justification that we represent a common interest.
I really think that is what we need to work on. I do not mean a common interest in the sense of the Vannevar Bush model. If you remember, there were two metaphors in Bush's report. One was "The Frontier"—that would require an hour-long lecture. The second metaphor was the reservoir metaphor: Bush said we have to put information into that reservoir, and society dips it out. In that view, research is therefore a common interest, because it creates a common good, the pool of information, and society then takes out what it needs. His logical flaw, of course, is that there is no guarantee that the information society needs will be in there, because the reservoir is not a coupling agent, it is a de-coupling agent. That is, the reservoir serves to decouple science from society, and makes it look like a special interest.

I think we really need to work on making this identification with common interests, rather than setting ourselves up as a special interest. This will involve becoming connected to society and responding to its needs.

DAVID SKORTON: I want to take the chair's prerogative to give my answer to David's question about what was the point of the discussion today. When the Big Ten VPs were working on this, we purposefully stayed away from discussions of particular allocations, or particular appropriations. Our overriding idea was to reexamine the principles underlying government/university/industry interactions in research.

Okay. In the interest of time—and I apologize to Marty and others who wanted to ask questions—we are going to take a break now. We are going to reconvene here under Dr. Ed Hayes' Chairship at 3:45.

Thank you, very much.
The 1996 Jerome B. Wiesner Symposium

The Future of the Government/University Partnership

Closing Session

Cornelius J. Pings
Edward F. Hayes

Discussion
As we begin, I would like to say that as one of the research officers in the CIC, I have been very impressed by Homer Neal's leadership in this effort. As I listened today, I have gone back to the preamble to the "principles of partnership" [Appendix E]. I think these are probably words that have remained since Homer's first draft: that we believe that the most productive and meaningful changes in the partnership will occur on the basis of discussion and mutual understanding.

I hope, through this conference, we have made a good deal of progress in that direction. As this session proceeds, we will be able to move beyond this particular meeting and talk about the next step.

When Homer asked Neal and me to bring this symposium to a conclusion, it seemed like a relatively easy task. I thought, well, he obviously reached out to chemists, chemical engineers, because chemists and chemical engineers have solutions. That is a reasonable view from a physicist, right?

Neal has four major summary points that he will make, and then I will talk about some of the next steps and possibly a few of the items that may need some additional emphasis. Then we will open it for a broader comment and observation.

Neal.
It is an often-used cliché, but in this case I think it is true that everything I have to say has already been said.

I have been, literally, given the task here to look back over the documents that were prepared in advance and what has been said today and see if we can pick up some common themes—some areas where we seem to have agreed and maybe a few where there seem to be contradictions or differences.

I have gathered my remarks into four, non-symmetric categories: 1) the new era that we started discussing early this morning; 2) the enigma of priority and resources; 3) some miscellaneous items I want to emphasize, and then finally, 4) an issue we have been discussing throughout the day, namely, making our case for the partnership and for the ongoing support.

So with respect to the first point: we are in a fourth era of partnership with the federal government.

The first era—which has not been mentioned today—preceded the Morrill Act. It was an era of considerable support for science by the federal government—mostly scientific exploration of the continent, but on the scale of national budgets of the time, it was a perceptible investment.

We have been reminded several times today of the second era, which began with the land grants. Some of you might have learned from David Goldston, as I did, the odd bit of history of what it took to get the land-grant act voted in during the Civil War years. The land-grant act was followed then by sixty or seventy years of very significant federal involvement in the support of agricultural research, but little else.
The 1930s and 1940s industrial support for scientific research became perceptible. Most of my thesis work, for instance, was supported by the American Petroleum Institute. However, as several speakers have indicated, industrial support waned in the following era.

Then we had World War II, which was a key benchmark, and was followed by—according to virtually all of the descriptions—a golden era of federal support for scientific research.

The next benchmark for scientific research came with the end of the Cold War, although we did not immediately recognize it as a benchmark. Those of us who had the privilege of being at the Ford Library last night saw in the lobby a chunk of the Berlin Wall. One might have, perhaps, thought that there was more symbolism for science in the Wall's coming down than we realized. Since then, we have been in this new era that we are trying to define. We are trying to know ourselves, know the partners, and see if we can come to an ongoing, better, steady state, or a better level of comfort, at least.

So we won the wars, World War II and the Cold War, but in the process we seem to have lost our rationale. We are floundering now over identifying a new rationale and articulating the new challenges that we face. There certainly are things that we can do and should be doing effectively, but as a community we have not come to a consensus on what they are.

Let me make several points, then, about this new era and what might be the challenges inherent in it. I am looking for those issues that seem to have emerged today and that were mentioned by more than a few individuals.

First, we are now in the era of the knowledge industry. We are the knowledge producers. And we are the producers of those who will handle and use the knowledge. A number of you sketched the importance of the research university in this knowledge age, because of our joint responsibility: we teach, and we teach in the context of the creation of new knowledge. That is what is special about our institutions.

Incidentally, despite the supposed difficulties, such as professors not being available to students, students in unheard-of numbers continue to knock on our doors, even though they presumably have alternatives
for education. This belies the argument that the research university is not a place that is optimum for learning.

Nonetheless, Kumar Patel pointed out that we are not turning out students with the flexibility for multiple careers—multiple careers, even within a company that they might stay with for many years, much less if they have to move back and forth. There will be a report forthcoming from the Business/Higher Education Forum in about four months that is based on considerable research, including interviews with students, and I believe that it will affirm that position.

David Goldston advanced a somewhat harsher view: “Federal funding has provided disincentives for education.” That is a position, I think, not subscribed to by all in this room.

Chuck Vest, in his stunningly effective paper this morning, asked us to consider new patterns of research and perhaps a new way of describing research activity, rather than basic and applied and strategic. He suggests a typology of basic, top level research; mid-range research; and short-term development. And he warns that there is erosion, if not disarray, in the mid-range—and that this disarray affects all of the research communities, including universities. We do not quite know yet how to handle this situation, although many of today's speakers hold to the view that research feeds the technology base. Technology, in turn, fosters a vigorous economy and increases the quality of life and provides for our national security.

Incidentally, no one mentioned today that we still have a national defense challenge. We still have a very large military enterprise. There is a bit of a contradiction here, because as we have a smaller force—we have made a national commitment to that—that force must be technologically much more sophisticated. Basic research will provide the foundation for that technological sophistication. The people who develop the weapons systems are not doing that basic research; they are dependent upon the universities for it.

Let me turn, then, to my second main point, the enigma of the priorities and the availability of resources. One might imagine asking, why did we bother to come here, after all, to discuss this topic? Are we not favored? Is not basic research a high priority in the country? We
have heard from many today that it is, and that it should be. The answer to both of those questions is, yes, we are favored and research is a priority. We see substantiation of that claim in the FY96 federal budget, and hints of it in the FY97 budget. (Someone said, “Why are we spending so much time on budgets?” One lesson I learned when I came to the AAU is, watch where the money is.)

So we are favored, we are a priority. Unfortunately, there is simply not enough money to go around, particularly if we are to have a balanced budget in seven years. Guy Stever took a somewhat optimistic view, based, I think, on his long experience: “A lot can happen in seven years and maybe we will not have to face this reality.” But Congressman Ehlers cautioned us more than once today about the shortage of money and Yochelson said that we are in the midst of a structural change, not a cyclical one. I think that we need to pay attention to that message.

All of my university colleagues here, I know, when you return to your campuses, you will probably dust off your five-to-ten-year strategic plan (you all have one worked out in consultation with your faculty senates, I know). Does it contain within it a contingency for a 25-percent-smaller research enterprise in seven years? Have you thought about the already difficult problem of senior faculty not retiring? Steady state funding would be bad enough, but if we shrink our budgets at the same time that retirement rates decline, how will we bring the new generation into our laboratories, into our teaching force? Are we going to forego an entire generation? That is unacceptable.

Can the states pick up the difference? As Skorton pointed out, the states are already doing an immense amount; can we expect them to do even more? I would like to see them support some of the private universities a bit—but even there, in some states they are already doing so through student aid.

Will industry pick up the difference? My guess is, not much and not very quickly, and the price may be too high in any event. There will undoubtedly be some selective support from industry in engineering and in the basic sciences, but emphasizing the former. But it is not going to replace what could be dropped from the federal budget.
My third point includes some miscellaneous issues that were mentioned today, but only in passing. I think they should be given a little more prominence.

First, allusion was made to the NEH and the NEA. The Endowment for the Arts is not particularly important to our campuses, unless you happen to be one of the professors who is supported by it. But the erosion of NEH is a serious blow to scholarship on our campuses. It is strange, on a relative scale, because the budget of NEH before it was reduced by 40 percent, was $180 million a year, in contrast to $15 billion that comes onto our campuses for support of science, mathematics, and engineering. I was proud to see our presidents in AAU really turn to, to try to support that $180-million budget. Well, NEH is still with us, but it is severely eroded, and I do not think it is going to come back rapidly. Fortunately, we have challenged the powers that be and at least have sustained something.

The second miscellaneous topic is our obligation as a university community to pay more attention to K-12 science education. As many of you know, there is reform under way. There have been new standards issued. The National Academy of Sciences has given education a very high priority in recent years. For those of you who do not know, the AAU universities are in discussion now with the National Academy of Sciences to broaden the whole educational reform endeavor to K through 16. We want to make particularly sure that we are prepared to teach the new generation of scientifically trained students coming to our campuses from the 12th grade, in a style that will be effective for them. We need to ensure that the SAT exams and other qualifiers are appropriate measures of the new training.

Most important, we should be looking toward a greater scientific literacy for all students who pass through our campuses. The revolution in science education in grades K through 12 can soon offer our university campuses the opportunity to meet that goal.

In talking about the partnerships between the research universities and the federal government, in the area of education, we sometimes think that we are only talking about science education. I reminded you of NEH; we are talking about education in the humanities as well.
Moreover, we must not forget the significant federal education budget, which contains amounts of money comparable to those in the science budgets.

I was startled—and I will say it to him personally—when Ernie Moniz pointed out that one of the major challenges we face is increasing access for students to our campuses. He followed that right away by saying that we have to make attention to cost containment a greater priority. I will, when I see him, point out that I think therein is a very serious contradiction, because most of our campuses have done a remarkable job of cost containment in the last half dozen years, with one exception. Namely, they have been unable without raising tuition to meet the immense burden of providing access to women, minorities and those, historically, who have not entered our systems—because the federal government, and state governments, have leveled their support for those activities. This is an area in which universities are not monolithic industries—and the government certainly is not, either. In effect, we have different parts of the federal establishment looking at our institution somewhat differently.

Now, let us talk about my fourth point: making the case for sustaining our partnership, perhaps in a somewhat new style. Universities hope that the partnership will continue to involve significant funding, but this is an area of some uncertainty. Congresswoman Rivers said—I like the phrase—“We have to plan to make intellectual currency a priority.” Intellectual currency a priority: she used the analogue of the family that decides that the first thing to do is commit to savings, and she was urging that as a policy. Her colleague Congressman Ehlers said, though, “We are dealing with a political process. And we, the university, and scientific committee are not being effectively heard”—apparently, according to him, with the occasional exception of the loan voice of Chuck Vest.

Ehlers called for a new model and a new definition and a better understanding of the government role in the partnership. To his credit, he was not here telling us what that model should be, he was asking us to work with the agencies and the Congress to fashion that new model. He said, “We must do a better job of educating the public.” And Rivers
supported that notion, saying, “We just cannot talk among ourselves, we must take the message to the broader community.” But Goldston cautioned, “It's time to recognize that there are internal university problems, all the obstacles are not external.”

Other points on assuring the continuation of the partnership and the maintenance of resources: Chuck Vest, both in his statement and in his questions, made a persuasive case that we can make a good argument for the return on investment in research and that we should step up and be prepared to do so. But, Don Hornig reminded us that we cannot grow preferentially forever. He sketched us all being in the research laboratory by the year 2025.

We have talked about educating the public. I picked this idea up in the hallway—you better be wary when you have someone summarizing who hovers around—Guy Stever, I heard you say in the hallway, not in your prepared remarks. “One of our biggest challenges is to educate scientists about the public.”

John Yochelson, getting grim near the latter part of the day, said that we need to speak to the common interest; we need to keep a discussion of the common good going.

Finally, since he started our day, I allude to, again, this remark from Chuck Vest: “We have to stop looking so much to the past and instead try to glimpse at the future.”

Thank you.
Edward F. Hayes  
Vice President for Research  
Ohio State University

With that very effective overview I would like to bring out two or three additional points.

One that struck me early on was made by Don Hornig: "The problems we are facing now, they really have not changed that much."

I just happened to bring along a transparency, and since I did not want David to be the only one to have used a transparency here, I would like to show it now [Figure K]. As you can see, from the early sixties to the turn of the century, there has been a lot going on in the dynamics of the federal budget. Guy Stever mentioned that there have been few things good in the budget that were achieved without effort—significant efforts made by many people. One of the things that we have benefited from is that we have had, in Administrations and Congress over many years, people who are willing to take the time to learn, and who have had the interest in and understanding of what science and technology are all about, and why they are important to the nation.

Many of us remember that the period from '68 to '76 was a very tough time for support of research in the R&D budget. It was only when President Ford came on board that we started to see some growth.

Someone mentioned to me a “theory of tranquillity,” which basically goes as follows: in times of political turbulence, the support for many things, including science and technology, suffers. Why is that? The voices of reason that support science, in order to be effective, must be heard. But in the present political environment, where sound bites and political rhetoric often carry the day, it is very difficult for thoughtful people to explain the strong case for support of science and technology.
In addition to the effort that we have before us of balancing the budget, we are also engaged in a campaign to downsize the government. Guy Stever mentioned earlier how proud he was when the cost of running the National Science Foundation was only five percent. It is even lower now, three-and-a-half to four percent. One of the things that I have felt very comfortable about is that many of our science agencies—NIH and NSF particularly—have been models of efficiency. But in the push to downsize government, there is the real possibility that NSF and NIH will be downsized to the point where they can no longer be effective. The cost of the personnel, the salaries and travel, the administrative costs of running the foundations, is really a small percentage of the total budget. It really would not be cost effective—and some might even say that it would be foolhardy—to further cut the budgets for these science agencies.

I think, then, that one of the things we can all help communicate to Congress and the public is that there are some agencies that are models for how the system should operate. Slashing them inappropriately or mindlessly may have a significant multiplier effect, with unintended and counterproductive consequences.
So as we look to the future and toward next steps, I think we have to be concerned about communication, as has been mentioned many times. I submit that there are many different environments in which we communicate. Within our community, we have a language and traditional ways in which we communicate. We need to include industry, the national laboratories, university and government in the community. But for me, one of the lessons of the time that I spent in Washington—and also, one of the things that has come out of this particular symposium—is that the language of politics is not the same as the language that we use with our colleagues in the research community. We have all heard the old saying that the political process is like making sausage; the more you know about it, the less you like it. Nonetheless, as we move forward, we have to engage the political process. We have to understand it, and we have to communicate many of the points that were discussed so well here today.

Let us turn to some of the steps we might take next:

- We must engage the broader scientific community in discussion of the issues.
- We must deal with the issue of a unified science policy and what that would mean for the partnership.
- We must make a case for support for the “middle layer” of research that Chuck Vest spoke about. Is it a federal responsibility, a state responsibility, or a shared responsibility?
- We must answer the question that David Auston raised about the cost of education in research activities. How do we allocate those costs? What does it mean for the government to pay the total cost of research? Do our graduate students have any responsibility to pay a portion of the research costs associated with their thesis research? I do not want to trivialize that issue; I think it will be very much before us.
- We must pursue the question of the state policy for science and technology—particularly as it relates to the service industry, as opposed to the manufacturing sector.

We have before us right now the political process leading to the elections. One of the questions we should ask ourselves in terms of
next steps is, should we work very hard, in a very coordinated way, to have written into each of the political party platforms an appropriate statement on the support of science and technology? I submit that this is important. It is important not only because it reflects what most of us here believe, but also because the process of getting cogent statements into the platforms will provide an organizing mechanism for our communication effort.

So there are some thoughts that I had about possible next steps, and I would like to stop at this point and open the discussion up for other comments and suggestions on possible next steps.

Thank you.
AUDIENCE MEMBER: I think a possible next step is to clarify our language a little bit more, especially if we are going to be dealing with the public. I found one thing that came out of this meeting today, which is new to me, is the use of the term "modes of inquiry" to describe what we do, as opposed to generation of new knowledge. Because if all the universities did was generate new knowledge and new concepts, we could get by with a much smaller research and development budget than we currently have. The new concept could have tremendous leverage, not only outside of our community, but also within the community, because a lot of what we do in our education programs requires integration and synthesis through the organization of new knowledge and new concepts.

Furthermore, I believe that a lot of our research—and we ought to face this—does have a practical outlook. It does have to be seen in the context of national outcomes. It has to be seen in the context of requirements in industry. And even within the science community, it has to be integrated across disciplines. Unless we can figure out a way to define it correctly, and to indicate in a much broader way what it is that universities do, I think we are going to have difficulty.

EDWARD HAYES: Thank you, Arden.

NEAL PINGS: I alluded to the new K through 12 science standards. Those of you who have seen them know that they are very much based on a new style and a new approach to teaching and to learning. They are inquiry-based. They are hands-on, experimentation-based, and
they significantly decrease the emphasis on the body of knowledge. I think that is a good sign.

CHARLES VEST: That was my comment. Thank you.

EDWARD HAYES: Okay. Other observations? Please? Would we follow Homer’s suggestion of name and affiliation, please.

RAD BYERLY: Neal, I am glad you were prowling the halls with your notebook because I think the comment you picked up from Guy Stever was very important. That is, I think there is also a need to explain the public to scientists. That may be more important than the reverse, i.e., explaining science to the public, because the public already has great faith in science.

Ed, I liked your comments about trying to get a plank into the platforms of the political parties. Not because I think anybody is going to pay any attention—I mean, can anyone remember what plank was in any platform ever?—but I think it would be very educational for everybody involved on both sides of the horse trading, to see the promises they will have to make and the word-smithing that will have to be done. I have never tried to do it, but I think it would be very educational for scientists to make the attempt.

EDWARD HAYES: Any follow-up comments on that point?

MARTIN APPLE: As you point out, almost no one reads the platforms, nor pays inordinate attention to them. I could not cite a single item which I am certain was in either platform last election. But I do remember, and many people will, what the League of Women Voters asked candidates in their various election forums all over the country, whether they were local, national, or presidential level, especially if they were in publicized TV debates. So why not frame a question or two that we might provide for these TV debate forums, questions that would both require the candidates to have learned a little bit in order to be able to comment effectively on the subject?
EDWARD HAYES: Anne?

ANNE PETERSEN: I have a different issue. Kumar Patel mentioned the importance of including young people in further steps. I spent three hours at the AAAS meeting with a panel of graduate students and post docs. These students are acutely aware of all the issues that Neal Pings summarized, although they have come to science for exactly the same reasons that all of us did. They really care deeply about inquiry and discovery and want to be engaged in that process, but they are terrified that they will not have food for themselves, much less for their families if they ever dared get married. Their anxiety about their lives as scientists was palpable. I think that we need to incorporate the interests of students into our planning both at the federal level and in our universities.

NEAL PINGS: Too many of our students are leaving our institutions with crushing debt burdens at the undergraduate level, especially if they persist on into graduate education. It is affecting career decisions. Individuals are selecting jobs that they would not otherwise take. I think that is a public policy matter that is not directly thought of as a matter of science policy— but in terms of assuring and nurturing that new generation of scientists, those that will carry on for us, we need to take a look at it.

EDWARD HAYES: I would just add one little footnote to that in agreement; it also ties into a point that was made several times in the discussion today, and that is the importance of excellence. Implicit in your comment, I think, is the realization that if we do not have some of our most outstanding students going into science and engineering careers, we will not have the level of excellence that is in the national interest.

MARTIN APPLE: I will make another comment on economics for a minute. I am going to borrow from Alvin Toffler, because I really think there is something to his Third Wave hypothesis.
Essentially, in the 10,000-year era of agriculture, we could pass along from generation to generation how to plant seed.

In the industrial age, education and training had to be much more complicated, and we developed a new, effective education system for training factory workers.

What we are now in is an age in which transition is incredibly quicker and things are much more complex; we think it is an information age. We have learned in this century that most of our development of new economy, and most of our growth in commerce, has come out of new knowledge—new development and research-based knowledge.

The greatest invention for us at this point, for our economy, is the 20th-century research university. Research universities are the engines of our economy for the 21st century. If we have a belief in the importance of our economic future, we need to understand the complexities of our economic future, and we need to convince federal and business sources that the nation must invest in universities for the future. We develop our future human capital and subsequent economic capital at the same time in universities. This is the story, the message, that I think has power.

EDWARD HAYES: Homer?

HOMER NEAL: I wonder if any of the universities represented here are planning to host one of the presidential debates?

NEAL PINGS: I believe, Homer, that has been set and I understand that Washington University and the University of San Diego have been selected. Can anybody affirm that?

CHARLES VEST: I know Washington University is firm, and I am also sure that they would be delighted to be helpful in any way that we could encourage them to be.

HOMER NEAL: We should consider seeking the cooperation of one of those universities, to make sure that certain issues are raised in the
debates. I do not know how much more leverage you might have, just because you are hosting the debate...

NEAL PINGS: Probably less.

HOMER NEAL: ...well, I should tell you, there are people here who have been trying to attract a presidential debate. I have indicated that the only way I would support them is to just take some role in setting the format.

EDWARD HAYES: I think that is a very interesting point.

I also wanted to come back in this connection to say, I was struck by the discussion that took place following David Auston's comments and Allan Bromley's observation about—and I am using my own language now—how our desire to tidy up the political process, may have unintended consequences. I think that at least from my perspective, having those kinds of discussions within the community, and thinking about what the strategies should be, and trying to get people on board from the different experiences and perspectives that we have within the community, is very important. Because what might work very well in analysis and understanding of what we might think about setting priorities for science, might not carry over into our political process. In part, because it is not clear who can speak for science, whether it is the President or a chair of an appropriation committee or what have you.

In my own passage through the valley of death, during the Stockman era at OMB, I was always struck by the strategies that were used. David Stockman had a marvelous negotiating strategy in setting the budget, an uncanny ability to differentiate between the going-in position and where he wanted to come out.

H. GUYFORD STEVER: This argument has a new look. Both Allan and Congressman Ehlers gave me their proxy as they left, so we probably have a different result in the conversation.
EDWARD HAYES: My main point is that having those kinds of discussions within the community will elevate the level of understanding, and not only is it a matter of understanding the public, but our understanding the political process as well.

I do not see any other hands or comments.

Homer, I would again want to thank you. I hope everyone else will join me in thanking you.

HOMER NEAL: On behalf of our committee, I think it has been fantastic that you spent the day with us to review these weighty issues.

Several of my colleagues from the Big Ten Universities, I think, will gather now down the hall for a few minutes to discuss what additional steps we will suggest to our presidents that should be taken.

But we would like very much to hear from any of you that are not part of the steering committee group as to what you think we should do.

We have not had any particular preconceived notion about the next steps. We, like reasonable scientists, wanted to see what the results were.

But the concept of trying to influence the platforms and trying to help foster additional discussions, they seem extremely reasonable, and I suspect that would be something that we would want to assist with.

But the issues are just much, much bigger than any region of the country. It would be very important that whatever it is we do would be something that would have the broader support of the academic community.

We wish you a safe return to your homes.

Thank you, again.
The 1996 Jerome B. Wiesner Symposium

The Future of the Government/University Partnership

Appendix A

1996 Symposium Program
The 1996 Jerome B. Wiesner Symposium
The Future of the Government/University Partnership
University of Michigan
February 26, 1996

Sponsored by the
Office of the Vice President for Research
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The 1996 Jerome B. Wiesner Symposium was made possible by the generous assistance of the Ford Motor Company.
Condensed Program
University of Michigan, Ann Arbor
Horace H. Rackham Building

Monday, February 26, 1996

8:00 a.m.
Registration
Rackham East Conference Room

8:30 - 9:00
Opening Statements
Amphitheater

9:00 - 10:00
Keynote Session: Jerome B. Wiesner Lecture
Amphitheater

10:00 - 11:00
The Research University in National Science and Technology Policy
Amphitheater

11:15 - 12:45
Outputs: Research and Education for the 21st Century
Assembly Hall

2:00 - 3:30
Inputs: Responsible Allocation and Stewardship of Resources
Assembly Hall

3:45 - 4:30
Closing Session
Assembly Hall
Full Program
University of Michigan, Ann Arbor
Horace H. Rackham Building

February 26, 1996
Monday

8:30 - 9:00
Opening Statements

Homer A. Neal
Vice President for Research, University of Michigan

Vernon J. Ehlers
Member, United States House of Representatives, Michigan 3rd District

Lynn N. Rivers
Member, United States House of Representatives, Michigan 13th District

9:00 - 10:00
Jerome B. Wiesner Lecture

Introduction of speaker
James J. Duderstadt
President, University of Michigan

Keynote Address
"Not What We Think: What We Haven't Thought Of"
Charles M. Vest
President, Massachusetts Institute of Technology
10:00 - 11:00
The Research University in National Science and Technology Policy

Presenter and Chair
John P. Mctague
Vice President, Technical Affairs, Ford Motor Company; Acting Science Advisor to President Ronald Reagan

Panelists
D. Allan Bromley
Science and Technology Advisor to President George Bush

Donald F. Hornig
Science and Technology Advisor to President Lyndon Johnson

Ernest J. Moniz
Associate Director for Science, Office of Science and Technology Policy, Executive Office of the President

H. Guyford Stever
Science and Technology Advisor to President Richard Nixon and President Gerald Ford

11:15 - 12:45
Outputs: Research and Education for the 21st Century

Presenter and Chair
Robert Galvin
Chairman of the Executive Committee, Motorola, Inc.

Panelists
Vernon J. Ehlers
Member, United States House of Representatives, Michigan 3rd District

Kumar N. Patel
Vice President, Research Programs, University of California at Los Angeles

Anne C. Petersen
Deputy Director, National Science Foundation

Lynn N. Rivers
Member, United States House of Representatives, Michigan 13th District
2:00 - 3:30
Inputs: Responsible Allocation and Stewardship of Resources

Presenter and Chair
David Skorton
Vice President for Research, University of Iowa

Panelists
David H. Auston
Provost, Rice University; Member, NAS Committee on Criteria for Federal Support of Research and Development

R. Thomas Weimer
Staff Director, Science Subcommittee on Basic Research, United States House of Representatives

John N. Yochelson
President, Council on Competitiveness

3:45 - 4:30
Closing Session

Panelists
Edward F. Hayes
Vice President for Research, Ohio State University

Cornelius J. Pings
President, Association of American Universities
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Biographical Sketches

David H. Auston is Provost and Herman Brown Professor of Engineering at Rice University. He has contributed to research in the fields of high speed optics and electronics. He pioneered the development of a new method for generating and measuring extremely fast electrical signals that uses optical pulses from lasers to measure the electronic properties of materials, circuits, and devices with a time resolution of less than one picosecond. Dr. Auston received his Ph.D. in Electrical Engineering from the University of California, Berkeley, in 1969. He was on the technical staff of AT&T Bell Laboratories, Murray Hill, from 1969 to 1987, when he joined the faculty of Columbia University. Dr. Auston became Provost of Rice University in 1994. He is a member of the National Academy of Sciences and the National Academy of Engineering; he is a recipient of the R.W. Wood Prize from the Optical Society of America and the Morris E. Leeds Award from the Institute of Electrical and Electronic Engineers. Dr. Auston served on the Committee for the Study of Allocation of Federal Resources for Science and Technology, of the National Academy of Sciences.

D. Allan Bromley is Sterling Professor of the Sciences and Dean of Engineering at Yale University. During 1989-1993 he was The Assistant to the President for Science and Technology and Director of the Office of Science and Technology Policy (OSTP) in the Executive Office of the President of the United States; he was the first person to hold the position at cabinet-level rank. One of the world's leading nuclear physicists, he was founder and director of the A.W. Wright Nuclear Structure Laboratory at Yale from 1963-1989. He has carried out pioneering studies on both the structure and dynamics of nuclei and is considered the father of modern heavy ion science, one of the major areas of nuclear science. As the Assistant to the President, he revitalized and chaired the Federal Coordinating Council for Science, Engineering and Technology and published the first formal statement of U.S. Technology Policy. Dr. Bromley chaired the National Academy Physics Survey in the early 1970s; he has served as president of the American Association for the Advancement of Science. He is currently President-elect of the American Physical Society.

James J. Duderstadt is the eleventh President of the University of Michigan and Professor of Nuclear Engineering at the University. He joined the Michigan faculty in 1969, having received his Ph.D. from the California Institute of Technology. He
became Dean of Engineering in 1981, Provost and Vice President for Academic Affairs in 1986, and President in 1987. Dr. Duderstadt has served on numerous public and private boards, including the National Science Board, which he also chaired. During his career Dr. Duderstadt has received numerous awards for his research, teaching, and service activities, including the President's National Medal of Technology, the E.O. Lawrence Award for excellence in nuclear research, the Arthur Holly Compton Prize for outstanding teaching, and the National Engineer of the Year Award for professional service. He is a member of the National Academy of Engineering and the American Academy of Arts and Sciences.

Vernon J. Ehlers was first elected to the 103rd Congress in December 1993 in a special election and was sworn into office on January 25, 1994, representing the 3rd District of Michigan, centered on Grand Rapids. He was reelected to the 104th Congress in 1994. The first research physicist in Congress, Congressman Ehlers serves as vice chair of the House Science Committee. He also serves as vice chair of the House Oversight Committee and is responsible for computer technology issues. He is a member of the Transportation and Infrastructure Committee. Following the 1994 elections, Ehlers was tapped to serve as a member of the House Republican Transition Team. Ehlers began a full-time career in public office in 1983 when he was elected to the Michigan State House of Representatives; he was elected to the State Senate in 1985. Ehlers received his Ph.D. in Physics from the University of California, Berkeley and subsequently taught there and also held research positions in Europe and at Lawrence Berkeley Laboratory before joining the faculty of Calvin College in 1966. He served at Calvin until his election to the State legislature, and in both 1970 and 1973 was named an Outstanding Educator of the Year.

Robert Galvin started his career at Motorola in 1940. He held the senior officership position in the company from 1959 until January 11, 1990, when he became Chairman of the Executive Committee. He continues to serve as a full time officer of Motorola. Galvin has been awarded honorary degrees and other recognitions, including election to the National Business Hall of Fame and the presentation of the National Medal of Technology in 1991. Motorola is the first large company-wide winner of the Malcolm Baldrige National Quality Award presented by President Reagan at a White House ceremony in November 1988. As one of his many contributions in public service, Mr. Galvin chaired the recent study of the future of the Department of Energy laboratories. He attended the University of Notre Dame and the University of Chicago, and is currently a member and was the recent chairman of the Board of Trustees of Illinois Institute of Technology.

Edward F. Hayes is Vice President for Research at The Ohio State University and President of The Ohio State University Research Foundation, positions he has held since July 1991. He also holds an appointment as Professor of Chemistry. Dr. Hayes
Donald F. Hornig is Professor Emeritus at the Harvard School of Public Health, where he was Professor of Chemistry and Director of the Interdisciplinary Programs in Health from 1977 to 1990, and Chair of the Department of Environmental Science and Physiology from 1988 to 1990. He is also President Emeritus of Brown University. President Eisenhower named him to the President's Science Advisory Committee in 1959 and he continued in that position under President Kennedy, who asked him, two weeks before his assassination, to be his Special Assistant for Science and Technology, the successor to Jerome Wiesner. That request was repeated by President Johnson and Hornig served as Science Advisor from 1964 to 1969. He chaired the President's Science Advisory Committee and the Federal Council on Science and Technology while also serving as Director of the Office of Science and Technology in the Executive Office of the President. Before going to Washington Hornig was Donner Professor of Science and Chairman of the Department of Chemistry at Princeton University (1957-1964) and professor of chemistry at Brown University (1946-1957). During World War II he served at the Los Alamos Scientific Laboratory in New Mexico, where his group developed the firing unit for the first atomic bomb.

John P. McTague is Vice President - Technical Affairs for Ford Motor Company, a position he has held since March 1, 1990. Before joining Ford in June 1986, Dr. McTague was Acting Science Advisor to President Reagan. On February 2, 1990, he was appointed by President Bush to his Council of Advisors on Science and Technology (PCAST). In his present position with Ford, Dr. McTague directs the operations of Ford Research Laboratory, Environmental and Safety Engineering Staff, and the Technical Strategy Office. Prior to that he was Ford's Vice President - Research. A physical chemist, Dr. McTague was appointed deputy director of the Office of Science and Technology Policy in 1983, becoming its acting director in 1986. Dr. McTague earned a doctorate from Brown University in 1965. He was a member of the North American Rockwell Science Center in Los Angeles from 1964 to 1970. He then joined the chemistry faculty of the University of California at Los Angeles, where
he also was a member of the Institute of Geophysics and Planetary Physics. During 1982-1983 he was chairman of the National Synchrotron Light Source Department at the Brookhaven National Laboratory in New York and an adjunct professor of chemistry at Columbia University.

**Ernest J. Moniz** was nominated for the position of Associate Director for Science at the Office of Science and Technology Policy in June 1995. He was confirmed by the United States Senate on December 22, 1995. Dr. Moniz was previously employed by OSTP when he consulted on the Science in the National Interest policy statement in 1994. Prior to this appointment, Dr. Moniz was Professor of Physics and Head of the Department of Physics (1991-1995) at the Massachusetts Institute of Technology. He will be on leave from MIT as Professor of Physics (1983-) during his official tenure at OSTP. Dr. Moniz joined the MIT faculty in 1973 and served as the Director of the Bates Linear Accelerator Center, a nuclear physics research facility operated by the MIT Laboratory for Nuclear Science for the Department of Energy. From 1992-1995, Dr. Moniz served the Department of Energy and the National Science Foundation as Chairman of the Nuclear Science Advisory Committee, leading a Long Range Plan development for American nuclear physics. He was a Director of American Science & Engineering, Inc., a small high technology company making X-ray security equipment. Dr. Moniz is a Fellow of the American Association for the Advancement of Science, the Humboldt Foundation, and the American Physical Society.

**Homer A. Neal** is Vice President for Research, Interim President designate, and Professor of Physics at the University of Michigan. He has served as Vice President since 1993; previously he was Chair of the Department of Physics (1987-93). He has served as Vice President for Academic Affairs and Provost at the State University of New York at Stony Brook and Dean for Research and Graduate Development at Indiana University. His research area is experimental high energy physics; his research group is part of the DZERO collaboration at Fermi National Accelerator Laboratory that recently announced the discovery of the top quark. Neal is a Regent and Executive Committee member of the Smithsonian Institution and is a member of the Oak Ridge National Laboratory Advisory Board. He is also a member of the MIT Visiting Committee on Sponsored Research, a Fellow of the American Physical Society, and a member of the Board of Trustees of the Center for Strategic and International Studies. He has been a member of the National Science Board and of the Board of Overseers for the Superconducting Super Collider. He has delivered testimony on numerous occasions to Congress on matters ranging from the funding of national laboratories to the state of undergraduate science education.
C. Kumar N. Patel is the Vice Chancellor for Research at the University of California, Los Angeles. Prior to joining UCLA in March 1993, he was the Executive Director, Research, Materials Science, Engineering and Academic Affairs Division at AT&T Bell Laboratories, Murray Hill, New Jersey. He has made numerous seminal contributions in several fields, including gas lasers, nonlinear optics, molecular spectroscopy, pollution detection, and laser surgery. For his discovery of the laser action on the vibrational-rotational transitions of molecules, for his invention of the high power carbon dioxide lasers, for his nonlinear optical studies leading to the invention of the spin flip Raman lasers and for molecular spectroscopy and pollution detection studies, Dr. Patel has received numerous honors, including the Frederic Ives Medal of the Optical Society of America and the Institute of Electrical and Electronic Engineers Medal of Honor. Most recently, he received the William T. Ennor Manufacturing Technology Award of the American Society of Mechanical Engineers for his seminal contribution to manufacturing technology through his invention of the high-power carbon dioxide laser. Dr. Patel is a member of the National Academy of Sciences and the National Academy of Engineering. He is a fellow of the American Academy of Arts and Sciences and past President of the American Physical Society (1995) and Sigma Xi (1993-95).

Anne C. Petersen was nominated by the President and confirmed by the U.S. Senate on July 1, 1994, to be the 9th Deputy Director of the National Science Foundation (NSF). In addition to sharing various leadership duties with the Director, her primary role is that of Chief Operating Officer, providing overall organizational management to improve agency performance in implementing its mission. Additionally, she oversees and coordinates NSF's activities in a number of interdisciplinary research and education areas as well as other topics that span NSF. Prior to her NSF appointment, Dr. Petersen was Vice President for Research and Dean of the Graduate School at the University of Minnesota from 1992-94. At Minnesota she held the rank of Professor of Adolescent Development and Pediatrics. Previously, she was Dean of the College of Health and Human Development, and Head of the Department of Individual and Family Studies from 1982-87. Dr. Petersen, a founding member of the Society for Research on Adolescence, also served as President and as a member of its Council. She is a Fellow of the American Association for the Advancement of Science.

Cornelius John Pings became President of the Association of American Universities in Washington, D.C. on February 15, 1993. Dr. Pings had been Provost and Senior Vice President for Academic Affairs at the University of Southern California since 1981. He was previously Professor of Chemical Engineering and Chemical Physics, Vice Provost, and Dean of Graduate Studies at the California Institute of Technology, from which he received a B.S. degree in Applied Chemistry in 1951 and Ph.D. degree in Chemical Engineering in 1955. He served as Chairman of the Public Policy Com-
committee (COSEPUP), a joint committee of the National Academies of Sciences and Engineering, and the Institute of Medicine from 1988 to 1992. He has served as a member and the Director of the National Commission on Research, as President of the Association of Graduate Schools, and as a member of the Boards of Directors of the Council on Governmental Relations and the Council of Graduate Schools. During 1987-1989 he chaired an ad hoc committee for the Association of American Universities which undertook a major review of “Indirect Costs Associated with Federal Support of Research on University Campuses.” Dr. Pings was elected a member of the National Academy of Engineering in 1981, and a Fellow of the American Academy of Arts and Sciences in 1995.

Lynn N. Rivers was born on December 19, 1956 in Au Gres, Michigan. Ms. Rivers began her public service career as a member of the Ann Arbor school board where she served from 1984-1992, including three years as president. She then went on to the Michigan State Legislature and served one term, from 1993-1994. In November 1994, Ms. Rivers was elected to her first term in the U.S. House of Representatives where she currently serves. She then went on to Wayne State University Law School, where she was awarded her J.D in 1992. She married her husband Joe on May 31, 1975. They now live in Ann Arbor, Michigan with their two daughters, Bridgitte and Jeanne.

David J. Skorton was appointed Vice President for Research of the University of Iowa in August 1992. He joined the Iowa faculty in 1980 and holds a joint appointment as professor of internal medicine in the College of Medicine and professor of electrical and computer engineering in the College of Engineering. Skorton has served as director of the Cardiovascular Image Processing Laboratory, as director of the division of general internal medicine and as associate chair for clinical programs in the department of internal medicine. He is co-founder and co-director of the University of Iowa Adolescent and Adult Congenital Heart Disease Clinic, an internationally recognized center of excellence in clinical care of patients with congenital heart disease. He has served as chair of the International and Cooperative Projects (Fogarty Center) Study Section at the National Institutes of Health. Skorton has published numerous articles and two major texts in the areas of cardiac imaging and image processing. He was director of the NIH-sponsored Specialized Center for Research in Coronary and Vascular Diseases. As vice president, Skorton leads one of the nation’s largest public university-based research and development programs, which won nearly $189.3 million in external support in 1994-95. Skorton received the B.A. degree in 1970 and the M.D. degree in 1974, both from Northwestern University.
H. Guyford Stever has had a career as a scientist, engineer, educator and administrator. In the past decade he has been a member of the Carnegie Commission on Science, Technology and Government; director of TRW Inc., a Schering-Plough Corporation, and of Goodyear Tire and Rubber Company; a trustee of Woods Hole Oceanographic Institute and of Science Service; and President and Trustee of Universities Research Association. In 1976 and 1977, he was Science and Technology Advisor to President Ford, Director of the White House Office of Science and Technology Policy, and an ex officio member of the President's Commission on Science and Technology. From 1972 to 1976, he was Director of the National Science Foundation, and, from 1973 to 1976, Science Advisor to Presidents Nixon and Ford. Prior to his government service, he was President of the Carnegie-Mellon University from 1965 to 1972, during which time the Carnegie Institute of Technology and the Mellon Institute were merged. His academic and research appointments have also included Professor of Aeronautics and Astronautics as well as Head of the departments of Mechanical Engineering and Naval Architecture and Marine Engineering at MIT, and Chief Scientist of the U.S. Air Force. A member of the National Academy of Sciences and the National Academy of Engineering, he received the National Medal of Science in 1991.

Charles M. Vest is the fifteenth President of the Massachusetts Institute of Technology. Dr. Vest serves as a member of the President's Committee of Advisors on Science and Technology (PCAST), the Executive Committee of the Council on Competitiveness, the Massachusetts Governor's Task Force on Economic Growth and Technology, and the National Research Council Board on Engineering Education. He was also chairman of the President's Advisory Committee on the Redesign of the Space Station. Prior to taking office at MIT in 1990, Dr. Vest was the Provost and Vice President for Academic Affairs of the University of Michigan. His other positions in the academic administration of that university included Dean of Engineering and Associate Dean for Academic Affairs. He earned his B.S.E. degree in mechanical engineering from West Virginia University in 1963 and both his M.S.E. and Ph.D. degrees from the University of Michigan, in 1964 and 1967 respectively. He joined the university's mechanical engineering faculty in 1968 and became full professor in 1977. He is a Fellow of the Optical Society of America, the American Academy of Arts and Sciences, and the American Association for the Advancement of Science, and is a member of the American Society of Mechanical Engineers and the National Academy of Engineering.

R. Thomas Weimer is the staff director for the Subcommittee on Basic Research, whose jurisdiction includes the National Science Foundation, the Department of Energy's National Laboratories, and the White House's Office of Science and Technology Policy. His previous government experience includes serving as Chief of Staff to the U.S. Secretary of the Interior, as Republican Staff Director of the U.S. House Committee on Science, Space, and Technology, and as the Republican Nuclear Sci-
ence Advisor to the U.S. House's Committee on Interior and Insular Affairs. Mr. Weimer has also worked as a Technical Staff Member at Sandia National Laboratories in Albuquerque, New Mexico, and at the Lockheed Missiles and Space Company in Sunnyvale, California. An engineering graduate of Harvey Mudd College and the University of Washington, Mr. Weimer is a registered professional engineer.

John N. Yochelson became president of the Council on Competitiveness in December 1995. Previously, he was a senior vice president at the Center for Strategic and International Studies (CSIS), where he was responsible for policy research on international trade, investment and finance. He created the Center's program in international business and economics, focusing on the challenge of globalization to the U.S. economy. Yochelson launched the bipartisan Strengthening of America commission co-chaired by Senator Pete Domenici (R-NM) and Senator Sam Nunn (D-GA) whose recommendations have contributed substantially to the current debate on putting the U.S. economic house in order. Before his work at CSIS, Yochelson spent three years at the Department of State. He was research fellow at the Center for International Affairs at Harvard University and at the Brookings Institution. He has been a consultant to the Joint Economic Committee of the U.S. Congress and a collaborator of the late Jean Monnet. President Bush appointed Yochelson to the President's Export Council where he served as vice chair of the Subcommittee on Resources and Communications. He is also a member of the Department of State's Advisory Committee on International Investment, the board of directors of the National Coalition of Advanced Manufacturing, and the Council on Foreign Relations.
Appendix C

Registered Participants
Registered Participants

Allan Afuah  
School of Business  
Administration  
University of Michigan

Michael Aiken  
Chancellor  
University of Illinois-Urbana/Champaign  
Urbana, IL

Paula Allen-Meares  
Dean, School of Social Work  
University of Michigan

Richard Altschuler  
Kresge Hearing Research Institute  
University of Michigan

Todd Anuskiewicz  
Executive Vice President  
MERRA

Martin Apple  
Executive Director  
Council of Scientific Society Presidents  
Washington, D.C.

Daniel E. Atkins, III  
Dean, School of Information and Library Studies  
University of Michigan

David Auston  
Provost  
Rice University  
Houston, TX

Terry Barr  
President  
Libralter Plastics, Inc.  
Bloomfield Township, MI

Giles G. Bole, Jr.  
Dean, Medical School  
University of Michigan

Darlene Bourne  
Business School  
University of Michigan

Mark Brenner  
Vice President for Research  
University of Minnesota  
Minneapolis, MN
Registered Participants

Michael Bretz
Department of Physics
University of Michigan

Garry D. Brewer
School of Natural Resources & Environment
University of Michigan

David Allan Bromley
Dean of Engineering
Yale University
New Haven, CT

Thomas A. Butts
Associate V. P. for Government Relations
University of Michigan

Radford Byerly, Jr.
Retired Chief of Staff of the House Science Committee
Boulder, CO

Timothy Chupp
Department of Physics
University of Michigan

Roger Clark
Director
Committee on Institutional Cooperation
Urbana, IL

Noreen M. Clark
Dean, School of Public Health
University of Michigan

Jon Cosovich
Deputy to the President
University of Michigan

Gerard Crawley
Dean of Graduate Studies
Michigan State University
Lansing, MI

James J. Duderstadt
President
University of Michigan

Thomas M. Dunn
Department of Chemistry
University of Michigan

Debra Eadie
Ophthalmology Department
University of Michigan

Dee W. Edington
Director, Division of Kinesiology
University of Michigan

Vernon Ehlers
Member, U.S. House of Representatives
Michigan 3rd District
Grand Rapids, MI
Geraldine Bledsoe Ford  
Recorder's Court Judge  
The Circuit Court  
Detroit, Michigan

Debbie Gallagher  
M Link  
University of Michigan

Robert Galvin  
Chairman of the Executive Committee  
Motorola Corporation  
Schaumburg, IL

Edie N. Goldenberg  
Dean, College of Literature, Science, and the Arts  
University of Michigan

David Goldston  
Legislative Director  
Office of Representative Sherwood Boehlert, NY  
U.S. House of Representatives  
Washington, D.C.

Robert A. Greenkorn  
Special Assistant to the President  
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Appendix D

Membership of the National Academy of Sciences Committee on Criteria for Federal Support of Research and Development

Details on Figures from the Committee Report
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on Criteria for Federal Support
of Research and Development

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PAUL M. ROMER, University of California at Berkeley
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(1)—Resigned on July 12, 1995, to become chair of the U.S. Nuclear Regulatory Commission.
(2)—Resigned on March 22, 1995, due to schedule conflicts.
(3)—Resigned on June 22, 1995, to become deputy secretary of defense.
Notes on the Figures from the NAS Report, Allocating Federal Resources for Science and Technology

Figure D  SOURCE: Data on federal R&D are from Table 4, National Science Foundation, Federal Funding by Budget Function: Fiscal Years 1993-95 (Arlington, Va.: NSF/Division of Science Resources Studies, forthcoming). FS&T data were derived by substituting FS&T funding by DOD, DOE, and NASA from Figure II.1 for National Defense, Energy, and Space Research and Technology R&D totals (this exercise involves making a somewhat arbitrary division of DOE FS&T between national defense activities (atomic energy) and energy activities).

Figure E-1  SOURCE: Data are from the American Association for the Advancement of Science, unpublished tables of federal R&D funding by budget function and agency, Fiscal Years 1994 through 1996, provided by Kei Koizumi, Directorate for Science and Policy Programs, AAAS, September 26, 1995.

Figure E-2  SOURCE: Data as for Figure II.4, modified as noted in Figure II.1.

Figure F-1  SOURCE: Data calculated from Table C-8, National Science Foundation, Federal Funds for Research and Development: Fiscal Years 1992, 1993, and 1994 (Arlington, Va.: NSF/Division of Science Resources Studies, 1995).

Figure F-2  SOURCE: Derived as follows: (1) R&D obligations by performer (for all federal agencies except DOD, DOE, and NASA) were taken from Table C-8, NSF, Federal Funds for Research and Development: Fiscal Years 1993, 1994, and 1995, forthcoming. (2) DOD, DOE, and NASA obligations for research, by performer, were taken from the same source. (3) Obligations for 6.3A by DOD were allocated among performers in the same proportions as reported in Appendix A, DOD Response to NSTC/PRD #1, Presidential Review Directive on an Interagency Review of Federal Laboratories (February 24, 1995). (4) Obligations for the equivalent to 6.3A by DOE in FY 1994 ($1.5 billion), as estimated by the Office of the Director of Defense Research and Engineering (see Box II.3, footnote 4), were allocated among performers in the same proportions as DOE obligations for all development in FY 1993, as reported in Table C-9, NSF, Federal Funds for Research and Development: FY 1992, 1993, and 1994, 1995. (5) The same approach used in 4 above was also used to allocate 6.3A-equivalent obligations by NASA in FY 1993 ($1.4 billion) among performers. (6) The funding by type of performer in 1-5 was summed and the overall percentages determined.
Figure G  SOURCE: Data on federal R& D from Table C-93a, NSF, Federal Funds for Research and Development: Fiscal Years 1993, 1994, and 1995, NSF 95-334 (Arlington, Va.: NSF/Division of Science Resources Studies, forthcoming). The data for FY 1985 through FY 1993 are actual obligations; those for FY 1994 and FY 1995 were estimated by the R&D agencies. The GDP implicit price deflators (1987=100) were taken from Table B-1, NSF, National Patterns of R&D Resources: 1994 (NSF/Division of Science Resources Studies, 1995), p. 8. FS&T numbers were derived from agency R&D budgets by subtracting spending for DOD research categories 6.3b through 6.6 and spending for equivalent activities at NASA and DOE in 1993, as estimated by the Office of the Director of Defense Research and Engineering, and extrapolated to 1994.

An online version of the report, Allocating Federal Funds for Science and Technology, may be found at the National Academy of Sciences World Wide Web site, URL http://www.nap.edu/nap/online/fedfunds/.
Appendix E

Principles of Partnership
Version 3.0
This year’s Jerome B. Wiesner Symposium in part follows from an effort to develop a set of Principles of Partnership, which might help guide the future of universities and the federal government in their partnership. We reproduce the draft Principles here as a point of reference.

The following draft of the Principles for the Future of the Government-University Research Partnership is the result of discussion and commentary involving numerous representatives from academe, industry, and the Legislative and Executive Branches of the federal government. These discussions were initiated by a Steering Committee appointed from the senior research officers of the schools of the Committee on Institutional Cooperation. We wish to note that this draft of the principles should not be construed, either wholly or in any particulars, as reflecting the definitive views of any one university, or of the CIC universities collectively. The Principles have been developed in the hope that they will help focus discussion.

The Committee on Institutional Cooperation includes the following universities:

University of Chicago, University of Minnesota
University of Illinois, Chicago, Northwestern University
University of Illinois, Urbana, Indiana University
Ohio State University, University of Iowa
Pennsylvania State University, University of Michigan
Purdue University, Michigan State University
University of Wisconsin, Madison
Principles for the Future of the Government-University Research Partnership

Draft
Version 3.0
October 12, 1995
Preamble

The quest for knowledge and understanding is one of the critical driving forces of human existence. In part this quest is itself driven by practical need: knowledge of the world in which we live allows us to adapt to it, to master parts of our environment, and to improve our human habitat. In part this quest is driven by pure curiosity: we wonder at the magnificence of nature, of the human mind and spirit, and we seek to understand. In part the quest is driven by a complicated mixture of curiosity and need, as we participate in the age-old human effort to build better, fuller, and more meaningful lives for ourselves as individuals and as peoples.

We live in an age of exceptional potential for the development of new knowledge, and of exceptional need for new understanding. Scientific, technological, and scholarly research and creative activity are increasingly important elements in addressing human needs, dealing with societal problems, and generating economic development. Over the past decade, three major reports on science and technology in the United States have been considered by three successive presidential administrations. Despite their differences, the reports reached at least two conclusions in common: (1) a sustained emphasis on research and education is essential to the achievement of this nation's social and economic goals, and (2) research-intensive universities are critical to American scientific and technological leadership.

We proudly note that the system of research universities of the United States is the envy of the world, but we are also aware that the geopolitical and economic contexts within which research is conducted have changed dramatically in recent years: the Cold War has ended; the economy is increasingly global in nature; the public resources available for support of various activities, including research, are more constrained. Along with other sectors of our society, our research institutions must make dramatic changes to adjust to the new contexts. They must learn how to carry out their fundamental service to the nation and to posterity—the conduct of rational inquiry—in the most productive and efficient manner, within new parameters.

As universities and the government both adjust to the new contexts, so must their partnership adjust. We believe that the most productive and meaningful changes in the partnership will occur on the basis of discussion and mutual understanding. These principles—a "work in progress"—are set forth in the hope that they will prompt discussion and collaboration about how best to respond to the new contexts of research in the most creative, productive, and responsible ways possible.
Principles for the Future of the Partnership
Draft Version 3.0  October 12, 1995

I. Research and scholarship in support of the nation’s well-being
We seek a partnership that will promote our nation’s ability to

- develop new knowledge in response to intellectual opportunity, emerging fields of inquiry, and national need
- convert information into knowledge and understanding
- communicate knowledge quickly and effectively to those who can use it
- apply knowledge to pressing human concerns
- compete effectively in a global economy

The Partnership Should Promote Outstanding Research, Guided By Diverse Goals and Values, Including Intellectual Opportunity and National Need.

The core competence of the research university is the conduct of rational inquiry—directed to curiosity-driven expansion of our general understanding of the world, but also to the solution of shorter-term problems. Increasingly, it is difficult to separate the short-term or “applied” cleanly from the long-term or “basic”: much research involves a variety of modes, related in complicated ways. Both universities and the government should be sensitive to the complex mix of activities that constitute the universities’ essential service to the nation; they should develop policies and practices consistent with promoting that core ability and service. We believe that this can be done in concert with other federal goals.

a) Universities collectively should continue to conduct research at the leading edge of the full range of disciplines and should be responsive to emerging new fields of study, based on both intellectual motivation and public need. In the new context of research, it is essential that they systematically endeavor to improve their accountability for the public investment in research. They should seek to develop cooperative strategies, in order to conduct research productively and efficiently; this might entail an alteration in universities’ competitive orientation, in order to produce a more cost-effective sharing of resources.
They should explore creative ways to facilitate communication with the public and other sectors of society, so that the public needs for inquiry are well understood and are addressed to the extent feasible by university research. It is important to recognize that not all universities will or should concern themselves to the same degree with responding directly to public needs for inquiry into shorter-term problems; one of the strengths of the system of universities and other research institutions has been its diversity on this issue.

b) The federal government should recognize the public value of the full range of intellectual inquiry and should base support for research on the goal of nurturing the research system in its full complexity, even while it works to reduce costs. The government should consult extensively with the community of university researchers and scholars, with representatives of industry and other sectors of society, in setting priorities across, among and within the various fields of inquiry and in determining the appropriate federal role in each area, including:
   - the physical sciences, mathematics and engineering
   - the medical, biomedical, and health sciences
   - the biological and agricultural sciences
   - the social and behavioral sciences
   - the arts and humanities
   - the professional disciplines

Research institutions should facilitate this process not only by contributing to the discussion but also by taking steps to attain better cost efficiency.

c) In an economy that is increasingly global, information-intensive, and technologically sophisticated, it is vital that the partnership be continually responsive to the needs of American industry, as well as to needs arising within states and localities. Universities make a potent contribution to economic development and public service simply by carrying out curiosity-driven research that expands the overall fund of knowledge. They also make a potent contribution by training future workers and citizens—a role that is increasingly important in an ever more technologically sophisticated age. The requirements of the modern global economy and modern society, however, are also leading some research institutions, including universities, to take a more direct and active role in facilitating the transmission of appli-
Appendix E: Principles of Partnership, Version 3.0

...cable knowledge to industry and society. Not all universities will become involved in matters of technology transfer, economic development, and community service to the same degree, and indeed, the diversity of philosophies and policies among universities should be counted as a strength of our research system. Nonetheless, the more active approach to the application of knowledge to short-term problems can be consistent with the fundamental mission of reasoned inquiry and pursuit of new knowledge, but it falls to universities to ensure that the values of fundamental research are not compromised in the process.

II. Education for the next century

We seek a partnership that will foster

- education for productive life in an age that is information-intensive, technologically demanding, culturally complex, and globally competitive.
- education that will continue to assist our citizens in adjusting to the rapid changes in the modern world
- public understanding of the key technological, economic, cultural, and social issues that we face.

The Partnership Should Foster the Innovative Application of the Strengths of the Research University to the Enhancement of Education.

Education of the nation's citizens for productive life and work is one of the primary functions of the research universities, and a function to which they can bring unique assets. One of the greatest strengths of the research university has traditionally been graduate education—the training of the new generations of scientists and scholars. The same assets of the university that have made our doctoral programs the envy of the world can be turned — and are being turned — to improvements in other areas of education as well. Universities, in addition to training the next generation of researchers, seek to instill in their undergraduate students the culture of rational inquiry, and the skills to be effective workers and knowledgeable citizens. In our rapidly developing world, education is more than ever a life-long process: this implies that one of the most important outcomes of undergraduate education is the ability to think clearly and to earn effectively. It also implies that universities have a larger role to play in ongoing...
education, and in serving as a resource that the broader public can draw upon in trying to understand new issues and problems that arise.

a) Universities should seek, review, and implement innovative ways to further utilize their research competency to enhance undergraduate education, by expanding opportunities for undergraduates to participate directly in research and scholarship; and by endeavoring to ensure that all students who graduate have attained the necessary levels of scientific and cultural literacy;

b) Universities should seek, review, and implement innovative ways to improve further their performance in graduate education. The prevailing model of graduate education, which envisions an academic career as the highest achievement, must be supplemented to give new emphasis to students' multiple career paths, intellectual opportunities, and life goals. Universities should explore ways to rejuvenate masters programs, to expand continuing education opportunities, and to restructure and supplement existing professional and doctoral degree programs to meet the needs of a changing society, economy, and world.

c) In our ever more complex, information-intensive world, it is vital for universities to take on a more prominent role in helping the public to understand the complicated issues that the nation faces. Universities should explore creative ways to make their resources for knowledge and understanding available and accessible to the public; they should explore and implement ways to facilitate timely public understanding of important scientific and technological issues; they should be increasingly receptive and responsive to public interests and concerns and should seek to facilitate meaningful dialogue between the public and academic communities.

III. Responsible allocation and utilization of resources

We seek a partnership that will foster

- prudence and cooperation in the utilization of the nation's investment in research, scholarship, and creative activity;
- continuing improvement in the efficient administration of resources.
Appendix E: Principles of Partnership, Version 3.0

1. The Partnership Should Foster Accountability for the Nation's Investment in Research.

Universities and the federal government should seek the most effective and efficient distribution and use of the nation's investment in research. Universities should:

a) further consolidate and share resources, coordinating wherever possible large research proposals, resources and activities among groups such as the CIC.

b) further communicate to the public the values and goals of research, scholarship, and creative activity.

The federal government should:

a) contribute to funding for research at levels sufficient to safeguard the vitality of the nation's scientific and technological enterprise, including its research universities, government laboratories, and industry. Leaders in both the academic and industrial communities are prepared to assist in determining what these priorities must be, consistent with overall economic and societal goals—working both through established governmental mechanisms and councils, and through other processes as appropriate.

b) develop mechanisms to improve stability, efficiency and effectiveness in federal commitments to large, long-term research projects. In too many cases, long-term research projects have either collapsed or have been difficult to mount as a result of massive uncertainties in funding from one fiscal year to the next, one Congress to the next, or one Administration to the next. The impact of such difficulties upon the research disciplines and, equally important, upon the community of researchers within the discipline, is great, as it is upon the ability of the federal government to achieve its own goals.

Universities and the federal government should work together to clarify and promote mutual understanding of the total costs of research, to assure predictability and consistency in the treatment of the administrative and facilities costs of research, and to assist universities in gaining greater
efficiency in their management of these costs.

2. The Partnership Should Facilitate the Streamlining of the Administration of Research.

The federal government should reduce fiscal and regulatory disincentives for research for universities and the private sector by:

a) working to reduce bureaucratic loads in the management and administration of research.

b) working with universities to develop costing policies and procedures that will provide a sound and equitable rationale for the government to cover reasonable costs of research on university-based research projects.

c) improving the fiscal and regulatory environment toward encouragement of robust industrial research and development activity.

Universities should explore changes in organizational structure that would facilitate responsiveness to emerging areas of inquiry and reduction in administrative costs, recognizing that with reduced federal regulation comes a greater accountability by universities directly to the public.

3. The Partnership Should Protect the Investment in the Research Infrastructure.

Over the decades, the nation has made a tremendous investment in research and has created a research infrastructure of great effectiveness. The physical side of that infrastructure is showing considerable signs of strain. The federal government should work with universities and industry, as well as national laboratories, to modernize the research infrastructure, including both capital facilities needs and large-scale equipment needs. It is essential for the university research infrastructure to be brought and kept up to date. The federal government must play an important role in helping to support the infrastructure, both through direct investment and through encouraging private-sector investment.

Universities should explore ways to increase collaboration among themselves and with other research institutions on facilities and equipment upgrades.
IV. Stewardship of the public trust

We seek a partnership that will exemplify:

- responsiveness to the needs, vital interests, and concerns—short-term and long-term—of the American people.
- the highest standards of open communication, ethics, and integrity in the conduct of research, scholarship and creative activity.
- inclusiveness and opportunity for all members of society, in all kinds and at all levels of activity.
- our best and deepest understanding of the culture of rational inquiry, including the conduct of inquiry in service to and partnership with the nation's citizens, communities, and industry.

The Partnership Should Cultivate Pursuit of the Highest Ethical Standards in Research and Education.

Universities and the government should pursue the highest ethical standards in the conduct of research. They should continually be alert to the ways in which new ethical issues arise as science and technology advance, and as universities become more closely associated with other sectors of our society. It is incumbent upon both partners to work ethically to expand and deepen our ethical understanding and conduct, in concert with the advances of research and the revitalization of the partnership.
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