# Tilting at Windmills

Policy Battles Won, Lost, or Long Since Forgotten

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Dedication to all those
frustrated policy wonks...

# Preface

*God, grant me the serenity*
*to accept things I cannot change,*
*the courage to change the things I can,*
*and the wisdom to know the difference.*

Reinhold Neibuhr

People usually think of careers as a university professor as a continuous progression from an energetic young scholar with lots of original ideas evolving over the years of teaching and writing into an obsolete and occasionally senile old curmudgeon teaching the same course from the same set of yellowed notes. Yet there is as much evolution in the nature of these careers as in any other profession as faculty members frequently take on additional roles of administration, consultation, and service.

In my own case, this evolution occurred on an unusually rapid pace, since my traditional faculty role as a teacher and scholar lasted only a decade before I was thrust into the leadership role of dean of an engineering college with 5,000 students and 300 faculty members. Although continuing into other administrative roles as provost and then president of the University of Michigan, I was also quickly drawn into significant public policy roles, with the appointment by President Reagan to the National Science Board in 1984 (which I was later to chair) and election to the National Academy of Engineering in 1987, following by both service and chairing many of its boards and studies through the National Research Council. The visibility of these roles rapidly cascaded into other policy activities with various federal agencies (e.g., National Science Foundation, Department of Energy, Department of Education, NASA, the National Intelligence Community) and nonprofit organizations (e.g., the Brookings Institution, higher education groups such as AAU and APLU, and numerous state-based organizations).

Indeed, looking back now, I realize that roughly 80% (40 years) of my career has been involved as much in leading a broad array of policy studies as in the more usual activities of the academy (e.g., teaching, research, and academic leadership).

Hence it seemed an interesting exercise to attempt to look back over these many projects and studies to assess their impact–what was recommended, what gained traction, and what sank beneath the waves without making a ripple–i.e., to assess from this set of case studies of policy assignments what worked and what failed. Put another way, were these policy efforts simply a series of quixotic quests, tilting at one windmill after another, or did they actually accomplish something. Although I recognized that this could be a rather frustrating and disappointing exercise, perhaps it would at least be amusing if not educational.

The University of Michigan
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Table of Contents

Chapter 1

# Introduction

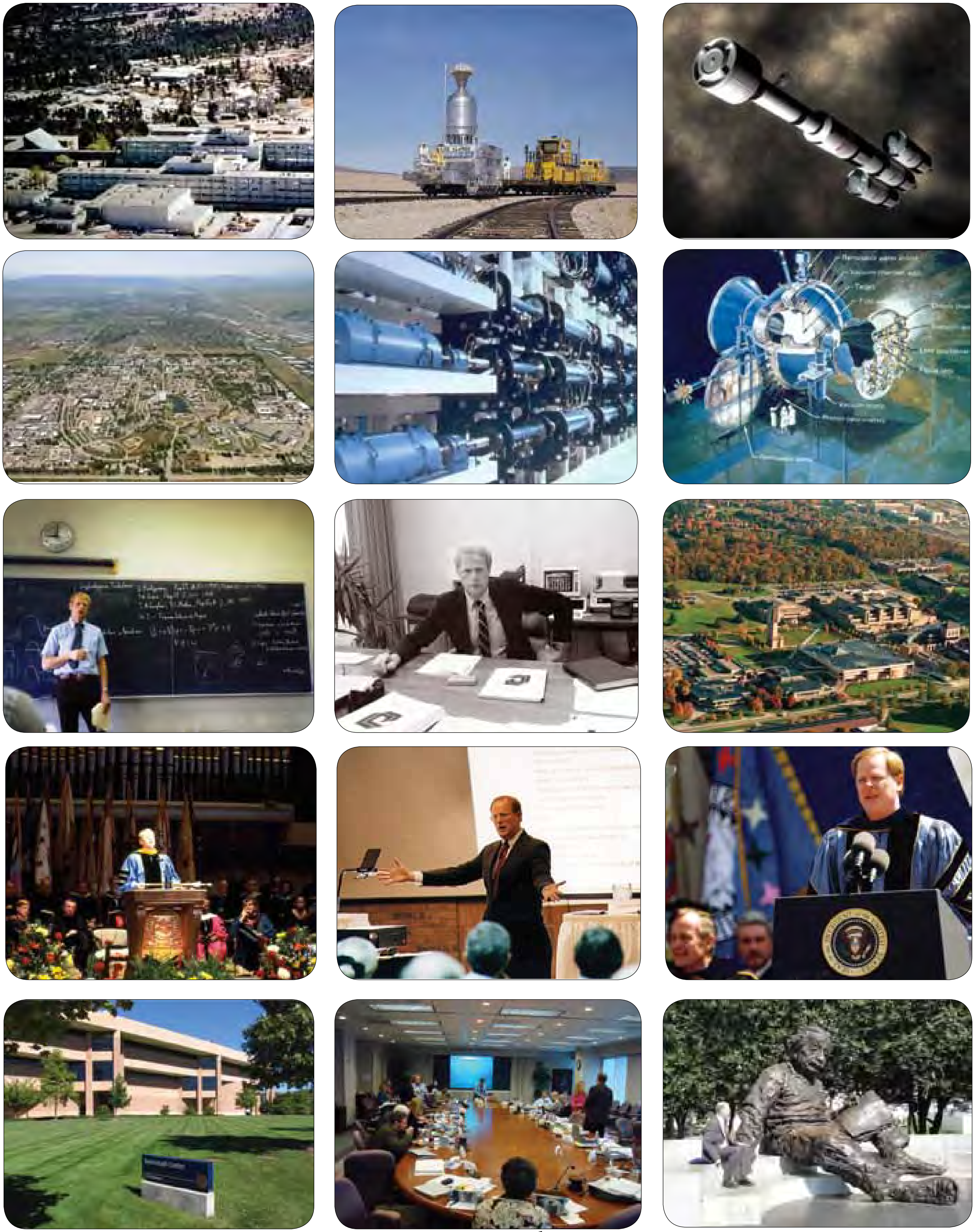
Looking back over a fifty-year career as a faculty member at the University of Michigan, it becomes apparent that while this has been anchored at the same institution for almost half-a-century, my activities have changed considerably every few years and broadened substantially to address issues at the national and global level during this career. Of course during the early years from 1964 to 1980, these were focused on the typical faculty activities of teaching and research in nuclear science and engineering, including brief stints at two major national laboratories, the Los Alamos National Laboratory and the Lawrence Livermore National Laboratory. Most of my teaching and research were involved theoretical studies of nuclear fission reactors and controlled thermonuclear fusion, with side ventures into statistical physics and high powered lasers. In addition to the usual production of publications (100) and PhD students (22 during this period), during the later years of the 1990s my activities broadened to include textbooks in nuclear science and engineering (five major textbooks) and television productions (including a 10 course sequence in nuclear engineering similar to today's MOOCs).

However my activities shifted dramatically in the 1980s with appointments first as Dean of Engineering in 1981, then as Provost of the University in 1986, and finally as the University's President in 1988, a post I held until 1996. Beyond the usual leadership responsibilities of academic administration, the University of Michigan's prominence as one of the world's leading research universities soon enabled me to assume an increasing level of activity in national science policy. In 1984 I was appointed by President Reagan to the National Science Board, serving for 12 years and eventually chairing this Board, regarded as one of the nation's leading sources of science policy. In addition, my election in 1985 as a member of the National Academy of Engineering, soon led to engagement with a large number of policy assignments with organizations such as the National Research Council, the NRC Committee on Science, Engineering, and Public Policy, the Executive Committee and Governing Board of the National Academies, as well as assignments with federal agencies such as the National Science Foundation, the National Aeronautics and Space Administration, the Departments of Energy, Education, and Commerce, and the National Intelligence Community. (A more complete list of these policy activities is provided as an appendix to this chapter.)

My experience as a scientist, engineer, and university academic leader at the University of Michigan led to chairing a broader range of policy activities, from higher education to economic development to global affairs to national security. Indeed, looking back now, I realize that roughly 80% (40 years) of my career has been involved as much in leading a broad array of policy studies as in the more usual activities of the academy (e.g., teaching, research, and leadership).

Hence it seemed an interesting exercise to attempt to look back over these many projects and studies to assess their impact–what was recommended, what gained traction, and what sank beneath the waves without making a ripple–i.e., to assess from this set of case studies of policy assignments what worked and what failed. Put another way, were these policy efforts simply a series of quixotic quests, tilting at one windmill after another, or did they actually accomplish something, recognizing that while this could be a rather frustrating and disappointing exercise, perhaps it would at least be amusing if not educational.

To be sure, there are many lessons to be learned from even failed causes. In such efforts, consistency



Career transitions over the years...

and perseverence can be as important as creativity and political acumen. It is essential to stay on message to both key constituencies and broader public bodies as well. Any uncertainty or wavering will rapidly erode support for your efforts. Fighting battles you know you are likely to lose is frustrating, to be sure. But it is also very important, since giving up the fight and walking away usually only makes things much worse. Besides, you might even make things better. Many apparently hopeless causes have been won. Sometimes, the key to progress is to continue to beat your head against the wall, until a window of opportunity is suddenly jarred open in what appears to be an immovable barrier.

## The Organization of this Report

In this report, these activities have been organized both by topic (e.g., general science and technology policy, economic development, education, national security, and global affairs; specific topics such as energy, information technology, and demographics; and even amusing topics such as intercollegiate athletics–both a serious threat to American higher education and a hopeless topic for corrective action. In several cases when policy studies of similar issues occurred over a period of time, these were pulled together. In each case, an effort is made to explain the nature of the study and its recommendations (usually quoting directly from the reports), then to add a personal assessment of impact, and finally to end each example with a few lessons learned–perhaps the most valuable contribution of this report.

## References

Deborah D. Stein, Science and Technology Policymaking: A Primer, CRS Reports for Congress, 2008

James J. Duderstadt, All Publications, University of Michigan, HathiTrust: http://www.hathitrust.org

## JJD Major Policy Activities

National Science Board

- 1982 University Industry Research
- 1986 Undergraduate S, M, E Education
- 1987 NSF in Polar Regions
- 1988 State of U.S. S&E
- 1989 Foreign Involvement in US Universities
- 1989 Loss of Biological Diversity
- 1992 A Foundation for the 21st Century
- 1993 Desktop to Teraflop
- 1994 State of US S&E
- 1995 K-12 STEM Education
- 1996 US S&E in Changing World
- 1998 Graduate Postdoc Education
- 1998 NSB Strategic Plan
- 2000 NSB History in Highlights
- 2006 NSF 2020 Strategic Plan

Other NSF Efforts

- Nuclear Engineering Minor Study
- Strategic Plan Input for NSF
- ACCI Reports

National Science Policy

- 1992 Chair, NSB Study of Future of NSF
- 1998 Federal Science and Technology Committee
- 1998 GUIRR-NSB Stresses on the Academy
  - 1999 Draft Proposal NSF NSB
  - 2000 FS&T Op Ed
  - 2002 Triana Satellite NASA Study
- 2001 Chair, COSEPUP Scientific Research in the States
- 2003 Chair, NAE Study of Engineering Research
- 2003 DOE Secretary Committee on Research
- 2006 Chair, NRC Review Committee for Keck Futures Program
- 2009 Member, President's Project Advisory Committee, FRIB
- 2010 Chair, Policy and Global Affairs Division, National Research Council

The role of the committee chair...including getting advice.

National Higher Education Policy

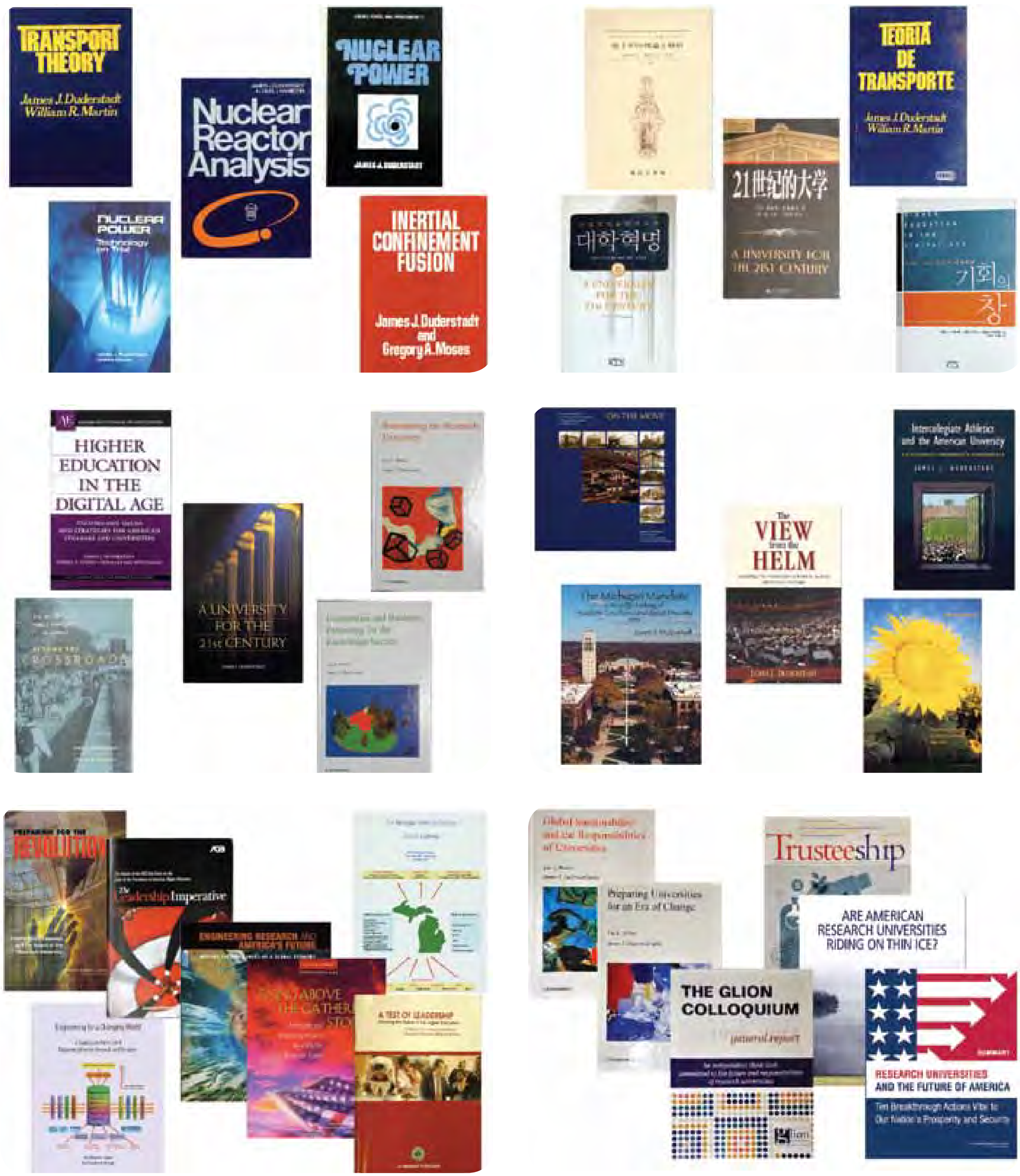
- 1990s Diversity (Michigan Mandate Leadership)
- 1994 Chair, NASULGC Federal Relations Committee
- 1994 Direct Student Lending Act
- 1995 BHEF Study with Red Poling
- 1998 President, Michigan Virtual University
- 1998 GUIRR-NSB Stresses on the Academy
- 1998 University for 21st Century
- 1999 Author, Intercollegiate Athletics
- 1999 Director, UM Oberlin Kalamazoo project 2000 NASULGC White Paper
- 2000 ACE Presidency
- 2000 EDARPA Letter
- 2001 COSEPUP EARPA
- 2005 Fixing the Fragmented University
- 2005 Framing Paper for Commission on Future of American Higher Education (Spellings Commission), Department of Education
- 2005 Spellings Commission Quality Subcommittee
- 2005 Member, Spellings Commission, Department of Education
- 2005 Member, Association of Governing Board Task Force on State of University Presidency
- 2005 Member, University of California Task Force on Compensation, Accountability, and Transparencies
- 2005 Member, Tulane University Post-Katrina Planning
- 2005 Learn Grant Act
- 2005 Diversity in Science and Technology
- 2007 Member, Evolution of the Research University Project, National Research Council
- 2007 Member, Association of Governing Boards, Miller Center, Public Purpose
- 2010 Member, National Academies Study of Research Universities
- 2010 Director, Chicago Council Higher Education Master Plan for Great Lakes States
- 2011 New School Conference
- 2012 De Lange Rice Convocation JJD
- 2012 National Academies Report on Future of American Research University
- 2013 National Academies Research University Project, Phase II, The States
- 2013, National Academies Research University National Convocation
- 2014, National Academies Research University Projec, Phase III

Economic Development

- 1999 Ontario Master Plan
- 2003 Regional Learning Ecologies
- 2004 Member, KC Project Team, Time to Get It Right
- 2004 Member, Great Lakes Brookings Project
- 2005 Chair, Michigan Energy Research Council
- 2005 Gathering Storm
- 2005 Michigan Roadmap
- 2005 Time to Get It Right KC
- 2005 Member, Great Lakes Brookings Study
- 2006 Member, Advisory Committee, New Economy Initiative for Michigan
- 2007 Chair, Brookings Next Energy Project
- 2007 Member, Chicago Council study of Regional Economic Development
- 2007 Chicago Midwest Media Project
- 2007 Michigan Roadmap Redux
- 2008 Chair, Study to Assess Economic Progress of Greater KC
- 2009 Kansas City–time-to-get-it-right-Update
- 2010 Brookings Hubs of Innovation
- 2010 Director, Chicago Council HE Master Plan
- 2011 Midwest Master Plan Launch
- 2011 Midwest Master Plan Heartland Paper

Information Technology and Cyberinfrastructure

- 1999 Scholarship in the Digital Age
- 2001 IT and Future of Research University
- 2004 IT Forum
- 2003 Preparing for the Revolution
- 2005 Cyberinfrastructure Advisory Committee, NSF
- 2011 Festshrift for Dan Atkins
- 2011 NSF DLI Conference
- 2011 Future of the DC
- 2012 NSF DLI Workshop Description




The evolution of activities from science to education to policy
can be seen in the changing nature of the books published.

Engineering

2003 NAE Study of Engineering Research
2004 21st Century Engineering
2005 Engineering Research and America Future
2005 PI NSF, Flexner - 21st Century Engineering
2007 5XME Workshop
2007 Engineering Flexner Report
2008 ABET Effort
2008 NAE Study of Lifelong Engineering Learning
2009 Brookings Energy Report
2012 Member, NAE, Educate to Innovate Study

## Energy-General

2003 DOE Secretary Committee on Research
2003 DOE-SC SWOT Analysis
2003 DOE_Task_Force
2005 Phoenix Energy Institute
2007 Brookings Next Energy Project
2009 Brookings Energy Report
2011 Glion VIII Duderstadt Black Swans
2012 Member, Review of UT Fracking Study

## Energy-Nuclear

1999 Nuclear Energy Research Advisory Committee
2000 NERAC Testimony
2001 Nuclear Engineering Minor Program
2004 Energy France
2004 Vest Report Secretary of Energy
2009 Member, President's Project Advisory Committee,Facility for Rare Ion Beams
2012 Chair, Board of Directors, CASL Energy Innovation Hub, Department of Energy

International Issues

1989 UM International Center
1992 Michigan Tree Tops Strategy for State Support
2002 JAPAN Revised2
2002 Nagoya Keynote Lecture
2003 UM Co-Chair, World University Workshop
2005 Canadian Provosts
2007 Salzburg Paradigms
2008 Co-Chair, NSF Roundtable for Global Sustainability

Glion Colloquium Topics

1999_Glion_I_Challenges_Facing_HE
2001_Glion_II_University_Governance
2002_Glion_III_Walls_Come_Tumbling_Down
2003_Glion_IV_Reinventing_the_University
2005_Glion_V_Universities_and_Business
2007_Glion_VI_Globalization_of_HE
2009_Glion_VII_Universities_and_Innovation
2012_Glion_VIII_Global Sustainability
2013 Glion IX Sustainability of Research University Paradigm

Game-Changers and Paradigm Shifts

1999 Activities of the Millennium Project
2013: The View from the Oort Cloud
2013: Game Changers and Paradigm Shifts
2013: The Third Century

Intercollegiate Athletics

1990 Mainstreaming Athletics
2003 Sports Book Epilogue

Specific Universities

1997 Georgia Tech Planning
1997 Iowa State
1998 Texas A&M ideas
1999 Henry Lecture
2003 U Missouri Strategy
2003 Ohio State Talk
2003 UCLA Higher Ed Future
2003 UNC Chapel Hill Talk
2003 USC Strategy
2004 UCSC Accreditation Assessment
2007 UC Compensation Task Force
2002 Oberlin COHFE
2009 Dartmouth Commencement
2010 ASU Grand Challenges
2010 U Hawaii Strategy
2011 UIUC Strategy
2011 CIC Innovation Conference

Advisory Committees

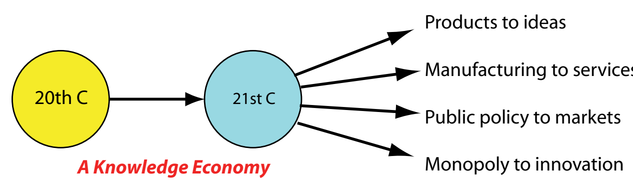
- MIT
- Caltech
- Yale
- Georgia Tech
- U Texas
- State of Ohio
- U Missouri
- UC System
- UC Davis
- UI Chicago
- SUNY Research Foundation

Chapter 2

# An Environmental Scan

All policy studies are clearly shaped by the context of issues characterizing the period during which they were conducted. Since this report is looking back over four decades of such efforts, it seemed appropriate to begin with an "environmental scan" to provide an appropriate framework. Indeed, such an exercise is included as the first step in many of the studies themselves.

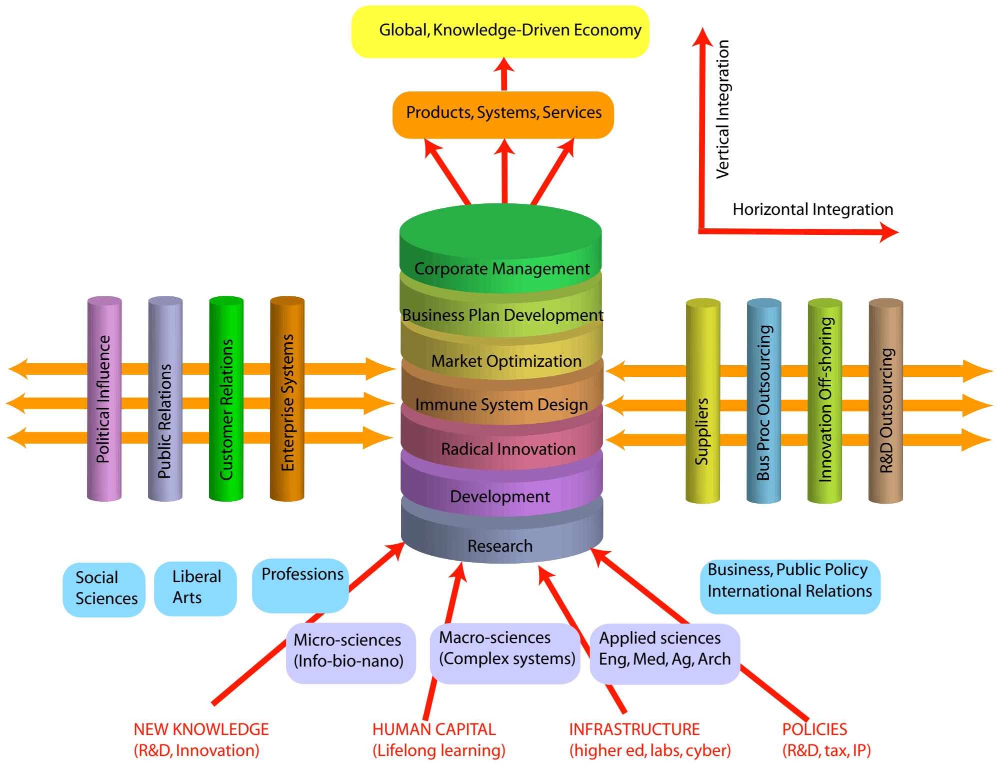
Looking back over history, one can identify certain abrupt changes, discontinuities in the nature, the fabric, of our civilization. Clearly we live in a time of such great change, an increasingly global society, driven by the exponential growth of new knowledge and knitted together by rapidly evolving information and communication technologies. It is a time of challenge and contradiction, as an ever-increasing human population threatens global sustainability; a global, knowledge-driven economy places a new premium on technological workforce skills through phenomena such as outsourcing and off-shoring; governments place increasing confidence in market forces to reflect public priorities even as new paradigms such as open-source software and open-content knowledge and learning challenge conventional free-market philosophies; and shifting geopolitical tensions are driven by the great disparity in wealth and power about the globe, manifested in the current threat to homeland security by terrorism. Yet it is also a time of unusual opportunity and optimism as new technologies not only improve the human condition but also enable the creation and flourishing of new communities and social institutions more capable of addressing the needs of our society.




## The Age of Knowledge

Looking back over history, one can identify certain abrupt changes, discontinuities in the nature, the fabric, of our civilization. Clearly we live in just such a time of very rapid and profound social transformation, a transition from a century in which the dominant human activity was transportation to one in which communication technology has become paramount, from economies based upon cars, planes, and trains to one dependent upon computers and networks. We are shifting from an emphasis on creating and transporting physical objects such as materials and energy to knowledge itself; from atoms to bits; from societies based upon the geopolitics of the nation-state to those based on diverse cultures and local traditions; and from a dependence on government policy to an increasing confidence in the marketplace to establish public priorities.

Today we are evolving rapidly into a post-industrial, knowledge-based society as our economies are steadily shifting from material- and labor-intensive products and processes to knowledge-intensive products and services. A radically new system for creating wealth has evolved that depends upon the creation and application of new knowledge. Unlike natural resources, such as iron and oil, which have driven earlier economic transformations, knowledge is inexhaustible. The more it is used, the more it multiplies and expands. But knowledge can be created, absorbed, and applied only by the educated mind. The knowledge



The way the global knowledge-driven economy works

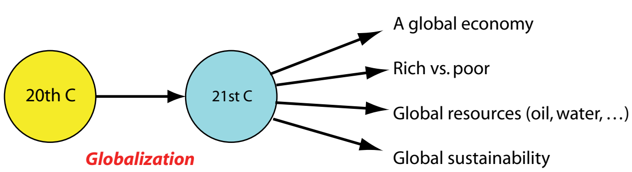
economy is demanding new types of learners and creators and new forms of learning and education.

As a survey in *The Economist* put it, “The value of ‘intangible’ assets–everything from skilled workers to patents to know-how–has ballooned from 20 percent of the value of companies in the S&P 500 to 70 percent today. The proportion of American workers doing jobs that call for complex skills has grown three times as fast as employment in general”. (*The Economist*, 2006) Economists estimate that 40 to 60 percent of economic growth each year is due to research and development activity, particularly in American universities. Another 20 percent of the increased resources each year are based upon the rising skill levels of our population. In other words, 60 to 80 percent is really dependent upon higher education in terms of research and development and skills of the labor force. (Augustine, 2005)

Nations are investing heavily and restructuring their economies to create high-skill, high-pay jobs in knowledge-intensive areas such as new technologies, financial services, trade, and professional and technical services. From Paris to San Diego, Bangalore to Shanghai, there is a growing recognition throughout the world that economic prosperity and social well being in a global knowledge-driven economy requires public investment in knowledge resources. That is, regions must create and sustain a highly educated and innovative workforce and the capacity to generate and apply new knowledge, supported through policies and investments in developing human capital, technological innovation, and entrepreneurial skill. Nations both large and small, from Finland to China, are reaping the benefits of such investments aimed at stimulating and exploiting technological innovation, creating serious competitive challenges to American industry and business both in the conventional marketplace (e.g., automobiles) and through new paradigms such as the off-shoring of knowledge-intensive services (e.g. software development).

In the knowledge economy, the key asset driving corporate value is no longer physical capital or unskilled labor. Instead it is intellectual and human capital. An increasingly utilitarian view of higher education is reflected in public policy. Education is becoming a powerful political force. Just as the space race of the 1960s stimulated major investments in research and education, there are early signs that the skills race of the 21st Century may soon be recognized as the dominant domestic policy issue facing our nation. But there is an important difference here. The space race galvanized public concern and concentrated national attention on educating "the best and brightest," the academically elite of our society. The skills race of the 21st Century will value instead the skills and knowledge of our entire workforce as a key to economic prosperity, national security, and social well-being. The National Governors Association concludes that, "The driving force behind the 21st Century economy is knowledge, and developing human capital is the best way to ensure prosperity." Some governors are even taking the courageous step of proposing tax increases to fund new investments in higher education, research, and innovation. (NGA, 2007)

Perhaps former University of California president Clark Kerr stated it best a half-century ago: "The basic reality for the university is the widespread recognition that new knowledge is the most important factor in economic and social growth, and since that is the university's invisible product, it may be the most powerful single institution in our culture." (Kerr, 1963)




## Globalization

Whether through travel and communication, through the arts and culture, or through the internationalization of commerce, capital, and labor, or our interconnectness through common environmental concerns, the United States is becoming increasingly linked with the global community. The liberalization of trade and investment policies, along with the revolution in information and communications technologies, has vastly increased the flow of capital, goods, and services, dramatically changing the world and our place in it. Today globalization determines not only regional prosperity but also national and homeland security. Our economy and companies are international, spanning the globe and interdependent with other nations and other peoples.

Most policy issues are shaped by their global character.

A truly domestic United States economy has ceased to exist. It is no longer relevant to speak of the health of regional economies or the competitiveness of American industry, because we are no longer self-sufficient or self-sustaining. Our economy and many of our companies are international, spanning the globe and interdependent with other nations and other peoples. Worldwide communication networks have created an international market, not only for conventional products, but also for knowledge professionals, research, and educational services.

As the report of the National Intelligence Council's 2020 Project has concluded, "The very magnitude and speed of change resulting from a globalizing world-apart from its precise character–will be a defining feature of the world out to 2020. During this period, China's GNP will exceed that of all other Western economic powers except for the United States, with a projected population of 1.4 billion. India and Brazil will also likely surpass most of the European nations. Globalization–the growing interconnectedness reflected in the expanded flows of information, technology, capital, goods, services, and people throughout the world–will become an overarching mega-trend, a force so ubiquitous that it will substantially shape all other major trends in the world of 2020" (National Intelligence Council, 2004).

In his provocative book The World Is Flat, Tom Friedman warns that "Some three billion people who were excluded from the pre-Internet economy have now walked out onto a level playing field, from China, India, Russia, Eastern Europe, Latin American, and Central Asia. It is this convergence of new players, on a new playing field, developing new processes for horizontal collaboration, that I believe is the most important force shaping global economics and politics in the early 21st century" (Friedman, 2005). Or as Craig Barrett, CEO of Intel, puts it: "You don't bring three billion people into the world economy overnight without huge consequences, especially from three societies like India, China, and Russia, with rich educational heritages."

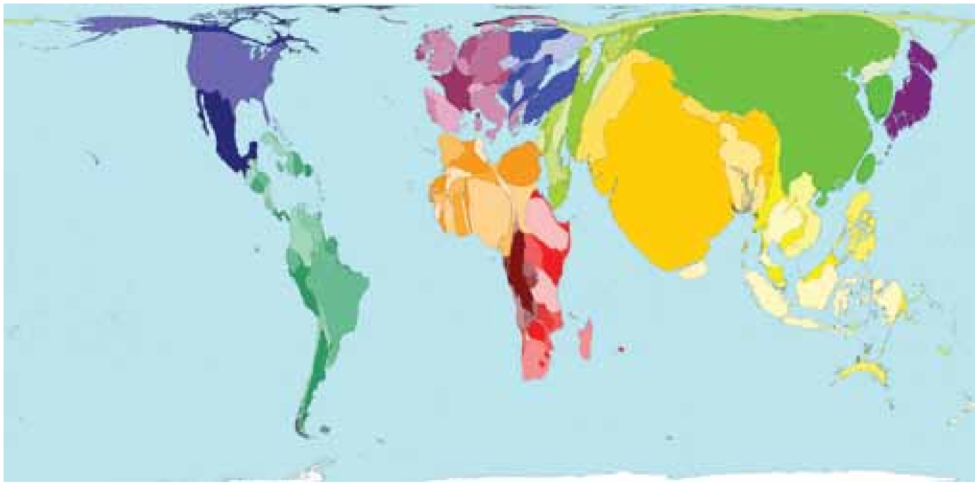
Of course, some would contend that rather than flattening, world economic activity is actually becoming more peaked about concentrations of knowledge-workers and innovation centers. Others suggest that rapidly evolving information and communications are enabling the participation of billions "at the bottom of the economic pyramid" through microeconomic transactions (Prahalad, 2005). But whether interpreted as a flattening of the global playing field or a peaking about concentrations of innovation, most nations have heard and understood the message about the imperatives of the emerging global knowledge economy. They are investing heavily and restructuring their economies to create high-skill, high-pay jobs in knowledge-intensive areas such as new technologies, financial services, trade, and professional and technical services. From Dublin to Prague, Bangalore to Shanghai, there is a growing recognition throughout the world that economic prosperity and social well being in a global knowledge-driven economy require public investment in knowledge resources. That is, regions must create and sustain a highly educated and innovative workforce and the capacity to generate and apply new knowledge, supported through policies and investments in developing human capital, technological innovation, and entrepreneurial skill.

Today's global corporation conducts its strategy, management, and operations on a global scale. The multinational organization has evolved far beyond a collection of country-based subsidiaries to become instead a globally integrated array of specialized components–procurement, management, R&D, manufacturing, sales, etc.–distributed through the world, wherever attractive markets exist and skilled workers can be found. Geopolitical borders are of declining relevance to global business practices. Global corporations are showing less loyalty to countries of origin and more to regions in which they find new markets and do business (Palmisano, 2006).

It is this reality of the hyper-competitive, global, knowledge-driven economy of the 21st Century that is stimulating the powerful forces that will reshape the nature of our society and our knowledge institutions. Again to quote Friedman, "Information and telecommunications technologies have created a platform where intellectual work and intellectual capital can be delivered from anywhere–disaggregated, delivered, distributed, produced, and put back together again, or in current business terms and this gives an entirely new freedom to the way we do work, especially work of an intellectual nature". Today rapidly evolving technologies and sophisticated supply chain management are allowing "global sourcing", the ability to outsource not only traditional activities such as low-skill manufacturing, but to offshore essentially any form of knowledge work, no matter how sophisticated, to whatever part of the globe has populations most capable and cost-effective to perform it. Put another way, "The playing field is being leveled. Countries like India and China are now able to compete for global knowledge work as never before. And America had better get ready for it" (Friedman, 2005).

Clearly, today's companies require new skills and competence that address the challenges and opportunities of globally integrated business. This has particularly serious implications for the future of engineering, since not only must engineers develop the capacity to work with multinational teams and be internationally mobile, but they also must appreciate the great diversity of cultures characterizing both the colleagues they work with and the markets they must compete in. Furthermore, the American engineer faces the additional challenge of competing globally with engineers of comparable talents and determination in economies with considerably lower wage structures.

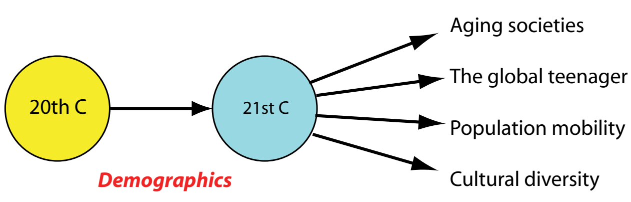
In such a global economy, it is critical that nations not only have global reach into markets abroad, but also have the capacity to harvest new ideas and inno-



The distribution of the world's population represented by the distorted size of nations. (Worldmapper, 2005)

vation and to attract talent from around the world. Interestingly enough, perhaps the best way to do this is to invest in flagship research universities, since these are truly international institutions. They reflect a strong international character among their students, faculty, and academic programs. These institutions also stand at the center of a world system of learning and scholarship. They are the magnets states use to attract new talent, new industry, and new resources from around the world.

Globalization requires thoughtful, interdependent and globally identified citizens. New technologies are changing modes of learning, collaboration and expression. And widespread social and political unrest compels educational institutions to think more concertedly about their role in promoting individual and civic development.




## Demographics

Regions face numerous challenges in positioning themselves for prosperity in the global economy, among them changing demographics, limited resources, and cultural constraints. The populations of most developed nations in North America, Europe, and Asia are aging rapidly where over the next decade the percentage of the population over 60 will grow to over 30% to 40%. Half of the world's population today lives in countries where fertility rates are not sufficient to replace their current populations, e.g. the average fertility rate in EU has dropped to 1.45, below the 2.1 necessary for a stable population. Aging populations, out-migration, and shrinking workforces are having an important impact, particularly in Europe, Russia, and some Asian nations such as Japan, South Korea, and Singapore. The implications are particularly serious for schools, colleges, and universities that now experience not only aging faculty, but excess capacity that could lead to possible closure.

In sharp contrast, developing nations in Asia, Africa, and Latin America are characterized by young and growing populations in which the average age is less than 20. Here the demand for education is staggering since in a knowledge economy, it is clear to all that this is the key to one's future security. Unless developed nations step forward and help address this crisis, billions of people in coming generations will be denied the education so necessary to compete in, and survive in, the knowledge economy. The resulting despair and hopelessness among the young will feed the terrorism that so threatens our world today.

Today we see a serious imbalance between educational need and educational capacity–in a sense, many of our universities are in the wrong place, where populations are aging and perhaps even declining rather than young and growing. This has already triggered some market response, with the entry of for-profit providers of higher education (e.g., Laureate, Apollo) into providing higher education services on a global basis through acquisitions of existing institutions or distance learning technologies. It also is driving the interest in new paradigms such as the Open Education Resources movement. (Atkins, 2007) Yet, even if market forces or international development efforts are successful in addressing the urgent educational needs of the developing world, there are also concerns about whether there will be enough jobs to respond to a growing population of college graduates in many of these regions.

Growing disparities in wealth and economic opportunity, frequently intensified by regional conflict, continue to drive population migration. The flow of workers across the global economy seeking prosperity and security presents further challenges to many nations. The burden of refugees and the complexity of absorbing immigrant cultures are particularly apparent in Europe and North America. There is another demographic fact of life that need concern us: The United Nations now projects the Earth's population in the year 2050 as 9.1 billion, 50% larger than today. Which of course raises the logical question: Can we sustain a population of that magnitude on Spaceship Earth? This is an issue to which I will return momentarily.

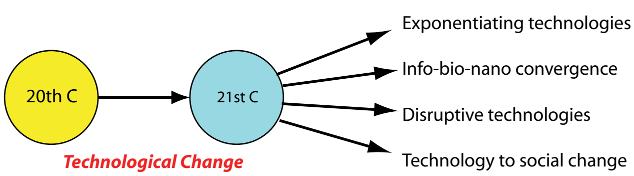
America's population is changing rapidly today. One of the most significant demographic trends in the country is that our population is getting older; the baby boomers are approaching retirement, and the number of young adults is declining. In the U.S., there are already more people over the age of sixty-five than teenagers in this nation, and this situation will continue for decades to come. In our lifetime the United States will not again be a nation of youth, in sharp contrast to the developing nations in Asia, Africa, and Latin America, where the average age is less than 20.

Immigration is the principal reason why the United States stands apart from much of the rest of the developed world with respect to our demographic challenges. Like Europe and parts of Asia, our population is aging, but our openness to immigration will drive continued growth in our population from 300 million today to over 450 million by 2050. Today differential growth patterns and very different flows of immigration from Asia, Africa, Latin America, the Caribbean, and Mexico are transforming our population. In fact, over the past decade, immigration from Latin America and Asia contributed 53% of the growth in the United States population exceeding that provided by births (National Information Center, 2006). As it has been so many times in its past, America is once again becoming a nation of immigrants, benefiting greatly from their energy, talents, and hope, even as such mobility changes the ethnic character of our nation. By the year 2030 current projections suggest that approximately 40% of Americans will be members of racial or ethnic minority groups. By mid-century we will cease to have any single majority ethic group. By any measure, we are evolving rapidly into a truly multicultural society with a remarkable cultural, racial, and ethnic diversity. This demographic revolution is taking place within the context of the continuing globalization of the world's economy and society that requires Americans to interact with people from every country of the world.

While such immigrants bring to America incredible energy, talents, and hope, and continue to diversify the ethnic character of our nation, this increasing diversity is complicated by social, political, and economic factors. The full participation of immigrants and other underrepresented ethnic groups continues to be hindered by the segregation and non-assimilation of minority cultures and backlash against long-accepted programs designed to achieve social equity (e.g., affirmative action in college admissions). Furthermore, since most current immigrants are arriving from developing regions with weak educational capacity, new pressures have been placed on U.S. educational systems for the remedial education of large numbers of non-English speaking students.

Largely as a consequence of immigration, the United States is rapidly becoming one of the most pluralistic, multicultural nations on earth. Those groups we refer to today as "minorities" will become the majority population of our nation in the century ahead, just as they are today throughout the world and in an increasing number of states, including California, Arizona, and Texas, The increasing diversity of the American population with respect to race, ethnicity, gender and nationality is both one of our greatest strengths and most serious challenges as a nation. A diverse population gives us great vitality. However the challenge of increasing diversity is complicated by social and economic factors. Far from evolving toward one America, our society continues to be hindered by the segregation and non-assimilation of minority cultures. Our society is challenging in both the courts and through referendum long-accepted programs such as affirmative action and equal opportunity aimed at expanding access to higher education to underrepresented communities and diversifying our campuses and workplaces. (Economist, 2005)

In this future, the full participation of currently underrepresented minorities will be of increasing concern as we strive to realize our commitment to equity and social justice. The achievement of this objective also will be the key to the future strength and prosperity of America, since our nation cannot afford to waste the human talent presented by its minority populations. If we do not create a nation that mobilizes the talents of all of our citizens, we are destined for a diminished role in the global community and increased social turbulence. Most tragically, we will have failed to fulfill the promise of democracy upon which this nation was founded.




## Technological Change

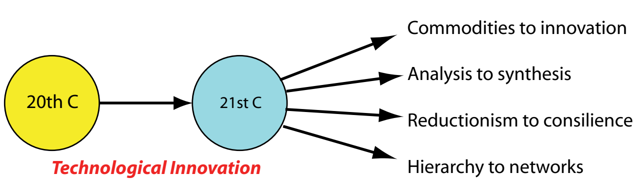
The new technologies driving such profound changes in our world–information technology, biotechnology, and nanotechnology–evolve at an exponential pace. For example, the information and communications technologies enabling the global knowledge economy double in power for a given cost every year or so, amounting to a staggering increase in capacity of 100 to 1,000 fold every decade. Computer scientists and engineers believe this trend will continue for the foreseeable future, suggesting that these technologies will become a thousand, a million, and a billion times more powerful as the decades pass. (Reed, 2005; Kuzweil, 2006)

In particular, the fundamental intellectual activities of discovery and learning enabling the knowledge economy are being transformed by the rapid evolution of information and communications technology. Although many technologies have transformed the course of human history, the pace and impact of digital information technology is unprecedented. In little more than half a century, we have moved from mammoth computer temples with the compute power of a digital wristwatch to an ecosystem of billions of microelectronic devices, linked together at nearly the speed of light, executing critical complex programs with astronomical quantities of data. Rapidly evolving digital technology has played a particularly important role in expanding our capacity to generate, distribute, and apply knowledge. It has become an indispensable platform for discovery, innovation, and learning. Information and communications services are increasingly delivered as a utility, much like electricity, from remote data centers and networks. Both hardware and software are now moving into massive network "clouds" managed by providers, such as Microsoft, Google, and Amazon. They provide not only global connectivity to organizations (e.g., corporations, governments, and universities) but also to individuals in rapidly changing forms, such as instant messaging, televideo, crowd sourcing, and affinity communities.

Titan supercomputer (Oak Ridge National Laboratory)

As Brynjolfsson and McAfee suggest, information technology is both quantitatively and qualitatively different in character since it evolves exponentially (Moore's Law), is easily and cheaply reproduced because of its digital character, and is highly recombinant through networks and ubiquitous access. (Brynjolfsson, 2013) More generally it is becoming increasingly clear that we are approaching an inflection point in the potential of rapidly evolving information and communications technology to transform how the scientific and engineering enterprise does knowledge work, the nature of the problems it undertakes, and the broadening of those able to participate in research activities. To quote Arden Bement, former director of the National Science Foundation, "We are entering a second revolution in information technology, one that may well usher in a new technological age that will dwarf, in sheer transformational scope and power, anything we have yet experienced in the current information age". (Bement, 2007)

Beyond acknowledging the extraordinary and unrelenting pace of such exponentially evolving technologies, it is equally important to recognize that they are disruptive in nature. Their impact on social institutions such as corporations, governments, and learning institutions is profound, rapid, and quite unpredictable. As Clayton Christensen explains in his book, *The Innovator's Dilemma*, while many of these new technologies are at first inadequate to displace today's technology in existing applications, they later explosively displace the application as they enable a new way of satisfying the underlying need. (Christensen, 1997) If change is gradual, there will be time to adapt gracefully, but that is not the history of disruptive technologies. Hence organizations–and states, regions, and nations–must work to anticipate these forces, develop appropriate strategies, and make adequate investments if they are to prosper–indeed, survive–such a period. Procrastination and inaction (not to mention ignorance and denial) are the most dangerous of all courses during a time of rapid technological change.

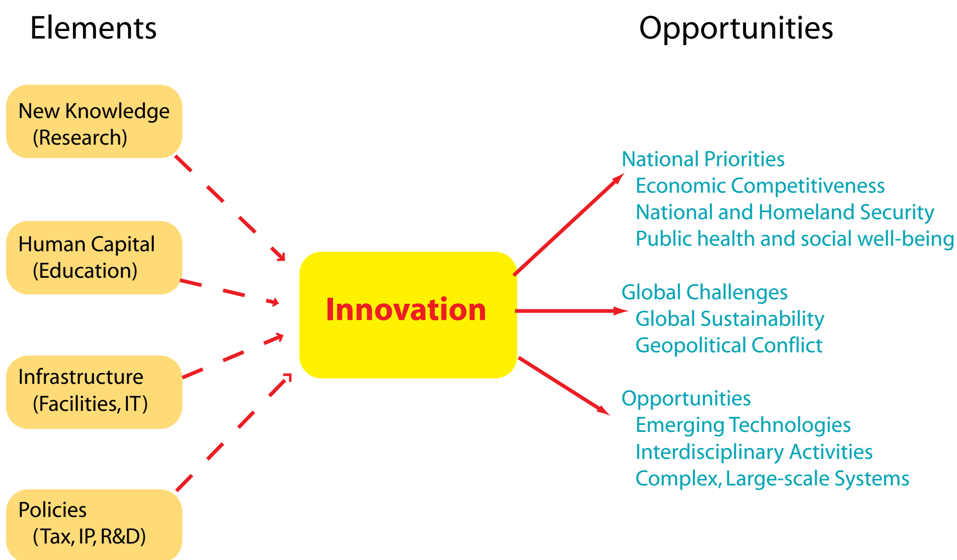



## Technological Innovation

In its major study, Rising Above the Gathering Storm (Augustine, 2005), the National Academies of Science, Engineering, and Medicine highlight innovation as the single most important factor in determining America's success throughout the 21st century. "American's challenge is to unleash its innovation capacity to drive productivity, standard of living, and leadership in global markets. At a time when macro-economic forces and financial constraints make innovation-driven growth a more urgent imperative than ever before, American businesses, government, workers, and universities face an unprecedented acceleration of global change, relentless pressure for short-term results, and fierce competition from countries that seek an innovation-driven future for themselves. For the past 25 years we have optimized our organizations for efficiency and quality. Over the next quarter century, we must optimize our entire society for innovation" (Council on Competitiveness, 2005).

Of course innovation is more than simply new technologies. It involves how business processes are integrated and managed, how services are delivered, how public policies are formulated, and how markets and more broadly society benefit (Lynn, 2007). However it is also the case that in a global, knowledge-driven economy, technological innovation–the transformation of new knowledge into products, processes, and services of value to society–is critical to competitiveness, long-term productivity growth, and an improved quality of life. The National Intelligence Council's 2020 Project concludes, "the greatest benefits of globalization will accrue to countries and groups that can access and adopt new technologies" (National Intelligence Council, 2004). This study notes that China and India are well positioned to become technology leaders, and even the poorest countries will be able to leverage prolific, cheap technologies to fuel–although at a slower rate–their own development. It also warns that this transition will not be painless and will hit the middle classes of the developed world in particular, bringing more rapid job turnover and requiring professional retooling. Moreover, future technology trends will be marked not only by accelerating advancements in individual technologies but also by a force-multiplying convergence of the technologies–information, biological, materials, and nanotechnologies–that have the potential to revolutionize all dimensions of life.

In summary, the 2020 Project warns that "A nation's or region's level of technological achievement generally will be defined in terms of its investment in integrating




The role of technological innovation in the knowledge economy

and applying the new globally available technologies–whether the technologies are acquired through a country's own basic research or from technology leaders. Nations that remain behind in adopting technologies are likely to be those that have failed to pursue policies that support application of new technologies–such as good governance, universal education, and market reforms–and not solely because they are poor."

This has been reinforced by a recent study by the National Academy of Engineering that concludes, "American success has been based on the creativity, ingenuity, and courage of innovators, and innovation that will continue to be critical to American success in the twenty-first century. As a world superpower with the largest and richest market, the United States has consistently set the standard for technological advances, both creating innovations and absorbing innovations created elsewhere" (Duderstadt, 2005).

It is certainly true that many of the characteristics of our nation that have made the United States such a leader in innovation and economic renewal remain strong: a dynamic free society that is continually renewed through immigration; the quality of American intellectual property protection and the most flexible labor laws in the world, the best regulated and most efficient capital markets in the world for taking new ideas and turning them into products and services, open trade and open borders (at least relative to most other nations), and universities and research laboratories that are the envy of the world. If all of this remained in place, strong and healthy, the United States would continue to remain prosperous and secure, even in the face of an intensely competitive global knowledge economy. We would continue to churn out the knowledge workers, the ideas and innovation, and the products and services (even if partially outsourced) that would dominate the global marketplace.

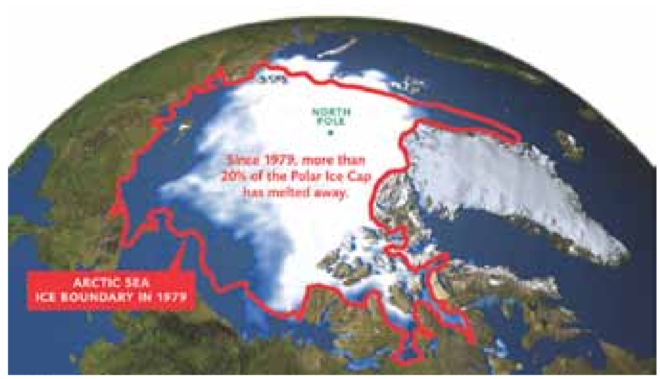
But today many nations are investing heavily in the foundations of modern innovation systems, including research facilities and infrastructure and a strong technical workforce. Unfortunately, the United States has failed to give such investments the priority they deserve in recent years. The changing nature of the international economy, characterized by intense competition coexisting with broad-based collaboration and global supply chains and manifested in unprecedented U.S. trade deficits, underscores long-standing weaknesses in the nation's investment in the key ingredients of technological innovation: new knowledge (research), human capital (education), and infrastructure (educational institutions, laboratories, cyberinfrastructure). Well-documented and disturbing trends include: skewing of the nation's research priorities away from engineering and physical sciences and toward the life sciences; erosion of the engineering research infrastructure; a relative decline in the interest and aptitude of American students for pursuing education and training in engineering and other technical fields; and growing uncertainty about our ability to attract and retain gifted science and engineering students from abroad at a time when foreign nationals constitute a large and productive fraction of the U.S. R&D workforce.

## Tomorrow's Possibilities

### Global Sustainability

While history has always been characterized by periods of both change and stability – war and peace, intellectual progress and decadence, economic prosperity and contraction – today the pace and magnitude of such changes have intensified, driven by the powerful forces of globalization, changing demographics, rapidly evolving technologies and the expanded flows of information, technology, capital, goods, services and people worldwide. Economies are pushing the human exploitation of the Earth's environment to the limits; the military capacity of the great powers could destroy the world population many times over, business corporations have become so large that they can influence national policies, the financial sector has become so complex and unstable that it has the capacity to trigger global economic catastrophes in an instant, and corrupted regimes leading to failed states still appear in all parts of the world. Many believe that the impact of human activities, ever more intense, globally distributed and interconnected, threatens the very sustainability of humankind on Earth, at least in terms that we currently understand and enjoy.

While the fruits of development and modernity are indisputable, the negative consequences of these recent developments appear to be increasingly serious. For example, there is compelling evidence that the growing population and invasive activities of humankind are now altering the fragile balance of our planet. The concerns are multiplying in number and intensifying in severity: the destruction of forests, wetlands and other natural habitats by human activities, the extinction of millions of species and the loss of biodiversity; the buildup of greenhouse gases and their impact on global climates; the pollution of our air, water and land. We must find new ways to provide for a human society that presently has outstripped the limits of global sustainability.




The melting of Arctic summer ice is a sign of how serious global warming has become.

So, too, the magnitude, complexity, and interdependence (not to mention accountability) of business practices, financial institutions, markets and government policies now threaten the stability of the global economy, as evidenced by the impact of complex financial instruments and questionable market incentives in triggering the collapse of the global financial markets that led to the "Great Recession" of 2008-2009. Again, the sustainability of current business practices, government policies and public priorities must be questioned.

Of comparable concern are the widening gaps in prosperity, health and quality of life characterizing developed, developing and underdeveloped regions. To be sure, there are some signs of optimism: a slowing population growth that may stabilize during the 21st century, technological advances such as the "green revolution" that have fed much of the world, and the rapid growth of developing economies in Asia and Latin America. of the world's population from extreme poverty. Yet it is estimated that one-sixth of the world's population still live in extreme poverty, suffering from diseases such as malaria, tuberculosis, AIDS, diarrhea and others that prey on bodies weakened by chronic hunger, claiming more than 20,000 lives daily. These global needs can only be addressed by the commitment of developed nations and the implementation of technology to alleviate poverty and disease.

The world's research universities have for many years been actively addressing many of the important issues associated with global sustainability. The "green revolution" resulting from university programs in agricultural science has lifted a substantial portion of the world's population from the ravages of extreme poverty. University scientists were the first to alert the world to the impact of human activities on the environment and climate, e.g., the impact of CFCs on atmospheric ozone depletion; the destruction of forests, wetlands and other natural habitats by human activities leading to the extinction of thousands of biological species and the loss of biodiversity; and the buildup of greenhouse gases, such as carbon dioxide and their impact on the global climate. University biomedical research has been key to dealing with global health challenges, ranging from malaria to Nile virus to AIDS, and the international character of research universities, characterized by international programs, collaboration and exchanges of students and faculty provide them with a unique global perspective.

Universities are also crucial to developing academic programs and culture to produce a new generation of thoughtful, interdependent and globally identified citizens. These institutions are evolving rapidly to accept their global responsibilities, increasingly becoming universities not only "in" the world, in the sense of operating in a global marketplace of people and ideas, but "of" the world, accepting the challenge of extending their public purpose to addressing global concerns. To quote from the 1999 Glion Declaration:

"The daunting complexity of the challenges that confront us would be overwhelming if we were to depend only on existing knowledge, traditional resources, and conventional approaches. But universities have the capacity to remove that dependence by the innovations they create. Universities exist to liberate the unlimited creativity of the human species and to celebrate the unbounded resilience of the human spirit. In a world of foreboding problems and looming threats, it is the high privilege of universities to nurture that creativity, to rekindle that resilience, and so provide hope for all of Earth's peoples." (Rhodes, 2009)

Energy

There are few contemporary challenges facing our nation–indeed, the world–more threatening than the unsustainable nature of our current energy infrastructure. Every aspect of contemporary society is dependent upon the availability of clean, affordable, flexible, and sustainable energy resources. Yet our current energy infrastructure, heavily dependent upon fossil fuels, is unsustainable. While there are substantial reserves of coal, oil, and national gas–particularly with new technologies such as hydraulic fracturing of shale deposits_the mining, processing, and burning of these fossil fuels poses increasingly unacceptable risk to both humankind and the environment, particularly within the context of global climate change. Furthermore, the security of our nation is threatened by our reliance on foreign energy imports from unstable regions of the world. Clearly if the federal government is to meet its responsibilities for national security, economic prosperity, and social well-being, it must move rapidly and aggressively to address the need for a sustainable energy future for the United States. Yet time is not on our side.

The increasing consensus that utilization of fossil fuels in energy production is already causing significant global climate change. Evidence of global warming is now incontrovertible–increasing global surface and air temperatures, receding glaciers and polar ice caps, rising sea levels, and increasingly powerful weather disruptions all confirm that unless the utilization of fossil fuels is sharply curtailed, humankind could be seriously threatened. Although there continues to be disagreement over particular strategies to slow global climate change–whether through regulation that restricts the use of fossil fuels or through market pressures (e.g., "cap and trade" strategies)–there is little doubt that energy utilization simply must shift away from fossil fuels toward non-hydrocarbon energy sources (IPCC, 2007).

Alternative energy technologies such as electric- or hybrid cars, hydrogen fuels, nuclear power, and renewable energy sources such as solar, wind, or biofuels still require considerable research and development before they evolve to the point of massive utilization. Numerous studies from groups such as the National Academies, the President's Council of Advisors on Science and Technology, and the American Association for the Advancement of Science have given the very highest priority to launching a massive federal R&D effort to develop sustainable energy technologies.

In fact, a high level task force created by the Secretary of Energy's Advisory Board stated in the strongest possible terms: "America cannot retain its freedom, way of life, or standard of living in the 21st century without secure, sustainable, clean, and affordable sources of energy. America can meet its energy needs if and only if the nation commits to a strong and sustained investment in research in physical science, engineering, and applicable areas of life science, and if we translate advancing scientific knowledge into practice. The nation must embark on a major research initiative to address the grand challenge association with the production, storage, distribution, and conservation of energy as both an element of its primary mission and an urgent priority of the United States. "(Vest, 2005)

Yet today there is ample evidence that both the magnitude and character of federal energy R&D programs are woefully inadequate to address the urgency of the current energy challenges faced by this nation.

The scale of the necessary transformation of our energy infrastructure is immense. It is estimated that over $16 trillion in capital investments over the next two decades will be necessary just to expand energy supply to meet growing global energy demands, compared to a global GDP of $44 trillion and a U.S. GDP of $12 trillion. Put another way, to track the projected growth in electricity demand, the world would need to bring online a new 1,000 MWe powerplant every day for the next 20 years! Clearly this requires a federal R&D effort comparable in scale to the Manhattan Project or the Apollo Program. (Lewis, 2007)

Yet over the past two decades, energy research has actually been sharply curtailed by the federal government (75% decrease), the electrical utility industry (50% decrease), and the domestic automobile industry (50% decrease). Today the federal government effort in energy R&D is less than 20% of its level during the 1980s! To gain a better sense of the priority given today to energy research, one might compare the $2.7 billion proposed for the President's Advanced Energy Initiative with the $17 billion NASA budget, the $30 billion NIH budget, or the $83 billion R&D budget for DOD. More specifically, of the current annual $23 B budget of the Department of Energy, only $6.1 B goes for basic scientific research and technology development related to energy.

How much should the federal government be investing in energy R&D? A comparison of the size of the energy sector ($1.9 T) compared to health care ($1.7 T) and national defense ($1.2 T) would suggest annual R&D investments in the range of $40 to $50 B, roughly ten times the current investments. Clearly Washington has yet to take the energy crisis seriously–and as a consequence our nation remains at very great risk.

Beyond scale, there are few technology infrastructures more complex than energy, interwoven with every aspect of our society. Moving to sustainable energy technologies will involve not simply advanced scientific research and the development of new technologies, but as well complex issues of social priorities, economic and market issues, international relations, and politics at all levels. Little wonder that one commonly hears the complaint that "The energy crisis is like the weather; everybody complains about it, but nobody does anything about it!"

## Global Poverty and Health

During the past several decades, technological advances such as the "green revolution" have lifted a substantial portion of the world's population from the ravages of poverty. In fact, some nations once burdened by overpopulation and great poverty such as India and China, now are viewed as economic leaders in the 21st century. Yet today there remain substantial and widening differences in the prosperity and quality of life of developed, developing, and underdeveloped regions; between the North and South Hemisphere; and within many nations (including the deplorable level of poverty tolerated in our own country).

It is estimated that roughly one-sixth of the world's population, 1.5 billion people, still live in extreme poverty-defined by Jeffrey Sachs as "being so poor you could die tomorrow", mostly in sub-Saharan Africa, parts of South America, and much of central Asia. Put in even starker terms, "More than 8 million people around the world die each year because they are too poor to stay alive. Malaria, tuberculosis, AIDS, diarrhea, respiratory infections, and other diseases prey on bodies weakened by chronic hunger, claiming more than 20,000 lives each day" (Sachs, 2004).

These massive global needs can only be addressed by both the commitment of developed nations and the implementation of technology to alleviate poverty and disease. The United States faces a particular challenge and responsibility in this regard. With just 5% of the world's people, we control 25% of its wealth and produce 25% to 30% of its pollution. It is remarkable that the richest nation on earth is the lowest per capita donor of international development assistance of any industrialized country. As the noted biologist Peter Raven observes, "The United States is a small part of a very large, poor, and rapidly changing world, and we, along with everyone else, must do a better job. Globalization appears to have become an irresistible force, but we must make it participatory and humane to alleviate the suffering of the world's poorest people and the effective disenfranchisement of many of its nations" (Raven, 2003).

### Infrastructure

Engineering of the 20th century was remarkable in its capacity to meet the needs of a rapidly growing global population, building great cities, transportation networks, and economic infrastructure. To be sure, it also developed horrific weapons of mass-destruction that laid to waste entire nations and their populations in global conflict. Yet eventually rebuilding occurred, and at least in much of the world, the infrastructure is in place to provide for societal well being and security.

Yet much of this infrastructure is aging, already inadequate to meet not simply population growth but growing economic activity. The patchwork approach used all too often to rebuild civic infrastructure–electrical distribution networks, water distribution systems, roads and bridges–has created new complexities poorly understood and even more difficult to address. These infrastructure challenges are intensified by demographic trends toward urbanization, where jobs and resources are found. A recent United Nation's study notes that for the first time in human history, more people are living in cities than rural areas. Over the next 30 years, more than two billion people will be added to the population of cities in the developing world, where within the next decade urban will exceed rural populations.

When combined with the incredible strain on urban systems in developing nations caused by population concentrations in mega-cities of tens of millions or transportation networks overwhelmed by the desire for mobility, it is clear that entirely new technologies and engineering approaches are needed to build and maintain the infrastructure necessary to accommodate a global population of 8 to 10 billion while preserving the capacity of the planet to support humankind.

Clearly U.S. engineering must play a critical role in meeting the most basic needs of the world's population. New technologies are needed to address urgent needs for food, water, shelter, and education in the developing world. Yet even in our own country the increasing complexity of our society requires new levels of reliability and confidence. When levies fail in New Orleans, a bridge falls in Minneapolis, a blackout occurs in the Northeast, or a national computer network goes down under cyberattack, people become not only more aware of the impact of technology on personal safety and public health, but moreover question the competency of American engineering to design and manage such complex systems. Such failures, both unavoidable and yet predictable, diminish our ability to contribute value to society, placing a high premium on reliability and, when necessary, recovery and forthright communication.

As economic activity shifts from exploitation of natural resources and the manufacturing of material goods to knowledge services, i.e., from atoms to bits, we will need entirely new intellectual paradigms to create value in the global knowledge economy. Just as two decades ago new methods such as total quality management and lean manufacturing reshaped our factories and companies while triggering entirely new forms of engineering, today we need to develop the new methods capable of creating innovation in a services economy characterized by extraordinarily complex global systems. The engineering profession will be challenged to develop new and more powerful approaches to design, innovation, systems integration, and entrepreneurial activities in support of the global knowledge economy (Donofrio, 2005).

### Still More Possibilities

There are other possibilities that might be considered for the longer-term future. Balancing population growth in some parts of the world might be new pandemics, such as AIDS or an avian flu virus, that appear out of nowhere to ravage our species. The growing

Perhaps mankind will once again launch an era of space exploration....to Mars and beyond.

Or perhaps we will encounter a technological singularity such as artificial intelligence

divide between rich and poor, the developed nations and the third world, the North and South hemispheres, could drive even more serious social unrest and terrorism, perhaps armed with even more terrifying weapons.

Then, too, the unrelenting–indeed, accelerating pace–of technology could benefit humankind, extending our lifespan and quality of life (although perhaps aggravating population growth in the process), meeting the world's needs for food and shelter and perhaps even energy, and enabling vastly new forms of communication, transportation, and social interaction. Perhaps we will rekindle our species' fundamental quest for exploration and expansion by resuming human spaceflight and eventually colonizing our solar system and beyond.

The acceleration of technological progress has been the central feature of the past century and is likely to be even more so in the century ahead. But technology will also present new challenges that almost seem taken from the pages of science fiction. Clearly if digital technology continues to evolve at its current pace for the next decade, creating machines a thousand, a million, a billion times more powerful that those which are so dominating our world today, then phenomena such as the emergence of machine consciousness and intelligence become very real possibilities during this century.

John von Neumann once speculated that "the ever accelerating progress of technology and changes in the mode of human life gives the appearance of approaching some essential singularity in the history of the race beyond which human affairs, as we know them, could not continue." The acceleration of technological progress has been the central feature of the past century and is likely to be even more so in the century ahead. Some futurists have even argued that we are on the edge of change comparable to the rise of human life on Earth. The precise cause of this change is the imminent creation by technology of entities with greater than human intelligence. For example, as digital technology continues to increase in power a thousand-fold each decade, at some point computers (or, more likely, large computer networks) might "awaken" with superhuman intelligence. Or biological science may provide the means to improve natural human intellect. (Kurzweil, 2005).

When greater-than-human intelligence drives technological evolution, that progress will be much more rapid, including possibly the creation of still more intelligent entities, on a still shorter timescale. To use Von Neumann's terminology, at such a technological "singularity", our old models must be discarded and a new reality appears, perhaps beyond our comprehension. We probably cannot prevent the singularity, driven as it is by humankind's natural competitiveness and the possibilities inherent in technology, we are likely to be the initiators. We have the freedom to establish initial conditions, make things happen in ways that are less inimical than others.

Technology could present new challenges that seem almost taken from the pages of science fiction. Clearly if digital technology continues to evolve at its current pace for the next decade, creating machines a thousand, a million, a billion times more powerful that those which are so dominating our world today, then phenomena such as the emergence of machine consciousness and intelligence become very real possibilities during this century. In fact some even suggest that we could encounter a "technological singularity," a point at which technology begins to accelerate so rapidly (for example, as intelligent machines develop even more intelligent machines) that we lose not only the ability to control but even to predict the future.

Clearly phenomena such as machine consciousness, contact by extraterrestrial intelligence, or cosmic extinction from a wandering asteroid are possibilities for our civilization, but just as clearly they should neither dominate our attention nor our near-term actions. Indeed, the most effective way to prepare for such unanticipated events is to make certain that our descendants are equipped with education and skills of the highest possible quality.

When confronted with these concerns–particularly those associated with the challenge of a global, knowledge-driven economy to our national prosperity and security, some suggest that the emergence of Friedman's "flat world" is just another one of those economic challenges that arise every decade or so to stimulate American industry to bump up its competitiveness yet another notch. Hakuna Matata, not to worry! After all, many predicted doom and gloom in the face of Japanese competition in the 1980s. American industry found a way to adapt and compete. Just look at the difficulties Japan faces today.

It is certainly true that many of the characteristics of our nation that have made the United States such a leader in innovation and economic renewal remain strong: a dynamic free society that is continually renewed through immigration; the quality of American intellectual property protection and the most flexible labor laws in the world, the best regulated and most efficient capital markets in the world for taking new ideas and turning them into products and services, open trade and open borders (at least relative to most other nations), and universities and research laboratories that are the envy of the world. If all of this remained in place, strong and healthy, the United States would continue to remain prosperous and secure, even in the face of an intensely competitive global knowledge economy. We would continue to churn out the knowledge workers, the ideas and innovation, and the products and services (even if partially outsourced) that would dominate the global marketplace.

Chapter 3

# National Science Policy

My experience in science policy really began with my appointment by President Reagan to the National Science Board in 1984. The NSB, comprised of 24 members appointed by the President and confirmed by the Senate is not only the oversight board for the National Science Foundation but assigned major responsibility for science policy developed by the organic act creating the NSF itself. During my 12 years on the NSB, I served both as chair of its Education and Human Resources Committee but eventually as the chair of the National Science Board itself from 1992 to 1995. During this period and afterward I have been involved in a number of studies concerned with national science policy and the role of the federal government.

Swearing in to the National Science Board (1984)

## The Future of the National Science Foundation and the National Science Board

The establishment of an external commission by the National Science Board is a remarkable event, occurring only a few times in our history. During my tenure as NSB Chairman, the Director of the National Science Foundation, Walter Massey, and I decided to form just such a commission, chaired by William Danforth and Robert Galvin, to consider the futures of both the NSB and the NSF during a period of considerable change.

The NSB during my years as chair

The Commission began with the mission statement for the NSF: "To promote the progress of science; to advance national health, prosperity, and welfare; to secure the national defense; and for other purposes." (National Science Foundation Act of 1950) The goal was to help the NSB better understand the role of science and engineering in meeting national goals and a better linking of scientific results with those goals. The Commission urged that the role of the NSF should be further clarified within an overall national policy, the goal of which should be to maintain the premier position of US science and engineering and its capability to contribute more fully to America's priorities.

The beginning premise was that while NSF represented only about 4% of the federal R&D budget, it has had extraordinary impact on our nation's leadership in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**ROBERT GALVIN**
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**JOHN A. ARMSTRONG**
Vice President for Science and Technology, IBM

**JACQUELINE BARTON**
Professor, California Institute of Technology

**LINDY BOGGS**
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Leaders and members of the NSB Commission

science and engineering–and hence upon our national security, economic prosperity, and social well-being. Key here was its unusually broad mandate to strengthen American science and engineering, a partnership of trust with America's scientists, engineers, and academic institutions, a reliance on investigator-initiated proposes and selection of the best of these based on merit, strong education programs, and the flexibility to pursue new ideas–all characteristics they believed should be preserved.

The Commission observed the transformation of the political, economic, and social context occurring both domestically and abroad was changing how we as a society view and support science and engineering research. It stressed the fundamental importance of continuing the National Science Foundation's basic mission of supporting first-rate research, identified and defined by the best researchers within the academic research community. At the same time the Commission also underscored the importance of supporting key strategic research areas in response to scientific opportunities to meet national goals.

The challenges the National Science Foundation faced went to the core of our assumptions about the role of science in our society. In the context of enhanced public confidence in and support of science and engineering research the Foundation faced the challenge of better positioning itself to respond to strategic research opportunities. Strong linkages between research and education would be critical to this endeavor, as would be more effective partnerships between the academic research community and other sectors of our society such as industry and government.

The Commission identified challenging issues that would require NSF attention. These included evolving research fields, interdisciplinary opportunities, increasing dependencies among stages in technology development, grant size, student support, improved science education, knowledge diffusion and facility needs. Yet the Commission also acknowledged that the NSF budget was inadequate to support even its present responsibilities and programs, and that the National Science Foundation would find it difficult to respond to these new challenges without an increase in resources.

Hence the Commission recommended that both the NSB and the NSF leadership work closely with the White House to generate a strong science policy into which the NSF mission fit. In particular, they stressed the need for NSF to be both responsive to national needs as voiced by society as well as the intellectual priorities initiated by scientists and engineers.

More specifically, the Commission set out two important goals:

i) To support first-rate research at many points on the frontiers of knowledge, identified and defined by the best researchers, and

ii) To achieve a balanced allocation of resources in strategic research areas in response to scientific opportunities to meet national goals.

While strongly supporting the initiation of proposals by investigators determined by merit, the Commission cautioned that many fields not covered by traditional disciplines offered challenges for new knowledge and opportunities for creative, investigative research worthy of strong support, and this might require exceptions from current NSF funding practices.

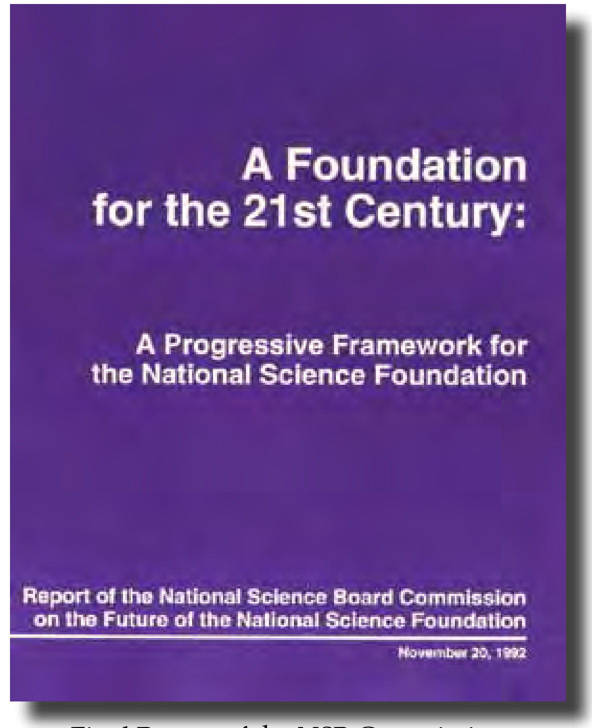
The Commission's report affirms the importance of the NSF's historical mission, provides an excellent starting point for assessing the new environment for research and education, and offered recommendations for meeting the needs imposed by these changes.

General Recommendations

To realize these benefits of the NSF and its research community more fully, the Commission commended to the National Science Board and the broader scientific community the following recommendations:

1. The United States should have a stronger and more coherent policy wherein science and engineering can contribute more fully to America's strength. The Board is encouraged to work with the President, his Science Advisor, and the Federal Coordinating Council on Science, Engineering, and Technology to assess the health of science and engineering broadly and to generate a stronger policy into which the NSF mission fits.

2. Society's support for the NSF and for university research is based on the confident expectation that the generation of new knowledge and the education of a skilled workforce are necessary (though not sufficient) investments to achieve our national goals of a high quality of life in a productive and growing economy. In accepting society's support, the scientific community




Final Report of the NSB Commission

naturally assumes an obligation to be both responsive to national needs voiced by society as well as the intellectual priorities solely initiated by the scientist or engineer.

3. The Commission strongly supported the initiation of proposals by investigators and selection of those to be funded by merit review carried out by experts. This method has proved to be the best way of tapping into the creativity of research scientists and engineers. Periodic examination of how to improve the functioning of the system is in order. The system, of course, must assure the selection of work of the highest quality and promise.

4. The NSB, the NSF, and the science and engineering community must better come to grips with the reality that many fields not covered by traditional disciplines offer challenges for new knowledge and opportunities for creative, investigative research worthy of the most gifted scholar. These fields should be valid candidates for support and may both yield key knowledge and enable timely response to national goals.

5. Since the private sector plays the major role in the translation of knowledge into new products and services, and since the speed and efficiency of this process is an important factor in a productive and growing

economy, it is appropriate that the NSB involve the private sector more fully than heretofore in the decisions which affect the classes of research allocation as well as some evaluation of the effectiveness of the expenditures. It is more than incidentally significant that scientific advances are as likely to be driven by advances in technology as the reverse, and the interplay between parties who are conversant in both fields holds promise of synergy.

Research Recommendations

1. The NSB's and NSF's key role in the support of research in science and engineering should be strongly reaffirmed.

2. The NSB and the NSF should encourage interdisciplinary work and cooperation among sectors. Nature knows nothing about disciplinary boundaries.

3. There is a convergence between science and technology arising from technology today having a stronger basis in theory and data, which creates increased demand for research at every stage of the innovation process. Goals for science are, for the most part, necessarily long-term. However, new knowledge from fundamental research is important early-on, to the technical community, as a guide for anticipating future progress in technology and in the selection of strategies for future developments.

4. It is urged that the size of NSF grants be examined. Many believe that on average, NSF individual research grants are too small. Examination of separate fields and wide consultation within the community would help in understanding the issues. Research grants should be sufficient to do the work.

5. The management of NSF should from time to time review the make up and combinations of Directorates to maintain the most effective focus and management of the selection process, taking into account the evaluation of research, the desirability of interdisciplinary research, the needs of different types of research and efficiency of operation.

6. The diffusion and dissemination of the knowledge and skills derivable from scientific and engineering discoveries are important. Although complex, the system is working better than many presume. It works particularly well when university trained researchers and professionals move from position to position in academia or in industry.

7. The Foundation should more aggressively lead in communicating the "case" for science and engineering, which deserve a high priority in the mind of public officials and citizens alike.

8.The NSF should both set an example and work with others in fostering international cooperation and agreements for the most effective ex change of research results and for research collaboration. To do so is beneficial to all parties, as important discoveries can be made anywhere.

9. Undergraduate education is enriched by faculty participating in research. Research is essential to preparing graduate students for scientific careers in academia, government, and industry. The Commission endorsed the importance of graduate fellowships and traineeships. Students are quite responsive to perceived national needs in their selection of fields of research. The involvement of underrepresented groups should continue to be vigorously encouraged.

10. Successful research requires increasingly sophisticated instrumentation and facilities. The Commission urged the NSB to maintain surveillance over the state of these national resources and to work for a national plan to keep them adequate for the conduct of pioneering science and engineering.

Education Recommendations

1. A major priority for the NSB and the NSF should continue to be education in science and engineering. NSF's support of education has a cascading influence. The Foundation should be at the leading edge of ever-emerging improvements in curricula, and methodologies of teaching and training for research.

2. The NSF should encourage further development of joint science, engineering, and management education by implementing previous research recommendations, which call for recognizing the importance and equivalence of scholarly research in a broader range of fields.

3. The Foundation is chartered to support improved education in mathematics and science throughout all the school years, from kindergarten through graduate and post doctoral studies. The two most critical areas

needing improvement are K-12 education and undergraduate education.

Structural Recommendations

1. Measurement of systems generates improved quality of operations. All reasonable measurements of the quality of the output of research, the quality of research allocation and the other principal functions of the Foundation should be subject to rigorous and common sense metrics for the evaluation and increase in the quality of its activities.

2. NSF should continue to support shared, common use facilities that cannot be built and maintained by individual institutions. Such facilities make economic sense and are an essential part of the research infrastructure for many individual investigators.

Concluding Remarks

The Commission strongly urged that the role of both the National Science Foundation and the National Science Board be further clarified within an overall national policy, the goal of which should be to maintain the premier position of U.S. science and engineering while regaining America's lead in the commercialization of technology.

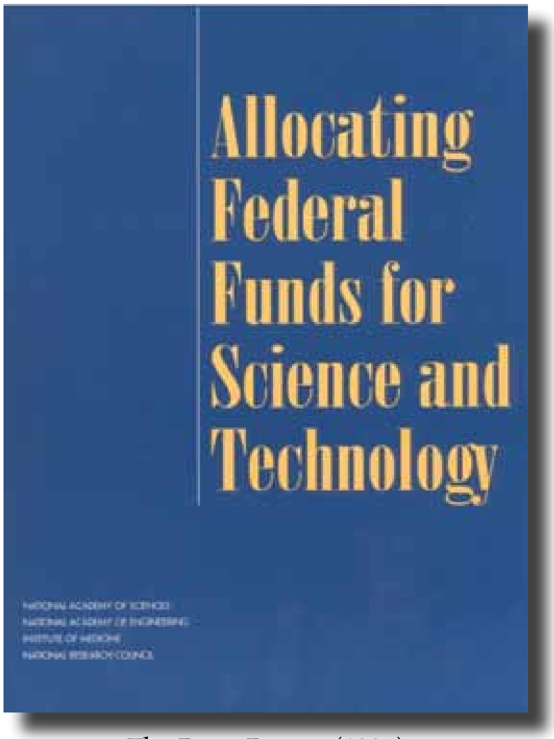
More specifically, it recommended that the United States should have a stronger and more coherent policy wherein science and engineering can contribute more fully to America's strength. It stated that "A call of this nature is not new. The strategy has been voiced in many terms—national science policy, national technology policy, and others. We do not emphasize a title. But, we do advocate a broad national policy going beyond science and engineering and including technology and its applications. The policy should be responsive to the voice and needs of society. NSF, with its emphasis on research in science and engineering and its complementary emphasis on education for science and engineering, will play a major, direct, and cascading role in fulfilling the overall policy."

It stressed that the National Science Board, in helping to develop a national science and technology policy, should move quickly to propose a role for the NSF based on its past mission and a vision of what is needed today. In this plan the NSF should build on its accomplishments and strengths, specifically its partnership with the scientists and engineers of the nation's colleges and universities in developing outstanding research and strong science education; its partnership with the Department of Education and state and local governments working to strengthen science education in grades K-12; and its role in maintaining the nation's scientific infrastructure. The plan should include a response to the recommendations of this Commission in order to strengthen and make more effective the work of the NSF in meeting national goals.

In particular, it urged the NSB and those involved in the planning to resist any pressures to strip the NSF of its full spectrum of research goals and linkage mechanisms, from engineering research centers, to computer networks, to pure science and mathematics. The great strength of American science and of American universities is the absence of rigid cultural barriers between science and engineering and between pure research and its applications. To address this issue the Commission urged that the NSF's responsibilities, as spelled out in its mission statement, and its budgetary needs be examined in the context of a newly conceived federal R&D budget that supports the stronger, broader policy. Reallocation of funds could achieve an energizing result that stimulates academic scientists and engineers, government officials, and people from industry to serve better the U.S. public.

Finally, the Commission focused on the role of the National Science Board in influencing a stronger science and engineering and technology policy for the Nation. "The Board and the National Science Foundation are today the lead organizations representing the interests of broad science and engineering in the United States. The Board must work with its peers in the private and public sectors so that the nation might formulate a much needed science and technology roadmap. We are convinced that students, scientists, engineers, industry, and the public would join together to build and build on that roadway. It is a journey we must begin."

The 1992 Report of the NSB Commission on the Future of the National Science Foundation and National Science Board triggered a number of important follow-on studies and actions.




The Press Report (1995)

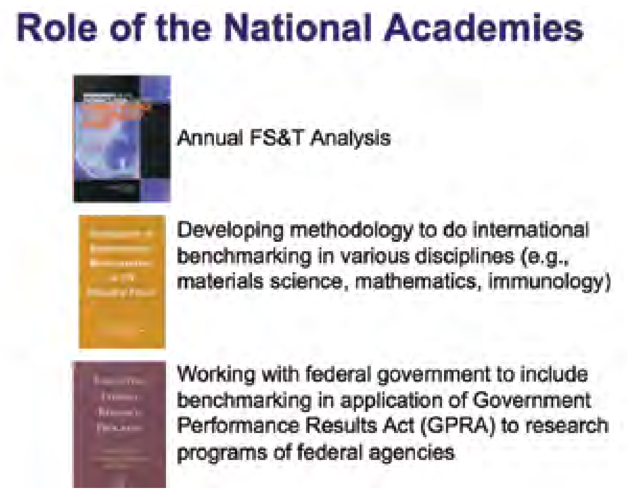
Allocating Federal Funds for Science and Technology: National Goals for a New Era, National Research Council Report (1995)

One of the earliest responses to the recommendations of the Danforth-Galvin Commission was an effort to better define national goals for federal investment in science and technology. This NRC study, chaired by Frank Press, President of the National Academy of Science (and hence sometimes referred to as "The Press Report") recommended two goals to guide federal investment in science and technology:

1) The United States should be among the world leaders in all major areas of science. Achieving this goal would allow this nation quickly to apply and extend advances in science wherever they occur.

2) The United States should maintain clear leadership in some areas of science. The decision to select a field for leadership would be based on national objectives and other criteria external to the field of research.

These goals provided the foundation upon which federal science and technology (FS&T) budgetary policy should be built and analyzed. The study furthermore recommended that the Executive Office of the President and Congress develop a more coherent budget process for determining the federal investment in programs that create new knowledge and technologies to meet these goals. It recommended that the President should present annually a Federal Science and Technology (FS&T) Budget proposal that addresses both current national priorities and the investments necessary to sustain a world-class science and technology enterprise, where the Federal Science and Technology budget was designed to reflect the real federal investment in the creation of new knowledge and technologies and excluding many elements of the usual federal research and development budget (R&D) such as the testing and evaluation of new weapons systems. For example in 2014 while the federal R&D budget amounted to $150 billion, the FS&T budget that created new knowledge was $60 billion. This was felt to be a better measure of whether our nation was investing adequately in scientific research to sustain our economic prosperity, public health, and national security.




Role of the National Academies in assessing progress on the recommendations of the Press Report.

As a member of the NRC Committee on Science, Technology, and Public Policy, for a number of years I chaired the development of an annual FS&T report that tracked both federal investment in knowledge creation as well as the degree to which the federal government was investing adequately in those areas of major priority to the nation. Of particular concern during the first decade of the 21st Century was the degree to which the


The FS&T analysis by the National Academies

FS&T budgets of key mission agencies such as the Departments of Defense, Energy, and Commerce began to decline. Indeed, the only federal agency experiencing a major growth in its FS&T budget was the National Institutes of Health, which expanded for a time due to a commitment in the 1990s to double its budget. However in recent years, even that has declined significantly, dropping 40% below the original doubling target.

## NSB and NSF Strategic Planning Activities

Throughout the 1990s and early 2000s, the strategic planning activities of both the National Science Board and the National Science Foundation echoed many of the themes of the 1992 NSB Commission, even as the planning environment continue to evolve, e.g. from the end of the Cold War transition (early 1990s) to the dot-com evolution (late 1990s) to terrorism and national security (early 2000s) to today's concern with energy, climate change, and global sustainability.

In testimony before the National Science Board in 2009, I suggested updating the 1992 NSB Board study to reflect several new themes:


The sequence of NRC FS&T reports

Intellectual ("ideas")

NSF is frequently criticized for the disciplinary silos resulting from the strong domain-focus of the R&RA directorates. Of course, this structure is necessary to some degree since many important scientific communities depend upon it. But there also needs to be a balance between domain-specific activities and those that span (or perhaps even ignore) the traditional disciplines.

In a similar sense, there needs to be a better diversity and balance among the nature of research programs. One of the NSF staff members once distinguished among "pathfinders" (research that breaks paradigms in a Kuhnian sense), "trailblazers" (that explore new directions), "pioneers" (that build the paths to new paradigms and establish the firm foundations of new disciplines), and "settlers" (that populate the new disciplines). In current language, this would span the spectrum from "transformational" to "established" to perhaps "translational" research activities. Again, the key here is balance, since all are important and necessary to fulfill NSF's dual responsibilities both to the scientific community and to the nation that supports these efforts.

Two related points: Transformational research requires "essential singularities" or "outliers", those whose work falls beyond the radar screen but who may be the key to major advances. Unfortunately, these are just the scientists usually ignored by peer review. Special steps are necessary to include them in the NSF portfolio. Second, it is also important to remember that NSF's mission spans BOTH science AND engineering. While a growing amount of research activity spans both endeavors, the intellectual purpose of each differs: science tries to understand what is; engineering tries to create what has never been to address a societal need.

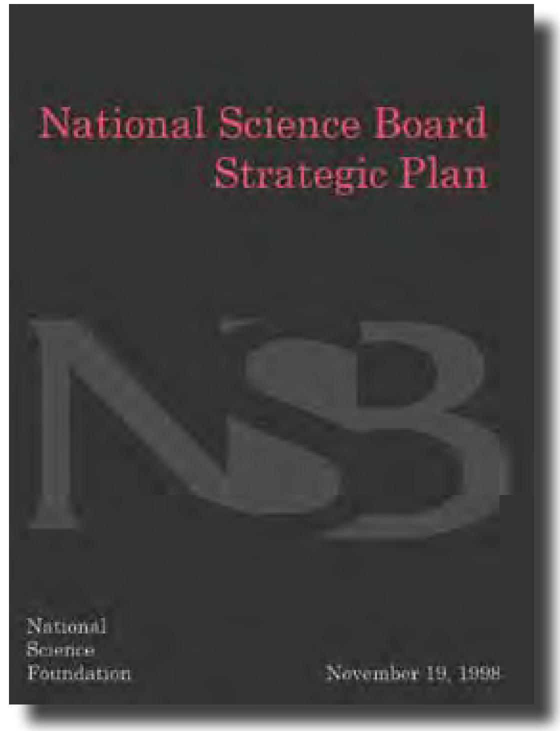
Continuing to provide advice to NSF and NSB

And, of course, this is just the balance between curiosity-driven and use-inspired investigations sought by earlier planning efforts.

Education ("people")

Here the biggest challenge is science and mathematics at the K-12 level. During the late 1990s when I served on COSEPUP, we organized several meetings bringing together leading educators and scientists to understand the total disconnect between the expanding base of scientific knowledge in areas of neuroscience/cognitive science and teaching practice in our schools. Try as we might, we were unable to get a handle on just how the National Academies could remedy this divide. But since the NSF is actually the only federal agency doing real research on learning (the Department of Education is largely an entitlement-focused organization with little rigorous research capacity), the Foundation has both a great opportunity as well as a national obligation to play a leadership role in this area (perhaps leading an interdepartmental effort with the DoEd and NIH). The NSF science of learning centers are an important start, but much more is needed.

The challenge in undergraduate education is a way to stimulate more experimentation (along the lines of Olin College) within a framework that will facilitate the propagation of successful efforts. I viewed the NSF's most important role as one of catalyzing institution-based and largely institution-funded efforts through providing credibility through highly visible grants.

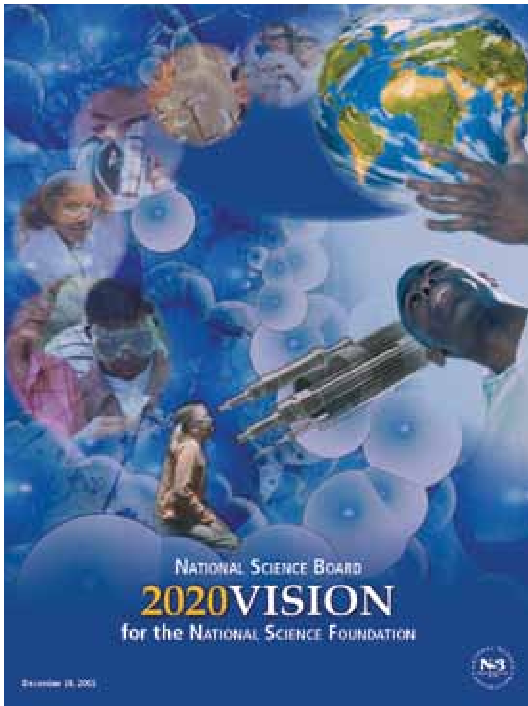



The Future of the NSB

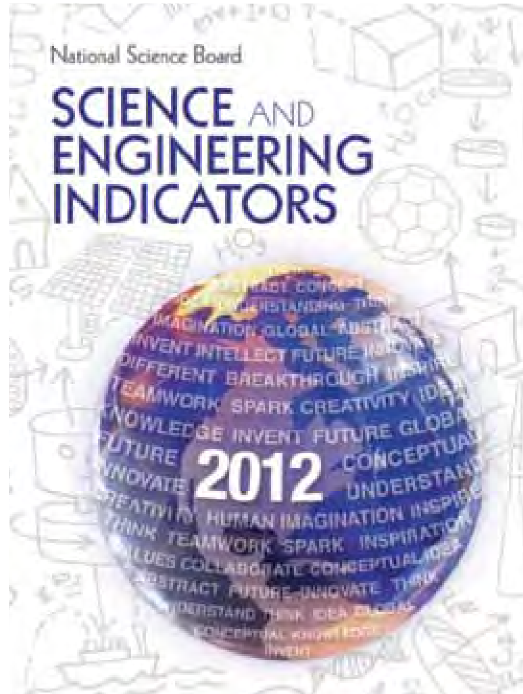
Many institutions are ready to explore truly transformative projects but they need a political umbrella to allow them to push aside campus resistance. The prestige provided by an NSF grant can help them do this.

At the graduate level, it is long past time for a "Flexner Report" for the PhD, which is rapidly diverging in both character and objective among the disciplines. While the humanities still consider the purpose of the PhD as preparing future faculty, the physical sciences and engineering view it as preparing researchers, while the biomedical community now views it as only the next educational stage on the way to the postdoc, which has become the true "terminal" educational stage.

Another important issue: the original purpose of graduate education was to recapture the *Universitas Magistrorum et Scholarium* theme of a learning community of masters and scholars. Yet today, in many disciplines this has become a feudal system in which graduate students are frequently used as indentured servants in large research grants. This is driven, I believe, by the dominance of research assistantships as the primary mechanism for graduate student support in science and engineering. Perhaps now, some 40 years after the Mansfield Amendment, it is time to return to fellowships




The NSF Strategic Plan




Science and Engineering Indicators

and traineeships as the dominant form of graduate student support, thereby providing more flexibility to graduate students and re-establishing the learning relationship between "masters and scholars" rather than the feudal relationship between lord and serf.

One more concern: It is becoming increasingly clear that the states are rapidly losing not only the capacity but, indeed, the rationale for the support of graduate (and professional) education at world-class levels. Not only are these graduates highly mobile, but the knowledge they produce through their research is quickly available to the world through "open" innovation and knowledge resource paradigms. More specifically, many of the states are beginning to conclude that they cannot, will not, and probably should not continue to support advanced education (or institutions) at world-class levels. Without federal intervention many of us fear that the United States will lose the contributions of world-class public research universities, since the priorities of the states (with aging populations) are rapidly diverging from those of the nation (e.g., competing in a knowledge-driven global economy). More on this later.

Infrastructure ("tools")

Many disciplines (e.g., biomedical, engineering, social sciences) are evolving toward the need for large multi-institution research centers, much as physics and astronomy have done over the past several decades. Few institutions can afford the acquisition and maintenance of massive experimental or computational facilities.

It is no longer enough for the NSF to fund principle investigators and avoid insofar as possible funding the capabilities required by those researchers. Unfortunately, the unrelenting pressure to fund more and more PI-based research has increased the burdens on research universities. Unpopular as it may be with research faculty, the Foundation needs to engage the issue of its responsibility for the support of research infrastructure in a comprehensive and systematic fashion.

The difficulty of addressing this need is exacerbated by the peer review funding approach. In some instances the best approach for the research community would be to award a single–or at most several grants–that would be tightly coordinated to provide a cost-effective facility or national infrastructure. Funding a number of loosely coordinated projects at a number of universities through peer review and competition is not only costly but also likely not to meet the needs of some fields. (Here a good example is cyberinfrastructure.) The upshot is that the NSF needs a different approach to community infrastructure needs–strong program officers combined with coordinating organizations like NCAR, although not limited to particular disciplines. Further, the NSF advisory structure needs to be more oriented to these challenges and less dominated by research faculty members who sometimes have little concern with the health of the overall research enterprise.

Funding (and politics, of course)

In my final remarks, I suggested that NSF add to the holy trinity of people, ideas, and tools the not-so-holy theme of politics (or at least funding). Both the 1993 and 2005 NSB studies stressed the importance of an NSF portfolio balanced among curiosity/investigator-driven investigations and use-inspired programs aimed at addressing urgent national priorities. This, of course, has been a dominant theme of NIH, riding this approach to a funding level now six times that of NSF.

It is critical that NSF be more clearly seen by the "body politic" as absolutely essential to national priorities such as innovation-driven economic competiveness, energy sustainability, climate change (and global sustainability), science education, and even public health. While some of this is packaging and marketing, it is also the case that NSF needs to do a better job of aligning its programs with national priorities, since this is what the public (and their elected representatives) thinks it is paying for…

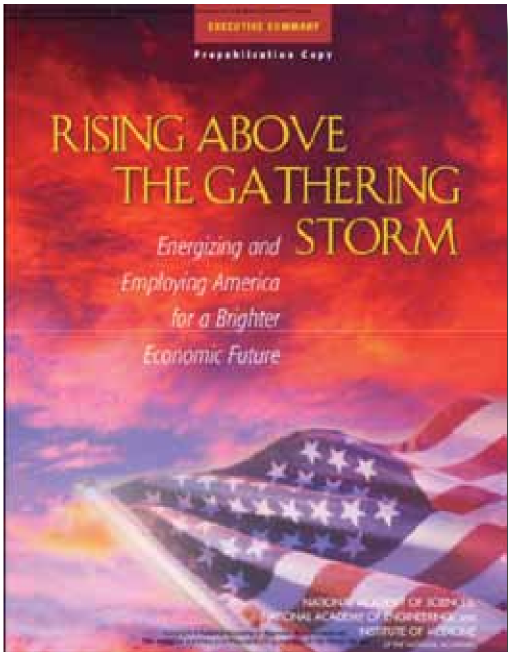
In the near term, I suggested a more highly visible role of NSF in addressing key national priorities would be very important to getting initiatives such as the America COMPETES Act adequately funded, particularly in a post-stimulus world with a serious federal current account deficit! This legislation is the near-term key to fixing the serious underfunding of the Foundation and enabling it to meet its current challenges, honor its responsibilities, and exploit some very exciting opportunity.


Council on Competitiveness Report

## Rising Above the Gathering Storm

During the early years of the 21st Century there were increasing concerns expressed about the erosion of federal R&D investments and policies that were essential to sustaining innovation and American competitiveness. Studies by the President's Council of Advisors on Science and Technology (PCAST) found that from 1993 to 2000, federal support for the physical sciences and engineering had remained relatively flat, with decreasing support in some critical areas (e.g., computer technology). furthermore federal support for graduate students in these areas also had declined significantly over the past two decades.

PCAST was also worried about the low interest of students in STEM careers, particularly as global outsourcing of jobs became more apparent. Cumbersome immigration policies in the wake of 9-11 was threatening the pipeline of talented foreign science and engineerng students. As Craig Barrett, CEO of Intel, stated the challenge: "The U.S. is not graduating the volume of scientists and engineers we need, we do not have a lock on the infrastructure, we do not have a lock on the new ideas, and we are either flat-lining, or in real dollars cutting back, our investments in physical sci-




COSEPUP Report


White House Innovation Initiative

ence and engineering. The only crisis the U.S. thinks it is in today is the war on terrorism. It is not!"

The Council on Competitiveness joined in with a National Innovation Initiative, framed by the premise that "Innovation will be the single most important factor in determining America's success throughout the 21st Century. The challenge is to unleash American innovation capacity to drive productivity, standard of living and leadership in global markets. For the past 25 years we have optimized our organizations for efficiency and quality. Over the next quarter century, we must optimize our entire society for innovation."

In response to these concerns, in 2005 the National Academies Committee on Science, Engineering, and Public Policy launched a very intense and rapid study chaired by Norm Augustine, named Rising Above the Gathering Storm (apparently originally entitled "The Gathering Storm" after Churchhill's warning about a possible war in Europe...but since the COSEPUP report was drafted at the time of Hurricane Katrina, they felt they should add "Rising Above" to the title. At the same time, the National Academy of Engineering was involved in a major study of the importance of engineering research to the nation, which I was chairing. These two studies were on parallel tracks and timing, but I will discuss the engineering research study in a later chapter.

The goals of RAGS were impressive:

Double federal support of long-term basic research over next 7 years

Create a program to support 200 of the nation's promising young researchers with grants of $500,000 (over 5 years) at a cost of $100 million per year when fully implemented

Institute a National Coordination Office for Research Infrastructure to manage a centralized research-infrastructure fund of $500 million per year over the next 5 years

Provide federal research agencies with the discretion and resources to catalyze high-risk, high-payoff research

Create in the Department of Energy (DOE) an organization like the Defense Advanced Research Projects Agency (DARPA) called the Advanced Research Projects Agency-Energy (ARPA-E)

Institute a Presidential Innovation Award to stimulate scientific and engineering advances in the national interest.


American COMPETES Act

Preparation of K12 Math and Science teachers: 10,000 Teachers, 10 Million Minds

Higher Education Policies: Developing the Best and the Brightest

Economic Policy: Incentives for Innovation

Interestingly enough, the RAGS report quickly caught the attention of President Bush, who reframed it as the American Competitiveness Initiative in his 2006 State of the Union address, adopting most of the recommendations of the RAGS report. With strong bi-partisan support this led to rapid passage by Congress of the America COMPETES Act (a rather tortured acronysm for "America Creating Opportunities to Meaningully Promote Excellence in Technology, Education, and Science Act", which authorized many of the RAGS recommendations:

Doubling funding for the National Science Foundation (NSF) from approximately $5.6 billion in Fiscal Year 2006 to $11.2 billion in Fiscal Year 2011.

Setting the Department of Energy Office of Science on track to double in funding over ten years, increasing from $3.6 billion in Fiscal Year 2006 to over $5.2 billion in Fiscal Year 2011.

Authorizing the National Institute of Standards and Technology (NIST) from approximately $703 million in Fiscal Year 2008 to approximately $937 million in Fiscal Year 2011 and requiring NIST to set aside no less than 8 percent of its annual funding for high-risk, high-reward innovation acceleration research.

Directing NASA to increase funding for basic research and fully participate in interagency activities to foster competitiveness and innovation, using the full extent of existing budget authority.

Strengthen Educational Opportunities in Science, Technology, Engineering, Mathematics, and Critical Foreign Language

Authorizing competitive grants to States to promote better alignment of elementary and secondary education with the knowledge and skills needed for success in postsecondary education

Strengthening the skills of thousands of math and science teachers by establishing training and education programs at summer institutes

Assisting states in establishing or expanding statewide specialty schools in math and science

Developing and implementing programs for bachelor degrees in math, science, engineering, and critical foreign languages

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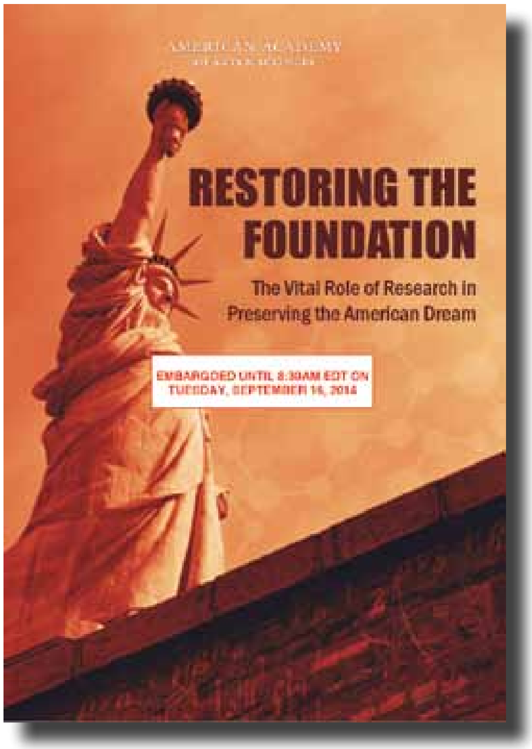
Rising Above the Gathering Storm Committee



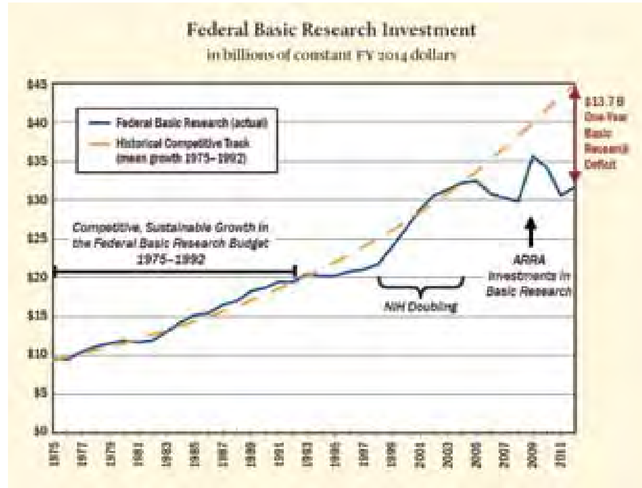

AAA&S Science Policy Report

Expanding existing NSF graduate research fellowship and traineeship program

Unfortunately, as Congress began to consider the association legislation to provide the necessary funding for these authorization, a disagreement broke out between a Republican White House and a Democratic Congress that led to removing the funding for the America COMPETES Act in late 2006. Although some progress was made in funding as a part of the stimulus package proposed by President Obama to address the challenges of the 2008 recession, and the America COMPETES Act was reauthorized in 2010, the necessary funding has still not been provided, and the effort remains on a dream...

## Securing the American Dream

In 2014 a new study launched by the American Academy of Arts and Sciences and chaired by Neal Lane and Norman Augustine added to this two-decade long effort to shape an effective science policy for America's future: The key recommendations of this study were:




Recommended goal for basic research funding

*Prescription 1 – Secure America's Leadership in Science, Engineering and Medical Research - Especially Basic Research - by Providing Sustainable Federal Funding and Setting Long-Term Investment Goals*

The study recommended that the President and Congress work together to establish a sustainable real growth rate of at least 4% in the federal investment in basic research, approximating the average growth rate sustained between 1975 and 1992. This growth rate would produce a target of at least 0.3% of GDP for federally-supported basic research by 2032, i.e., one-tenth of the national goal for combined public and private R&D that has been adopted by several presidents. Such an increase in support for basic research should not come at the expense of investments in applied research or development, both of which will remain essential for fully realizing the benefits of scientific discoveries and new technologies that emerge from basic research.

As the U.S. economy improves, the federal government should strive to exceed this rate, with the goal of returning to the sustainable growth path for basic research established between 1975 and 1992.

Productive first steps could include:

- A "Sense of the Congress" resolution affirming the importance of these goals as a high priority investment in America's future;
- Strong reauthorization bills, following the model set by the 2007 and 2010 America COMPETES Acts, that reinforce the use of expert peer review


American Academy of Arts & Sciences

Committee on New Models for U.S. Science & Technology Policy

in determining the scientific merit of competitive research proposals in all fields and authorize the investments necessary to renew America's commitment to science and engineering research and STEM education;

- Appropriations necessary to realize the promise of the authorization acts; and
- Establishment of an aggressive goal of at least 3.3% GDP for the total national R&D investment (by all sources) and a national discussion of the merit and means of attaining that goal.

The President and Congress should adopt multi-year appropriations for agencies (or parts of agencies) that primarily support research and graduate STEM education. Providing research agencies with advanced notice of pending budgetary changes would allow research agencies to adjust their grant portfolios and the construction of new facilities accordingly. The resulting efficiency gains would bring costs down while enhancing research productivity.

The White House Office of Management and Budget (OMB) should also establish a strategic capital budget process for funding major research instrumentation and facilities, ideally in the context of a broader national capital budget that supports the nation's infrastructure, and that enabling legislation specifically preclude earmarks or other mechanisms that avoid merit review.

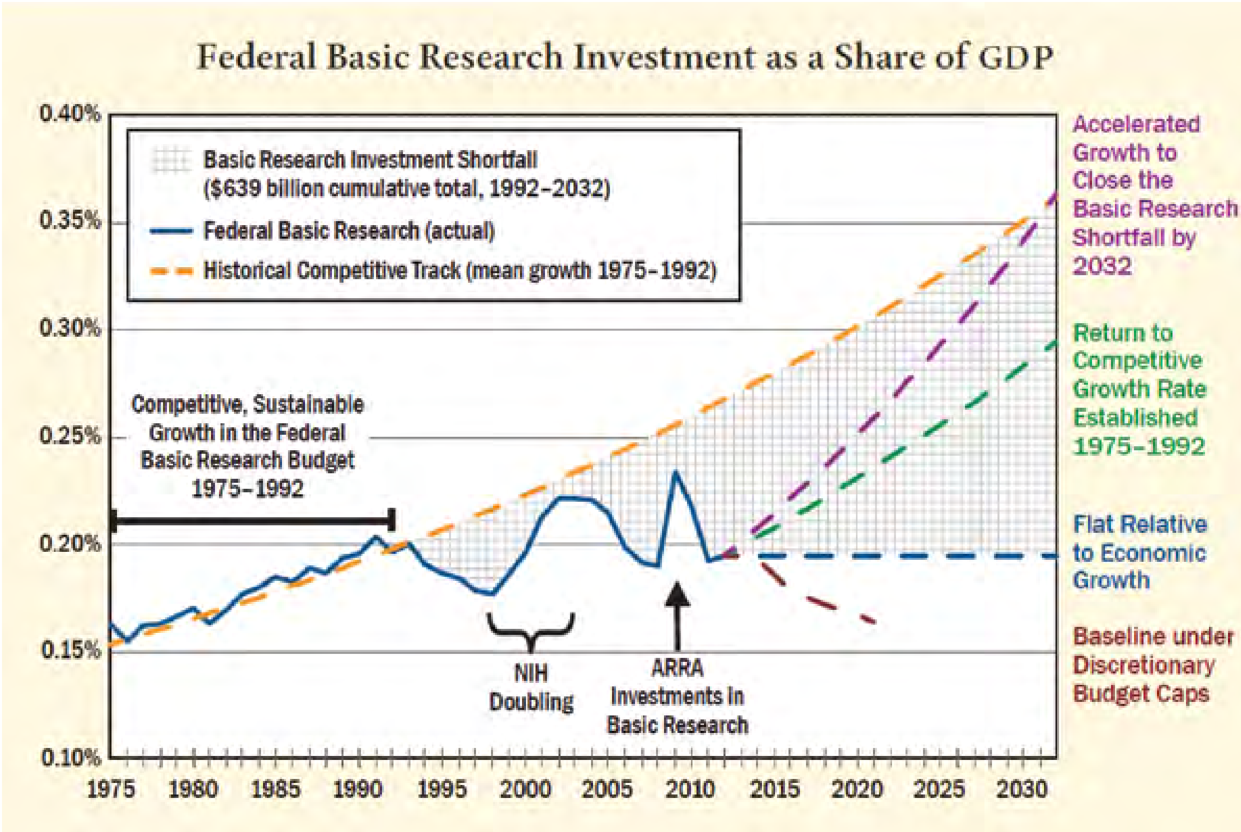
The President should include with his annual budget request to Congress a rolling long-term (5–10 year) plan for the allocation of federal R&D investments – especially funding for major instrumentation that requires many years to plan and build.

*Prescription 2 – Ensure that the American People Receive Maximum Benefits from Federal Investments in Research*

- *Establish long-term planning based on regular assessments of the state of American SE&T;*
- *Reduce administrative burdens and revise institutional policies that reduce productivity;*
- *Reaffirm the importance of peer review;*
- *Expand the research community's involvement in SE&T policy*
- *Provide Congress with the information it needs.*

The President should publish a biennial "State of American Science, Engineering and Technology" report giving the Administration's perspective on issues such as those addressed by the Science and Engineering Indicators published by the NSF National Science Board (NSB), and with input from the federal agencies that sit on the President's National Science and Technology Council (NSTC). The report, if released with the President's budget, could provide information that would be useful for both the appropriations and authorization legislative processes.

To facilitate this and other reviews, the President and Congress should empower the NSB to expand the




scope of its activities to include providing policy studies and recommendations on all matters relating to the status of America's science and engineering research enterprise, as specified in the NSF charter. (Note this was also a recommendation of the NSB study of 1992.)

A series of actions were proposed to enhance the productivity of America's researchers, particularly those based at universities:

i) OSTP and OMB should lead an effort to streamline or eliminate practices and regulations governing federally-funded research that have become burdensome and add to the universities' administrative overhead, while not yielding appreciable benefits.

ii) Universities should adopt "best practices" targeted at capital planning, cost-containment efforts, and resource sharing with outside parties, such as those described in the 2012 NRC report "Research Universities and the Future of America." (Discussed in Chapter 4.)

iii) The President and Congress should reaffirm the principle that competitive expert peer review is the best way to assure excellence. Hence, peer review should remain the mechanism used by federal agencies to make research award decisions, and review process and criteria should be left to the discretion of the agencies themselves. In the case of basic research, scientific merit, based on the opinions of experts in the field, should remain the primary consideration for awarding support.

The report recommended that research funding agencies accelerate their efforts to reduce the time that researchers spend writing and reviewing proposals, as by expanding the use of pre-proposals, providing additional feedback from program officers, allowing authors to respond to reviewers' comments, further normalizing procedures across the federal government, and by experimenting with new approaches to streamline the grant process.

Universities and the NIH should gradually adopt practices to foster an appropriately sized and sustainable biomedical research workforce. Key goals should include reducing the length of graduate school and postdoctoral training and shifting support for education to training grants and fellowships; providing funding for Masters programs that may provide more appropriate training for some segments of the biomedical workforce now populated by PhDs; enhancing the role of staff scientists in university laboratories and core facilities; reducing the percentage of faculty salaries supported solely by grants; and securing a renewed commitment from senior scientists to serve on review boards and study sections.

The National Academies, the American Association for the Advancement of Science (AAAS) and American Academy of Arts and Sciences should convene a series of meetings of non-government organizations, foundations, and professional societies that focus on science, engineering and medical research, for the purpose of establishing a formal task force, alliance or new organization to:

- develop a common message about the nature and importance of science and engineering research that could be disseminated by all the organizations;
- elevate SE&T issues in the minds of the American public, business community and political figures, at all levels and restore appropriate public trust;
- ensure that the recommendations offered by existing SE&T policy organizations, academies and other advisory bodies remain current and front-and-center with institutional leaders and policy makers in all GUI sectors;
- cooperate with organizations that are focused on business and commerce, national and domestic security, education and workforce, health and safety, energy and environment, culture and the arts, and other societal needs and interests to encourage a discussion of the role of SE&T in society; and
- offer assistance – in real time – to government (federal and state), universities, private foundations and leaders in business and industry to help with implementation of policy reforms.

In order to obtain analysis on science and technology issues, Congress should: (1) significantly expand the SE&T assessment capabilities of the Government Accountability Office (GAO), including the size of the technical staff, or establish and fund a new organization for that purpose; and (2) explore ways to tap the expertise of American researchers in a timely and non-biased way. In particular, consideration should be given to ways in which either GAO or another organization with scientific and technical expertise could use crowdsourcing and participatory technology assessment to rapidly collect research, data, and analysis related to specific scientific issues.

*Prescription 3 – Regain America's Standing as an Innovation Leader by Establishing a More Robust National Government-University-Industry Research Partnership*

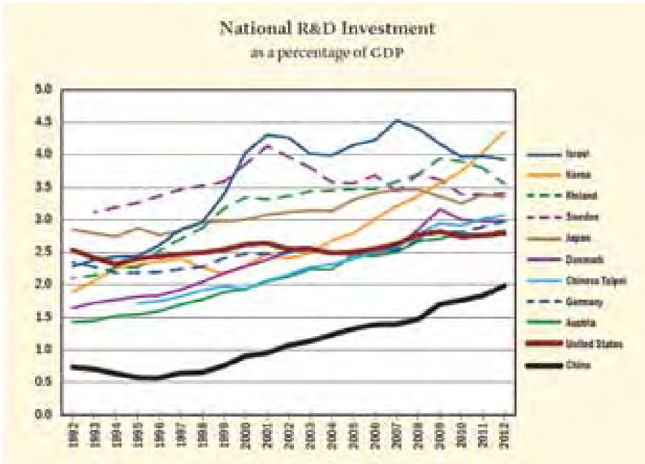
The President or Vice President should convene a "Summit on the Future of America's Research Enterprise" with participation from all GUI sectors and the philanthropic community. The Summit should have a bold action agenda to: assess the current state of science, engineering and medical research in the U.S. in a global context; review successful approaches to bringing each sector into closer collaboration; determine where further actions are needed to encourage collaboration; and form a new compact to ensure that the U.S. remains a leader in science, engineering, technology and medicine in the coming decades.

The President and Congress, in consultation with leaders of the nation's research universities and corporations, should enact legislation to supplement the Bayh-Dole Act and the Stevenson-Wydler Act by removing lingering barriers to University-Industry research cooperation and providing new incentives. This legislation should:

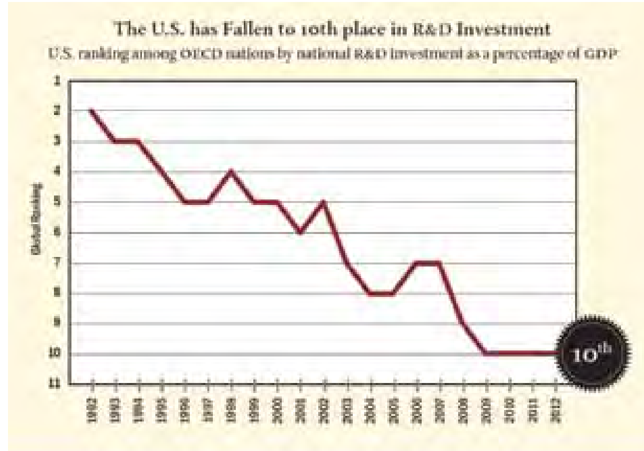
- Incentivize the adoption of the best practices for technology transfer;
- Improve technology transfer by increasing the flexibility of university intellectual property policies; and
- Amend the U.S. tax code to encourage closer university-industry cooperation. For example, in the case of industry-funded research conducted in university buildings financed with tax-exempt bonds, the tax code should be amended to allow universities to enter into advance licensing agreements with industry.

The report recommended that the nation's research universities:

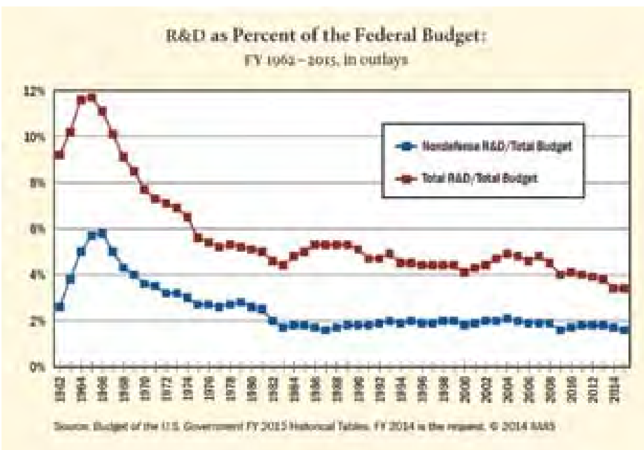
- revise IP policies and practices to favor the creation of stronger research partnerships with companies over the maximization of revenues;
- adopt innovative models for technology transfer that can better support the universities' mission to



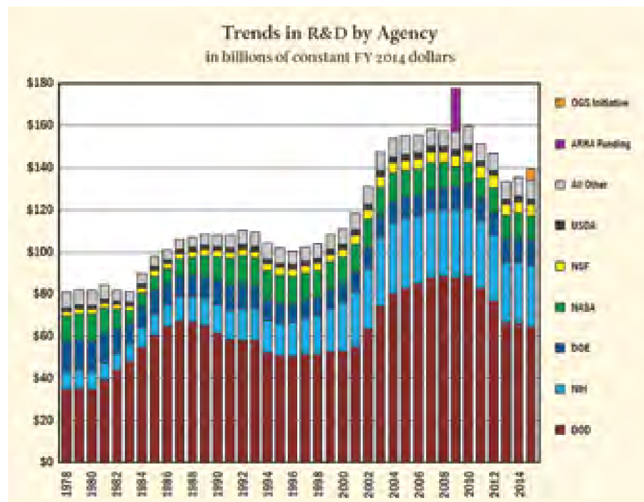

National comparisons of R&D/GDP




The decline of U.S. R&D compared to OECD nations




Decline of R&D as a share of Federal Budget




Trends in R&D for various federal agencies

produce and export new knowledge and educate students;

- enhance early exposure of graduate students (including doctoral students) to a broad range of non-research career options in business, industry, government and other sectors and ensure they have the necessary skills to be successful;
- expand professional master's degree programs in science and engineering, with particular attention to students interested in non-research career options; and
- increase permeability across sectors through research collaborations and faculty research leaves.

Since very few universities generate significant revenue from technology transfer, there was also the suggesting that the intellectual property resulting from public funding should be regarded as a "public good" rather than a revenue stream for universities.

Federal agencies that operate or provide major funding for national laboratories should review their current missions, management and operations, including the effectiveness of collaborations with universities and industry, and phase in changes as appropriate. While consultation with these laboratories is critical in carrying out such reviews, the burden of reviews and other agency requirements is already heavy and should, over time, be reduced.

Corporate boards and chief executives should give higher priority to funding research in universities and work with university presidents and boards to develop new forms of partnership–collaborations that can justify increased company investments in university research, especially basic research projects that provide new concepts for translation to application and are best suited for training the next generation of scientists and engineers.

Congress should act to make the R&E (Research and Experimentation) tax credit permanent, as recommended by PCAST, the National Academies, the Business Roundtable, and many others. Doing so would provide an incentive for industry to invest in long-term research, including collaborative research with universities such as recommended under Action 3.5.

The study strongly supported the recommendation made by many other organizations, including PCAST and the National Academies, to increase the number of H-1B visas and reshape its policies on foreign-born researchers. Productive steps include allowing foreign students who receive a graduate degree in STEM from a U.S. university to receive a green card (perhaps contingent on receiving a job offer) and stipulating that each employment-based visa automatically covers a worker's spouse and children.

In summary, the recommendations presented in this report, if acted upon, would move the nation in a productive direction – from gliding to propelling research, from an unguided to a strategic enterprise, from short-term to long-term focus, from linear to convergent thinking, from a 20th century to a 21st century partnership – by establishing a more robust research partnership across all sectors and securing American competitiveness through sustainable federal funding for basic research. It is the hope that Americans from all backgrounds and professions can work together to achieve these goals and ensure that our nation continues to thrive for decades to come.

Impact Assessment

This set of studies over the course of three decades demonstrates both a certain continuity in science policy concerns as well as the slow progress characterizing action on these issues. It also indicates that impact requires patience and sustained efforts, since when progress actually occurs, it is as much due to the opening of unexpected windows of opportunity, and frequently characterized by a two-steps forward, one-step back–or vice versa.

As this chapter demonstrates, over the past two decades there have been numerous studies involving the nation's leading scientists, engineering, corporate leaders, and university leaders that the nation is seriously under investing in the research that made it a great nation in the 20th Century. Yet throughout this period federal investment in both basic and applied research continued to fall, with the R&D commitments of the United States lagging increasingly far behind other nations. Despite a brief spike in the late 1990s with the doubling of NIH budgets (which have since dropped by 40%) and the ARRA stimulus package, federal research has continued to drop. The anticipated bonus investment from the end of the Cold War never appeared.

The response of Congress has been particularly disturbing, as conservative members have not only failed to view R&D as a priority but indeed wasteful, particularly in its investment in the social sciences and global issues such as climate change. Compared to earlier initiatives such as the Morrill Act and the strong investments in R&D following WWII, many in Congress saw no need in investing in either the development and application of new knowledge nor in education.

While science and technology policy can point to the future, today's political leaders refuse to respond. Whether it takes new political leadership–a 21st president with the vision and political skill of a Roosevelt (either TR or FDR), a more sophisticated and effective lobbying effort on the part of corporate leaders, or a crisis such as the disappearance of Florida beneath the rising oceans as the polar ice caps melt, or a massive pandemic driven by unforeseen forces such as an airborne Ebola virus, the reality today is that the R&D windmill seems quite resistant to change.

Chapter 4

# Research Universities

## Research Universities and the Future of America (National Academies)

The crucial importance of the research university as a key asset in achieving economic prosperity and security is widely understood, as evidenced by the efforts that nations around the globe are making to create and sustain institutions of world-class quality. Yet while America's research universities remain the strongest in the world, they are threatened by many forces: the economic challenges faced by the nation and the states, the emergence of global competitors, changing student demographics, and rapidly evolving technologies. And even as other nations have emulated the United States in building research universities to drive economic growth, America's commitment to sustaining the research partnership that built a great industrial nation seems to have waned.

During past eras of challenge and change, our national leaders have acted decisively to enable universities to enhance American prosperity and security. While American was engaged in the Civil War, Congress passed the Morrill Land-Grant Act of 1862 to forge a partnership between the federal government, the states, higher education, and industry aimed at creating universities that could extend educational opportunities to the working class while conducting the applied research that would enable American to become world leaders in agriculture and industry. Eighty years later, emerging from the Great Depression and World War II, Congress acted once again to strengthen that partnership by investing heavily in basic research and graduate education to build the world's finest research universities, capable of providing the steady stream of well-educated graduates and scientific and technological innovations central to our robust economy, vibrant culture, vital health enterprise, and national security in a complex, competitive, and challenging world.

Today, our nation once again faces a period of rapid and profound economic, social, and political transformation driven by the growth in knowledge and innovation. Educated people, the knowledge they produce, and the innovation and entrepreneurial skills they possess have become the keys to economic prosperity, public health, and national security. As President Obama stated the challenge in his 2011 State of the Union Address:

"The world has changed. In a single generation, revolutions in technology have transformed the way we live, work and do business. The competition for jobs is real. But this shouldn't discourage us. The future is ours to win. But to get there, we can't just stand still. We need to out-innovate, out-educate, and out-build the rest of the world."

Investing in innovation creates the jobs of the future. Investing in education prepares our citizens to fill these jobs. Building the infrastructure for a knowledge-based economy will ensure prosperity and security for our nation.

Key to the achievement of all three of these goals is the American research university, which, through its research, creates the new knowledge required for innovation; through its advanced graduate and professional programs, produces scientists, engineers, physicians, and others capable of applying innovation to create economic value; and through its development and deployment of advanced infrastructure, such as information and communications technology, provides the foundation for the knowledge economy.

Economists estimate that 40 to 60 percent of eco-

Several of the leading American research universities nomic growth each year is due to research and development activity. Another 20 percent of the increased resources each year are based upon the rising skill levels of our population. When asked to identify the one federal policy that could most increase the long-term economic growth rate, economists put further investment in education and research at the top of the list.

Despite the fact that in the past United States built the world's leading research universities, today our nation is not adequately investing in its research universities, nor has it developed a national strategy to support them. For many years, public universities have seen steep reductions in state appropriations per student. Federal support for university research has also been declining in real terms, at the same time that other countries have increased funding for research and development. Meanwhile, American business and industry have not fully partnered with research universities to create the industrial leadership that was found in the past in large corporate research labs, such as Bell Labs.

The unfortunate consequence of the low priority given to support the unique missions of the American research university by the states, the federal government, and the public puts not only the leadership of higher education at risk, but also threatens the economic prosperity and security of the nation.

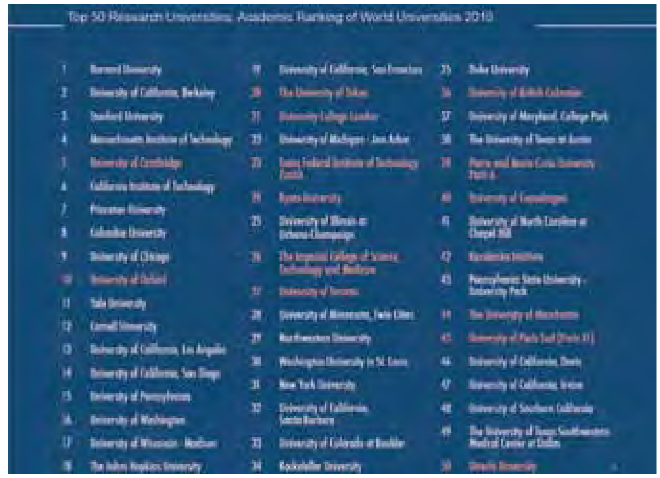
## A Request from Congress

To address these concerns, in 2010 Congressional leaders (including Senators Lamar Alexander and Barbara Mikulski and Representatives Bart Gordon and Ralph Hall) made the following request to the National Academies of Science and Engineering and the Institute of Medicine:

"America's research universities are admired throughout the world, and they have contributed immeasurably to our social and economic well-being. Our universities, to an extent unparalleled in other countries, are our nation's primary source of long-term scientific, engineering, and medical research. We are concerned that they are at risk.

"We ask the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine to assembly a distinguished group of individuals to assess the competitive position of American research universities, both public and private, and to respond to the following question:

"What are the top 10 actions that Congress, state governments, research universities, and others can take to maintain the excellence in research and doctoral education needed to help the United States compete, prosper, and achieve national goals for health, energy, the environment, and security in the global community of the 21st Century?"




The United States has 35 of the world's leading research universitites.

In response, the National Academy leadership recruited an extraordinary group of participants in this effort, roughly balanced between leaders of American research university, industry, government, and science, with an exceptional chairman, Chad Holliday, former CEO of Dupont and current nonexecutive chair of the Bank of American board of directors. (I served both as a member of the committee and, as chair of the Policy and Global Affairs Division of the National Research Council, which hosted the study, help to organize, keep on track, and develop following activities for the study.)

## Findings of the National Academies Study

### The Key Concerns

While America's research universities remain the strongest in the world, they are threatened today by many forces:

COMMITTEE ON RESEARCH UNIVERSITIES

Chad Holliday, *Chair*, Chairman of the Board, Bank of America, and Chairman and CEO, E. I. du Pont de Nemours and Company (DuPont) (retired) [NAE]
Peter Agre, University Professor and Director, Johns Hopkins Malaria Research Institute, Department of Molecular Microbiology and Immunology, Bloomberg School of Public Health, Johns Hopkins University [NAS/IOM]
Enriqueta Bond, President, Burroughs Wellcome Fund (retired) [IOM]
C. W. Paul Chu, T. L. L. Temple Chair of Science and Professor of Physics, University of Houston, and Former President, Hong Kong University of Science and Technology [NAS]
Francisco Cigarroa, Chancellor, The University of Texas System [IOM]
James Duderstadt, President Emeritus and University Professor of Science and Engineering, University of Michigan [NAE]
Ronald Ehrenberg, Irving M. Ives Professor of Industrial and Labor Relations and Economics, and Director, Cornell Higher Education Research Institute, Cornell University
William Frist, Distinguished University Professor, Owen Graduate School of Management, Vanderbilt University, and United States Senator (retired)
William Green, Chairman and CEO, Accenture
John Hennessy, President and Bing Presidential Professor, Stanford University [NAS/NAE]
Walter Massey, President, School of the Art Institute of Chicago, and President Emeritus, Morehouse College
Burton McMurtry, Former Silicon Valley Venture Capitalist and Former Chair, Stanford University Board of Trustees
Ernest Moniz, Cecil and Ida Green Professor of Physics and Engineering Systems, Director of the Energy Initiative, and Director of the Laboratory for Energy and the Environment at the MIT Department of Physics, Massachusetts Institute of Technology
Heather Munroe-Blum, Principal (President) and Vice Chancellor, and Professor, Faculty of Medicine, McGill University
Cherry Murray, Dean, Harvard School of Engineering and Applied Sciences, John A. and Elizabeth S. Armstrong Professor of Engineering and Applied Sciences, and Professor of Physics, Harvard University [NAS/NAE]
Hunter Rawlings, President Emeritus and Professor of Classical History, Cornell University*
John Reed, Chairman of the MIT Corporation and Chairman and CEO, Citigroup (retired)
Teresa Sullivan, President, University of Virginia
Sidney Taurel, Chairman and CEO, Eli Lilly & Company (retired)
Lee T. Todd, Jr., President, University of Kentucky
Laura D'Andrea Tyson, S. K. and Angela Chan Chair in Global Management, Haas School of Business, University of California Berkeley
Padmasree Warrior, Chief Technology Officer, Cisco Systems


The NRC Committee agreed with Congress that the nation's research universities were at some risk.

The economic challenges faced by the nation and the states,
The emergence of global competitors competing for the best students, faculty, resources, and impact on the global economy.
Changing demographics,
Rapidly evolving technologies,
Inadequate investment, and
The absence of a bold national strategy.

Of particular concern were the following issues:

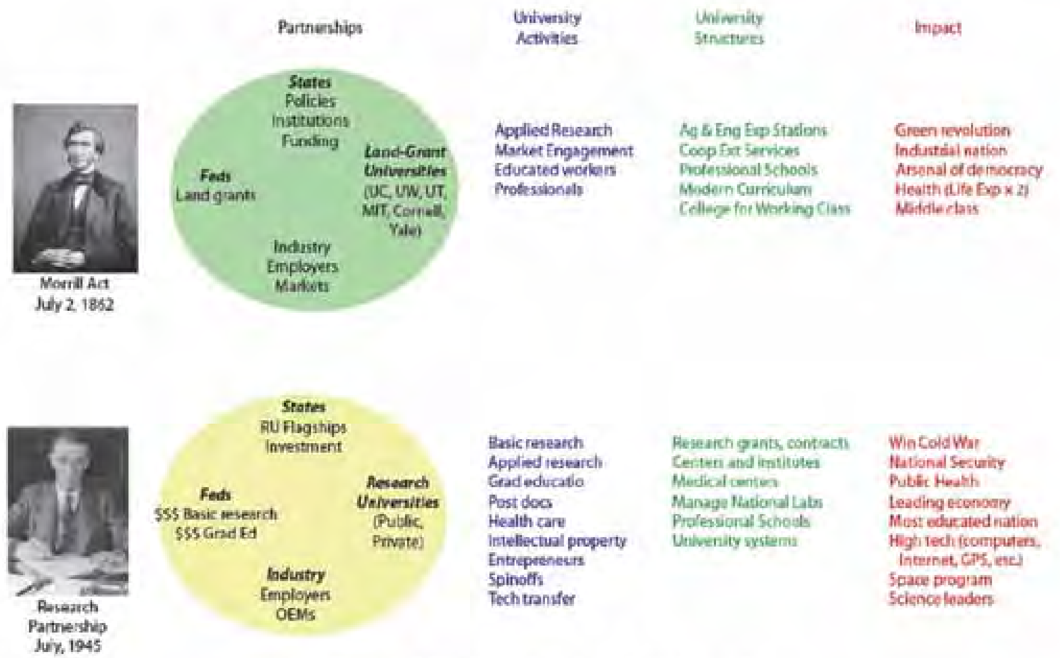
1. Federal policies no longer place a priority on university research and graduate education (basic research funding has dropped off roughly 20% over the past decade…and with the current meat-axe approach to the economy, could well decline another 20% in the next several years).

2. In the face of economic challenges and the priorities of aging populations, states no longer are either capable or willing to support their public research universities at world-class levels. They have lost roughly 35% of their state support since 2000. In fact, state support on an inflation adjusted basis is now back to the levels of the 1960s. (At Michigan, our state support is now below 8% of our academic budget and 4% of our total budget…including hospitals, housing, and football teams…)

3. Business and industry have largely abandoned the basic and applied research that drove American industrial leadership in the 20th century (e.g., Bell Labs), largely ceding this responsibility to research universities but with only minimal corporate support.

4. Research universities themselves have failed to achieve the cost efficiency and productivity enhancement in teaching and research required of an increasingly competitive world. There is great public concern…and misunderstanding about the rising "price" of higher education in America…although equal misunderstanding of its value to the nation.

While in the wake of the 2008 meltdown of the equity markets and subsequent recession, all research universities were facing challenges, there was general agreement that perhaps the more serious challenges were faced by the nation's public research universities as the states withdrew support. As John Hennessy put it looking across San Francisco Bay at the damage




The research partnerships that built America.

It was the federal government (and Congress) that created the partnership among the federal government, the states, industry, and higher education that built the world's leading research universities.

the State of California was doing to UC-Berkeley, "The states are methodically destroying the world-class quality and capacity of our leading public research universities, putting the nation at great risk. Endowments will recover rapidly, but state support is unlikely to recover for at least a generation!!!"

The Key Themes

In various breakout groups we began to converge on a framework of themes for various stakeholders:

To the Public: Update Vannevar Bush's *Science the Endless Frontier* themes for 21 century (economy, health, and security) We are still fundamentally strong, but threatened.

Federal Government: We are seriously under investing in this key asset necessary for economic prosperity, national security, and social well-being, putting the nation at considerable risk. However we recognize current economic constraints and are prepared to work with you to address our common problems, restructuring our activities and sacrificing as necessary.

States: In a global economy increasingly driven by knowledge and innovation, your public research universities are not only a critical asset to your citizens but also to the nation.

Business: Stress the role of the research university as a key source of intellectual and human output. Build business-university government partnerships to achieve mutual interests.

Universities: Stop whining and agree to "man up"! Accept fact that significant restructuring will be necessary to address SWOT themes, including transforming the faculty culture. Look at every activity to see how it can be done more efficiently and at higher quality.

More specifically, the Committee decided to frame its recommendations with the theme of partnership among universities, federal and state governments, and


Today it is time to recommit once again to this research partnership, rebuilding it for a new century.

stakeholders such as business and industry that has been key to the evolution and leadership of the American research university.

Here the committee stressed that America's research universities did not become the best in the world just by accident but by deliberate, visionary policy choices made by our political leadership, even during the most difficult of times, as evidenced by the Morrill Act 150 years ago during the early years of the Civil War and the research policies drafted by Vannevar Bush in the last years of World War II)!

During past eras of challenge and change, our national leaders have acted decisively to create innovation partnerships to enable the nation's universities to enhance American security and prosperity. Today our nation faces new challenges, a time of rapid and profound economic, social, and political transformation driven by the growth in knowledge and innovation.

A decade into the 21st century, a resurgent America must stimulate its economy, address new threats, and position itself in a competitive world transformed by technology, global competitiveness, and geopolitical change. In this milieu, educated people, the knowledge they produce, and the innovation and entrepreneurial skills they possess, particularly in the fields of science and engineering, have become the keys to America's future. Therefore it is essential that as a nation we both reaffirm and revitalize the unique partnership that has long existed among the nation's research universities, the federal government, the states, and business and industry.

## The Ten Recommendations

The approach taken by the Research University Committee was framed by several key principles:

1. A balanced set of commitments by each of the partners--federal government, state governments, research universities, and business and industry--to provide leadership for the nation in a knowledge-intensive world and to develop and implement enlightened policies, efficient operating practices, and necessary investments.

2. Linkages and interdependencies among these commitments that provide strong incentives for participation at comparable levels by each partner.

3. Sufficient flexibility to accommodate the differences among research universities and the diversity of their various stakeholders. While merit, impact, and need should continue to be the primary criteria for awarding research grants and contracts by federal agencies, investment in infrastructure should consider additional criteria such as regional and/or cross-insti-

tutional partnerships, program focus, and opportunities for building significant research capacity.

4. A recognition of the importance of supporting the comprehensive and interdependent nature of research university, spanning the full spectrum of academic and professional disciplines including the arts and humanities

5. A commitment to a decade-long effort when both challenges and opportunities are likely to change, evolving from an early emphasis on more efficient policies and practices to later increases in investment as the economy improves.

The actions we called for are organized to accomplish three broad goals. The first four recommendations will strengthen the partnership among universities, federal and state governments, philanthropy, and the business community in order to revitalize university research and speed its translation into innovative products and services.

The report of the National Academies Committee

<u>Recommendation 1</u>: Within the broader framework of United States innovation and research and development (R&D) strategies, the federal government should adopt stable and effective policies, practices, and funding for university-performed R&D and graduate education.

Over the next decade as the economy improves, Congress and the administration should invest in basic research and graduate education at a level sufficient to produce the new knowledge and educated citizens necessary to achieve national goals. As a core component of a national plan to raise total national R&D funded by all sources (government, industry, and philanthropy) to 3 percent of GDP, Congress and the administration should provide full funding of the amount authorized by the America COMPETES Act. That would double the level of basic research conducted by National Science Foundation, the National Institute of Standards and Technology, and the Department of Energy Office of Science, as well as sustain our nation's investment in other key areas of basic research, including biomedical research. Note that this recommendation is not calling for new programs, but rather asking the Congress to achieve funding goals authorized earlier for various federal research agencies.

<u>Recommendation 2</u>: The states should strive to restore appropriations for higher education to levels that allow public research universities to operate at world-class levels while providing them with greater autonomy to enable them to compete strategically and respond with agility to new opportunities.

Over the past two decades, in the face of shifting public priorities and weak economies, states have decimated the support of public higher education, cutting appropriations per enrolled student by an average of 30 percent, or more than $15 billion each year nationally. Yet even as the states have been withdrawing the support necessary to keep these institutions at world-class levels, they have also been imposing upon them increasingly intrusive regulation. As the leader of one prominent private university put it, "The states are methodically dismantling their public universities where the majority of the nation's campus research is conducted and two-thirds of its scientists, engineers, physicians, teachers, and other knowledge professionals are produced."

Hence, we challenge the states to recognize that the devastating cuts and meddlesome regulations imposed on their public research universities is not only harming their own future, but also putting at great risk the nation's prosperity, health, and security.

Recommendation 3: The role of business in the research partnership should be strengthened, facilitating the transfer of knowledge, ideas, and technology to society and accelerating "time to innovation" in order to achieve our national goals.

We recommend strongly that the relationship between business and higher education should shift from that of a customer-supplier—of graduates and intellectual property—to a peer-to-peer nature, stressing collaboration in areas of joint interest. Strong support of a permanent federal R&D tax credit and more efficient management of intellectual property by businesses and universities to improve technology transfer are also needed. Such a tax credit would stimulate new research partnerships, new knowledge and ideas, new products and industries in America, and new jobs. Better management of intellectual property would result in more effective dissemination of research results, thus also generating economic growth and jobs.

Recommendation 4: Universities must increase cost-effectiveness and productivity in order to provide a greater return on investment for taxpayers, philanthropists, corporations, foundations, and other research sponsors.

It is essential that the nation's research universities strive to address the American public's concern that their costs are out of control. To this end, universities should set and achieve bold goals in cost-containment, efficiency, and productivity. They should strive to constrain the cost escalation of all continuing activities—academic and auxiliary—to the national inflation rate (not the higher education price index) or less through improved efficiency and productivity. That will require the development of powerful and strategic tools for financial management and cost accounting, tools that better enable universities to determine the most effective methods for containing costs and increasing productivity and efficiency. It is essential that universities, working together with key constituencies, intensify efforts to educate people about the distinct character of American research universities and cease promoting activities that create a public sense of unbridled excess on campuses.

The next three actions are intended to streamline and improve the productivity of research operations within universities.

Recommendation 5: Create a Strategic Investment Program that funds initiatives at research universities that are vital to advancing education and research in areas of key national priority.

We recommend that the program begin with two 10-year initiatives. The first would be an endowed faculty chairs program to facilitate the careers of young investigators. During a time of economic difficulty and limited faculty retirements, it would help ensure that America is developing the research faculty we need for the future. We also call for a research infrastructure program that is initially focused on advancement of campus cyberinfrastructure, but perhaps evolves later to address as well emerging needs for the physical research infrastructure as they arise. Matching grant requirements would generate additional funds from private or state support.

Recommendation 6: Strive to cover the full costs of research projects and other activities they procure from research universities in a consistent and transparent manner.

Today, many research universities are forced to subsidize underfunded sponsored research grants from resources designated for other important university missions such as undergraduate tuition and patient fees for clinical care. This is no longer acceptable and must cease. If the federal government and other research sponsors would cover the full costs, research universities could hold steady or reduce the amount of funding from other sources like tuition that they have had to provide for research procured by the federal government. Universities should be able to allocate their various resources more strategically for their intended purpose. Both sponsored research policies and cost recovery negotiations should be applied in a consistent fashion across all academic institutions.

Recommendation 7: Reduce or eliminate regulations that increase administrative costs, impede research productivity, and deflect creative energy without substantially improving the research environment.

Federal and state policymakers and regulators should review the costs and benefits of federal and state regulations, eliminating those that are redundant, ineffective, inappropriately applied to the higher education sector, or impose costs that outweigh the benefits to society. Furthermore, the federal government should also harmonize regulations and reporting requirements across federal agencies. Reducing and eliminating regulations could trim administrative costs, improve productivity, and increase the nimbleness of American universities. With greater freedom, they will be better positioned to respond to the needs of their constituents and the larger society.

The final three recommendations will ensure that America's pipeline of future talent in science, engineering, and other research areas remains creative and vital, leveraging the abilities of all of its citizens and attracting the best students and scholars from around the world.

Recommendation 8: Improve the capacity of graduate programs to attract talented students by addressing issues such as attrition rates, time to degree, funding, and alignment with both student career opportunities and national interests.

Research universities should restructure doctoral education to enhance pathways for talented undergraduates, improve completion rates, shorten time-to-degree, and strengthen the preparation of graduates for careers both in and beyond the academy. To this end, the federal government should achieve a better balance of fellowships, traineeships, and research assistantships. Both universities and research sponsors should address the many concerns characterizing postdoctoral research appointments including the excessive length and low compensation of such service and the misalignment of these experiences with career opportunities. Such efforts would increase cost-effectiveness and ensure that we can draw from the "best and brightest" for our nation's future doctorates.

Recommendation 9: Secure for the United States the full benefits of education for all Americans, including women and underrepresented minorities, in science, mathematics, engineering, and technology.

Research universities should intensify their efforts to improve science education throughout the education ecosystem, including K-12 and undergraduate education. Furthermore, all research partners should take action to increase the participation and success of women and underrepresented minorities across all academic and professional disciplines and especially in science, mathematics, and engineering. As careers in STEM fields continue to expand, recruiting more underrepresented minorities and women into those fields is essential in order to meet the workforce needs of our nation and to secure economic prosperity and social well-being.

Recommendation 10: Ensure that the United States will continue to benefit strongly from the participation of international students and scholars in our research enterprise.

Federal agencies should make visa processing for international students and scholars who wish to study or conduct research in America as efficient and effective as possible, consistent also with homeland-security considerations. That should include the possibility of granting residency to each foreign citizen who earns a doctorate in an area of national need from an accredited research university ("attaching a green card to each diploma").

These recommendations reflect the consensus of extensive testimony before the National Academies committee, both oral and written, from many constituencies including federal agencies, business leaders, state governments, and, of course, leaders of American higher education. While sometimes bold and ambitious, we believe our recommendations and actions are necessary to preserve one of the nation's most important assets: its world-class research university. While achieving these goals will be challenging, particularly in a rapidly changing economic environment, we believe that it is important to state what we think is needed and then to develop implementation strategies in collaboration with the various constituencies that are key to achieving these goals.

It is important to keep the recommendations and the report sufficiently flexible to adapt to unforeseen challenges and opportunities as they arise. For example, the staging of implementation steps will depend significantly upon economic circumstances. During the current economic recession, most of the focus should probably be on those federal and state policies and university practices designed to improve cost-containment and productivity. As the current economic crisis recedes and the economy improves later in the decade, attention should turn to restoring or increasing investments in research and graduate education.

### Next Steps

The National Academies viewed this report as the launch of a decade-long (or longer) effort involving many constituencies, much like the RAGS effort. It is important to keep the recommendations and the report sufficiently flexible to adapt to unforeseen challenges and opportunities as they arise. (Recall here that in the case of RAGS, this led to the initial American Competitiveness Initiative of the White House followed by the American COMPETES Act passed by Congress.)

For example, the staging of implementation steps will depend significantly upon economic circumstances. During the current economic recession, most of the focus will likely be on those federal and state policies and university practices designed to improve cost-containment and productivity. As the economy improves later in the decade the current economic crisis recedes, attention will turn to restoring or increasing investments in research and graduate education.

The actions recommended in the research university study will require significant policy changes, productivity enhancement, and investments on the part of each member of the research partnership. However the National Academies believe these recommendations comprise a fair and balanced program for each of America's research partners–research universities, the federal government, the states, and business and industry–that will generate significant returns to the nation. We also believe such commitments are necessary for the future prosperity, health, and security of America!

## Regional Meetings

Following the release of the National Academies report on the future of the American research university in June, 2012, a series of meetings were held at the state level involving governors, state legislators, business leaders, and university presidents"

- Pittsburgh (11/19/12): Successfully focused its meeting on the role of Carnegie Mellon University, the University of Pittsburgh, and the Pitt Medical Center in re-building the Pittsburgh economy over the last several decades.

- Nashville (1/16/13): Focused on how the state of Tennessee could borrow ideas from its neighbors -- Ohio, North Carolina, and Georgia -- to enhancing the role of its universities in technological development, innovation, and economic growth. Vanderbilt used the forum to discuss how it might develop a university-state-business partnership to enhance Nashville's role as a drug development center.

- Tucson (2/25/13): Enumerated a list of actions that Arizona universities might take to better facilitate research partnerships with local industry. These included reforming ITAR (International Traffic in Arms Regulations) regulations and developing new intellectual property and tenure advancement paradigms to make industry and university reward systems more complementary.

- Ann Arbor (4/12/13): Discussed ways that Michigan business leaders can spur investment in higher education and develop linkages between their companies and state higher education institutions. Specific suggestions included a tax incentive model that encourages industry to invest in higher education or research, improve tech transfer by opening dialogues between research faculty and industry, and industry programs that help recruit and retain top talent (e.g. loan repayment assistance).

Summary of Investment Goals
(Annual Growth Targets Achieved by 2022)

New Investments Requested in Report ($B/y)

Federal Support for Research Universities

| | | |
|---|---|---|
| Full Funding of the American COMPETES Act (RU share) | $6 | |
| Full-cost funding of research grants (no net increase) | 0 | |
| Reduction of regulatory burdens | 0 | |
| Strategic Investment Fund (requiring matching grants) | | |
| Junior faculty chairs | 2 | |
| Cyberinfrastructure/research infrastructure | 5 | |
| Graduate fellowships and traineeships | 2 | |
| STEM programs for women and minorities | 1 | |
| R&D Tax Credits for industry-university research partnerships | 2 | |
| Total new federal support | | $18 |
| State support | | |
| Restoration of appropriations per student to 1990 levels | | $15 |
| Private Sector | | |
| Strategic Investment Fund Matching Grants | 9 | |
| Industry-University research partnerships (R&D Tax Credit) | 6 | $15 |
| Research university productivity and cost reduction (20%) | | $15 |
| Total Investment Requested from All Sources | | $63 B/y |

Implications for Research Universities ($B/y)

Impact of Federal Actions

| | | |
|---|---|---|
| Full funding of American COMPETES Act (RU share) | $6 | |
| Relief from full-cost funding of research grants (20% of $30 B/y) | 6 | |
| Relief from reduction of regulatory burdens (5% of $30 B/y) | 1.5 | |
| Strategic Investment Fund | 7 | |
| Graduate fellowships and traineeships | 2 | |
| STEM programs | 1 | 23.5 |
| State Support | | 15 |
| Private Sector | | |
| Strategic Investment Fund matching grants | 9 | |
| Industry-University research partnerships (R&D Tax Credit) | 6 | 15 |
| Research university funds available for reallocation through productivity and cost-containment | 15 | 15 |
| Total new resources available to research universities | | $68 B /y |

**NOTE: Implications for UM: $1.5 B/y ( = a $30 B endowment)!!!**

James Duderstadt and Chad Holliday interviewed by Judy Woodruff at the Time Summit

Speaking at the National Convocation on the future of research universities

• Morgantown (4/26/13): Reviewed the actions that West Virginia University has taken to implement recommendations from the report. These include developing a website to track costs and improve productivity, and launching a campus-wide initiative that outlines areas for strategic investment in which WVU has potential for growth and a high return on investment.

• Boulder (5/29/13): Discussed threats to Colorado's research ecosystem and identified best practices for bridging the cultural divide between industry and universities. These include a New Technology Meetup program that links that link entrepreneurs, attorneys, scientists, and investors, and CU Boulder's new Office for Industry and Special Opportunity.

• Dallas (6/4/13): Enumerated a list of actions that universities might take to improve productivity and efficiency and contain costs. These include better asset utilization, increased revenue generation (not tuition-based), and strategic deployment of administrative services. Discussed the importance of strategic investments and the large benefits that can come from strategic public-private partnerships.

• San Diego (6/6/13): Identified key challenges and opportunities in broadening participation in STEM fields. These include the need to formalize educational and career pathways and refocus efforts on scaling best practices and programs. San Diego's excellent research and innovation ecosystem may be a model for other regions.

• Baltimore (6/20/13): Enumerated a list of actions that universities and industry leaders might take to better facilitate research partnerships and develop Maryland's entrepreneurial infrastructure. These included expanding Entrepreneur-in-Residence programs, developing a strategic working group composed of federal agency and university leaders to develop and promote a cohesive and consistent set of research priorities, and persuading top science advisory panels like PCAST and NSTC to engage with regulatory burden issues.

## A National Convocation

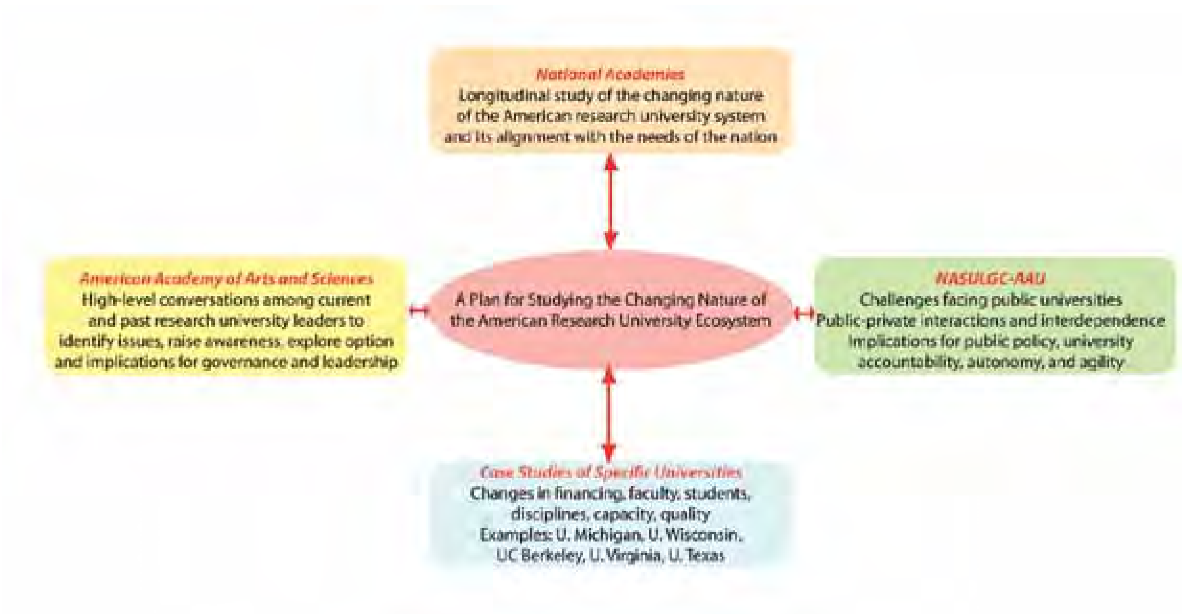
In October, 2013, a major national convocation was held at the National Academy of Sciences to evaluate both feedback and possible follow through to gain traction for the recommendations of the report.

There was a strong consensus that this project was of sufficient importance that it should continue to be a priority for the National Academies for the next decade. Among the suggested next steps were:

### Revitalizing the Partnership

Create a more unified voice portraying the long-term damage of sequestration to university R&D and hence to the nation's prosperity and security.

Build a coalition capable of convincing Congress to address the emerging "innovation deficit" by provid-




Key participants in the next phase of the American research university project

ing for real and sustained growth in the budgets in the key federal research agencies, in keeping with the vision set forth in the America COMPETES Act.

Create a 501(c) 3 organization similar to Research America that could implement a sustained lobbying effort on behalf of broad national research policy.

Encourage the federal government to create matching grant programs for R&D investment that stimulate matching support from states and other stakeholders (industry, foundations, philanthropy). Perhaps early authorization of the Strategic Initiative Fund (matching grants for junior faculty endowments and cyberinfrastructure investments) for now, then seeking funding as the economy improves.

Support university efforts to launch an effective PR campaign that stresses the damage states are causing not only to themselves but also to national prosperity and security by inadequate investments in education and workforce development in an increasingly competitive world.

Developing a model "social contract" for the states that provides more agility and autonomy to universities, to protect the world-class quality of their research universities until adequate state support is restored. (Note: Avoid the term "privatization" but rather stress that these must be provided with great agility if they are to become more "self-sufficient .)

Establish clear intellectual property policies at research universities consistent with the policies recommended by the recent 2010 NRC study on "Managing University IP in the Public Interest." Hold regional workshops to promote implementation of the reports recommendations

Create models for peer-to-peer relationships between universities and industry and establish, support and utilize mechanisms such at the University-Industry Partnership as a mechanism to share these models. Promote deeper relationships with a problem focused basis, such as discussed in the ARISE II report.

Industry should make strong use of its influence on government policies at the national and state level in areas of mutual interest (e.g., STEM immigration, support of R&D in key strategic areas)

Broaden new paradigms to promote economic development such as DOC's "regional innovation clusters" and DOE's "energy innovation hubs" capable of rebuilding the nation's capacity for translational research through peer-to-peer relationships among industry, national labs, and research universities.

Support the creation of innovative new government programs and approaches to supporting early stage proof-of-concept and market analysis work at universities. The recently introduced TRANSFER Act, which would allow for agencies to devote a small percentage of of their STTR funds to develop and support new proof-of-concept programs at universities is one such example which should be supported.

Encourage membership organizations such as AAU and APLU to set and achieve broad goals in cost-containment, efficiency, and productivity.

Launch a major National Academy effort to document the relationship between the cost, price, and value of a college education and make this analysis broadly available to the American public (using standing boards such as NRC's BHEW and STEP).

Publicize the very significant efforts of public research universities to stabilize the actual costs of education and research driven by the dramatic decline in state support. Encourage wealthy private universities to demonstrate their capacity control cost escalation and avoid competition by outspending other institutions.

Launch a campaign to better explain the complexities of financing higher education and research to policy makers, business leaders and to the general public. This includes highlighting what has already been done by both public and private universities to contain costs and stabilize tuition. Another key component of this campaign should be to educate key audiences about the importance of American research universities rather than simply compete for visibility with one another.

Working closely with industry, develop and implement more powerful strategic tools for financial management and cost accounting in ALL activities, e.g., business, instructional, and auxiliary (i.e., hospitals, housing, athletics) operations.

Seek agreement among institutions to better constrain the excessive cost increases in high visibility auxiliary activities such as intercollegiate athletics, which are damaging the credibility of the cost containment in academic programs.

Research universities, together with key stakeholders, should mount a major campaign to educate key audiences about the importance of American research universities rather than simply compete for visibility with one another.

Strengthening Research Universities

Seek Congressional legislation that would initially authorize these programs as multi-agency efforts, selling this as a way for the federal government to use matching grants (some requiring a 2 to 1 match) from other stakeholders such as states and philanthropy, but possibly delaying funding of these federal programs until more favorable economic conditions are achieved.

Universities ought to identify other sources of potential support, such as crowd funding for research. Though in its infancy, such solicitations by institutions might be used to enhance visibility and understanding of the exciting and worthy research underway, even if they do not immediately yield significant funding.

Work with OMB and COFAR to establish an effective mechanism for ongoing dialogue and discussion surrounding issues related to paying for the real and necessary costs associated with research conducted by universities on behalf of the federal government. This will include discussing the implementation of new guidance expected to be issued later this year by OMB relating to this matter.

Seek agreement from the membership of AAU and APLU to work together to convince other stakeholders (e.g., industry and foundations) of the importance of providing full support the costs associated with sponsored research.

Conduct a study, similar to the 1996 study conducted by Arthur Andersen at the request of the Government, University, Industry Research Roundtable, that provides a dollar to dollar comparison on how university expenditures and federal reimbursement of F&A expenses compares those of National Laboratories, non-profit research institutes and private industry.

Conduct specific studies to determine the actual amount of university subsidy required for research grants characterized by excessive cost-sharing and inadequate indirect cost recovery from each federal agency and private sponsor, along with data identifying where the funds for these subsidies come from as well as their impact on other activities of the university (e.g., undergraduate tuition?).

Since Congress has already expressed an interest in this subject, including hearings, efforts should be made to conduct the study requested by Congress in the most recent reauthorization of the higher education act of the need (if any), the effectiveness, and the burden of existing and all future federal regulations pertaining to both higher education and research. Similar efforts should be undertaken at the state level.

Unnecessary regulations should be eliminated or appropriately changed so that ensure accountability, but do not provide for excess regulatory or cost burden. A primary target for immediate reform is current requirements for university effort reporting.

The White House should task the research business models working group to engage the university research community in a dialogue about which regulations could be modified in a way that would both ensure accountability but also reduce cost and burden.

Congress should examine the current auditing practices of inspector generals to see if they are excessive, unwarranted and thus resulting in overly conservative and costly compliance measures being taking by universities.

Buildling Talent

Organizations such as AAU, APLU, AGS, and NRC should explore the possibility of a "Flexner Report" approach to doctoral education that recognizes the unique character of particular disciplines (e.g., natural sciences, social sciences, humanities, engineering, biomedical, etc.) and both document and address serious issues such as attrition rates, time-to-degree, and future employment objectives.

Effort should be made to implement recommendation made by the CGS in its report titled: The Path Forward: The Future of Graduate Education in the United States .

Better data should be collected by U.S. research universities to better document, understand and address issues such as attrition rates, time-to-degree, and future employment opportunities.

Working with the NRC, major federal agencies should assess the impact of particular forms of graduate student support (e.g., fellowships, traineeships, research assistantships, teaching assistantships) on time-to-degree, attrition rates, and career preparation.

A concerted effort should be made by both research universities and federal agencies to address the plight of postdoctoral scholars. In particular, the recommendations of NRC COSEPUP studies of postdoctoral education (both those of 2000 and the current study) should be seriously considered for immediate implementation by lead federal agencies such as NSF and NIH.

Higher education organizations such as AAU and APLU should request that each of their members provide a detailed plan for their engagement with K-12 education as part of a study of both the level of commitment and effectiveness of this mission (perhaps supported through a grant from DoEd or foundations).

Higher education organizations such as AAU and APLU, working with disciplinary societies, should continue their efforts to improve the quality of undergraduate STEM education at their universities by promoting the usage of evidence based teaching practices by faculty.

The federal government should collect and publish detailed annual comparisons of the participation of women and underrepresented minorities for each of the nation's research universities at all levels (e.g., undergraduate, graduate, professional)

Research universities, working closely with industry, should strongly push for immigration reform policies that not only streamline visa policies for international students and faculty but go further by enabling residency for each non-U.S. citizen who earns a doctorate from a regionally accredited university, subject to homeland security concerns.

Both public and private universities should better stress the importance of their impact on regional economic prosperity through their unique access to both global economic and talent markets.

Impact

## References

James J. Duderstadt, A University for the 21st Century (Ann Arbor, MI: University of Michigan Press, 2000) 342 pp.

James J. Duderstadt, The View from the Helm: Leading the American University during an Era of Change (Ann Arbor, MI: University of Michigan Press, 2006) 400 pp.

James J. Duderstadt and Farris W. Womack, The Future of the Public University in America: Beyond the Crossroads (Baltimore: Johns Hopkins University Press, 2002), 236 pp.

Chad Holiday, James Duderstadt, et. al., Research Universities and the Future of America: Ten Breakthrough Actions Vital to the Nation's Prosperity and Security, Report of the National Academies Committee on the Future of the American Research University (Washington DC: National Academies Press, 2012)

A FRAMING PAPER
Time Summit on Higher Education
October 10, 2014

## SOME PREMISES

• Congressional Premise: "America's research universities are admired throughout the world, and they have contributed immeasurably to our social and economic well-being. Our universities, to an extent unparalleled in other countries, are our Nation's primary source of long-term scientific, engineering, and medical research. We are concerned that they are at risk."

• National Academies Premise: Research universities provide the new knowledge and train the researchers necessary to sustain an innovation-driven and globally competitive national economy. As a follow-up to the Rising Above the Gathering Storm, the National Academies propose to undertake a study of the competitive position of U.S. research universities, public and private, and assess their ability to maintain the quality work needed to drive economic growth and competitiveness and advance the nation's goals in health, environmental quality, energy, and national security.

• Jonathan Cole: "Within the past century, and especially within the past 60 years, the United States has built the greatest system of higher learning in the world. What has made our universities so distinguished is not the quality of our undergraduate education. Other systems of higher learning, including our own liberal-arts colleges, compete well against research universities in transmitting knowledge to undergraduates. While such transmission of knowledge is a core mission of our universities, it is not what makes them the best. Our finest universities have achieved international pre-eminence because they produce a very high percentage of the most important fundamental and practical discoveries in the world. That is true across the board: in the sciences and engineering, the social and behavioral sciences, and the humanistic disciplines."

• One of the great strengths of American higher education is the presence of a system of world-class public and private research universities, sustained by public policies that ensure sufficient balance in financial assets, flexibility, and quality to serve the diverse needs of the nation. It is essential that federal policies in areas such as tax benefits, student financial aid, research funding, and regulation sustain quality, diversity, and balance in the research university system rather than threaten competitive balance and drive predatory behavior.

• For the past century American research universities have served as both the stepping stone for members of an increasingly diverse population to move into the knowledge professions (including science and engineering) and as a magnet to attract outstanding international students and faculty members to America as immigrants who have played critical roles in achieving national prosperity and security.

• The core educational and research activities of research universities require subsidies from an array of patrons–federal and state governments, students, and the private sector (foundations, corporations, donors). Yet the current model for financing world-class education and research appears to be increasingly unsustainable from all sources: federal support (threatened by growing federal debt), state support (collapsing with state budgets and shifting priorities), corporate support (declining for both research and employee education), tuition (approaching a market ceiling), gifts and endowments (sufficient for only a small number of institutions), and clinical income (threatened by new health legislation).

• Both public and private universities have an obligation to serve the public purpose and meet the needs of the nation, since all benefit from public support, and while characterized by different legal status and governance, are in fact public bodies.

## SOME QUESTIONS CHARACTERIZING U.S. RESEARCH UNIVERSITIES

0. What is a research university?

Defined by their role in creating new knowledge and educating those capable of generating new knowledge, e.g., Universitas Magistrorum et Scholarium

The roughly 100 U.S. institutions that have achieved international pre-eminence in producing a very high percentage of the most important fundamental and practical discovers in the world. They are the engines of our prosperity.

(Note Jonathan Cole: "What has made these universities so distinguished is NOT the quality of their undergraduate programs. While such transmission of knowledge is a core mission of our universities, it is now what makes them the best.")

1. Why are they important?

Congress: America's research universities are admired throughout the world, and they have contributed immeasurably to our social and economic well-being. Our universities, to an extent unparalleled in other countries, are our Nation's primary source of long-term scientific, engineering, and medical research.

National Academies: Research universities provide the new knowledge and train the researchers necessary to sustain an innovation-driven and globally competitive national economy.

Glion Declaration: For a thousand years the university has benefited our civilization as a learning community where both the young and the experienced could acquire not only knowledge and skills, but the values and discipline of the educated mind. It has defended and propagated our cultural and intellectual heritage, while challenging our norms and beliefs. It has produced the leaders of our governments, commerce, and professions. It has both created and applied new knowledge to serve our society. And it has done so while preserving those values and principles so essential to academic learning: the freedom of inquiry, an openness to new ideas, a commitment to rigorous study, and a love of learning.

2. Whom do they serve?

The nation? The states? The world?
The public? Industry? Students?

3. How many "world-class" research universities do we need?

Currently less than 100
30 private
60 public
(use David Ward's estimate that it takes 5 M citizens to support one world-class public research university)
Do we need more?

4. Who should support the core functions of the research university?

Old model:
Privates supported by tuition, philanthropy, endowment
Publics supported by states and tuition
New model: Graduate education and research supported primarily by federal government? (Just as they are in most other nations?)

5. How should they be governed?

Old model: Privates by trustees. Publics by political governing boards
New model: Hybrid boards representing multiple constituencies?

6. How diverse should the American research system be?

Comprehensive Us?
Specialized (MIT, Caltech?) Liberal Arts (Princeton?)
Graduate only (Rockefeller?)
Geographical distribution?

7. What is the balance among their roles?

Knowledge generation (research and scholarship)
Human resources (graduate education, professional education)
Knowledge diffusion (innovation, tech transfer)
Undergraduate education
Service missions
Health care
Economic development

International development
Entertainment (e.g., commercial-scale college sports???)

8. How should the research university ecosystem evolve?

Intensely competitive vs. highly coordinated (market-driven or policy-driven)
Entrepreneurial
Federal policies
State policies

9. Patrons and missions

UG education (parents, states, endowment)
Graduate education (feds)
Professional education (students)
Research and scholarship (feds)
Culture, values, humanities (private, foundations)
Knowledge diffusion (entrepreneurial, private sector, states, feds)
Other patrons (investment community, international)
Financed from "value" of degree (e.g., income-contingent loans)

10. To what degree do we need to address the internal character of the American research university, e.g., graduate education, research culture (e.g., its feudal nature of exploiting young scholars), challenges to academic integrity and values from forces such as commercialization, anti-intellectualism, etc.

## TODAY'S CHALLENGES

### Unsustainable financial models: Grad ed / research requires subsidy

Ivy Model: Focus on a small, high quality UG college for future leaders who will then pay back through philanthropy resources sufficient to build a massive endowment that can be used to sustain graduate education and scholarship (Yale, Harvard, Stanford)

UC Model: Exceptionally generous state support, part of which is designed to finance world-class graduate education and scholarship (UC, UNC, UT)

Today the Ivy Model is available only to a handful of elite private universities whose endowments have reached a level of $1 M/student or higher. With tuition levels now approaching a ceiling, it is unlikely that many other private institutions will be able to create the required endowments.

The UC Model looks increasingly problematic in the face of anticipated erosion of state support of public research universities over the next several decades as aging populations give highest priority for tax dollars to retirement security, health care, and tax relief rather than education.

In real dollars, our nation's investment in basic research peaked earlier this decade, then dropped and has remained flat in recent years. Federal policymakers have expressed a desire to bolster research funding but they have not yet followed through. Corporate support of both campus-based research and employee education has also dropped over the past decade. Furthermore, other resources that have subsidized graduate education and research such as clinical income are likely to decline in view of current federal policies (health care legislation, federal debt reduction).

In the current difficult financial climate, many private universities are facing challenging times as their endowments have seriously eroded. A few private research universities have endowments large enough to emerge strong from the current economic situation in the long-run. Smaller privates, however, may face a decade or more with depleted resources.

State appropriations, which are cyclical in nature to be sure, have over the long term declined relative to total state expenditures, personal income, and university instructional costs and operating budgets. This has had an important negative impact on public research universities with regard to faculty hiring, faculty-student ratios, research quality, and student learning outcomes even while public institutions also face growing expectations for broadening access, providing new knowledge, and meeting demands for transparency and accountability.

The outlook for improving this financial trend would have been cloudy at best given the competition for state resources from unfunded federal mandates (e.g., Medicaid) and the policy priorities of an aging population (e.g., tax reduction, health care, retirement, and security). With the current deep recession and financial storm, the outlook is even grimmer. Indeed, the sources that universities would have turned to help with difficult budget situations—state appropriations, tuition, private philanthropy, and clinical revenue—will all be constrained for the foreseeable future.

### Federal policies

Inadequate support of existing federally procured research (ICR rates, cost-sharing) (roughly 25% of costs of federal research born by institutions)

Imbalance of federal research support among the disciplines (e.g., NIH at $32 B/Y, NSF at $6 B/y, DOE Energy R&D at $3 B/y)

1970s policy shift in grad support, away from fellowships/traineeships to research assistantships (creating a feudal system)

Shifting balance from PhD students to postdocs (to avoid tuition costs)

The degree to which shifting state and federal policies (e.g., tax policy, financial aid policies, tuition constraints, sponsored research policies, affirmative action constraints) differentially affect various elements of the U.S. research university enterprise.

Absence of coherent federal policy aimed at sustaining research universities (and instead focusing on individuals, e.g., student financial aid and faculty research grants but NOT on institution building) in contrast to most other nations.

### State policies

This is a time when the strength, prosperity, and welfare of a nation demand a highly educated citizenry and institutions with the ability to discover new knowledge, develop innovative applications of discoveries, and transfer them to the marketplace through entrepreneurial activities. Yet such vital national needs are no longer top state priorities.

Highly trained and skilled labor has become more mobile and innovation more globally distributed. Many of the benefits from graduate training—like the benefits of research—are public goods that provide only limited returns to the states in which they are located. The bulk of the benefits is realized beyond state boundaries. Hence, it should be no surprise that many states have concluded that they cannot, will not, and probably should not invest to sustain world-class quality in graduate and professional education— particularly at the expense of other priorities such as broadening access to baccalaureate education. Today, not only is state support woefully inadequate to achieve state goals, but state goals no longer accumulate to meet national needs.

The declining priority that states have given to public higher education makes sense for them but is a disaster for the nation. The growing mismatch between state priorities and national needs suggests that it's time once again to realign responsibilities between the state and the nation for higher education and provide adequate resources to sustain American leadership.

### Global competition (Rick Levin):

"The U.S has reason to worry about the competitive position of its research universities. In the Times Higher Education ranking of the world's top 100 universities, the U.S. and Europe have equal numbers and there are strong and emerging institutions from Japan, Australia, China and South Korea. Across the world, other nations are taking steps to strengthen higher education generally and to advance their research capabilities. Meanwhile, our research universities are facing critical concerns

The rapid economic development of Asia since World War II -- starting with Japan, South Korea, and Taiwan, then extending to Hong Kong and Singapore, and finally taking hold powerfully in India and mainland China -- has forever altered the global balance of power. These countries recognize the importance of an educated work force to economic growth, and they understand that investing in research makes their economies more innovative and competitive.

Today, China and India aspire to create a limited number of world-class universities. In China, the nine universities that receive the most supplemental government funding recently self-identified as the C9 -- China's Ivy League. In India, the Ministry of Human Resource Development recently announced its intention to build 14 new comprehensive universities of "world-class" stature"

Such initiatives suggest that governments in Asia understand that overhauling their higher-education systems is required to sustain economic growth in a postindustrial, knowledge-based global economy. They are making progress by investing in research, reforming traditional approaches to curricula and pedagogy, and beginning to attract outstanding faculty from abroad. Many challenges remain, but it is more likely than not that by midcentury the top Asian universities will stand among the best universities in the world."

To this one should add the growing quality of European research universities, both because of major regional efforts such as the Bologna Process, and the commitment of nations to focus resources to build a small number of world-class universities.

Changing environment for education and research

Changing role and character of the faculty

Major responsibility for revenue generation added to traditional roles of teaching, research, and scholarship have overloaded many faculty members, particularly at the junior level

The use of non-tenure track instructors and lecturers that now provide the majority of undergraduate instruction in many institutions

Increasing mobility among institutions (including international mobility)

Graduate education

Use of RAs instead of fellowships/traineeships creates feudal culture

Time to degree (and permanent positions) is lengthening

Research training now requires postdoc beyond PhD

Research paradigm shifts

Physical and biomedical science to "big science" paradigm in which hundreds (at LHC thousands) work together on massive projects

Cyberinfrastructure paradigms

Augmenting theory and experiment with simulation and data mining

Functionally complete research environments in cyberspace

Social networking and immersive technologies

Winner-take-all competition: The changing nature of the interdependence of various elements of the American research university enterprise, both through competition and cooperation. The degree to which shifting state and federal policies (e.g., tax policy, financial aid policies, tuition constraints, sponsored research policies, affirmative action constraints) differentially affect various elements of the U.S. research university enterprise. Today serious imbalances have arisen in available funding, policy restrictions, and political constraints that are transforming beneficial competition into a predator-prey relationship that threatens not only numerous institutions but puts at risk the quality of the entire American research university ecosystem and hence the national interest.

Mission distraction

Pressures to expand undergraduate enrollments ("Massification"), e.g. UC.

Mission creep of auxiliary activities (inability to say "no" to increasing revenues)

Growth (budgets, facilities, enrollments, football stadiums…)

Imbalance between UG, Grad, and Prof education

Governance, Management, and Leadership: The implications of the changing needs, missions, and environment of American higher education for the leadership and governance of research universities (particularly for public universities). The complexity, scale, impact, and importance of contemporary research universities may have outstripped the capacity of lay boards to govern them with competence and accountability.

Inadequate public understanding (anti-intellectualism, costs)

While public understands UG education, they have little understanding of the role of the "universitas" in not only creating new knowledge (and stimulating innovation) but in training those capable of generating it

Recent university behavior has undermined public confidence.

Research integrity (e.g., conflict of interest)

Intercollegiate athletics

Executive compensation (Vanderbilt, Ohio

State, the Gee syndrome)
The "free agent" phenomenon

Intellectual challenges (Jonathan Cole):

"I believe that the chief threats to our standing come from within the United States rather than from foreign competition."

- Threats to the values of free inquiry and open communication (both political and misguided national security restrictions).
- Erosion of state support (with UC as poster child).
- Commercialization of intellectual property undermining core values of open communication.
- Intolerance of views that challenge orthodoxy.
- Impact of anti-intellectual forces on structure and values of higher learning.'

Issues to avoid

Intercollegiate athletics
Indirect costs

SWOT ANALYSIS
(STRENGTHS, WEAKNESSES, OPPORTUNITIES, THREATS)

## Strengths

National Priorities Requiring Research Universities
- Security (Defense, Terrorism)
- Economic Prosperity
- Public Health
- Preservation and Transmission of Culture
- Citizens for a Democratic Society
- Enlightened Criticism

Unique Contributions of Research Universities
- New knowledge (basic and applied R&D)
- Scholars, scientists, researchers
- Knowledge-intensive professionals
- Knowledge-intensive services
- Knowledge/culture repositories
- Social criticism, leadership

## Weaknesses

- Obsolete financial models
- Obsolete public policies (both federal and state)
- Inadequate alignment with U.S. prioritie
- Mission creep
- Institutional competition ("winner take all")
- STEM pipeline
- Obsolete governance, management, leadership
- Inadequate capacity for change
- Changing professoriate
- Obsolete doctoral/postdoc training (feudal system)

## Threats

- Globalization
- Human capital (changing demographics)
- Financial sustainability (particularly of flagship public universities)
- Technological change
- Public/political awareness
- Challenges to academic freedom and integrity
- Lack of a national strategy

## Opportunities

- Use crisis to stimulate change
- Develop new financial models for 21st Century
- Restructure graduate education ("Flexner Report" for the PhD)
- Rebalance competition and cooperation
- Redefine core mission ("core-in-cloud")
- Explore new paradigms (e.g., global, open-source, ecology)

## TOMORROW'S POSSIBILITIES

Driving Forces

- Knowledge Economy
- Globalization
- Demographics
- Technology
- Innovation
- Global sustainability

Game Changers

The Need for Lifelong Learning

The Globalization of Higher Education
The Changing Nature of Discovery, Learning, and Innovation
Universal Connectivity
Technological Singularities (e.g., sentient artifi cial intelligence)

Paradigm Shifts

Restructuring of higher education "industry"
Global knowledge and learning industry
Continued growth of for-profit sector
Mergers and acquisitions
Commodity products
Unbundling of missions of universities
Open knowledge and learning paradigms (digital libraries, OCW, MOOCs)
Learning ecologies and ecotones (intelligent tutors, immersive learning)
Renaissance ("maker" societies)
Enlightenment (providing the "light of knowledge and learning" to the world)
Globally connected, knowledge and learning enabled civilizations

WHENCE AND WHETHER THE UNIVERSITY OF THE FUTURE?

The triad mission of the university as we know it today—teaching, research, and service—was shaped by the needs of an America of the past. Since our nation today is changing at an ever-accelerating pace, is it not appropriate to question whether our present concept of the research university, developed largely to serve a homogeneous, domestic, industrial society, must not also evolve rapidly if we are to serve the highly pluralistic, knowledge-intensive world-nation that will be the America of the 21st Century?

Of course, there have been many in recent years suggesting that the traditional paradigm of the public university must evolve to respond to the challenges that will confront our society in the years ahead. But will a gradual evolution of our traditional paradigm be sufficient? Or, will the changes ahead force a more dramatic, indeed revolutionary, shift in the paradigm of the contemporary research university?

Just as with other institutions in our society, those universities that will thrive will be those that are capable not only of responding to this future of change, but that have the capacity to relish, stimulate, and manage change. In this perspective it may well be that the continual renewal of the role, mission, values, and goals of our institutions will become the greatest challenge of all!

The American university has changed quite considerably over the past two centuries, and it continues to evolve today. Colonial colleges have become private research universities; religious colleges formed during the early 19th century gradually became independent colleges; junior colleges have evolved into community colleges and then into regional universities. Today public research universities also continue to evolve to adapt to changes in students (from state to national to global), support (from state to national, public to private), missions (from regional to national to global), and perception (education from a public good to a private benefit). Public universities are already rapidly expanding their public purpose far beyond the borders of their states, since the more mobile the society, the more global the economy, the broader the "publics" served by the university must become.

Of course, this ever-changing nature of the university itself is part of the challenge, since it not only gives rise to an extraordinary diversity of institutions, but also a great diversity in perspectives. What is a university? Is it a "college", in the sense of the heritage of the colonial colleges (and, before that, the English boarding schools)? Is it the 20th century image of university life–football, fraternities, Joe-college, campus protests? Is it Clark Kerr's multiversity, accumulating ever more missions in response to expanding social needs–health care, economic development, technology transfer? Or is the true university something more intellectual: a community of masters and scholars (universitas magistrorum et scholarium), a school of universal learning (Newman) embracing every branch of knowledge and all possible means for making new investigations and thus advancing knowledge (Tappan)?

What is the core of its university activities? Student development (or, in the words of Lord Rugby, "transforming savages into gentlemen"). Or creating, curating, archiving, transmitting, and applying knowledge? Or serving society, responding to its contemporary needs– health care, economic development, national defense, homeland security, entertainment (e.g., athletics).

What are its core values? Critical, rigorous thinking (e.g., "the life of the mind")? Academic freedom? Individual achievement (noting that the contemporary organization of the university is really designed to enable individuals to strive to achieve their full potential (as students, faculty, athletes).

With much the character of the proverbial elephant being felt by the blind men, it is not surprising that discussions involving the future of the university can be difficult. It is particularly difficult to ignite such discussions among university leaders, who generally fall back upon the famous Clark Kerr quote: "About 85 institutions in the Western World established by 1520 still exist in recognizable forms, with similar functions and with unbroken histories, including the Catholic Church, the Parliaments of the Isle of Man, of Iceland, and of Great Britain, several Swiss cantons, and…70 universities."…Hakuna Matata

It is true that the university today looks very much like it has for decades–indeed, centuries in the case of many ancient European universities. They are still organized into academic and professional disciplines; they still base their educational programs on the traditional undergraduate, graduate, and professional discipline curricula; our universities are still governed, managed, and led as they have been for ages.

But if one looks more closely at the core activities of students and faculty, the changes over the past decade have been profound indeed. The scholarly activities of the faculty have become heavily dependent upon digital technology–rather cyberinfrastructure–whether in the sciences, humanities, arts, or professions. Although faculties still seek face-to-face discussions with colleagues, these have become the booster shot for far more frequent interactions over the Internet. Most faculty members rarely visit the library anymore, preferring to access digital resources through powerful and efficient search engines. Some have even ceased publishing in favor of the increasingly ubiquitous digital preprint or blog route. Student life and learning are also changing rapidly, as students bring onto campus with them the skills of the net generation for applying this rapidly evolving technology to their own interests, forming social groups through social networking technology (Facebook, Twitter), role playing (gaming), accessing web-based services, and inquiry-based learning, despite the insistence of their professors that they jump through the hoops of the traditional classroom paradigm.

In one sense it is amazing that the university has been able to adapt to these extraordinary transformations of its most fundamental activities, learning and scholarship, with its organization and structure largely intact. Here one might be inclined to observe that technological change tends to evolve much more rapidly than social change, suggesting that a social institution such as the university that has lasted a millennium is unlikely to change on the timescales of tech turns, although social institutions such as corporations have learned the hard way that failure to keep pace can lead to extinction. Yet, while social institutions may respond more slowly to technological change, when they do so, it is frequently with quite abrupt and unpredictable consequences, e.g., "punctuated evolution".

It could also be that the revolution in higher education is well underway, at least with the early adopters, and simply not sensed or recognized yet by the body of the institutions within which the changes are occurring. Universities are extraordinarily adaptable organizations, tolerating enormous redundancy and diversity. It could be that the information technology revolution is more of a tsunami that universities can float through rather than a rogue wave that will swamp them.

An alternative viewpoint of the transformation of the university might be as an evolutionary rather than a revolutionary process. Evolutionary change usually occurs first at the edge of an organization (an ecology) rather than in the center where it is likely to be extinguished. In this sense the forces that are now transforming scholarship and enabling new forms of learning communities have not yet propagated into the core of the university. Of course, from this perspective, recent efforts such as the Google Book project take on far more significance, since the morphing of the university library from stacks to Starbucks strikes at the intellectual soul of the university.

Admittedly it is also the case that futurists have a habit of overestimating the impact of new technologies in the near term and underestimating them over the longer term. There is a natural tendency to implicitly assume that the present will continue, just at an accelerated pace, and fail to anticipate the disruptive technologies and killer apps that turn predictions topsy-turvy. Yet we also know that far enough into the future, the exponential character of the evolution of Moore's Law technologies such as info-, bio-, and nano- technology makes almost any scenario possible.

Clearly we have entered a period of significant change in higher education as our universities attempt to respond to the challenges, opportunities, and responsibilities before them. This time of great change, of shifting paradigms, provides the context in which we must consider the changing nature of the university.

Much of this change will be driven by market forces—by a limited resource base, changing societal needs, new technologies, and new competitors. But we also must remember that higher education has a public purpose and a public obligation. Those of us in higher education must always keep before us two questions: "Whom do we serve?" and "How can we serve better?" And society must work to shape and form the markets that will in turn reshape our institutions with appropriate civic purpose.

From this perspective, it is important to understand that the most critical challenge facing most institutions will be to develop the capacity for change. As we noted earlier, universities must seek to remove the constraints that prevent them from responding to the needs of a rapidly changing society. They should strive to challenge, excite, and embolden all members of their academic communities to embark on what should be a great adventure for higher education.

As Frank Rhodes so eloquently stated it in his closing words of reassurance in the 1999 Glion Declaration:

"For a thousand years the university has benefited our civilization as a learning community where both the young and the experienced could acquire not only knowledge and skills, but the values and discipline of the educated mind. It has defended and propagated our cultural and intellectual heritage, while challenging our norms and beliefs. It has produced the leaders of our governments, commerce, and professions. It has both created and applied new knowledge to serve our society. And it has done so while preserving those values and principles so essential to academic learning: the freedom of inquiry, an openness to new ideas, a commitment to rigorous study, and a love of learning.

There seems little doubt that these roles will continue to be needed by our civilization. There is little doubt as well that the university, in some form, will be needed to provide them. The university of the twenty-first century may be as different from today's institutions as the research university is from the colonial college. But its form and its continued evolution will be a consequence of transformations necessary to provide its ancient values and contributions to a changing world. "

Certainly the need for research universities will be of increasing importance in our knowledge-driven future. Certainly, too, it has become increasingly clear that our current paradigms for the university, its teaching and scholarship, its service to society, its financing, all must change rapidly and perhaps radically. Hence the real question is not whether higher education will be transformed, but rather how and by whom. If the university is capable of transforming itself to respond to the needs of a culture of learning, then what is currently perceived as the challenge of change may, in fact, become the opportunity for a renaissance, an age of enlightenment, in higher education in the years ahead.

The remarkable resilience of universities, their capacity to adapt and change in the past, has occurred in part because it embraces and encourages an intensely entrepreneurial cultures. We have provided our faculty the freedom, the encouragement, and the incentives to move toward their personal goals in highly flexible ways, and they have done so through good times and bad. Our challenge is to tap this grassroots energy and creativity in the effort to transform our institutions to better serve a changing world.

Yet we must do so within the context of an exciting and compelling vision for the future of our institutions. Rather than allowing the university to continue to evolve as an unconstrained, transactional, entrepreneurial culture, we need to guide this process in such a way as to preserve our core missions, characteristics, and values. We must work hard to develop university communities where uncertainty is an exhilarating opportunity for learning and discovery.

Chapter 5

# Engineering for a Changing World

Powerful forces, including demographics, globalization, and rapidly evolving technologies are driving profound changes in the role of engineering in society. The changing workforce and technology needs of a global knowledge economy are dramatically changing the nature of engineering practice, demanding far broader skills than simply the mastery of scientific and technological disciplines. The growing awareness of the importance of technological innovation to economic competitiveness and national security is demanding a new priority for application-driven basic engineering research. The nonlinear nature of the flow of knowledge between fundamental research and engineering application, the highly interdisciplinary nature of new technologies, and the impact of cyberinfrastructure demand new paradigms in engineering research and development. Moreover, challenges such as the offshoring of engineering jobs, the decline of student interest in scientific and engineering careers, immigration restrictions, and inadequate social diversity in the domestic engineering workforce are also raising serious questions about the adequacy of our current national approach to engineering.

To this end, in 2006-2007 the National Science Foundation supported a comprehensive study of engineering practice, research, and education analogous to the famous Flexner Report of 1910 that transformed medicine in this country.

## The Challenges to American Engineering

During the past several years such considerations have led numerous groups, including the National Academies, federal agencies, business organizations, and professional societies to conclude that new paradigms in engineering practice, research, and education that better address the needs of a 21st-century nation in a rapidly changing world (e.g., see Augustine, 2005; Duderstadt, 2005; Clough, 2004, 2005; Sheppard, 2008). Among the many concerns these studies have raised about American engineering are the following.

### Engineering Practice

The implications of a technology-driven global economy for engineering practice are particularly profound. The globalization of markets requires engineers capable of working with and among different cultures and knowledgeable about global markets. New perspectives are needed in building competitive enterprises as the distinction between competition and collaboration blurs. The rapid evolution of high-quality engineering services in developing nations with significantly lower labor costs, such as India, China, and Eastern Europe, raises serious questions about the global viability of the United States engineer, who must now produce several times the value-added to justify wage differentials. Both new technologies (e.g., info-bio-nano) and the complex mega systems challenges arising in contemporary society (e.g., massive urban, transportation, and communications infrastructure) require highly interdisciplinary engineering teams characterized by broad intellectual span rather than focused practice within traditional disciplines. As technological innovation plays an ever more critical role in sustaining the nation's economic prosperity, security, and social well-being, engineering practice will be challenged to shift from traditional problem solving and design skills toward more innovative solutions imbedded in a complex array of social, environmental, cultural, and ethical issues.

Yet, despite the growing importance of engineering practice to society, the engineering profession still tends

High Tech industry in Bangalore

The changing nature of engineering research

to be held in relatively low esteem in the United States compared to other learned professions such as law and medicine. Perhaps this is not surprising, both because of the undergraduate nature of its curriculum and the evolution of the profession from a trade (a "servile art" such as carpentry rather than a "liberal art" such as law, medicine, or theology). Yet today this is eroding prestige and influence is intensified by the tendency of many companies to view engineers as consumable commodities, discarding them when their skills become obsolete or replaceable by cheaper engineering services from abroad. Students sense the eroding status and security of engineering careers and increasingly opt for other more lucrative and secure professions such as business, law, and medicine. Today's engineers no longer hold the leadership positions in business and government that were once claimed by their predecessors in the 19th and 20th century, in part because neither the profession nor the educational system supporting it have kept pace with the changing nature of both our knowledge-intensive society and the global marketplace. In fact, the outsourcing of engineering services of increasing complexity and the offshoring of engineering jobs of increasing value threaten the erosion of the engineering profession in America and with it our nation's technological competence and capacity for technological innovation.

Engineering Research

There is increasing recognition throughout the world that leadership in technological innovation is key to a nation's prosperity and security in a hypercompetitive, global, knowledge-driven economy (Council on Competitiveness, 2003). While our American culture, based upon a highly diverse population, democratic values, free-market practices, and a stable legal and regulatory environment, provides an unusually fertile environment for technological innovation and entrepreneurial activity, history has shown that significant federal and private investments are necessary to produce the ingredients essential for innovation to flourish: new knowledge (research), human capital (education), infrastructure (e.g., physical, cyber), and policies (e.g., tax, property).

One of the most critical elements of the innovation process is the long-term research required to transform new knowledge generated by fundamental scientific discovery into the innovative new products, processes, and services required by society. In years past this applications-driven basic research was a primary concern of major corporate R&D laboratories, national laboratories, and the engineering schools associated with research universities. However, in today's world of quarterly earnings pressure and inadequate federal support of research in the physical sciences and engineering, this longer-term, applications-driven basic engineering research has largely disappeared from the corporate setting, remaining primarily in national laboratories and research universities constrained by inadequate federal support. This has put at considerable risk the discovery-innovation process in the United States.

Numerous recent studies (COSEPUP, 1998-03; Duderstadt, 2005; Clough, 2002; Vest, 2003; Augustine, 2005) have concluded that stagnant federal investments in basic engineering research, key to technical innovation, are no longer adequate to meet the challenge of an increasingly competitive global economy. There is further evidence that the serious imbalance between federally supported research, now amounting to less than 26% of national R&D, along with the imbalance that has resulted from the five-fold increase in federal support of biomedical research during a period when support of research in the physical sciences and engineering has remained stagnant, threatens the national capacity for innovation.

Engineering Education

In view of these changes occurring in engineering practice and research, it is easy to understand why some raise concerns that we are attempting to educate 21st-century engineers with a 20th-century curriculum taught in 19th-century institutions. The requirements of 21st-century engineering are considerable: engineers must be technically competent, globally sophisticated, culturally aware, innovative and entrepreneurial, and nimble, flexible, and mobile (Continental, 2006). Clearly new paradigms for engineering education are demanded to: i) respond to the incredible pace of intellectual change (e.g., from reductionism to complexity, from analysis to synthesis, from disciplinary to multidisciplinary); ii) develop and implement new technologies (e.g., from the microscopic level of info-bio-nano to the macroscopic level of global systems); iii) accommodate a far more holistic approach to addressing social needs and priorities, linking social, economic, environmental, legal, and political considerations with technological design and innovation, and iv) to reflect in its diversity, quality, and rigor the characteristics necessary to serve a 21st-century nation and world (Sheppard, 2008).

The issue is not so much reforming engineering education within old paradigms but instead transforming it into new paradigms necessary to meet the new challenges such as globalization, demographic change, and disruptive new technologies. As National Science Board workshops involving representatives of industry, government, professional societies, and higher education concluded, the status quo in engineering education in the United States is no longer sufficient to sustain the nation's technological leadership (NSB, 2007).

Where will tomorrow's engineers come from?

The critical role of our engineering schools in providing human capital necessary to meet national needs faces particular challenges (Clough, 2004, 2006; Duderstadt, 2005). Student interest in science and engineering careers is at a low ebb–not surprising in view of the all-too-frequent headlines announcing yet another round of layoffs of American engineers as companies turn to offshoring engineering services from low-wage nations. Cumbersome immigration policies in the wake of 9-11, along with negative international reaction to U.S. foreign policy, are threatening the pipeline of talented international science and engineering students into our universities and engineering workforce. Furthermore, it is increasingly clear that a far bolder and more effective strategy is necessary if we are to tap the talents of all segments of our increasingly diverse society, with particular attention to the participation of women and underrepresented minorities in the engineering workforce.

The current paradigm for engineering education, e.g., an undergraduate degree in a particular engineering discipline, occasionally augmented with workplace training through internships or co-op experiences and perhaps further graduate or professional studies, seems increasingly suspect in an era in which the shelf life of taught knowledge has declined to a few years. There have long been calls for engineering to take a more formal approach to lifelong learning, much as have other professions such as medicine in which the rapid expansion of the knowledge base has overwhelmed the traditional educational process. Yet such a shift to graduate-level requirements for entry into the engineering profession has also long been resisted both by students and employers. Moreover, it has long been apparent that current engineering science-dominated curricula needs to be broadened considerably if students are to have the opportunity to learn the innovation and entrepreneurial skills so essential for our nation's economic welfare and security, yet this too has been resisted, this time by engineering educators.

Here part of the challenge–and key to our objectives–must be an appreciation for the extraordinary diversity in engineering and training to meet the ever more diverse technological needs of our nation. Different types of institutions and programs are clearly necessary to prepare students for highly diverse roles: from system engineers capable of understanding and designing complex systems from the atomic to the global level; master engineers capable of the innovative design necessary to develop products, processes, and services competitive in a global economy; engineering scientists capable of conducting the fundamental research necessary to address compelling global challenges such as energy sustainability; and engineering managers capable of leading global enterprises. And all of these institutions, programs, and roles must strive to provide exciting, creative, and adventurous educational experiences capable of attracting the most talented of tomorrow's students.

From a broader perspective, one might argue that as technology becomes an ever more dominant aspect of social issues, perhaps the discipline of engineering should evolve more along the lines of other academic disciplines such as physics and biology that have become cornerstones of the liberal arts canon. Perhaps the most urgent need of our society is a deeper understanding and appreciation for technology on the part of all college graduates rather than only those seeking engineering degrees. These, too, should be concerns of engineering educators.

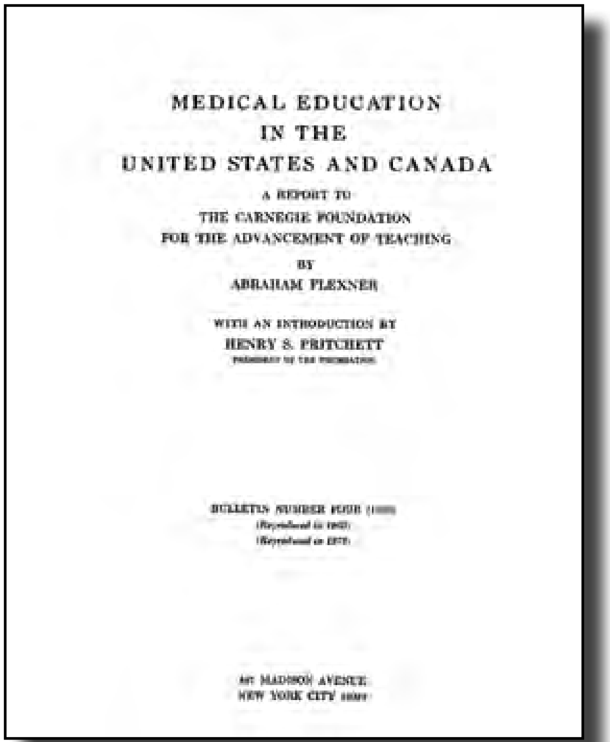
## A Flexner Report for Engineering

More generally, we need to address the question of what our nation should seek as both the nature and objectives of engineering in the 21st-century, recognizing that significant changes are required to address changing national needs and priorities. What is engineering–a discipline, an occupation, a career, or a profession? Whom should engineering serve–industry, government, the nation, the world, students, or the profession itself? Granted that engineering education should not be monolithic, but how can we achieve adequate intellectual depth, breadth, and rigor across a highly diverse engineering enterprise demanded by our changing needs as a society and as a nation?

Medicine as practiced in 1910

Note that such a general approach is quite similar in spirit to that conducted for the medical profession almost a century ago. At that time medicine was facing a tipping point when society's changing needs, coupled with a changing knowledge base of medical practice, would drive a very rapid transformation of the medical profession, along with medical education, licensure, and practice. The Carnegie Foundation for the Advancement of Teaching commissioned noted educator (but not physician) Abraham Flexner to survey 150 medical schools over a yearlong period and draft a report concerning the changing nature of the profession and the implications for medical education. During the 19th-century, medical education had evolved from a practice-based apprenticeship to dependence primarily upon didactic education (a year of lectures followed by a licensing exam), losing the rigor of training critical to competent health care. Many students had less than a high school education and none required a college degree. As Flexner observed, medical education was a farce as it was taught in most schools, "without laboratories, without trained and salaried men, without dispensaries, and without hospitals".

The questions Flexner raised about medical education still reverberate today (Bonner, 2002): How are scientific principles best joined to clinical problem solving and broadly liberal knowledge in a doctor's education?



MEDICAL EDUCATION
IN THE
UNITED STATES AND CANADA

A REPORT TO
THE CARNEGIE FOUNDATION
FOR THE ADVANCEMENT OF TEACHING

BY
ABRAHAM FLEXNER

WITH AN INTRODUCTION BY
HENRY S. PRITCHETT

The Flexner Report of 1910

How should students prepare for medical education and what should be its components? Flexner held up Johns Hopkins University as the standard to which all medical schools should be held, involving a full-time faculty, allied to a teaching hospital and integrated into a university (although other medical schools including Michigan, Harvard, and Pennsylvania had actually pioneered the practice of requiring a college education for admission into programs based on laboratory science and clinical training in a teaching hospital environment).

The Flexner Report of 1910 transformed medical education and practice into the 20th century paradigm of scientific (laboratory-based) medicine and clinical training in teaching hospitals (Flexner, 1910). The key to the impact of the report was to promote educational reform as a public health obligation: "If the sick are to reap the full benefit of recent progress in medicine, a more uniformly arduous and expensive medical education is demanded." Key would be the requirement that all physicians should be well-educated, highly trained diagnosticians and problem solvers who understand the laboratory basis for scientific knowledge and have become skilled through extensive clinical experience. A medical degree would require a four-year post-undergraduate program based on inductive teaching in medicine and science–learning by doing–in a university setting that joined investigative science to practical training.

The Flexner Report ignited a reform movement that transformed medical education and practice over the next several decades. Roughly two-thirds of medical colleges based on the didactic education of undergraduates were closed as the post-baccalaureate training paradigm proposed by Flexner was accepted as the requirement for medical practice.

Here it is interesting to note that during his study of medicine, Flexner raised very similar concerns about engineering education even at this early period. "The minimum basis upon which a good school of engineering accepts students is, once more, an actual high school education, and the movement toward elongating the technical course to five years confesses the urgent need of something more." However, he went on to contrast medical and engineering in two ways: first, engineering depends upon the basic sciences (chemistry, physics, mathematics) while medicine depends upon the secondary sciences (anatomy, physiology), which, in turn, depend upon basic sciences. Second, while engineers take on major responsibility for human life (e.g., buildings, bridges), they usually do so after gaining experience working up the employment ladder, while physicians must deal with such issues immediately upon graduation.

During the past century there have been numerous efforts to conduct an analysis of engineering very similar in spirit to the Flexner Report, including the Mann Report of 1918 (sponsored like Flexner's work by the Carnegie Foundation), the Wichenden Report of 1923, the ASEE Grinter Report of 1955, the ASEE report on Goals of an Engineering Education of 1968, the ASEE Green Report of 1994, the NRC BEEd Report leading to the ABET EC2000 program, and most recently the NAE Engineer of 2020 study (Clough, 2004). As Schowalter observes, "Appearance every decade of a definitive report on the future of engineering education is as predictable as a sighting of the first crocuses in spring" (Schowalter, 2003). Yet throughout the past century, engineering education has remained remarkably stable–to be sure, adding more scientific content, but doing

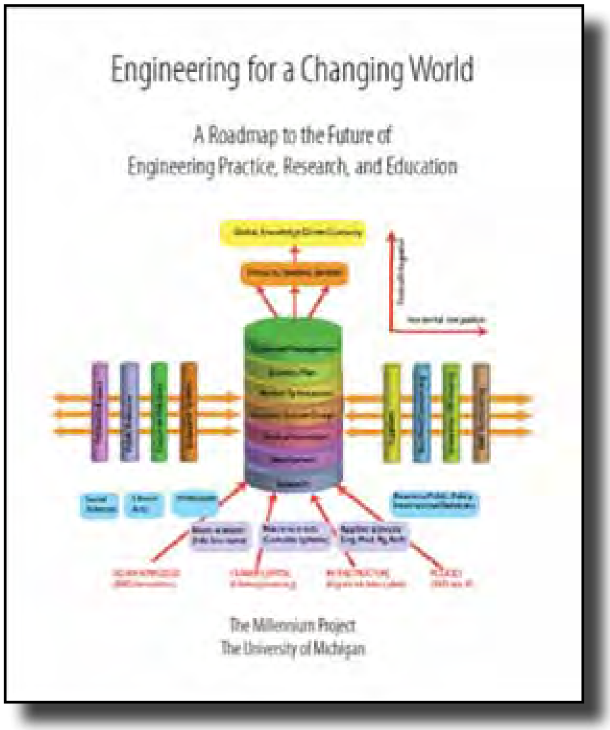

A cacophony of reports demanding change in engineering

so within a four-year undergraduate program based primarily upon scientific problem solving and resisting most efforts to elevate it to the post-graduate practice-based programs characterizing other learned professions such as medicine and law.

Ironically, although engineering is one of the professions most responsible for and responsive to the profound changes in our society driven by evolving technology, its characteristics in practice, research, and education have been remarkably constant–some might even suggest stagnant–relative to other professions. Over the past century medical knowledge has been transformed from apprenticeship (e.g., the barber shop) to macroscopic science-driven (physiology, epidemiology) to microscopic science (genetics, proteomics, nanotechnology). Medical practice is also continuing to evolve rapidly, from reactive (curing disease) to prescriptive (determining one's genetic susceptibility to disease) to preventive (wellness). The profession of law is also evolving rapidly because of the impact of information technology (e.g., the ability to rapidly search and analyze written material in digital form; new forms of incontrovertible evidence such as DNA analysis; and the evolution of computer-based pattern recognition and psychological profiling to detect lying). Yet many aspects of engineering, including engineering education and professional certification, remain much as they have for decades, despite the rapidly changing nature of engineering practice and technology needs of society.

## A Framework for Change

So what should our nation seek as both the nature and objectives of engineering in the 21st century, recognizing that these must change significantly to address rapidly changing needs and priorities? Here we need to consider the implications for American engineering from several perspectives: i) as a discipline (similar to physics or mathematics), possibly taking its place among the "liberal arts" characterizing a 21st-century technology-driven society; ii) as a profession, addressing both the urgent needs and grand challenges facing our society; iii) as a knowledge base supporting innovation, entrepreneurship, and value creation in a knowledge economy; and iv) as a diverse educational system characterized by the quality, rigor, and diversity neces-




Engineering for a Changing World (2005)

sary to produce the engineers and engineering research critical to prosperity, security, and social well being.

Here we begin with several premises:

In a global, knowledge-driven economy, technological innovation–the transformation of knowledge into products, processes, and services–is critical to competitiveness, long-term productivity growth, and the generation of wealth. Preeminence in technological innovation requires leadership in all aspects of engineering: engineering research to bridge scientific discovery and practical applications; engineering education to give engineers and technologists the skills to create and exploit knowledge and technological innovation; and the engineering profession and practice to translate knowledge into innovative, competitive products and services.

To compete with talented engineers in other nations with far greater numbers and with far lower wage structures, American engineers must be able to add significantly more value than their counterparts abroad through their greater intellectual span, their capacity to innovate, their entrepreneurial zeal, and their ability to address the grand challenges facing our world.

It is similarly essential to elevate the status of the engineering profession, providing it with the prestige and influence to play the role it must in an increasingly technology-driven world while creating sufficiently flexible and satisfying career paths to attract a diverse population of outstanding students. Of particular importance is greatly enhancing the role of engineers both in influencing policy and popular perceptions and as participants in leadership roles in government and business.

From this perspective the key to producing such world-class engineers is to take advantage of the fact that the comprehensive nature of American universities provide the opportunity for significantly broadening the educational experience of engineering students, provided that engineering schools, accreditation agencies such as ABET, the profession, and the marketplace are willing to embrace such an objective. Essentially all other learned professions have long ago moved in this direction (law, medicine, business, architecture), requiring a broad liberal arts baccalaureate education as a prerequisite for professional education at the graduate level.

In summary, we believe that to meet the needs of the nation, the engineering profession must achieve the status and influence of other learned professions such as law and medicine. Engineering practice in our rapidly changing world will require an ever-expanding knowledge base requiring new paradigms for engineering research that better link scientific discovery with innovation. The complex challenges facing our nation will require American engineers with a much higher level of education, particularly in professional skills such as innovation, entrepreneurship, and global engineering practice. To this end, we set the following objectives for engineering practice, research, and education:

1. To establish engineering practice as a true learned profession, similar in rigor, intellectual breadth, preparation, stature, and influence to law and medicine, with extensive post-graduate education and a culture more characteristic of professional guilds than corporate employees.

2. To redefine the nature of basic and applied engineering research, developing new research paradigms that better address compelling social priorities than those methods characterizing scientific research.

3. To adopt a systemic, research-based approach to innovation and continuous improvement of engineering education, recognizing the importance of diverse approaches–albeit characterized by quality and rigor–to serve the highly diverse technology needs of our society.

4. To establish engineering as a true liberal arts discipline, similar to the natural sciences, social sciences, and humanities, by imbedding it in the general education requirements of a college graduate for an increasingly technology-driven and -dependent society of the century ahead.

To achieve these objectives for American engineering, this study recommends the following actions:

## Transforming the Profession

When physicians are asked about their activities, they generally respond with their professional specialty, e.g., "I'm a cardiologist" or "I'm a neurosurgeon." So too, lawyers are likely to respond with a specialty such as corporate law or litigation. In sharp contrast, when asked about their profession, most engineers will respond with their employer: "I work for Ford" or Boeing or whomever. Hence the first goal is to transform engineering from an occupation or a career to a true learned profession, where professional identity with the unique character of engineering practice is more prevalent than identification with employment.

Part of the challenge here is that there are so many types of and roles for engineers, from low-level technicians or draftsmen to master design engineers to engineering scientists to technology managers. Hence as we explore possible futures for the engineering profession, it may be necessary to consider defining more formally through statute or regulation the requirements for various engineering roles. For example, one might distinguish these by degree levels, e.g., routine engineering services (sales, management) might require only a baccalaureate degree (B.S.) perhaps augmented by an M.B.A.; design engineers would require training at the masters level (M.S.); engineering scientists engaged in research would require a Ph.D.; and so forth, with the definition of role and degree requirements established by statute, as they are in medicine and law. As we will suggest later in this chapter, the changing nature of engineering and its increasing importance in an ever more technology-driven world may require even more senior engineering roles requiring advanced, practice-based engineering degrees.

A confusing cloud of professional societies

Of course there will be strong resistance by many employers to elevating the education level required for the engineering profession, since many companies will prefer to continue to hire baccalaureate-level engineering graduates at lower cost, although such graduates are usually less capable of high value-added activities such as radical technological innovation. So too, many students and parents will question whether the extension of engineering education beyond the baccalaureate level will add sufficient personal return to justify the additional time and expense requirements. Hence key in any effort to elevate the educational requirements and thereby the value, prestige, and influence of the engineering profession will be a coordinated effort by engineering professional and disciplinary societies to raise public awareness of the intensifying educational demands of engineering practice. Furthermore, as other learned professions have demonstrated, it will also be important for the engineering profession to become more influential in both defining and controlling the marketplace for engineers and engineering services if they are to break through the current resistance of employers, clients, and students to more advanced educational requirements for engineering practice.

Hence attaining the necessary prestige and influence will almost certainly require a major transformation of the culture of engineering practice and the engineering profession itself. To this end, the following proposal is offered.

*Proposal: Engineering professional and disciplinary societies, working with engineering leadership groups such as the National Academy of Engineering, the National Society for Professional Engineers, the American Association of Engineering Societies, ABET, and the American Society for Engineering Education, should strive to create a "guild-like" culture in the engineering profession, similar to those characterizing other learned professions such as medicine and law, which aims to shape rather than simply react to market pressures.*

The initial goal should be to create (actually, re–create) a guild culture for engineering, where engineers identify more with their profession than their employers, taking pride in being members of a true profession whose services are highly valued by both clients and society. While engineering does have some elements of these modern guilds, the great diversity of engineering roles, professional organizations, and clients (employers) prevent engineering from exerting the influence or control over the marketplace enjoyed by many other contemporary guilds. Hence our proposal is for a more concerted effort on the part of engineering organizations–professional and disciplinary societies, engineering education, and those engineers with influence in public policy and politics–to exert a more coordinated and strategic effort to establish a strong guild structure for the engineering profession. The necessary transformation is suggested by a transition in both language and perspective. Engineers would increasingly define themselves as professionals rather than employees. They primary markets would be clients rather than employers. And society would view engineering as a profession rather than an occupation.

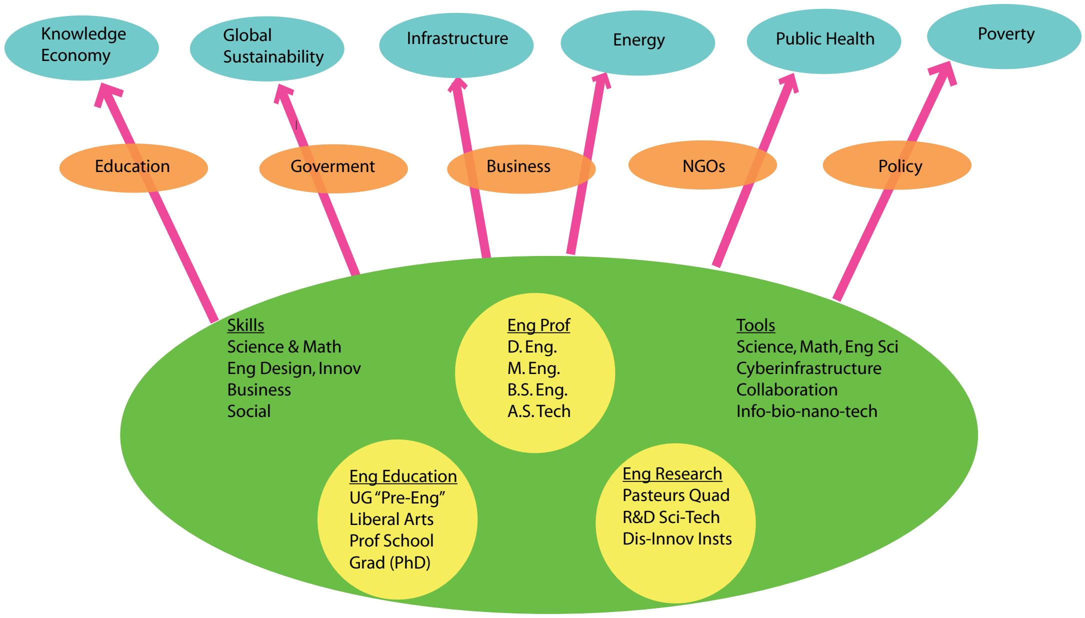
## Expanding the Engineering Knowledge Base

For over fifty years the United States has benefited from a remarkable discovery-innovation engine that has powered our economic prosperity while providing for our national security and social well being. As Charles Vest suggests, for America to prosper and achieve security, it must do two things: (1) discover new scientific knowledge and technological potential through research and (2) drive high-end, sophisticated technology faster and better than anyone else. We must make new discoveries, innovate continually, and support the most sophisticated industries (Vest, 2005).

Two federal actions at mid-century, the G.I. Bill and the government-university research partnership, provided the human capital and new knowledge necessary for the innovation that drove America's emergence as the world's leading economic power. Both federal actions also stimulated the evolution of the American research university to serve the nation by providing these assets critical to a discovery-innovation-driven economy. Today it has become apparent that the nation's discovery-innovation engine needs a tune-up in the face of the profound changes driven by a hypercompetitive, knowledge-driven global economy. Further federal action is necessary to generate the new knowledge, build the necessary infrastructure, and educate the innovators–entrepreneurs necessary for global leadership in innovation.

In 2005 the National Academy of Engineering completed a comprehensive study of the challenges facing engineering research in America and recommended a series of actions at the federal level to respond to the imperatives of a flattening world (Duderstadt, 2005). Among the more important recommendations contained in this report are the following:

*Proposal: The federal government should adopt a more strategic approach to research priorities and R&D funding. In particular a more balanced investment is needed among the biomedical sciences, physical sciences, and engineering is necessary to sustain our leadership in technological innovation. Long-term basic engineering research should again become a priority for American industry. The nation should secure an adequate flow of next-generation scientists and engineers through major federal fellowship-traineeships*



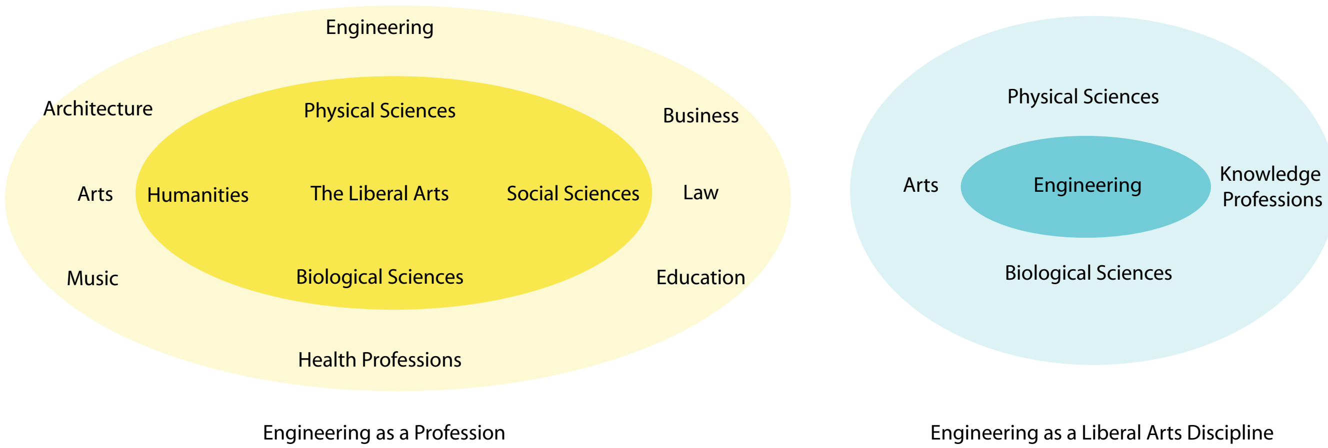

Engineering challenges for the 21st Century

*program in key strategic areas (e.g., energy, info-nano-bio, knowledge services), similar to that created by the National Defense Education Act. Immigration policies and practices should be streamlined (without compromising homeland security) to restore the flow of talented students, engineers, and scientists from around the world into American universities and industry. The federal government in close collaboration with industry, universities, and the states should explore new research paradigms that better link fundamental scientific discoveries with technological innovation to build the knowledge base essential for new products, process, and services to meet the needs of society.*

Similar concerns raised by leaders of industry, higher education, and the scientific community, culminating in the National Academies' Rising Above the Gathering Storm study, have stimulated the federal government to launch two major efforts aimed at sustaining U.S. capacity for innovation and entrepreneurial activities: the administration's American Competitiveness Initiative and Congress's America COMPETES Act (the latter being including an awkward acronym for "Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science".) If fully implemented, over the next decade these efforts will involve doubling federal investment in basic research in physical science and engineering; major investments in science and engineering education; tax policies designed to stimulate private sector in R&D; streamlining intellectual property policies; immigration policies that attract the best and brightest scientific minds from around the world; and building a business environment that stimulates and encourages entrepreneurship through free and flexible labor, capital, and product markets that rapidly diffuse new productive technologies.

## Transforming Engineering Education

Many nations are investing heavily in developing their engineering workforce within cultures in which science and engineering are regarded as exciting, respected fields by young people and as routes to leadership roles in business and government, in contrast to the relatively low popularity and influence of these fields in American society. But the United States does have one very significant advantage: the comprehensive nature of the universities in which most engineering education occurs, spanning the range of academic disciplines and professions from the liberal arts to law, medicine, and other learned professions. American universities have the capacity to augment education in science and engineering with the broader exposure to the humanities, arts, and social sciences that are abso-




The separation of engineering as a profession from as a discipline

lutely essential to building both the creative skills and cultural awareness necessary to compete in a globally integrated society. Furthermore their integration of education, research, and service–that is, learning, discovery, and engagement–provides a formidable environment for educating 21st-century engineers. By building a new paradigm for engineering education that takes full advantage of the comprehensive nature and unusually broad intellectual span of the American university, we can create a new breed of engineer, capable of adding much higher value in a global, knowledge-driven economy.

To take advantage of this unique character of American higher education, its capacity to integrate learning across the academic and professional disciplines, it will be necessary to separate the concept of engineering as an academic discipline from engineering as a learned profession. To this end, consider five specific proposals: 1) to establish graduate professional schools of engineering that would offer practice-based degrees at the post–baccalaureate level, 2) to restructure undergraduate engineering programs as a "liberal arts" discipline, 3) to develop a structured approach to lifelong learning for engineering professionals, 4) to include the academic discipline of engineering (or more broadly technology) in a 21st-century liberal arts canon suitable for all undergraduate students, and 5) to challenge the engineering community to commit itself to reflecting among its members the great diversity characterizing both our nation and the world. Let us consider each proposal in turn:

*Proposal: Working closely with industry and professional societies, higher education should establish graduate professional schools of engineering that would offer practice-based degrees at the post-baccalaureate level as the entry degree into the engineering profession.*

Perhaps the most effective way to raise the value, prestige, and influence of the engineering profession is to create true post-baccalaureate professional schools similar to medicine and law, which are staffed with practice-experienced faculty and provide clinical practice experience. More specifically, the goal would be the transformation of engineering into a true learned profession, comparable in rigor, prestige, and influence to medicine and law, by shifting the professional education and training of engineers to post-baccalaureate professional schools offering two- or three-year, practice-focused degree programs in contrast to research-focused graduate degrees such as the M.S. and Ph.D. The faculty of these schools would have strong backgrounds in engineering practice with scholarly interests in the key elements of engineering, e.g., design, innovation, entrepreneurial activities, technology management, systems integration, and global networking, rather than research in engineering sciences. Students would be drawn from a broad array of possible undergraduate degrees with strong science and mathematics backgrounds, e.g., from the sciences or mathematics or perhaps a broader engineering discipline similar to the pre-med programs preparing students for further study in medicine.

The M.Eng. degree programs developed for practicing engineers by many engineering schools might be a first step toward such professional schools, much as the M.B.A. suffices for the business profession. However, more extended programs akin to law and medical education would have greater impact on both student capabilities and the prestige of the profession. While a more extended post-graduate professional degree program would encounter the usual resistance from employers and students, if designed properly, the value-added provided by a graduate professional degree in engineering would likely outweigh any loss of income from a similar time period spent while employed following a baccalaureate engineering degree.

Clearly the educational content would be quite different from the engineering science curriculum characterizing most undergraduate engineering programs today. At the professional level, a practice-oriented and experienced faculty could develop topics such as design and synthesis, innovation, project and technology management, systems analysis, entrepreneurship and business development, and global engineering systems, as well as more abstract topics such as leadership and professional ethics. Additional electives could be offered in areas such as business (particularly management, strategic planning, and finance), policy (science, technology, and public policy), and other fields of particular student interest (e.g., biomedical and health, international relations, defense and security).

If the professional elements of an engineering education were shifted to a post-graduate professional school, this might provide a very significant opportunity to address many of the challenges that various studies have concluded face engineering education today at the undergraduate level. In particular, removing the burdens of professional accreditation from undergraduate engineering degree programs would allow them to be reconfigured along the lines of other academic disciplines in the sciences, arts, and humanities, thereby providing students majoring (or concentrating) in engineering with more flexibility to benefit from the broader educational opportunities offered by the comprehensive university.

*Proposal: Undergraduate engineering should be restructured as an academic discipline, similar to other liberal arts disciplines in the sciences, arts, and humanities, thereby providing students with more flexibility to benefit from the broader educational opportunities offered by the comprehensive American university, with the goal of preparing them for a lifetime of further learning rather than simply near-term employment as an engineer.*

Here we propose that the discipline of engineering would be taught by existing engineering schools through both degree programs at the undergraduate and graduate level, including courses provided to all undergraduates as a component of a new 21st-century liberal arts core curriculum. Of course, part of the challenge is the basic codification of the engineering discipline, still a subject of some uncertainty and requiring further study (e.g., see Vincenti, 1990). Furthermore, because of the strong research interests and background of most current engineering faculty, the curriculum and degrees offered in the discipline of engineering would initially have more of an applied science character and would not necessarily require ABET certification, thereby allowing more opportunity for a broader liberal education on the part of undergraduates.

The current pedagogies used in engineering education also need to be reconsidered. Although the science and engineering curriculum includes laboratory experiences, most instruction is heavily based on classroom lectures coupled with problem-solving exercises. Contemporary engineering education stresses the analytic approach to solving well-defined problems familiar from science and mathematics–not surprising, since so many engineering faculty members received their basic training in science rather than engineering. To be sure, design projects required for accreditation of engineering degree programs are introduced into advanced courses at the upper-class level. Yet design and synthesis are relatively minor components of most engineering programs. Clearly those intellectual activities associated with engineering design–problem formulation, synthesis, creativity, innovation–should be infused throughout the curriculum. This will require a sharp departure from conventional classroom pedagogy and solitary learning methods. Beyond team design projects, engineering educators should make more use of the case method approaches characterizing business and law education. More use might also be made of internships as a formal part of the engineering curriculum, whether in industry or perhaps even in the research laboratories of engineering faculty where engineering design is a common task.

An equally serious challenge to engineering education arises from the ever narrower specialization among engineering majors, more characteristic of the reductionist approach of scientific analysis rather than the highly integrative character of engineering synthesis. While this may be appropriate for careers in basic research, it is certainly not conducive to the education of contemporary engineers nor to engineering practice. Although students may be stereotyped by faculty and academic programs–and perhaps even campus recruiters–as electrical engineers, aerospace engineers, etc., they rapidly lose this distinction in engineering practice. Today's contemporary engineer must span an array of fields, just as modern technology, systems, and processes do.

There is yet another concern about engineering education that arises from the fundamental purposes of a college education and its foundation upon the concept of a liberal education. Two centuries ago Thomas Jefferson stated the purpose of a liberal education: "To develop the reasoning faculties of our youth, enlarge their minds, cultivate their morals, and instill into them the precepts of virtue and order." Note how appropriate the concept of a liberal education seems today as preparation for the profession of engineering. And note as well that most of the concerns that have been raised about today's engineering education could be addressed by simply accepting the broader objectives of a liberal education for our engineering students.

It is proposed that one views engineering education at the undergraduate level as a discipline suitable both for engineering majors as well as for other students interested in particular aspects of engineering, e.g., technology management and public policy. Engineering schools would continue to offer multiple degrees as they do now, e.g., ABET-accredited B.S. degrees in engineering, broader B.S. or B.A. degrees in engineering science, and of course an array of graduate degrees (M.S., Ph.D.). Students seeking an engineering background as preparation for further study in fields such as medicine, business, or law would continue to enroll in specific engineering majors, much as they do now. Many students would continue to enroll in ABET-accredited engineering degree programs to prepare them for entry into technology–based careers, although as we have noted earlier, these would require further professional education and training at the graduate level to enter the engineering profession. Students interested in research careers would major in either ABET-accredited or engineering science degree programs in preparation for further graduate study in engineering science (M.S. and Ph.D.).

However, of most interest here is the possibility that those students intending to enter the profession of engineering would no longer be subject to the overburdened curriculum characterizing ABET-accredited undergraduate degree programs. Instead they could earn more general liberal arts degrees in science, mathematics, engineering science, or even the arts, humanities, or social sciences with an appropriate pre-engineering foundation in science and mathematics, as preparation for further study in an engineering professional school. In this way they would have the opportunity for a true liberal education as the preparation for further study and practice in an engineering profession characterized by continual change, challenge, and ever–increasing importance.

Here one must always keep in mind that while engineering educators certainly have a responsibility to address the needs of industry, government, and society, their most fundamental commitment must be to the welfare of their students. There is an old saying that the purpose of a college education should not be to prepare a student for their first job but instead prepare them for their last job. This will sometimes require turning aside from the demands that engineering graduates be capable of immediate impact and instead stressing the far greater long-term value to the student–and our society more broadly–of a truly liberal education.

In recent years even science-intensive professions such as medicine have accepted the wisdom of broadening their admissions requirements to allow the enrollment of students from undergraduate majors in the social sciences and humanities. They seek more well-rounded students who can be molded into caring and compassionate physicians, who understand better the broader context of medical decisions and patient treatment. Although recent surveys have highlighted the difficulties that students currently have in transferring from other majors into engineering programs, the creation of graduate professional schools in engineering would provide the opportunity to broaden substantially the undergraduate requirements for engineering careers. Furthermore, the recent development of multiple course sequences to provide a concentration or minor in engineering for students in liberal arts colleges provide yet another route for broadly educated undergraduates to consider engineering careers after further graduate study, just as they can through the science sequences offered for pre-med students.

Broadening the undergraduate experience of engineering students would also provide a more sound foundation for lifelong learning. Today the United States faces a crossroads, as a global knowledge economy demands a new level of knowledge, skills, and abilities on the part of all of our citizens. To address this, the Secretary of Education's Commission on the Future of Higher Education in America has recently recommended: "America must ensure that our citizens have access to high quality and affordable educational, learning, and training opportunities throughout their lives. We recommend the development of a national strategy for lifelong learning that helps all citizens understand the importance of preparing for and participating in higher education throughout their lives." (Miller, 2006) The Commission believed it is time for the United States to take bold action, completing in a sense the series of these earlier federal education initiatives, by providing all American citizens with universal access to lifelong learning opportunities, thereby enabling participation in the world's most advanced knowledge society. The nation would accept its responsibility as a democratic society in an ever more competitive global, knowledge-driven economy to provide all of its citizens with the educational, learning, and training opportunities they need, throughout their lives, whenever, wherever, and however they need it, at high quality and affordable costs, thereby enabling both individuals and the nation itself to prosper.

This recommendation has particular implication for professions such as engineering where the knowledge base is continuing to increase at an ever-accelerating pace. The shelf life of education acquired early in one's life, whether K-12 or higher education, is shrinking rapidly. Today's students and tomorrow's graduates are likely to value access to lifelong learning opportunities more highly than job security, which will be elusive in any event. They understand that in the turbulent world of a knowledge economy, characterized by outsourcing and offshoring to a global workforce, employees are only one paycheck away from the unemployment line unless they commit to continuous learning and re–skilling to adapt to every changing work requirements. Furthermore, longer life expectancies and lengthening working careers create additional needs to refresh one's knowledge and skills on a continuous basis. Even today's college graduates expect to change not simply jobs but entire careers many times throughout their lives, and at each transition point, further education will be required–additional training, short courses, degree programs, or even new professions. And, just as students increasingly understand that in a knowledge economy there is no wiser personal investment than education, many nations now accept that the development of their human capital through education must become a higher priority than other social priorities, since this is the only sure path toward prosperity, security, and social well-being in a global knowledge economy.

Hence one of the important challenges to engineering educators is to design their educational programs not as preparation for a particular disciplinary career but rather as the foundation for a lifetime of continuous learning. Put another way, the stress must shift from the mastery of knowledge content to a mastery of the learning process itself. Moreover this will require a far more structured approach to continuing engineering education, more comparable to those provided for other learned professions such as medicine characterized by a rapidly evolving knowledge base and profound changes in professional practice. It seems clear that continuing education can no longer be regarded as simply a voluntary activity on the part of engineers, performed primarily on their own time and supported by their own resources. Rather it will require a major commitment by employers–both in industry and government–to provide the opportunity and support, and by engineering schools and professional societies to de-

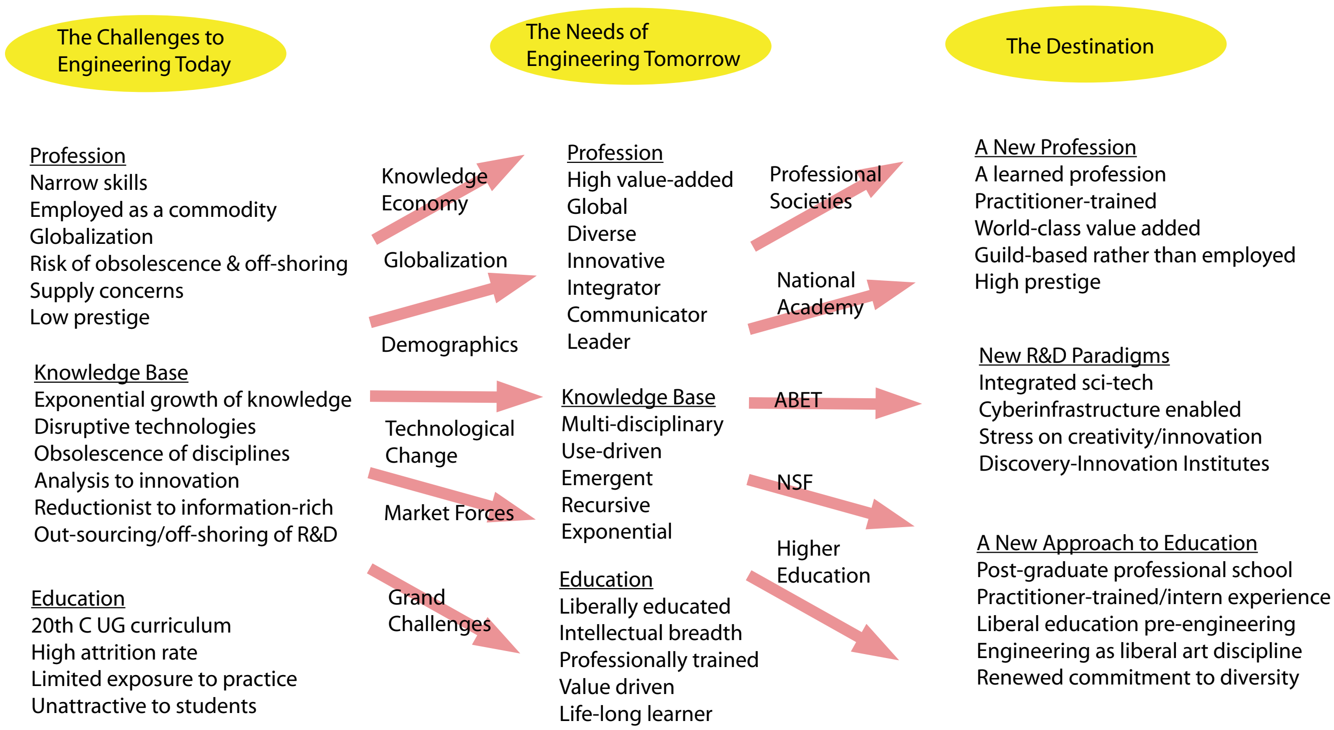
The key to the future of engineering education: diversity and innovation

velop and offer the necessary instructional programs. It likely will also require some level of mandatory participation through regulation and licensure, similar to the medical and legal professions.

*Proposal: In a world characterized by rapidly accelerating technologies and increasing complexity, it is essential that the engineering profession develop a structured approach to lifelong learning for practicing engineers similar to those in medicine and law. This will require not only a significant commitment by educators, employers, and professional societies but possibly also additional licensing requirements in some fields.*

This brings us to a broader proposal for a 21st-century college education. The liberal arts is an ancient concept that has come to mean studies that are intended to provide general knowledge and intellectual skills, rather than more specialized occupational or professional skills. The term liberal in liberal arts is from the Latin word *liberalis*, meaning "appropriate for free men" (social and political elites), and they were contrasted with the servile arts. The liberal arts thus initially represented the kinds of skills and general knowledge needed by the elite echelon of society, whereas the servile arts represented specialized tradesman skills and knowledge needed by persons who were employed by the elite. The scope of the liberal arts has changed with an evolving civilization. It once emphasized the education of elites in the classics; but, with the rise of science and humanities and a more pragmatic view of the purpose of higher education, the scope and meaning of "liberal arts" expanded during the 19th century. Still excluded from the liberal arts are topics that are specific to particular occupations, such as agriculture, business, dentistry, engineering, medicine, pedagogy (school–teaching), and pharmacy.

Yet here William Wulf reminds us of another important belief of Thomas Jefferson: one cannot have a democracy without informed citizens. Today we have




The roadmap to the future of engineering

a society profoundly dependent upon technology, profoundly dependent on engineers who produce that technology, and profoundly ignorant of technology. As Wulf observes, "I see this up close and personal almost every day. I deal with members of our government who are very smart, but who don't even understand when they need to ask questions about the impact of science and technology on public policy" (Wulf, 2003). He goes on to suggest that the concept of a liberal education for 21st-century society must include technological literacy as a component. Here he contrasts technological literacy with scientific and quantitative literacy, noting that everyone needs to know something about the process by which the knowledge of science is used to find solutions to human problems. But everyone also needs an understanding of the larger innovation engine that applies technology to create the wealth from which everyone benefits.

From this perspective, one could make a strong case that today engineering–or better yet technology–should be added to the set of liberal arts disciplines, much as the natural sciences were added a century ago. Here we are not referring to the foundation of science, mathematics, and engineering sciences for the engineering disciplines, but rather those unique tools that engineers master to develop and apply technology to serve society, e.g., structured problem solving, synthesis and design, innovation and entrepreneurship, technology development and management, risk-benefit analysis, and knowledge integration across horizontal and vertical intellectual spans.

*Proposal: The academic discipline of engineering (or, perhaps more broadly, technology) should be included in the liberal arts canon undergirding a 21st-century college education for all students.*

The final proposal addresses the challenge of building an engineering workforce with sufficient diversity to tap the full talents of an increasingly diverse American population and address the needs and opportunities of an increasingly diverse and competitive global society. Here the objectives have been forcefully stated in a recent National Academy of Engineering study, "All participants and stakeholders in the engineering community (industry, government, institutions of higher education, professional societies, et. al.) should place a high priority on encouraging women and underrepresented minorities to pursue careers in engineering. Increasing diversity will not only increase the size and quality of the engineering workforce, but it will also introduce diverse ideas and experiences that can stimulate creative approaches to solving difficult challenges. Although this is likely to require a significant increase in investment from both public and private sources, increasing diversity is clearly essential to sustaining the capacity and quality of the United States scientific and engineering workforce." (Duderstadt, 2005, Marburger, 2006)

To this end, it is appropriate to conclude with the following proposal:

*Proposal 7: All participants and stakeholders in the engineering community (industry, government, institutions of higher education, professional societies, et. al.) should commit the resources, programs, and leadership necessary to enable participation in engineering to achieve a racial, ethnic, and gender diversity consistent with the American population.*

## Concluding Remarks

America's leadership in engineering will require both commitment to change and investment of time, energy, and resources by the private sector, federal and state governments, and colleges and universities. Bold, transformative initiatives are necessary to reshape engineering research, education, and practice to respond to challenges in global markets, national security, energy sustainability, and public health. The proposals suggested in this paper involve not only technological but also cultural issues that will require the collective commitment of the engineering profession and engineering educators and the support of industry, federal and state government, and foundations.

Sometimes a crisis is necessary to dislodge an organization from the complacency that arises from past success. The same holds for a nation–and a profession, in fact. It could be that the emergence of a hypercompetitive, global, knowledge-driven economy is just what the United States and the profession of engineering need. The key to America's global competitiveness is technological innovation. And the keys to innovation are new knowledge, human capital, infrastructure, and enlightened policies. Not only must the United States match investments made by other nations in education, R&D, and infrastructure, but it must recognize the inevitability of new innovative, technology-driven industries replacing old obsolete and dying industries as a natural process of "creative destruction" (a la Schumpeter) that characterizes a hypercompetitive global economy.

The same challenge faces the engineering profession. The growing tendency of American industry to outsource engineering services and offshore engineering jobs should serve as a wakeup call in our times similar to that provided to industry by the outsourcing of manufacturing the 1980s. The global knowledge economy is merciless in demanding that companies seek quality services at minimal cost. When engineers in Bangalore, Shanghai, and Budapest produce high-quality results at one-fifth the cost of similar efforts in the U.S., America's engineering profession simply must recognize that our engineering core competency is no longer particular technical skills or narrowly tailored engineering careers. It requires new paradigms for engineering practice, research, and education. The magnitude of the challenges and opportunities facing our nation, the changing demands of achieving prosperity and security in an ever more competitive, global, knowledge-driven world, and the consequences of failing to sustain our engineering leadership demand bold new initiatives.

Yet we also acknowledge that the resistance to the bold actions proposed in this paper will be considerable. Many companies will continue to seek low-cost engineering talent, utilized as commodities similar to assembly-line workers, with narrow roles, capable of being laid off and replaced by offshored engineering services at the slight threat of financial pressure. Many educators will defend the status quo, as they tend to do in most academic fields. And unlike the professional guilds that captured control of the marketplace through licensing and regulations on practice in other fields such as medicine and law, the great diversity of engineering disciplines and roles continues to generate a cacophony of conflicting objectives that inhibits change.

Yet the stakes are very high. During the latter half of the 20th century, the economic leadership of the

United States was largely due to its capacity to apply new knowledge to the development of new technologies. With just 5% of the world's population, the U.S. employed almost one-third of the world's scientists and engineers, accounted for 40% of its R&D spending, and published 35% of its scientific articles. Today storm clouds are gathering as inadequate investment in the necessary elements of innovation–education, research, infrastructure, and supportive public policies–threatens this nation's technological leadership. The inadequacy of current government and industry investment in the long-term engineering research necessary to provide the knowledge base for innovation has been revealed in numerous recent reports. Furthermore, the growing compensation gap between engineering and other knowledge-intensive professions such as medicine, law, and business administration coupled with the risks of downsizing, outsourcing, and offshoring of domestic engineering jobs has eroded the attractiveness of engineering careers and precipitated a declining interest on the part of the best U.S. students. Current immigration policies combined with global skepticism about U.S. foreign policy continue to threaten our capacity to attract outstanding students, scientists, and engineers from abroad.

If one extrapolates these trends, it becomes clear that our nation faces the very real prospect of losing its engineering competence in an era in which technological innovation is key to economic competitiveness, national security, and social well-being. Bold and concerted action is necessary to sustain and enhance the profession of engineering in America–its practice, research, and education. It is the goal of this report both to sound the alarm and to suggest a roadmap to the future of American engineering. While it is important to acknowledge the progress that has been made in better aligning engineering education to the imperatives of a rapidly changing world and to commend those from the profession, industry, and higher education who have pushed hard for change, it is also important to recognize that we still have many more miles to travel toward the goal of better positioning American engineering to serve a rapidly changing world.

Those with most at stake:
future generations of engineers

## So...How Do We Get This Done?

With the destination of our roadmapping effort now established, we turn to the challenging task of getting from here to there, from the current 20th century paradigm for engineering practice, research, and education in America to a new paradigm appropriate for a 21st century world. But here we immediately encounter a very serious dilemma. We have suggested that to meet the needs of the nation, the engineering profession must achieve the status and influence of other learned professions such as law and medicine. This will require new paradigms for engineering research that better link scientific discovery with innovation. It will also require American engineers to achieve a much higher level of education, particularly in professional activities such as design, systems integration, and global engineering practice. And it will require very considerable investment and great commitment on the part of individuals and institutions.

Yet, resistance to such transformation will be considerable. Industry will continue to seek low-cost engineering talent, with narrow roles, vulnerable to layoffs or replacement by off-shored engineering services at the slight threat of financial pressure. Educators will defend the status quo. And unlike the professional guilds that captured control of the marketplace through licensing and regulations on practice in other fields such as medicine and law, the great diversity of engineering disciplines and roles continues to generate a cacophony of conflicting objectives that inhibits change.

More specifically, all of the actions we have proposed will require increased investment and hence raise the cost (and price) of American engineering. Since current global business practices seek the lowest-cost engineering services of acceptable quality, there is a very real possibility that such efforts could trigger even more out sourcing of engineering services and off shoring of engineering jobs, eroding even further this nation's domestic technological capacity.

Hence the key question is how to motivate the United States and its global industries to accept a higher cost for higher-quality engineering services and more capable engineers. Would a more influential engineering profession, involving a far more extensive process for professional education, really increase the value of American engineers sufficiently to compete in the global marketplace for engineering services? Even if the answer is yes, would the effort to raise the bar for engineering quality in this nation simply drive the remainder of more routine engineering services to off shore providers, except for a very small cadre of "master engineers" who would manage such "global supply chains" of engineering, technology, and innovation?

Let us consider several approaches to this dilemma.

### Option 1: Benign Neglect

One approach is to simply continue the status quo, accepting the current global market realities, reacting as best as one can to new requirements such as the need for global engineers, and wait until conditions deteriorate sufficiently to stimulate bolder action. Of course, if the current trends continue, such as the off shoring of engineering jobs in preference to hiring less experienced (and more expensive) young American engineers or inadequate investment in R&D, students will continue to turn away from engineering careers, and our domestic capacity for technological innovation will continue to deteriorate. Hence what could be at stake in this approach of benign neglect is the erosion not simply of American innovation and economic competitiveness, but perhaps even the leadership of the engineering profession itself as young people see more attractive career options in more highly compensated and secure professions such as law, business administration, and medicine.

### Option 2: Evolution (Education and Persuasion)

A more proactive approach would involve the launch of a major outreach and education campaign aimed at convincing American industry, government, and the public of the importance of sustaining and enhancing domestic engineering capacity through additional investments in engineering education and research to raise the value-added by American engineers, as reflected in enhanced prestige and compensation for the engineering profession. Here one would stress the dangers to both American competitiveness and national security by the accelerating tendency to off shore both engineering jobs and competence, driven by short-term financial pressures and the emergence of transnational corporations with declining interest in regional or national consequences. Such an effort would also stress the importance of STEM education at all levels as key to knowledgeable citizenship in an increasingly technological world. Both the federal administration's American Competitiveness Initiative and Congress's America COMPETES Act provide an unusual opportunity to address these concerns.

In parallel with this effort would be the launch of a number of experiments to create models of possible futures for engineering practice, research, and education. Examples might include a federally supported effort to create several Discovery-Innovation Institutes and privately supported post-graduate professional schools of engineering (similar to recent experiments such as Olin College of Engineering).

Such an effort would require broad leadership, e.g., through groups such as the National Academy of Engineering, the engineering professional societies, and business groups such as the Council on Competitiveness and National Business Roundtable. It would also require sustained commitment and substantial investment, perhaps from key foundations with strong interests in science and engineering. This would also require loosening somewhat the existing constraints (such as accreditation) to encourage far more innovation and risk-taking in engineering research and education.

## Option 3: Revolution (Politics and Cartels)

Here engineering professional societies would emulate the efforts of the medical and law professions (through the American Medical Association and American Bar Association) to seek legislation at the state and federal level to create a regulatory environment sufficient to empower the engineering profession. The goal would be to create through regulatory activities governing licensing and practice more of a guild-like culture in engineering, in which engineers like other learned professionals would increasingly identify more with their professional standards than their particular employment.

Of course there are some significant differences between engineering and more regulated professions such as medicine and law. For example, while law involves rather routine skills, it depends on significant cultural factors and precedents that limit the ability to outsource legal services. Medical practice has a high technical skill level more comparable to engineering with relatively few cultural constraints; yet it also is characterized by an urgency and personal character that again limits the outsourcing of most practice (with the exception of diagnostic evaluations). Business administration like law also involves more routine skills, characterized by relatively little urgency or cultural constraints. Yet the financial responsibilities of business executives create a highly compensated marketplace for business talent, unlike that for engineering services.

As we noted earlier, there is also a serious question as to whether the diverse array of engineering professional and disciplinary societies could be sufficiently corralled to agree on a unified agenda. Revolutions are launched by the proletariat, and it is difficult to see what would excite the rank and file of the engineering workforce to this level.

## Option 4: Punctuated Evolution and Spontaneous Emergence

Finally, one might simply take an opportunistic approach by keeping an eye out for possible tipping points that would drive–or at least allow–fundamental transformation of existing paradigms for engineering practice, research, and education, much as rapid climate changes drove occasional bursts of simultaneous co-evolution of biological species on Planet Earth. One example would be cyberinfrastructure, which is rapidly changing the very nature of scientific and engineering work. As NSF Director Arden Bement stresses, "These revolutionary technologies have helped us scan the research frontier at velocities that are orders of magnitude faster than ever before. These tools are not simply faster–they are also fundamentally superior. They have raised the level of complexity we can understand and harness. That capability is growing at a breathtaking pace." (Bement, 2007)

Another example would be the rapid evolution of open education resources such as the MIT's OpenCourseWare project, the Google Book Scan library consortium, or Massively Open Online Courses (MOOCs) that could well lead to the very rapid propagation of effectively universal access to knowledge and learning tools, bypassing traditional professional education and certification organizations to empower the amateur (Brown, 2005).

Finally, the rapidly changing nature of the global, knowledge economy, with its stress on innovation, flexibility, and rapid transformation might lead to new business structures. For example, enterprises might essentially become an aggregation of specialized entities with complementary interests–expanding, contracting, and reconfiguring themselves in a way that best adapt to or even anticipates market dynamics. Paradoxically, these super-flexible configurations may prove even more stable over time. Self-organizing and self-aggregating entities are often much more adaptable in the face of disruption (think of flocks of birds or schools of fish). For knowledge workers such as engineers in particular, a form of 21st-century guild could emerge to facilitate accreditation, skills development, and reputation management. Individual knowledge workers may one day command "agents" who seek out and negotiate short-term opportunities and effectively manage career paths on their behalf (IBM, 2006).

## Epilogue

In summary, while it is important to acknowledge the progress that has been made in better aligning engineering education to the imperatives of a rapidly changing world and to commend those from the profession, industry, and higher education who have pushed hard for change, it is also important to recognize that we still have many more miles to travel toward the goal of 21st-century engineering.

Perhaps, as Frank Splitt suggests, we could simply heed the advice of Thomas Paine:

> Perhaps the sentiments contained in the following pages, are not sufficiently fashionable to procure them general favour; a long habit of not thinking a thing wrong, gives it a superficial appearance of being right, and raises at first a formidable outcry in defense of custom. But the tumult soon subsides. Time makes more converts than reason (Paine, *Common Sense*, 1776).

Yet, unfortunately, the challenges of our changing world move ahead at a rapid pace despite our tendency toward procrastination. The future–indeed, the very survival–of American engineering demands the exploration of new paradigms of practice, research, and education today.

## References

AAAS (American Association for the Advancement of Science). 2007. Analysis of R&D in the FY 2008 Budget. Available online at: http://aaas.org/spp/rd/pre/08pr.htm#hs.

ABET. The Vision for Change:  A Summary Report of the ABET/NSF/Industry Workshops, Accreditation Board for Engineering and Technology, May, 1995.

American Society of Civil Engineers. “Academic Prerequisites for Licensure and Professional Practice”, ASCE Policy Statement 465. Washington: American Society of Civil Engineers, 2007.

Augustine, Norman (chair), National Academies Committee on Prospering in the Global Economy of the 21st Century. Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future. Washington, D.C.: National Academies Press, 2005.

Clough, G. Wayne (chair). The Engineer of 2020: Visions of Engineering in the New Century, National Academy of Engineering, Washington, DC: National Press, 2004.

Clough, G. Wayne (chair). Educating the Engineer of 2020: Adapting Engineering Education to the New Century, National Academy of Engineering, Washington, DC: National Press, 2005.

Clough, G. Wayne. “Reforming Engineering Education”, The Bridge, Washington, DC: National Academy of Engineering, 2006.

Continental AG. “In Search of Global Engineering Excellence: Educating the Next Generation of Engineers for the Global Workplace”. Hanover, Germany, Continental AG, 2006. (Available at http://www.conti-online.com)

Council on Competitiveness, Innovate America: Thriving in a World of Challenge and Change. The National Innovation Initiative. Washington, DC: Council on Competitiveness, 2005. http://www.compete.org/nii/

COSEPUP. Assessment of the Federal Science and Technology Budget, National Academies Committee on Science, Engineering, and Public Policy. 1998-2003. Washington, D.C.: National Academies Press, 2003.

Duderstadt, James, Engineering for a Changing World: *A Roadmap to the Future of Engineering Practice, Research, and Education* (Ann Arbor, MI: Millennium Project, University of Michigan, 2007).

Duderstadt, James (chair), *Engineering Research and America's Future: Meeting the Challenge of the Global Economy* (Washington, D.C.: National Academy Press, 2005).

Duderstadt, James, Glenn F. Knoll, George S. Springer, *Principles of Engineering* (John Wiley and Sons, New York, 1982)

Duderstadt, James J. (chair). National Academy of Engineering Committee to Assess the Capacity of the United States Engineering Research Enterprise, Engineering Research and America's Future: Meeting the Challenge of a Global Economy. Washington, D.C.: National Academies Press, 2005. www.nap.edu.

Friedman, Thomas. The World Is Flat: A Brief History of the 21st Century. New York: Farrar, Strauss, and Giroux, 2005.

Grasso, Domenico and David Martinelli. “Holistic Engineering”, Chronicle of Higher Education, Marcy 16, 2007, pp. B8-B9.

Kam, Moshe and Arnold Peskin. “What Should

Be the First Professional Degree in Engineering", The Institute. Washington: IEEE, 2006.

Lohman, Jack R. (editor), Special Issue: The Art and Science of Engineering Education Research, Journal of Engineering Education, January 2005.

Marburger, J.H. 2004. Achieving Diversity in Science and Engineering. Keynote Address, A Celebration of Pioneering African Americans in Physics, University of Michigan, Ann Arbor, Michigan, March 17, 2004.

Miller, Charles (chair). A Test of Leadership: Charting the Future of U.S. Higher Education, National Commission on the Future of Higher Education in America. Washington: U.S. Department of Education, 2006.

National Academy of Engineering. The Offshoring of Engineering: Facts, Myths, Unknowns, and Implications, October 25, 2006. See website: http://www.nae.edu/nae/engecocom.nsf/weblinks/PGIS-6SKKK2?OpenDocument

NSB (National Science Board). 2003. The Science and Engineering Workforce: Realizing America's Potential. NSB 0369. Available online at: http://www.nsf.gov/nsb/documents/ 2003/nsb0369/nsb0369.pdf.

NSB. 2006. Science and Engineering Indicators 2006. NSB 04-01B. Available online at: http://www.nsf.gov/nsb/documents/2004/nsb04-01B/nsb04-01B.pdf.

NSB. Moving Forward to Improve Engineering Education, ad hoc Task Group on Engineering Education, Committee on Education and Human Resources, Draft Report, July 23, 2007. Washington: National Science Foundation, 2007.

OSTP (Office of Science and Technology Policy). The American Competitiveness Initiative. Washington, DC: U.S. Office of Science and Technology Policy, 2006 (http://www.ostp.gov/html/ACIBooklet.pdf).

Princeton University, Engineering for a Better World, Princeton, NJ: Princeton School of Engineering and Applied Science, 2004.

Schowalter, W. R., "The Equations (of Change) Don't Change, But the Profession of Engineering Does", Chemical Engineering Education, American Society for Engineering Education, 2003.

Shulman, Lee S. "If Not Now, When? The Timeliness of Scholarship of the Education of Engineers", J. Eng. Ed. 94, 1, 2005. 11-13.

Sheppard, Sheri D., "Taking Stock: A Look at Engineering Education at the End of the 20th Century and Beyond", American Society for Engineering Education, June 19, 2006.

Sheppard, Sheri D. and William Sullivan. Educating Engineers: Theory, Practice, and Imagination. Palo Alto, CA: Carnegie Foundation for the Advancement of Teaching, 2008, to be published.

Technical University of Darmstadt. Global Engineering Excellence Study. See website:
http://www.global-engineering-excellence.org/

Ulsoy, Galip, M. L. Good, M. Jones, L. Matsch, and C. D. Mote, Jr. The "5XME" Workshop: Transforming Mechanical Engineering Education and Research in the USA, NSF Workshop, May 10-11, 2007. Washington: National Science Foundation, 2007.

Vest, Charles M. "Educating Engineers for 2020 and Beyond", The Bridge, Washington, DC: National Academy of Engineering, 2006. 38-44.

Vincenti, Walter. What Engineers Know and How They Know It: Analytical Studies from Aeronautical History, Johns Hopkins Studies in the History of Technology. Baltimore: Johns Hopkins University Press, 1990.

Williams, Rosalind. "Education for the Profession Formerly Known as Engineering", Chronicle of Higher Education, Vo. 49, January 24, 2003.

Wadhwa, Vivek, Gary Gereffi, Ben Rissing, Ryan Ong. "Where the Engineers Are", Issues in Science and Technology, Spring, 2007

Wulf, William. A. Annual Address. Annual Meeting of the National Academy of Engineering, October 12, 2003.

# Chapter 6

# Engineering Research

Leadership in innovation is essential to U.S. prosperity and security. In a global, knowledge-driven economy, technological innovation—the transformation of new knowledge into products, processes, and services of value to society—is critical to competitiveness, long-term productivity growth, and an improved quality of life. Preeminence in technological innovation depends on a wide array of factors, one of which is leadership in engineering research, education, and practice. A three-decade-long decline in the share of federal investment in research and development (R&D) devoted to engineering and a perceived erosion of basic, long-term engineering research capability in U.S. industry and federal laboratories have raised serious questions about the long-term health of engineering research in the United States.

To assess and document the current state of the U.S. engineering research enterprise and to raise awareness of the critical role of engineering research in maintaining U.S. technological leadership, the National Academy of Engineering initiated a broad study, *Assessing the Capacity of the U.S. Engineering Research Enterprise*. The focus of the study is primarily on academic research because of its importance to long-term basic engineering research and to educating future engineers and engineering researchers. The study was based on the opinions and judgments of a 15-member committee of experts from industry and universities. The committee's deliberations were informed by testimony from key decision makers and policy makers in the federal government, as well as a detailed review of many recent studies on national R&D policy, investment patterns, needs, and shortcomings.

Reports by the President's Council of Advisors on Science and Technology, National Science Board, U.S. Department of Energy Science Advisory Board, Council on Competitiveness, National Research Council, and others have consistently emphasized the importance of basic research in engineering and physical sciences and expressed concerns about the adequacy of federal investments in these critical fields. These studies found that support for engineering research has been relatively stagnant for more than two decades. The result has been erosion in the infrastructure necessary to conduct world-class engineering research and a worrisome decline in the number of engineering graduates, particularly native-born doctoral degree recipients. As other nations increase their investments in engineering research and education, the United States risks falling behind in critical research capabilities and ultimately the innovations that flow from research. To ensure continued U.S. competitiveness, the nation needs a renewed commitment to engineering research, most importantly by the federal government, but also by states, foundations, industry, and universities.

The committee recommended a number of actions to stimulate rapid changes to address these concerns. The committee also recognizes the need for bold steps that will lead to long-term changes, not only in the level of resources available for basic engineering research, but also in the cultural environment that must attract the best and brightest individuals to pursue careers in engineering research. The committee proposed the creation of a new paradigm, the discovery-innovation institute of hub, on the campuses of American research universities as a mechanism for achieving long-term change. By harnessing the intellectual power, diversity, and creativity on the nation's campuses and working in close collaboration with industry and government, discovery-innovation institutes can be engines of innovation.

## Findings

Leadership in innovation is essential to U.S. prosperity and security. In a global, knowledge-driven economy, technological innovation—the transformation of knowledge into products, processes, and services—is critical to competitiveness, long-term productivity growth, and the generation of wealth. Preeminence in technological innovation requires leadership in all aspects of engineering: engineering research to bridge scientific discovery and practical applications; engineering education to give engineers and technologists the skills to create and exploit knowledge and technological innovation; and the engineering profession and practice to translate knowledge into innovative, competitive products and services.

Historically, engineering research has yielded knowledge essential to translating scientific advances into technologies that affect everyday life. The products, systems, and services developed by engineers are essential to national security, public health, and the economic competitiveness of U.S. business and industry. Engineering research has resulted in the creation of technologies that have increased life expectancy, driven economic growth, and improved America's standard of living. In the future, engineering research will generate technological innovations to address grand challenges in the areas of sustainable energy sources, affordable health care, sufficient water supplies, and homeland security.

### Erosion in Federal Support of Basic Research

Unfortunately, U.S. leadership in technological innovation seems certain to be seriously eroded unless current trends are reversed. The accelerating pace of discovery and application of new technologies, investments by other nations in research and development (R&D) and the education of a technical workforce, and an increasingly competitive global economy are challenging U.S. technological leadership and with it future U.S. prosperity and security. Although many current measures of technological leadership—percentage of gross domestic product invested in R&D, number of researchers, productivity level, volume of high-technology production and exports—still favor the United States, worrisome trends are already adversely affecting the U.S. capacity for innovation. These trends include: (1) a large and growing imbalance in federal research funding between the engineering and physical sciences on the one hand and biomedical and life sciences on the other; (2) increased emphasis on short-term applied R&D in industry and government-funded research at the expense of fundamental long-term research; (3) erosion of the engineering research infrastructure due to inadequate investment over many years; (4) declining interest of American students in engineering, science, and other technical fields; and (5) growing uncertainty about the ability of the United States to attract and retain gifted engineering and science students from abroad at a time when foreign nationals constitute a large and productive component of the U.S. R&D workforce.

Today more than ever the nation's prosperity and security depend on its technical strengths. The United States will need robust capabilities in both fundamental and applied engineering research to address future economic, environmental, health, and security challenges. To capitalize on opportunities created by scientific discoveries, the nation must have engineers who can invent new products and services, create new industries and jobs, and generate new wealth. Applying technological advances to achieve global sustainability will require significant investment, creativity, and technical competence. Advances in nanotechnologies, biotechnologies, new materials, and information and communication technologies may lead to solutions to difficult

**Committee to Assess the Capacity of the U.S. Engineering Research Enterprise**

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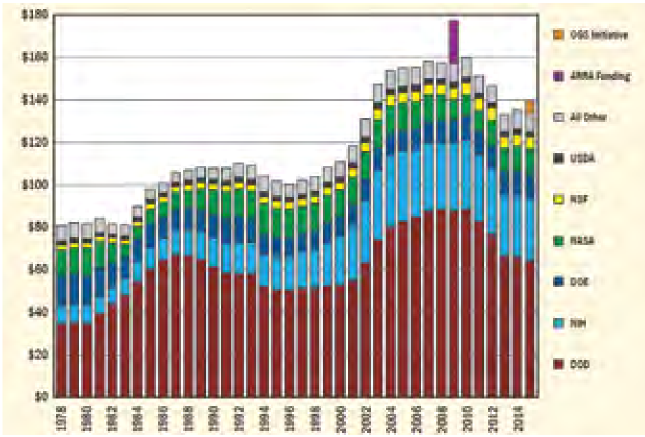
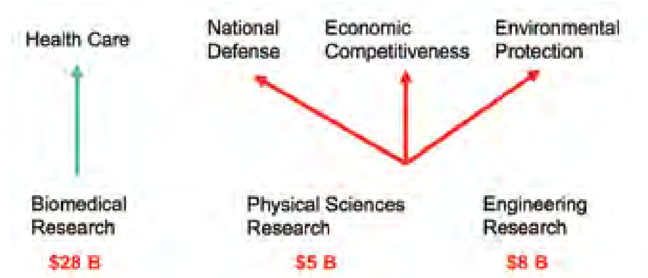



Federal R&D funding has been growing only in the life sciences: funding in engineering has been stagnant.




The imbalance in federal funding is extraordinary.

environmental, health, and security challenges, but their development and application will require significant investments of money and effort in engineering research and the engineering workforce.

### Imbalance in the Research Portfolio

Current patterns in research funding do not bode well for future U.S. capabilities in these critical fields. Record levels of federal funds are being invested in R&D, but these levels reflect large increases in funding for biomedical and life sciences; investments in other fields of engineering and science have increased slowly and intermittently (if at all). Because of competitive pressures, U.S. industry has downsized its large, corporate R&D laboratories in physical sciences and engineering and reduced its already small share of funding for long-term, fundamental research. The committee believes that the decline in long-term industrial research is exacerbating the consequences of the current decline in federal R&D funding for long-term fundamental research in engineering and physical sciences.

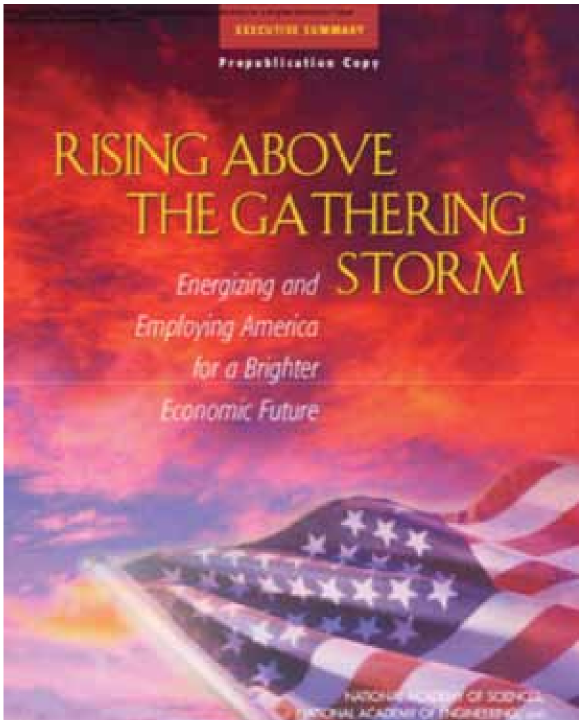
### Endangered Technical Workforce

These funding trends have had a predictably negative impact on academic research and student enrollments in engineering and physical sciences. In fact, foreign nationals now comprise 40 percent or more of graduate enrollments in physical sciences, mathematics and computer science, and engineering. In addition, nearly two-thirds of the graduate and undergraduate students in engineering who are U.S. citizens and permanent residents are white males. Increasing the overall number of American students pursuing degrees in physical sciences and engineering will be essential to meeting the future challenges facing the nation, but it will not be enough. We must also increase diversity by recruiting more women and underrepresented minorities in technical fields to ensure that we have the intellectual vitality to respond to profound and rapid change.

Current trends in research investment and workforce development are early warning signs that the United States could fall behind other nations, both in its capacity for technological innovation and in the size, quality, and capability of its technical workforce. Unless the United States maintains its resident capacity for technological innovation, as well as its ability to attract the best and brightest engineers and scientists from abroad, the economic benefits of technological advances may not accrue to Americans.

### Warnings from Earlier Studies

We must take action immediately to overcome existing imbalances in support for research and to address emerging critical challenges. These actions must include both changes in direction by key stakeholders in the engineering research enterprise and bold new programs designed specifically to promote U.S. technological innovation. This conclusion echoes the findings of other recent assessments by the Council on Competitiveness




Risiing Above the Gathering Storm


The American Competitiveness Initiative

(2001, 2004), President's Council of Advisors on Science and Technology (2002, 2004a,b), National Science Board (2003), National Academies (COSEPUP, 2002; NAE, 2003, 2004; NRC, 2001), and other distinguished bodies (DOE, 2003; National Commission on Mathematics and Science Teaching for the 21st Century, 2000).

Considering the magnitude and complexity of the challenges ahead in energy, security, health care, the environment, and economic competitiveness, we simply do not have the option of continuing to conduct business as usual. We must change how we prioritize, fund, and conduct research; how we attract, educate, and train engineers and scientists; how we consider and implement policies and legal structures that affect intellectual property rights and related issues; and how we maximize contributions from institutions engaged in technological innovation and workforce development (e.g., universities, corporate R&D laboratories, federal agencies, and national laboratories).

Of course, major undertakings in anticipation of opportunities are always difficult, but the United States has a history of rising to the occasion in times of need. At least twice before in times of great challenge and opportunity, the federal government responded in creative ways that not only served the needs of society, but also reshaped institutions. Consider, for example, the Land Grant Acts in the nineteenth century, which not only modernized American agriculture and spearheaded America's response to the industrial revolution, but also led to the creation of the great public universities that have transformed American society and sustained U.S. leadership in the production of new knowledge and the creation of human capital. Another example is the G.I. Bill and government-university research partnerships during the 1940s that were instrumental in establishing U.S. economic and military leadership.

With this history in mind, and with full recognition of the magnitude of the effort needed to prepare the United States for long-term technological leadership, the committee offers the following recommendations

## Recommendations

### Federal Research and Development Budget

Despite record levels of federal funding for research, most of the increases in the past quarter century have been focused on the life sciences, which currently ac-


Engineering for a Changing World (2005)

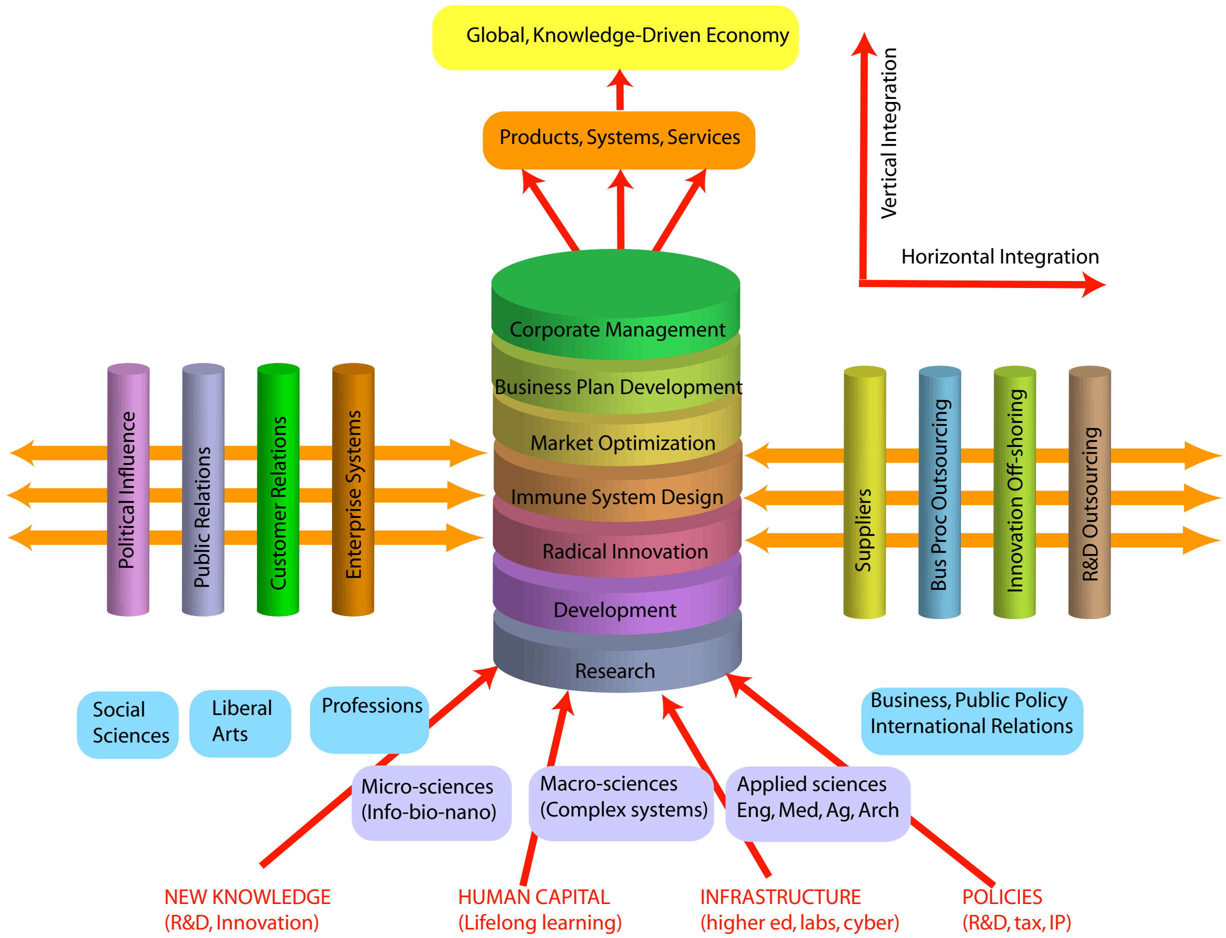
count for about two-thirds of federal funds for academic R&D. In fiscal year (FY) 2002, 45 percent of these funds went directly to medical schools. By contrast, as data from the National Science Foundation (NSF) show, federal funding for research in other scientific and engineering fields has been relatively stagnant for the past two decades (NSB, 2004). Support for applied engineering research did increase briefly between 2000 and 2003, mainly as a result of funding increases at the U.S. Departments of Defense (DOD) and Homeland Security (DHS), but subsequent federal budgets suggest a return to minimal increases (AAAS, 2005; NSB, 2004). Thus, the funding trend is on a collision course with the changing nature of technological innovation, which is becoming increasingly dependent on interdisciplinary, systems-oriented research.

The National Academies have long urged the federal government to adopt a more strategic approach to prioritizing federal funding for R&D. In a NRC report published in 1995, recommendations were proposed urging that federal investment be sufficient to (1) achieve absolute leadership in research areas of key strategic interest to the nation (e.g., areas that clearly determine public health and national security) and (2) keep the nation among the leaders in all other scientific and technological areas to ensure that rapid progress can be made in those areas in the event of technology surprises (NAS, 1995). The current federally funded R&D portfolio clearly falls short of both of these goals. Current investments in engineering and physical science research are not sufficient to support the broad range of key national priorities, such as national defense, homeland security, and the economic competitiveness of American industry.

*Recommendation 1. The committee strongly recommends that the federal R&D portfolio be rebalanced by increasing funding for research in engineering and physical science to levels sufficient to support the nation's most urgent priorities, such as national defense, homeland security, health care, energy security, and economic competitiveness. Allocations of federal funds should be determined by a strategic analysis that identifies areas of research in engineering and science that support these priorities. The analysis should explicitly include interdependencies among engineering and scientific disciplines to ensure that important advances are supported by advances in complementary fields to accelerate technology transfer and innovation.*

Long-Term Research and Industry

The imbalance in federal funding for research, combined with a shift in funding by industry and federal mission agencies from long-term basic research to short-term applied research, raises concerns about the level of support for longterm, fundamental engineering research. The market conditions that once supported industrial investment in basic research at AT&T, IBM, RCA, General Electric, and other giants of corporate America no longer hold. Because of competitive pressures, U.S. industry has downsized its large, corporate R&D laboratories in physical sciences and engineering and reduced its already small share of funding for long-term, fundamental research. Although industry currently accounts for almost three-quarters of the nation's R&D expenditures, its focus is primarily on short-term applied research and product development. In some industries, such as consumer electronics, even product development is increasingly being outsourced to foreign contractors.



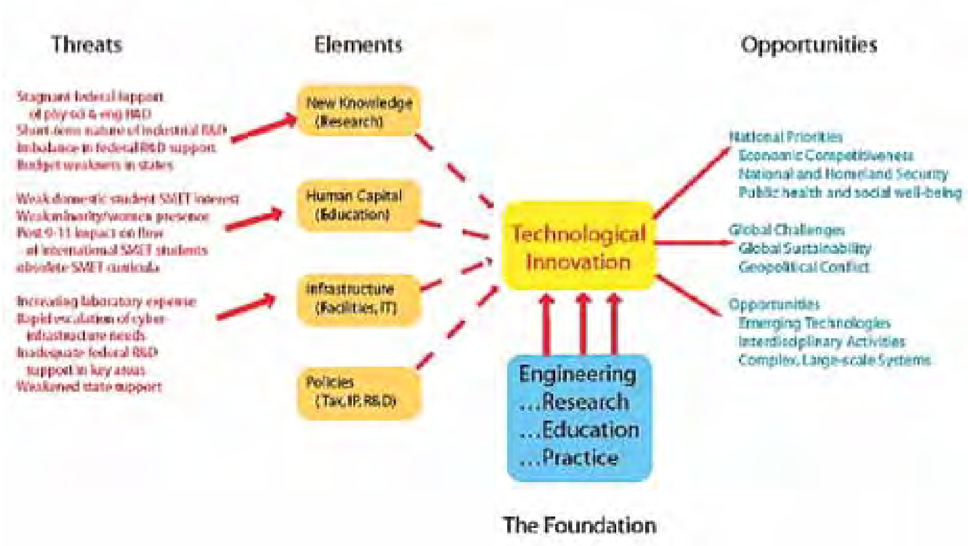

The Knowledge Economy of 2020

The committee believes that restoring long-term engineering research in industry to a substantial level would enhance the nation's long-term economic health. Although publicly traded corporations continue to be subject to intense financial pressures to limit R&D to near-term product development, a strong case can be made for federal incentives to encourage individual companies or consortia to reestablish basic research programs. In addition, more investment by NSF and mission agencies will be necessary, not only to keep pace with the accelerating rate of technological change, but also to meet the economic, social, environmental, and security challenges of an increasingly competitive, knowledge driven, global economy.

*Recommendation 2. Long-term basic engineering research should be reestablished as a priority for American industry. The federal government should design and implement tax incentives and other policies to stimulate increased industry investment in long-term engineering research (e.g., tax credits to support private-sector investment in university-industry collaborative research).*

Engineering Research Infrastructure

One result of the stagnation of federal investment in engineering research has been the deterioration of the engineering research infrastructure at many schools of engineering. Only a few research universities have facilities adequate for advanced engineering research that can support increasingly systems-oriented, interdisciplinary technological innovation. Many engineering schools operate in old facilities, with laboratory equipment dating from before the invention of the transistor, let alone the personal computer. These institutions do not have the clean rooms, information systems, or instrumentation necessary to contribute to technological leadership.




The Challenges to Innovation

*Recommendation 3. Federal and state governments and industry should invest in upgrading and expanding laboratories, equipment and information technologies and meeting other infrastructural needs of research universities and schools of engineering to ensure that the national capacity to conduct world-class engineering research is sufficient to address the technical challenges that lie ahead.*

Quality of the Technical Workforce

A technically skilled workforce is essential to maintaining leadership in innovation. Although future demand for specific science and engineering skills is notoriously difficult to predict, it is reasonable to assume that an increasingly technical world will require a technically proficient workforce. We can also predict that meeting national and homeland security needs will require many more U.S. citizens who are educated in engineering. But simply increasing the number of engineers will not be enough. The United States needs engineers with the skills, imagination, and drive to compete and take the lead in the world. Moreover, the United States must ensure that it can still attract talented scientists and engineers from abroad.

The stagnating federal investment in engineering research and research infrastructure has weakened the human-capital foundation of the engineering research enterprise. The innovation-driven nation we envision will require a large cadre of engineering researchers with the depth of knowledge and creativity to create breakthrough technologies and systems. In addition to solid grounding in fundamental engineering concepts, these engineers musthave the ability to address complex systems in multidisciplinary research environments.

However, like the engineering research infrastructure, the engineering professoriate is aging rapidly. The faculty hiring boom of the 1960s, which was followed by a sharp downturn in hiring in the 1970s and a moderate pace since then, has resulted in increasing numbers of engineering faculty at or near retirement age (NSB, 2003). Along with many other factors, the aging research infrastructure and aging faculty, combined with inadequate support for and commitment to long-term, interdisciplinary research and associated curricular innovation, have made it extremely difficult to interest qualified American students in pursuing undergraduate and graduate programs in engineering and science. In addition to solid grounding in fundamental engineering concepts, these engineers must have the ability to address complex systems in multidisciplinary research environments.

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*Recommendation 4. Considering the importance of technological innovation to the nation, a major effort should be made to increase the participation of American students in engineering. To this end, the committee endorses the findings and recommendations of a 2005 National Academy of Engineering report, Educating the Engineer of 2020: Adapting Engineering Education to the New Century, which calls for system-wide efforts by professional societies, industry, federal agencies, and educators at the higher education and K–12 levels to align the engineering curriculum and engineering profession with the needs of a global, knowledge-driven economy with the goal of increasing student interest in engineering careers. Engineering education requires innovations, not only in the content of engineering curricula but also in teaching methods that emphasize the creative aspects of engineering to excite and motivate students.*

One key approach to increasing the number of U.S. citizens with advanced degrees in science and engineering is to attract more women and minorities to these fields. Currently, males receive more than 75 percent of the doctoral degrees granted in physical sciences, mathematics and computer science, and engineering, and more than two-thirds of graduate students in these fields are white (Figure 2). Increasing diversity in the engineering student population and, ultimately, the engineering workforce will be essential to generating the intellectual vitality and tapping into the reservoirs of talent essential to long-term U.S. economic and technological success.

*Recommendation 5. All participants and stakeholders in the engineering community (industry, government, institutions of higher education, professional societies, et al.) should place a high priority on encouraging women and underrepresented minorities to pursue careers in engineering. Increasing diversity will not only increase the size and quality of the engineering workforce, but will also introduce diverse ideas and experiences that can stimulate creative approaches to solving difficult challenges. Although this is likely to require a very significant increase in investment from both public and private sources, increasing diversity is clearly essential to sustaining the capacity and quality of the U.S. scientific and engineering workforce.*

Up to now, foreign nationals have made up for the shortfall in domestic technical talent. More than 50 percent of U.S. workers with doctorates in engineering and nearly 30 percent with master's degrees in engineering in 2000 were foreign nationals (NSB, 2003). In U.S. graduate schools, almost one-third of all science and engineering graduate students are foreign-born; in computer science and engineering, the proportion is almost half (NSF, 2004a). The U.S. R&D workforce in industry and academia is, and will continue to be, heavily dependent on foreign nationals, who have made significant contributions to U.S. innovation in the past and will certainly continue to do so in the future (NAE, 1996; National Academies, 2003).

However, as technical capabilities and economic opportunities abroad improve and as global competition for workers skilled in science and engineering increases, questions are being raised about the ability of the United States to continue to attract and retain as many foreign-born engineers and scientists in the future (NSB, 2003). Moreover, post-9/11 changes to U.S. immigration procedures may make attracting and retaining foreign scientists and engineers even more difficult (National Academies, 2003; NSB, 2003).

*Recommendation 6. A major federal fellowship-traineeship program in strategic areas (e.g., energy, info- nano- and biotechnology, knowledge services, etc.), similar to the program created by the National Defense Education Act, should be established to ensure that the supply of next-generation scientists and engineers is adequate.*

*Recommendation 7. Immigration policies and practices should be streamlined (without compromising homeland security) to restore the flow of talented students, engineers, and scientists from around the world into American universities and industry.*

Industry and Research Universities

An academic campus is one of the few places where precompetitive, use-inspired, long-term basic research can be conducted without the demands of meeting quarterly earnings goals. In partnership with industry and national laboratories, universities can bring together experts from many disciplines to investigate problems related to agency missions or meet specific product/service goals. At the same time, university students can learn systems thinking and gain an understanding of market forces through internships and participation in research projects. No other institutions have the same capabilities.

The federal government must take the lead in initiating and sustaining investment to maximize the potential of universities to generate human capital, fundamental knowledge, and systems understanding. With sufficient resources, many schools of engineering could modernize their facilities, thereby making engineering much more attractive to incoming freshmen and helping to sustain their interest in pursuing advanced degrees. Engineering laboratories with state-of-the-art technology would greatly improve the quality of engineering education and create opportunities for thousands of creative young people to contribute to the innovation process. Increased funding for engineering research would also create opportunities for doctoral students and attract gifted U.S. citizens, as well as talented students from around the world, to doctoral programs. The influx of dollars and creativity would make research more exciting and diverse.

*Recommendation 8. Links between industry and research universities should be expanded and strengthened. The committee recommends that the following actions, funded through a combination of tax incentives and federal grants, be taken:*

- *Support new initiatives that encourage multidisciplinary research to address major challenges facing the nation and the world.*
- *Streamline and standardize intellectual-property and technology-transfer policies in American universities to facilitate the transfer of new knowledge to industry.*
- *Support industry engineers and scientists as visiting "professors of practice" in engineering and science faculties.*
- *Provide incentives for corporate R&D laboratories to host advanced graduate and postdoctoral students (e.g., fellowships, internships, etc.).*

Discovery Innovation Institutes

United States leadership in innovation will require commitments and investments of funds and energy by the private sector, federal and state governments, and colleges and universities. The committee believes that a bold, transformative initiative, similar in character and scope to initiatives undertaken in response to other difficult challenges (e.g., the Land Grant Acts, the G.I. Bill, and the government-university research partnerships) will be necessary for the United States to maintain its leadership in technological innovation. The United States will have to reshape its engineering research, education, and practices to respond to challenges in global markets, national security, energy sustainability, and public health. The changes we envision are not only technological, but also cultural; they will affect the structure of organizations and relationships between institutional sectors of the country. This task cannot be accomplished by any one sector of society. The federal government, states, industry, foundations, and academia must all be involved.

*Recommendation 9. Multidisciplinary discovery-innovation institutes should be established on the campuses of research universities to link fundamental scientific discoveries with technological innovations to create products, processes, and services to meet the needs of society. Funding for the institutes should be provided by federal and state governments, industry, foundations, the venture capital and investing community, and universities.*

With the participation of many scientific disciplines and professions, as well as various economic sectors (industry, government, states, and institutions of higher education), discovery-innovation institutes would be similar in character and scale to academic medical centers and agricultural experiment stations that combine research, education, and professional practice and drive transformative change. As experience with aca-


The Discovery Innovation Institute (Hub) Concept

demic medical centers and other large research initiatives has shown, discovery-innovation institutes would stimulate significant regional economic activity, such as the location nearby of clusters of start-up firms, private research organizations, suppliers, and other complementary groups and businesses.

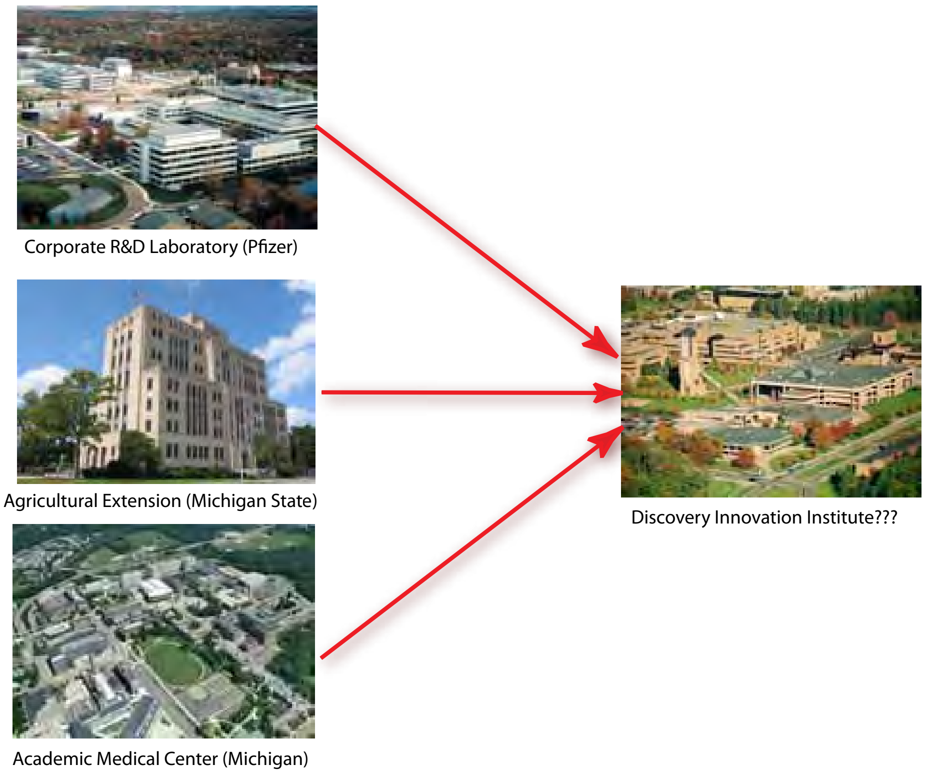
On the federal level, the discovery-innovation institutes should be funded jointly by agencies with responsibilities for basic research and missions that address major national priorities (e.g., National Science Foundation, U.S. Department of Energy, National Aeronautics and Space Administration, U.S. Department of Defense, U.S. Department of Homeland Security, U.S. Department of Transportation, U.S. Department of Commerce, Environmental Protection Agency, and U.S. Department of Health and Human Services).

States would be required to contribute to the institutes (perhaps by providing capital facilities). Industry would provide challenging research problems, systems knowledge, and real-life market knowledge, as well as staff who would work with university faculty and students in the institutes. Industry would also fund student internships and provide direct financial support for facilities and equipment (or share its facilities and equipment). Universities would commit to providing a policy framework (e.g., transparent and efficient intellectual property policies, flexible faculty appointments, responsible financial management, etc.), educational opportunities (e.g., integrated curricula, multifaceted student interaction), knowledge and technology transfer (e.g., publications, industrial outreach), and additional investments (e.g., in physical facilities and cyberinfrastructure). Finally, the venture capital and investing community would contribute expertise in licensing, spin-off companies, and other avenues of commercialization.

Some of the existing NSF-sponsored Engineering Research Centers (ERCs) may serve as a starting point for the development of discovery-innovation institutes. Yet the multidisciplinary scope and scale of the research, education, innovation, and technology transfer activity of fully developed discovery-innovation institutes will certainly dwarf the important though more limited activities of ERCs.

To ensure that the discovery-innovation institutes would lead to transformative change, they should be funded at a level commensurate with past federal initiatives and current investments in other areas of research, such as biomedicine and manned spaceflight. Federal funding would ultimately increase to a level of several billion dollars per year distributed throughout the engineering research and education enterprise; states, industry, foundations, and universities would invest comparable amounts.

The committee recognizes that current federal and state budgets are severely constrained and are likely to




Existing elements of the Discovery Innovation Institute (hub) paradigm

remain so for the foreseeable future. Nevertheless, as the public comes to understand the importance of leadership in technological innovation to the nation's economic prosperity and security, the committee believes this initiative could be given a high priority in the federal budget process.

To transform the technological innovation capacity of the United States, the discovery-innovation institutes should be implemented on a national scale and backed by a strong commitment to excellence by all participants. Most of all, they would be engines of innovation that would transform institutions, policies, and cultures and enable our nation to solve critical problems and maintain its leadership in the global, knowledge-driven society of the twenty-first century.

## Conclusion

Exciting opportunities in engineering lie ahead. Some involve rapidly emerging fields, such as information systems, bioengineering, and nanotechnology. Others involve critical national needs, such as sustainable energy sources and homeland security. Still others involve the restructuring of engineering education to ensure that engineering graduates have the skills, understanding, and imagination to design and manage complex systems. To take advantage of these opportunities, however, investment in engineering research and education must be a much higher priority.

The country is at a crossroads. We can either continue on our current course—living on incremental improvements to past technical developments and gradually conceding technological leadership to trading partners abroad—or we can take control of our destiny and conduct the necessary research, capture the intellectual property, commercialize and manufacture the products, and create the high-skill, high-value jobs that define a prosperous nation. The United States has the proven ability and resources to maintain the global lead in innovation. Engineers and scientists can meet the technological challenges of the twenty-first century, just as they responded to the challenges of World War II by creating the tools for military victory and just as they mounted an effective response to the challenge of Sputnik and Soviet advances in space.

## Impact of Study

Interestingly enough, the Engineering Research study had immediate impact since its final report was being reviewed by the National Research Council in 2005 at the same time that the COSPUP Study, Rising Above the Gathering Storm, was undergoing review. There was some interaction both among the study groups and the reviewers, since the two studies strongly complemented one another.

The Engineering Research study also had major impact several years later through the acceptance of the discovery-innovation institute paradigm for translational research. This was first adopted in several studies by the Brookings Institution (see Chapter 7). But perhaps more significant, this paradigm was the basis for the energy innovation hub program of the Department of Energy, first authorized and funded by Congress in 2008 and then later a series of manufacturing innovation hubs created by the Department of Commerce in 2014. The success of these innovation hubs (aka discovery-innovation institutes) provided an important new mechanism for rapidly translating fundamental research into products and processes capable of success in the marketplace.

## Major Reports

James J. Duderstadt (chair), Engineering Research and America's Future: Meeting the Challenge of the Global Economy (Washington, D.C.: National Academy Press, 2005).

James J. Duderstadt, Mark Muro, and Sarah Rahman, Hubs of Transformation: Leveraging the Great Lakes Research Complex for Energy Innovation (Brookings Institution, Washington, D.C., 2010)

James J. Duderstadt, et. al., Energy Discovery-Innovation Institutes: A Step Toward America's Energy Sustainability (Brookings Institution, Washington, D.C., 2009)

James J. Duderstadt, New University Paradigms for Technological Innovation, Glion VII Conference (Economica, Paris, 2009)

Augustine, Norman (chair). Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future. National Academies Committee on Prospering in the Global Economy of the 21st Century. Washington, DC: National Academies Press, 2005.

## References

COSEPUP (Committee on Science, Engineering and Public Policy). 2002. Observations on the President's Fiscal Year 2003 Federal Science and Technology Budget. Washington, D.C.: National Academies Press.

Council on Competitiveness. 2001. Imperatives for Innovation: The Second National Innovation Summit 2001. Washington, D.C.: Council on Competitiveness. Executive summary available online at: http://www.compete.org/pdf/summit_exsumm.pdf.

Council on Competitiveness. 2004. Innovate America. Washington, D.C.: Council on Competitiveness. Available online at: http://www.compete.org/pdf/NII_Final_Report.pdf.

DOE (U.S. Department of Energy). 2003. Critical Choices: Science, Energy, and Security. Final Report of the Secretary of Energy Advisory Board Task Force on the Future of Science Programs at the Department of Energy. Washington, D.C.: U.S. Department of Energy.

NAE (National Academy of Engineering). 2005. Educating the Engineer of 2020: Adapting Engineering Education to the New Century. Washington, D.C.: National Academies Press.

NAE. 2003. The Impact of Academic Research on Industrial Performance. Washington, D.C.: National Academies Press.

NAE. 2004. The Engineer of 2020: Visions of Engineering in the New Century. Washington, D.C.: National Academies Press.

National Commission on Mathematics and Science Teaching for the 21st Century. 2000. Before It's Too Late: A Report to the Nation. Jessup, Md.: Education Publications Center.

NRC (National Research Council). 2001. Trends in Federal Support of Research and Graduate Education. Washington, D.C.: National Academy Press.

NSB (National Science Board). 2003. The Science and Engineering Workforce: Realizing America's Potential. NSB 0369. Available online at: http://www.nsf.gov/nsb/documents/2003/nsb0369/nsb0369.pdf.

PCAST (President's Committee of Advisors on Science and Technology). 2002. Assessing the U.S. R&D Investment. Available online at: http://www.ostp.gov/PCAST/FINAL R&D REPORT WITH LETTERS.pdf.

PCAST. 2004a. Sustaining the Nation's Innovation Ecosystem: Maintaining the Strength of Our Science and Engineering Capabilities. Available online at: http://www.ostp.gov/PCAST/FINALPCASTSECAPABILITIESPACKAGE.pdf.

PCAST. 2004b. Sustaining the Nation's Innovation Ecosystem: Information Technology, Manufacturing and Competitiveness. Available online at: http://ostp.gov/pcast/FINALPCASTITManuf%20ReportPackage.pdf.

# Chapter 7

# Discovery Innovation Hubs

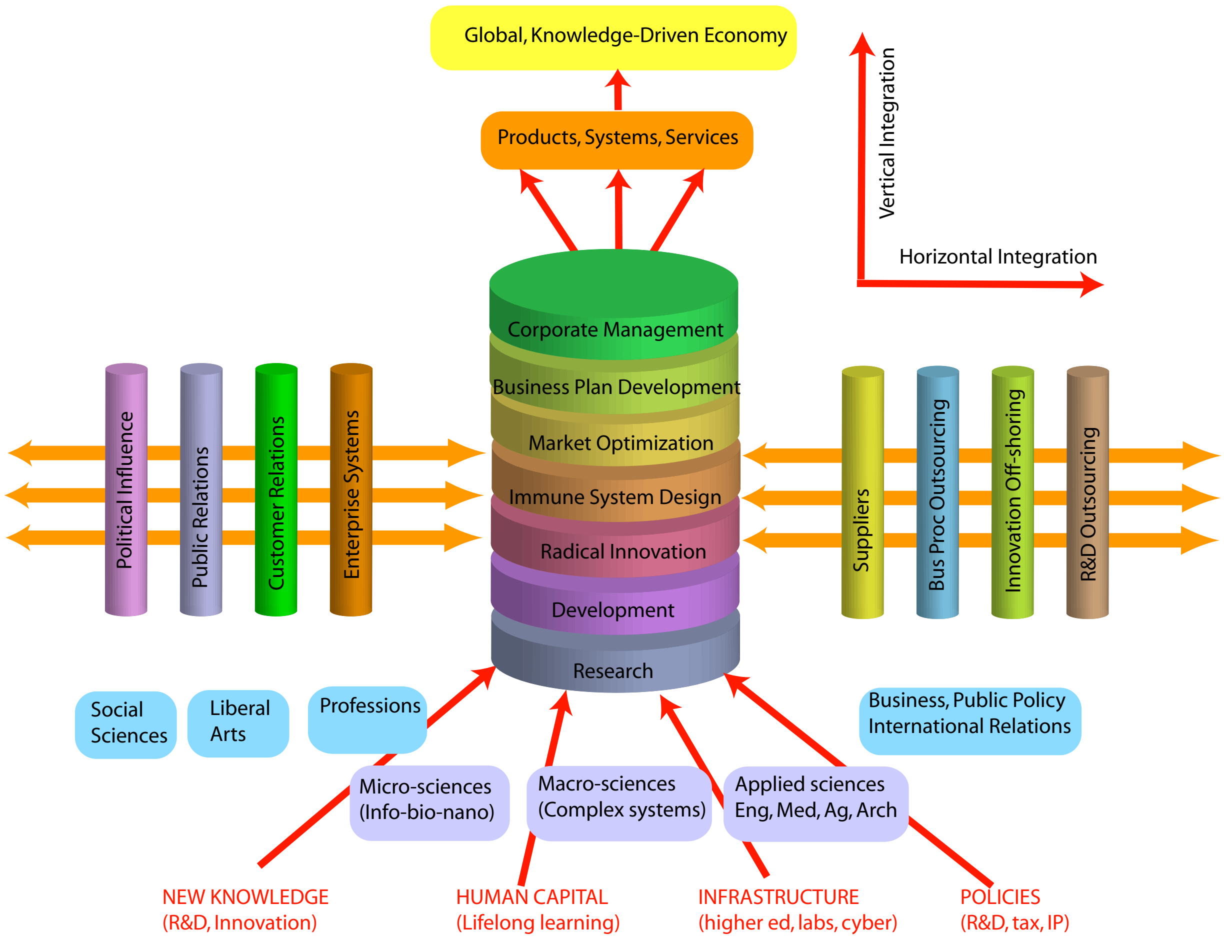
In today's global, knowledge-driven economy, leadership in innovation is essential to a nation's prosperity and security. In particular, technological innovation–the transformation of new knowledge into products, processes, and services of value to society–is critical to economic competitiveness, national security, and an improved quality of life. The United States has long benefited from a fertile environment for innovation, such as a diverse population continually renewed through immigration, democratic values that encourage individual initiative, and free market practices that drive the ongoing process of creative destruction (a la Schumpeter). But history has shown that public investment is necessary to produce the key ingredients for technological innovation including: new knowledge (research and development), human capital (education, particularly at the advanced level), infrastructure (physical and now cyber), and supportive policies (tax, intellectual property) (Augustine, 2005).

Although the flow of knowledge from scientific discovery through development and technological innovation, commercialization, and deployment was once thought of as a linear, vertical process, it is now viewed as far more complex, both vertical and horizontal, and involving many interacting disciplines and participants. For innovation to occur, there cannot be any missing steps or elements in the continuum of necessary activities.

Traditionally, one thinks of the appropriate activities for each of the key factors in the innovation continuum–namely, government, industry, and universities–in terms such as basic research, applied research, development, commercialization, and deployment. For example, basic research activities, usually speculative, long term, and driven by scientific curiosity, are usually viewed as the proper role of research universities, while use-driven basic research, applied research, and development are more commonly roles for government or industrial laboratories. Commercialization and deployment are similarly viewed most appropriate for industry (both established and entrepreneurial).

Yet, there are other types of research important to the innovation continuum. In his theory of scientific revolution, Thomas Kuhn suggested that major progress was achieved not through gradual evolution of conventional disciplinary research but rather through revolutionary, unpredictable transformations after the intellectual content of a field reaches saturation (Kuhn, 1963). The U.S. National Science Foundation refers to such activities as transformative research, "research driven by ideas that stand a reasonable success of radically changing our understanding of an important existing concept or leading to the creation of a new paradigm or field of science. Such research is also characterized by its challenge to current understanding or its pathway to new frontiers" (National Science Board, 2007).

While it might be assumed that such transformative research would most commonly occur in research universities, ironically the peer pressure of merit review in both grant competition and faculty promotion can discourage such high risk intellectual activities. In fact, transformative research occurs just as frequently in some industrial research laboratories (e.g., Bell Laboratories in the past and Google Research today) where unusually creative investigators are freed from the burdens of grant seeking or commercial deadlines. It also occurs in a small number of unique government agencies such as the Defense Advanced Research Project Agency (and hopefully in its spinoffs of ARPA-E and IARPA) where path-breaking research is shielded from the pressures of grant competition and applica-



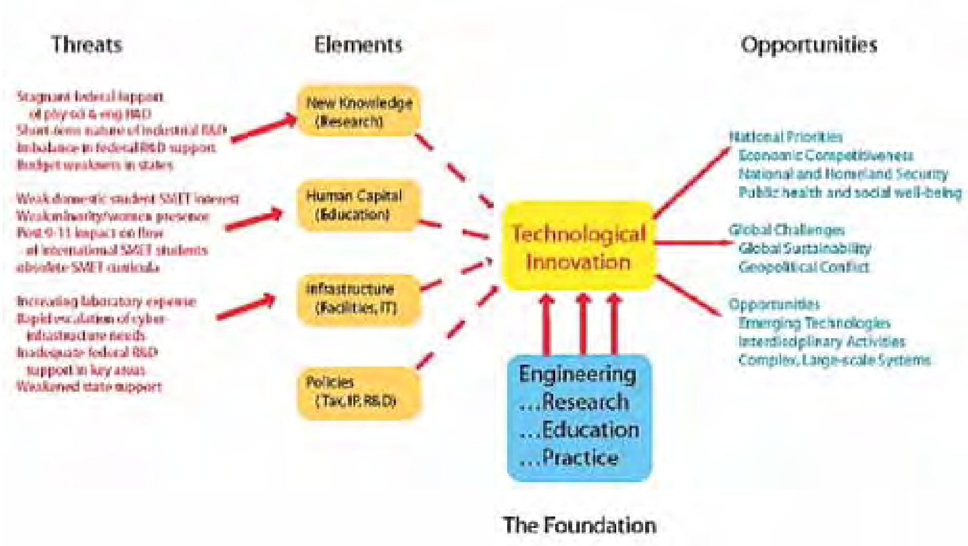

The Knowledge Economy of 2020

tion deadlines.

At the other end of the innovation continuum is translational research, aimed at building the knowledge base necessary to link fundamental scientific discoveries with the technological innovation necessary for the development of new products, processes, and services. While translational research is both basic and applied in nature, it is driven by intended application and commercial (or social) priorities rather than scientific curiosity. Such translational research is a common feature of the biomedical industry, moving "from bench to bedside" or from laboratory experiments through clinical trials to actual point-of-care patient applications. While it is also a necessary component of the innovation continuum in other areas, particularly in corporate and federal R&D (with Bell Laboratories and the U.S. Department of Energy Laboratories as prominent examples), it has generally not been identified as a specific activity of research universities.

## Discovery-Innovation Institutes

Over the past several years there has been an increasing recognition that U.S. leadership in innovation will require commitments and investments of resources by the private sector, federal and state governments, and colleges and universities. In 2005, the U.S. National Academies issued a series of reports suggesting that a bold, transformative initiative, similar in character and scope to initiatives undertaken in response to other difficult challenges (e.g., the Land Grant Acts, the G.I. Bill, and the post-WWII government-university research partnerships) will be necessary for the United States to maintain its leadership in technological innovation (Augustine, 2005). The United States will have to reshape its research, education, and practices to respond to challenges in global markets, national security, energy sustainability, and public health. The changes en-




The Challenges to Innovation

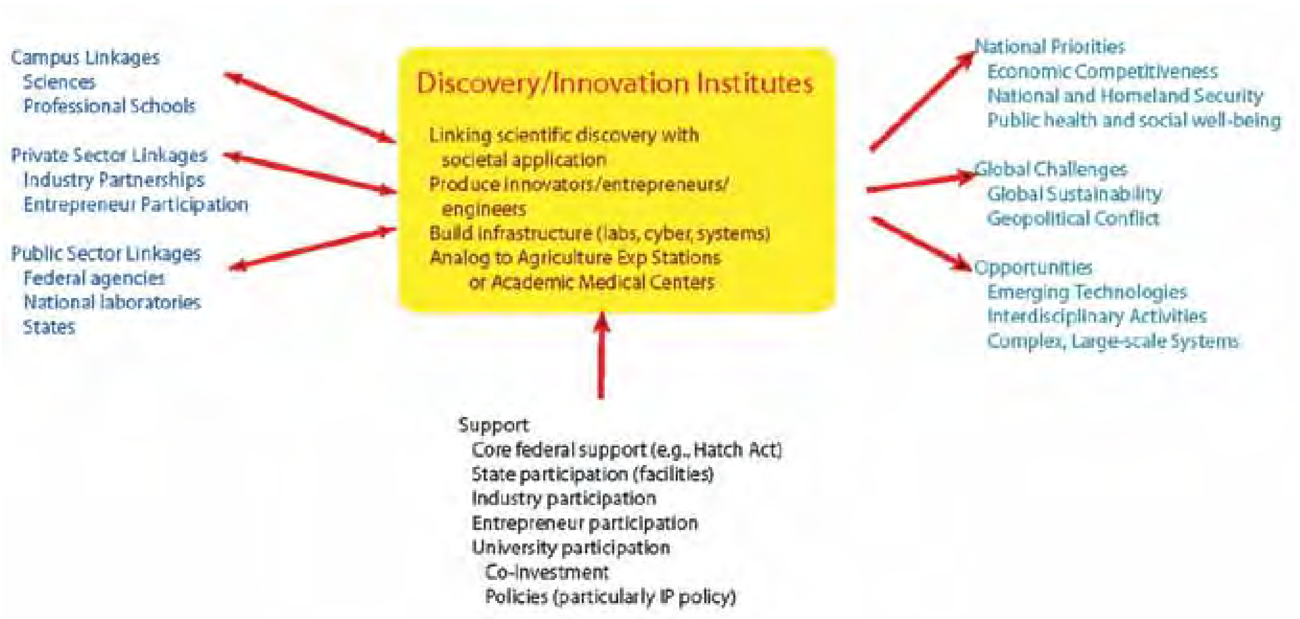
visioned were not only technological, but also cultural; they would affect the structure of organizations and relationships between institutional sectors of the country.

To this end, it was the recommendation of the U.S. National Academy of Engineering that a major federal initiative be launched to create translational research centers aimed at building the knowledge base necessary for technological innovation in areas of major national priority (Duderstadt, 2005). These centers, referred to as discovery-innovation institutes, would be established on the campuses of research universities to link fundamental scientific discoveries with technological innovations to create products, processes, and services to meet the needs of society. With the participation of many scientific disciplines and professions, as well as various economic sectors (industry, government, states, and institutions of higher education), discovery-innovation institutes would be similar in character and scale to academic medical centers and agricultural experiment stations that combine research, education, and professional practice and drive transformative change. As experience with academic medical centers and other large research initiatives has shown, discovery-innovation institutes would have the potential to stimulate significant regional economic activity, such as the location nearby of clusters of start-up firms, private research organizations, suppliers, and other complementary groups and businesses.

More specifically, discovery-innovation institutes would be characterized by partnership, interdisciplinary research, education, and outreach:

Partnership: The federal government would provide core support for the discovery-innovation institutes on a long-term basis (perhaps a decade or more, with possible renewal). States would be required to contribute to the institutes (perhaps by providing capital facilities). Industry would provide challenging research problems, systems knowledge, and real-life market knowledge, as well as staff who would work with university faculty and students in the institutes. Industry would also fund student internships and provide direct financial support for facilities and equipment (or share its facilities and equipment). Universities would commit to providing a policy framework (e.g., transparent and efficient intellectual property policies, flexible faculty appointments, responsible financial management, etc.), educational opportunities (e.g., integrated curricula, multifaceted student interaction), knowledge and technology transfer (e.g., publications, industrial outreach), and additional investments (e.g., in physical facilities and cyberinfrastructure). Finally, the venture capital and investment community would contribute expertise in licensing, spin-off companies, and other avenues of commercialization.

Interdisciplinary Research: Although most discovery-innovation institutes would involve engineering



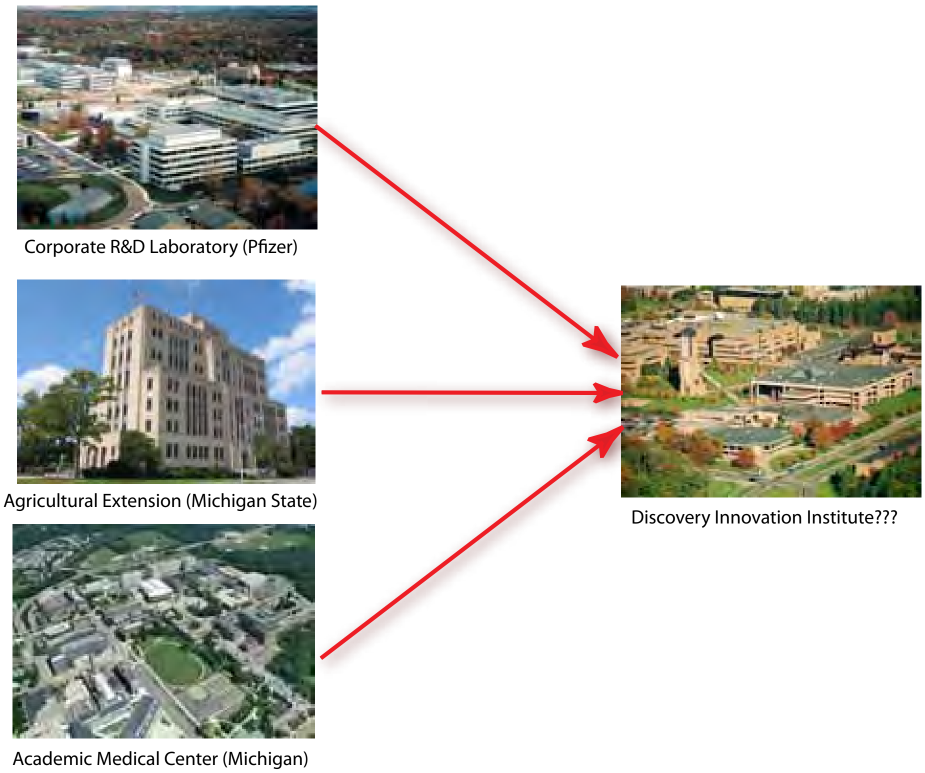

The Discovery Innovation Institute Concept

schools (just as the agricultural experiment stations involve schools of agriculture), they would require strong links with other academic programs that generate fundamental new knowledge through basic research (e.g., physical sciences, life sciences, and social sciences), as well as other disciplines critical to the innovation process (e.g., business, medicine, and other professional disciplines). These campus-based institutes would also attract the participation (and possibly financial support) of established innovators and entrepreneurs.

Education: Universities hosting discovery-innovation institutes would be stimulated to restructure their organizations, research activities, and educational programs. Changes would reflect the interdisciplinary team approaches for research that can convert new knowledge into innovative products, processes, services, and systems and, at the same time, provide graduates with the skills necessary for innovation. Discovery-innovation institutes would provide a mechanism for developing and implementing innovative curricula and teaching methods.

Outreach: Just as the success of the agricultural experiment stations established by the U.S. Land Grant Acts depended on their ability to disseminate new technologies and methodologies to the farming community through the cooperative extension service, a key factor in the success of discovery-innovation institutes would be their ability to facilitate implementation of their discoveries in the user community. Extensive outreach efforts based on existing industry and manufacturing extension programs at universities would be an essential complement to the research and educational activities of the institutes. Outreach should also include programs for K–12 students and teachers that would build enthusiasm for the innovation process and generate interest in math and science.

Research Priorities: The National Academy report envisioned a very wide range of discovery-innovation institutes, depending on the capacity and regional characteristics of a university or consortium and on national priorities. Some institutes would enter into partnerships directly with particular federal agencies or national laboratories to address fairly specific technical challenges, but most would address broad national priorities that would require relationships with several federal agencies. Awards would be made based on (1) programs that favor fundamental research driven by innovation in a focused area; (2) strong industry commitment; (3) multidisciplinary participation; and (4) national need. Periodic reviews would ensure that the institutes remain productive and continue to progress on both short- and long-term deliverables.




Existing elements of the Discovery Innovation Institute paradigm

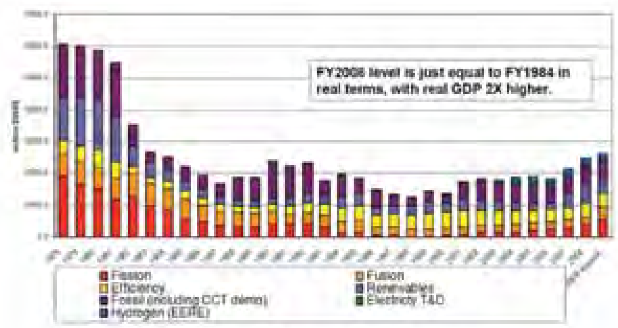
Funding: To ensure that the discovery-innovation institutes lead to transformative change, they would be funded at a level commensurate with past federal initiatives and current investments in other areas of research, such as biomedicine and manned spaceflight. Federal funding would ultimately increase to several billion dollars per year distributed throughout the university research and education enterprise, with states, industry, foundations, and universities investing comparable amounts in these research centers. To transform the technological innovation capacity of the United States, the discovery-innovation institutes would be implemented on a national scale and backed by a strong commitment to excellence by all participants. Most of all, they would become engines of innovation that would transform institutions, policies, and cultures and enable our nation to solve critical problems and maintain its leadership in the global, knowledge-driven society of the twenty-first century.

## A Case Study: Energy Research

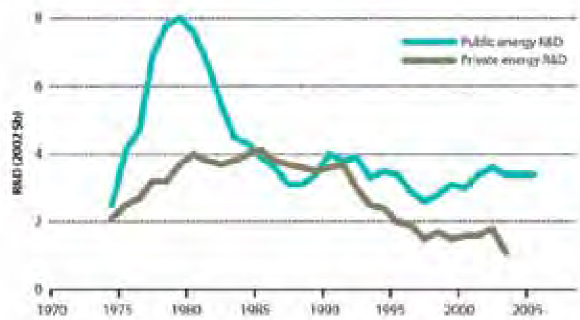
Today's energy challenges stem from an unsustainable energy infrastructure, largely dependent on fossil fuels characterized by unacceptable environmental impact and supply constraints, with clear implications for a nation's economic, public health, and national security. Addressing these challenges will require substantial investments in clean and efficient energy technology, much of which has yet to be developed, making innovation the centerpiece of successful energy policy (Lewis, 2007).

Transformative innovation will be required to address fundamental energy challenges. As Presidential Science Advisor John Holdren warns, the multiplicity of challenges at the intersection of energy with the economy, the environment, and national security–led by excessive dependence on fossil fuels and the dangerous consequences of energy's environmental impact, particularly global climate change, requires a major acceleration of energy-technology innovation that, over time, can reduce the limitations of existing energy options, bring new options to fruition, and reduce the tensions among energy-policy objectives and enable faster progress on the most critical ones (Holdren, 2006).

Near term impact can be achieved from adopting existing technologies and practices that improve the efficiency of energy utilization, bringing fuel savings and




U.S. DOE energy R&D (Kerry Gallagher, February, 2008)




Declining energy R&D by economic sector (Kammen, 2005)

By any measure, federal and private funding of energy research is woefully inadequate.

creating new jobs. Yet, large and sustained efficiency investments in existing technologies will not be enough to achieve global sustainability goals. New technologies and practices are needed to mitigate the harmful impact and resource constraints of existing energy sources. Of longer term importance is the deployment of affordable, carbon-free renewable energy technologies, which will require energy storage technologies and an expanded electricity grid. With today's renewable technologies, a substantial gap remains in achieving the scale and cost structures necessary for major impact.

Here, innovation is needed not only through greatly increasing R&D in energy technologies but to demonstrate these on a commercial scale and deploy them rapidly into the marketplace. Yet, over the past two decades, energy research in the United States has actually been sharply curtailed by the federal government (75% decrease), the electrical utility industry (50% decrease), and the domestic automobile industry (50% decrease). The energy industry has the lowest level of R&D investment (relative to revenues) of any industrial sector. In 2009, federal investment in energy R&D amounted to less than $3 billion, compared to the federal R&D effort characterizing other national priorities such as health care ($30 B/y) and defense ($80 B/y) (Kammen, 2005; Friedman, 2008).

Furthermore, today's United States energy research program does not have the mission, capacity, or the organizational structure to equip the nation to meet the full span of its challenges. It continues to be primarily conducted by national labs that are not only fragmented and insulated from the marketplace, but fail to tap the considerable resources of the nation's industry and research universities. (Vest, 2003) Major innovation in research paradigms, policy, and management will be necessary to bring about the needed pace of energy-technology innovation (Holdren, 2006):

- To provide the scale, continuity, and coordination of effort in energy R&D and demonstration needed to bring an appropriate portfolio of improved options to commercialized in a timely way;
- To tap the nation's top scientific and engineering talent and facilities, which are currently distributed throughout the nation's research universities, corporate R&D centers, and federal laboratories;
- To address adequately the unusually broad spectrum of issues involved in building a sustainable energy infrastructure, including, in addition to science and technology, attention to complex social, economic, legal, political, behavioral, consumer, and market issues;
- To build strong partnerships among multiple players–federal agencies, research universities, established industry, entrepreneurs and investors, and federal, state, and local government;
- And to launch robust efforts capable of producing the human capital and public understanding required by the emerging energy sector at all education levels.

In view of these market and governance challenges, it is clear that the search for breakthrough technologies and practices should be placed at the center of energy research efforts. This will require a far more compre-


The various partners comprising an energy discovery-innovation institute or hub

hensive and interactive engagement of the entire national research enterprise: research universities, corporate R&D laboratories, and federal laboratories.

To address these challenges, a recent report by the Brookings Institution made two important recommendations (Duderstadt, 2009):

1. The United States should first commit itself to increasing federal investments in energy R&D to a level appropriate to address the dangerous and complex economic, environmental, and national security challenges presented by the nation's currently unsustainable energy infrastructure. Comparisons with federal R&D investments addressing other national priorities such as public health, national defense, and space exploration suggest an investment in federal energy R&D, an order of magnitude greater than current levels, growing to perhaps $20 to $30 billion per year, with most of this flowing to existing research players and programs (e.g., national laboratories and industry).

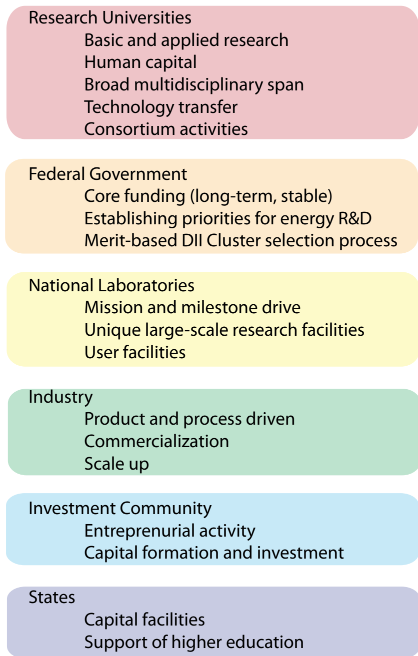
2. A significant fraction of this increase should be directed toward a new research paradigm consisting of a national network of regionally-based energy discovery-innovation institutes (e-DIIs) that serve as hubs in a distributed research network linked through spokes to concentrations of the nation's best scientists, engineers, and facilities.

Recall that the discovery-innovation institute concept is characterized by institutional partnerships, interdisciplinary research, technology commercialization, education, and outreach. In this sense, the e-DII paradigm would place a very high priority on connection and collaboration rather than competition to achieve deeper engagement of the nation's scientific, technology, business, and policy resources in an effort to achieve a sustainable energy infrastructure for America.

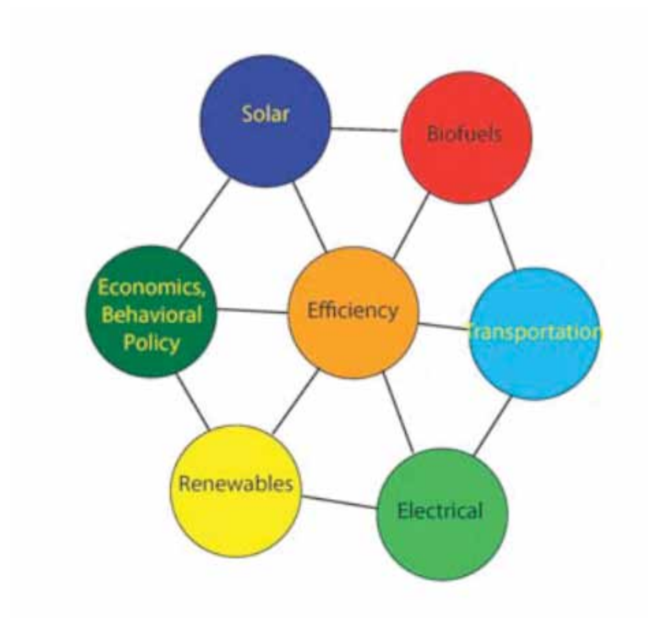
As envisioned here, therefore, the proposed e-DIIs would do the following:

1. Organize around a theme, such as renewable energy technologies, advanced petroleum extraction, carbon sequestration, biofuels, transportation energy, carbon-free electrical power generation and distribution, or energy efficiency. Each e-DII would be charged with addressing the economic, policy, business, and social challenges required to diffuse innovative energy technologies of their theme area into society successfully. This mission would require each e-DII to take a systems-approach to technology development and help to transcend the current "siloed" approach common at DOE and its national labs.

2. Foster partnerships to pursue cutting-edge, applications-oriented research among multiple participants, including government agencies (federal, state, and local), research universities, industry, entrepreneurs, and investors. The e-DIIs would encourage a new research culture based on the nonlinear flow of knowledge and activity among scientific discovery, technological innovation, entrepreneurial business development, and economic, legal, social, and political imperatives. In a sense, e-DIIs would create an "R&D commons," where strong, symbiotic partnerships could be created and sustained among partners with different missions and cultures. Building a sustainable energy infrastructure




Roles for each of the innovation hub partners




A cluster of energy innovation hubs

depends as much on socioeconomic, political, and policy issues as upon science and technology. The e-DIIs would encompass disciplines such as the social and behavioral sciences, business administration, law, and environmental and public policy, in addition to science and engineering.

3. Act as the hubs of a distributed network, linking together as spokes, the basic research programs of campus-based, industry-based, and federal laboratory-based scientists and engineers, research centers, and facilities, to exploit the fundamental character of discovery-innovation institutes to couple fundamental scientific research and discovery with translational research, technology development, and commercial deployment. But the hub-and-spoke network architecture would go further by enabling the basic research group spokes to interact and collaborate among themselves (through exchanges of participants, regularly scheduled meetings, and cyberinfrastructure). Just as the rim of a bicycle wheel greatly strengthens its hub-and-spoke structure, the direct interaction of the basic research groups (the spokes) would greatly facilitate collaboration and research progress, creating a basic energy research community greater than the sum of its individual parts and with sufficient flexibility, synergy, and robustness to enable the participation of leading scientists and engineers to address the unusual complexity of the nation's energy challenges.

4. Develop an effective strategy for energy technology development, commercialization, and deployment, working closely with industry, entrepreneurs, and the investment community. For example, this might draw on the experience of major medical centers (the commercialization of translational research through business startups), agricultural and industrial extension programs, federal initiatives for regional economic development, or entirely new paradigms for technology transfer.

5. Build the knowledge base, human capital, and public awareness necessary to address the nation's energy challenges. The e-DIIs are envisioned as the foci for long-term, applications-driven research aimed at building the knowledge base necessary to address the nation's highest priorities. Working together with industry and government, the e-DIIs would also lead to the development of educational programs and distributed educational networks that could produce new knowledge for innovation and educate not only the scientists, engineers, innovators, and entrepreneurs of the future, but learners of all ages, about the challenge and excitement of changing the US energy paradigm. Thus, the e-DIIs would have a fundamental educational mission of public education through the involvement of their scientists and engineers in sharing best educa-

A national network of energy innovation hubs

tional practices and developing new educational programs in collaboration with K-12 schools, community colleges, regional universities, and workplace training that lead to significantly increased public engagement.

6. Develop and rapidly transfer highly innovative technologies into the marketplace. The treatment of intellectual property is critical to the rapid and efficient transfer of energy technologies to the marketplace. The e-DIIs should provide a safe zone where intellectual property issues could be worked out in advance. Technology transfer within e-DIIs should be structured to maximize the introduction and positive societal impact of e-DII technologies, learning from successful industry-university partnerships (e.g., BP and the Universities of California and Illinois).

6. Encourage regional economic development. With the participation of many scientific disciplines and professions as well as various economic sectors, e-DIIs are similar in character and scale to academic medical centers and agricultural experiment stations that combine research, education, and professional practice and drive transformative change. This organizational form has been successful at generating jobs and stimulating regional economic activity, by the nearby location of clusters of start-up firms, private research organizations, suppliers, and other complementary groups and businesses. The e-DIIs should have an explicit mission to focus, at least in part, on the unique energy needs and opportunities characterizing their home regions, to ensure that new technologies would respond to local challenges and thus could be rapidly deployed.

7. Expand the scope of possible energy activities. The partnership character of the e-DII, involving a consortium of universities, national laboratories, industry, investors, state, and federal government, coupled with its regional focus, would give it the capacity to launch projects that are beyond the capability of a national laboratory or industry consortium alone.

To achieve a critical mass of activities, our report recommended the creation over the next several years of a national network of several dozen energy discovery-innovation institutes distributed competitively among the nation's research universities and federal laboratories:

<u>University-based e-DIIs</u>: Those e-DII's located adjacent to research university campuses would be managed by either individual universities or university

consortia, with strong involvement of partnering institutions such as industry, entrepreneurs and investors, state and local government, and participating federal agencies. While most university-based e-DIIs would focus both on research addressing national energy priorities and regional economic development from new energy-based industries, there would also be the possibility of distributed or virtual e-DIIs (so-called "collaboratives") that would link together institutions on regional or national bases. As mentioned earlier, each e-DII would also act as a hub linking together investigators engaged in basic or applied energy research in other organizations.

Federal laboratory-based e-DIIs: There should be a parallel network of e-DIIs associated with federal laboratories. To enable the paradigm shifts represented by the discovery-innovation institute concept, these e-DIIs would be stood up "outside the fence" to minimize laboratory constraints of security, administration and overhead and driven by the bottom-up interests of laboratory scientists. Like university-based e-DIIs, their objectives would be the conduct of application-driven translational research necessary to couple the extraordinary resources represented by the scientific capability of the national laboratories with the technology innovation, development, and entrepreneurial efforts necessary for the commercial deployment of innovative energy technologies in the commercial marketplace. A given national laboratory might create several e-DIIs of varying size and focus that reflect both capability and opportunities. There might also be the possibility of e-DIIs jointed, created and managed by national laboratories and research universities.

Satellite energy research centers: The large e-DIIs managed by research university consortia or national laboratories would anchor "hub-and-spoke" sub-networks linking satellite energy research centers comparable in scale to DOE's Energy Frontier Research Centers or NSF's Engineering Research Centers, thereby enabling faculty in less centrally-located regions or at institutions with limited capacity to manage the large e-DII hubs to contribute to the nation's energy R&D as an element of the national e-DII network.

A merit-based competitive process would award core federal support ranging from $5 M/y to $10 M/y for modest centers in single institutions to as much as $100 M/y to $200 M/y for large e-DIIs managed by consortia of universities and national laboratories. Federal funding would be augmented with strong additional support and participation from industry, investors, universities, and state governments, for a total federal commitment growing to roughly $6 billion/y (or %25 of the recommended total federal energy R&D goal of $20 to $30 billion/y estimated to be necessary to address adequately the nation's energy challenge.)

Interestingly enough, this strategy has important antecedents in American history. In earlier times during periods of great challenge or opportunity, the United States responded to the changing needs of the nation with massive investments in the nation's research capacity. The Land Grant Acts of the 19th century created, through the great land-grant universities, the capacity to assist the nation's transition from an agricultural to an industrial economy. The Manhattan Project developed the nuclear technology to protect the nation during a period of great international peril. The post-WWII research partnership between the federal government and the nation's universities was not only critical to national security during the Cold War but drove much of America's economic growth during the latter half of the 20th century. The Apollo Program fulfilled mankind's dream to conquer space by sending men to the moon.

Most analogous to the present situation was the visionary action taken by Congress to respond to the challenge of modernizing American agriculture and industry with the Hatch Act of 1887. This act created a network of agricultural and engineering experiment stations through a partnership involving higher education, business, and state and federal government that developed and deployed the technologies necessary to build a modern industrial nation for the 20th century while stimulating local economic growth. The proposed network of regional "energy innovation hubs" is remarkably similar both in spirit and structure, since it will bring together a partnership among research universities, business and industry, entrepreneurs and investors, and federal, state, and local government working together across a broad spectrum of scientific, engineering, economic, behavioral, and policy disciplines to build a sustainable national energy infrastructure for the 21st century while stimulating strong regional economic growth. It will represent an important element of a broader national effort to achieve a sustainable energy future for both our nation and the world.

## Assessment of Impact

The role of research in contributing to the innovation necessary to compete in a knowledge-driven global economy is widely recognized. Clearly, the traditional approaches to fundamental research and education are essential for creating the new knowledge and knowledge professional to this effort. Yet, study suggested that something more is necessary: transformational research to stimulate the breakthrough discoveries that create entirely new economic activities and translational research and development to transfer new knowledge generated on the campuses into products, processes, and systems capable of addressing the needs of society. These, in turn, will likely require new paradigms for research similar to those suggested in recent U.S. National Academy and National Science Foundation studies and currently being applied to address the urgent need for sustainable energy technologies.

In May 2009, the U.S. Department of Energy announced the first step of building just such a significant energy research program by launching a new transformational research program patterned after the U.S. Department of Defense's Advanced Research Projects Agency (DARPA) known as ARPA-E and funded at an initial level of $400 M/y; funding 46 new Energy Frontier Research Centers on university campuses and national laboratories for small research teams; and creating an initial set of eight "energy innovation hubs", similar in concept to the energy discovery innovation institutes, for translational research funded at $280 M for the first year. President Obama has also committed to increasing federal energy research by at least $15 B/y, hence beginning to approach the target set by our Brookings report (Chu, 2009).

## Studies

Duderstadt, James J. (chair), Engineering Research and America's Future: Meeting the Challenge of the Global Economy (Washington, D.C.: National Academy Press, 2005).

Duderstadt, James J., Mark Muro, and Sarah Rahman, Hubs of Transformation: Leveraring the Great Lakes Research Complex for Energy Innovation (Brookings Institution, Washington, D.C., 2010)

Duderstadt, James J., et. al., Energy Discovery-Innovation Institutes: A Step Toward America's Energy Sustainabilitiy (Brookings Institution, Washington, D.C., 2009)

Duderstadt, James J., "New University Paradigms for Technological Innovation", Glion VII Conference (Economica, Paris, 2009)

## References

Augustine, N. (chair) (2005). National Academies Committee on Prospering in the Global Economy of the 21st Century, Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future. Washington, D.C.: National Academies Press.

Chu, Stephen (2009). Presentation on Department of Energy 2010 Budget. United States Department of Energy, http://www.energy.gov/media/Secretary_Chu_2010_Budget_rollout_presentation.pdf

Duderstadt, J. J. (chair) (2005). Committee to Assess the Capacity of the United States Research Enterprise, Engineering Research and America's Future: Meeting the Challenges of a Global Economy. Washington, D.C.: National Academies Press.

Duderstadt, J.J. (chair) (2009). Energy Discovery-Innovation Institutes: A Step Toward America's Energy Sustainability, Brookings Institution Blueprint for American Prosperity. Washington, D.C.: Metropolitan Policy Program, Brookings Institution.

Friedman, T. (2005). The World Is Flat: A Brief History of the 21st Century. New York, New York: Farrar, Strauss, and Giroux.

Friedman, T. (2008). Hot, Flat, and Crowded: Why We Need a Green Revolution–and How It Can Renew America. New York, New York: Farrar, Strauss, and Giroux.

Holdren, J. (2006). "The Energy Innovation Imperative: Addressing Oil Dependence, Climate Change, and Other 21st Century Energy Challenges", Innovations, 1 (2), p. 3.

IPCC (2007). Intergovernmental Panel on Climate Change, Climate Change 2007. Cambridge, England: Cambridge University Press.

Kammen, D. M. and G. F. Nement (2005). "Reversing the Incredible Shrinking Energy R&D Budget", Issues in Science and Technology, Fall 2005, pp. 88.

Kuhn, T. S. (1963). The Structure of Scientific Revolutions. Chicago, Illinois: University of Chicago Press.

Lewis, N. S. (2007). "Powering the Planet", Caltech Engineering & Science, No. 2, p. 13.

National Academies (2007). America's Energy Future: Technology Opportunities, Risks and Tradeoffs, study under way.

National Science Board (2007). Transformational Research. Washington, D.C.: National Science Foundation.

Suh, Nam (2009). "On Innovation Strategies: An Asian Perspective". Glion Colloquium VII, Glion-over-Montreux, Switzerland.

Vest, C. M. (chair) (2003). Final Report of the Secretary of Energy's Advisory Board Task Force on the Future of Science Programs at the Department of Energy, Critical Choices: Science, Energy, and Security. Washington, D.C.: U. S. Department of Energy.

Chapter 8

# Information Technology and the Research University

Higher education has entered a period of significant change as our universities attempt to respond to the challenges, opportunities, and responsibilities facing them in the new century. The forces driving change are many and varied: the globalization of commerce and culture, the advanced educational needs of citizens in a knowledge-driven global economy, the exponential growth of new knowledge and new disciplines, and the compressed timescales and nonlinear nature of the transfer of knowledge from campus laboratories into commercial products. We are in a transition period where intellectual capital is replacing financial and physical capital as the key to prosperity and social well being. In a very real sense, we are entering a new age, an age of knowledge, in which the key strategic resource necessary for prosperity has become knowledge itself, that is, educated people and their ideas.

Our rapid evolution into a knowledge-based, global society has been driven in part by the emergence of powerful new information technologies such as digital computers and communications networks. Modern digital technologies have vastly increased our capacity to know and to do things and to communicate and collaborate with others. They allow us to transmit information quickly and widely, linking distant places and diverse areas of endeavor in productive new ways. This technology allows us to form and sustain communities for work, play, and learning in ways unimaginable just a decade ago. It has broadened access to knowledge, learning, and scholarship to millions throughout the world. Information technology changes the relationship between people and knowledge. It is likely to reshape in profound ways knowledge-based institutions such as our colleges and universities.

Of course higher education has already experienced significant change driven by digital technology. Our management and administrative processes are heavily dependent upon this technology. Research and scholarship are also highly dependent upon information technology, for example, the use of computers to simulate physical phenomena, networks to link investigators in virtual laboratories or "collaboratories," and digital libraries to provide scholars with access to knowledge resources. There is an increasing sense that new technology will also have a profound impact on teaching, freeing the classroom from the constraints of space and time and enriching learning by providing our students with access to original source materials.

Yet, while information technology has the capacity to enhance and enrich teaching and scholarship, it also poses certain threats to our colleges and universities. We can now use powerful computers and networks to deliver educational services to anyone, anyplace, anytime, no longer confined to the campus or the academic schedule. Technology is creating an open learning environment in which the student has evolved into an active learner and consumer of educational services. Faculty loyalty is shifting from campus communities and universities to scholarly communities distributed in cyberspace. The increasing demand for advanced education and research from a knowledge-driven society, the appearance of new for-profit competitors, and technological innovations are stimulating the growth of powerful market forces that could dramatically reshape the higher education enterprise.

## Preparing for the Revolution

Reflecting their broad interest in the health of America's research enterprise, the National Academies launched a study in early 2000 on the implications of information technology for the future of the nation's

PANEL ON THE IMPACT OF INFORMATION TECHNOLOGY ON THE FUTURE OF THE RESEARCH UNIVERSITY

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MARYE ANNE FOX, Chancellor, North Carolina State University
RALPH E. GOMORY, President, Alfred P. Sloan Foundation
NILS HASSELMO, President, Association of American Universities
PAUL M. HORN, Senior Vice President for Research, IBM
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research university—a social institution of great importance to our economic strength, national security, and quality of life. The premise of this study was a simple one. Although the rapid evolution of digital technology will present numerous challenges and opportunities to the research university, there is a sense that many of the most significant issues are not well understood by academic administrators, faculty, and those who support or depend on the institution's activities.

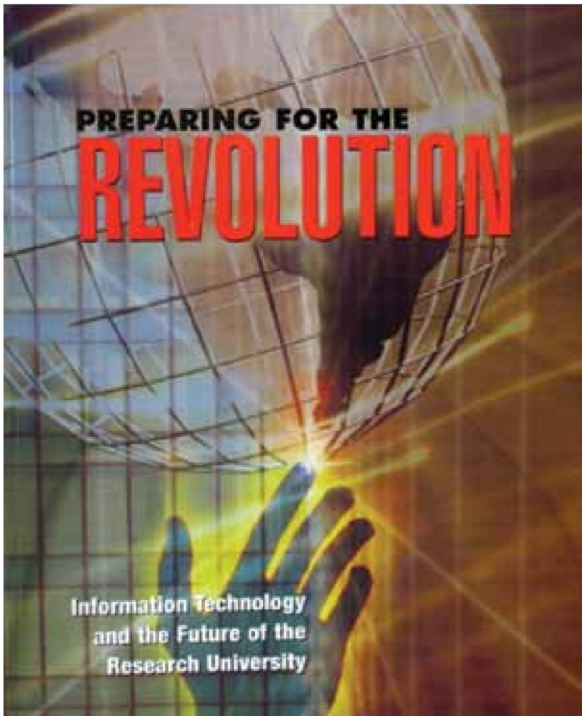
The steering group for the effort was comprised of leaders from higher education, the chief technology officers of major IT companies, and leaders in national science policy. This group met on numerous occasions over a two-year period to consider these issues, including site visits to major technology laboratories such as Bell Labs and IBM Research Labs and drawing upon the expertise of the National Academy complex. At the end of this period, over one hundred leaders from higher education, the IT industry, and the federal government, and several private foundations convened for a

Roundtable discussions with university leaders

two-day workshop at the National Academy of Sciences to focus this discussion. Beyond the insight brought by these participants, perhaps even more striking was their agreement on a number of key issues.

The first finding was that the extraordinary pace of information-technology evolution is likely to continue for the next several decades, possibly even accelerating. Hence, in thinking about changes to the university, one must think about the technology that will be available in 10 or 20 years, technology that will be thousands of times more powerful as well as thousands of times cheaper. The second finding was that the impact of IT on the university is likely to be profound, rapid, and disruptive, affecting all of its activities (teaching, research, service), its organization (academic structure, faculty culture, financing, and management), and the broader higher education enterprise as it evolves toward a global knowledge and learning industry. If change is gradual, there will be time to adapt gracefully, but that is not the history of disruptive technologies. As Clayton Christensen explains in *The Innovators Dilemma*, new technologies are at first inadequate to displace existing technology in existing applications, but they later explosively displace the application as they enable a new way of satisfying the underlying need.

While it may be difficult to imagine today's digital technology replacing human teachers, as the power of this technology continues to evolve 100- to 1000-fold each decade, the capacity to reproduce all aspects of human interactions at a distance with arbitrarily high fidelity could well eliminate the classroom and perhaps




DOE Task Force Report

even the campus as the location of learning. Access to the accumulated knowledge of our civilization through digital libraries and networks, not to mention massive repositories of scientific data from remote instruments such as astronomical observatories or high energy physics accelerators, is changing the nature of scholarship and collaboration in very fundamental ways.

The third finding stresses that although information technology will present many complex challenges and opportunities to universities, procrastination and inaction are the most dangerous courses to follow all during a time of rapid technological change. Attempting to cling to the status quo is a decision in itself, perhaps of momentous consequence.

The first phase of this study, its conclusions, and its recommendations were published in a report, Preparing for the Revolution, available both online and through hard copy from the National Academies Press.

## The IT Forum

In 2003 the National Academies have extended this effort to involve directly a large number of research universities by creating a National Academy roundtable on information technology and research universities ("the IT-Forum") to track the technology, identify the key issues, and raise awareness of the challenges and opportunities. The IT Forum has also conducted a series of workshops for university presidents and chief academic officers in an effort to help them understand better the transformational nature of these technologies and the importance of developing strategic visions for the future of their institutions.

The IT Forum began its activities in spring of 2003 with a two-day workshop involving two dozen leaders of major research universities at the spring meeting of the Association of American Universities (AAU). To launch the discussion, Louis Gerstner, CEO of IBM, spoke at a dinner meeting the evening before the workshop to share with the presidents some of his own observations concerning leadership during a period of rapid change. The IBM experience demonstrated the dangers of resting on past successes. Instead, leaders need to view information technology as a powerful tool capable of driving a process of strategic change, but only with the full attention and engagement of executive leadership–meaning university presidents themselves.

Noting that university presidents listen most carefully to their own voices, the workshop was organized about several panels of the participating presidents. The first panel was asked to discuss what was currently in their in-out box, the here-and-now issues. These included the usual concerns such as how to meet the seemingly insatiable demand for computing resources (particularly bandwidth), how to pay for this technology, and how to handle privacy and security issues. It is probably no surprise that that most of the presidents believed that they had these issues well in hand–a perception quite different than we were to find with their provosts several months later.

Members of the IT Forum then attempted to move the discussion farther into the future and elevate it to a more strategic level by posing a number of provocative possibilities to the presidents. For example, how would adapt their library planning to the very real possibility that within a decade, the entire Library of Congress (about 10 TB) could be contained in a consumer device about the size of a football (a size university presidents understand well)–or more to the point of students, an iPod? How would the rapid evolution


IT Forum Participants


IT Forum Meetings

of cyberinfrastructure–the hardware, software, organizations, people, and policy increasing undergirding scientific research–into functionally complete environments for scholarship and learning affect their faculty and students? What if their students utilized IT to take control of their learning environments? These rhetorical hand-grenades triggered a broader discussion of related concerns such as the technological generation gap among students and faculty, the disruptive force of the marketplace brought onto campus by IT, and the disaggregation and reaggregation of the traditional roles and functions of the university.

As the discussions moved on to consider increasingly unpredictable futures, there was a growing recognition of the challenge of providing leadership in the face of such uncertain futures. Finally one of the presidents suggested that he had no idea how presidents were to lead in such a chaotic environment, and that he and his colleagues needed help. Hence, the workshop had managed to bring the presidents through several critical stages: from denial to acceptance to bargaining to seeking help…

The IT Forum followed several months later with a very similar workshop for the provosts of AAU research universities. Again the session began by first asking a panel of provosts to lay out the issues as they saw them at the moment, then to move the discussion to a longer-term perspective, and finally to conclude with a discussions of next steps. The near-term concerns of the provosts were very similar to those of the presidents: network and bandwidth manage, the financing of technology, the protection of security and privacy, and data management and preservation.

Perhaps not surprising was a far greater degree of sophistication among the provosts in understanding and addressing these issues than shown by the presidents, perhaps since as chief academic officers, they were on the front line. But here there was an even more significant difference: unlike the presidents, the provosts recognized (or at least admitted) that these were very difficult issues and that they certainly did not have the answers. The provosts also were willing to discuss issues that would require major cultural changes in their institutions. For example, they expressed growing concern about the degree to which universities were being disadvantaged by the effective monopolies created by IT providers. As one provost put it, universities acted like deer paralyzed in the oncoming headlights, continuing to re-invent the wheel and getting devoured by the marketplace. The provosts were essentially unanimous in their belief that it was time for the universities to set aside their competitive instincts and to build consortia to develop together the technologies to support their instructional, research, and administrative needs through open-source paradigms that would break the stranglehold of the current IT marketplace.

Many provosts suspected that while the faculty believed they knew how their students learned, in reality they had not a clue, particularly in technology-rich environments. This was a theme we were to encounter again and again in our later workshops. The provosts believed that their universities needed far more sophisticated help to understand the learning and cognitive processes characterizing contemporary students, although they also recognized the disruptive nature of these studies which might eliminate over time the rationale for the lecture-classroom paradigm.

## In-Depth Meetings

To explore in depth several of the issues raised in the workshops with presidents and provosts, the IT Forum arranged several more focused site visits:

IT-Forum Meeting on "Cognition, Communication, and Communities"
Carnegie-Mellon University (September 5-6, 2003)

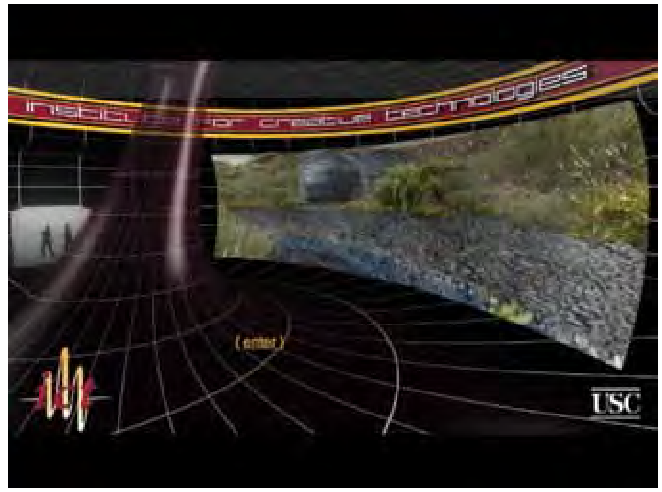
To learn more about how learning occurs in technology-intensive environments, the IT Forum held its fall 2003 meeting at Carnegie Mellon University, renown both as one of the nation's most wired—and now wireless—campuses and also for its strength in the cognitive sciences. As the CMU faculty put it, their students have embraced IT to become a transformative force, frequently forcing the faculty to react to their learning styles and activities. An example is the way students use this technology for communication. From instant messaging to e-mail to blogs, students are in continual communication with one another, forming learning communities that are always interacting, even in classes (as any faculty member who has been "Googled" can attest). A young professor of physics told us he had been forced to give up trying to teach difficult concepts in his classes. Instead he introduces a topic by pointing to several resources until a few students in the class figure out a way to teach themselves the concept. Then they teach their fellow students, and through peer-to-peer learning, the concepts propagate rapid through the class.

Today's students are active learners, building their own knowledge structures and learning environments through interaction and collaboration. Their approach to learning is highly nonlinear rather than following the sequential structure of the typical university curriculum. They are adept at multitasking and context switching. And they are challenging the faculty to shift their instructional efforts from the development and presentation of content, which is more readily accessible through the web and open-content efforts such as the Open CourseWare initiative of MIT, and instead become more of a mentor and consultant to student learning.

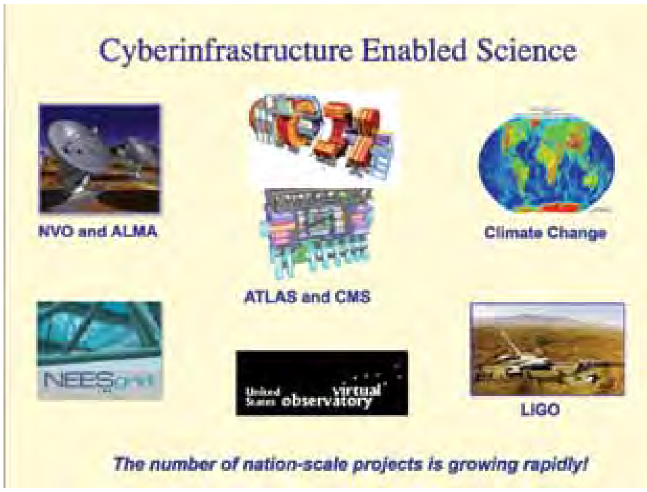
Some CMU faculty members have concluded that perhaps the best approach in these technology-rich environments is to turn the students loose, letting them define their own learning environments. Peer-to-peer learning is rapidly replacing faculty teaching as the dominant educational process on this technology-rich campus. There is not yet a consensus among the faculty as to where they are headed, but there is strong agreement that the net generation is both challenging and changing the learning process in very fundamental ways.

On a deeper level, information technology is forcing us to rethink the nature of literacy: From literacy in the oral tradition…to the written word…to the images of film and then television…to the computer and multimedia. Of course there are many other forms of literacy: art, poetry, mathematics, science itself, etc. But more significantly, the real transformation is from literacy as "read only, listening, and viewing" to composition in first rhetoric, then writing, and now in multimedia.

Increasingly, we realize that learning occurs not simply through study and contemplation but through the




Meetings of the IT Forum





active discovery and application of knowledge. From John Dewey to Jean Piaget to Seymour Papert, we have ample evidence that most students learn best through inquiry-based or "constructionist" learning. As the ancient Chinese proverb suggests "I hear and I forget; I see and I remember; I do and I understand." To which we might add, "I teach and I master!!!"

IT Forum Meeting on "Virtual Worlds" at
The Institute for Creative Technologies, Marina del Rey (March 11, 2004)

To understand new paradigms of technology-assisted learning, the spring 2004 meeting of the IT-Forum was held at the Institute for Creative Technologies in Marina del Rey. Here, the University of Southern California is applying the entertainment and gaming technologies developed by Hollywood and others to create a "holodeck" to train military officers in high level cognitive activities such decision making and leadership. They have learned something that universities have yet to grasp: how technology can be used to create an emotional connection between knowledge and learning.

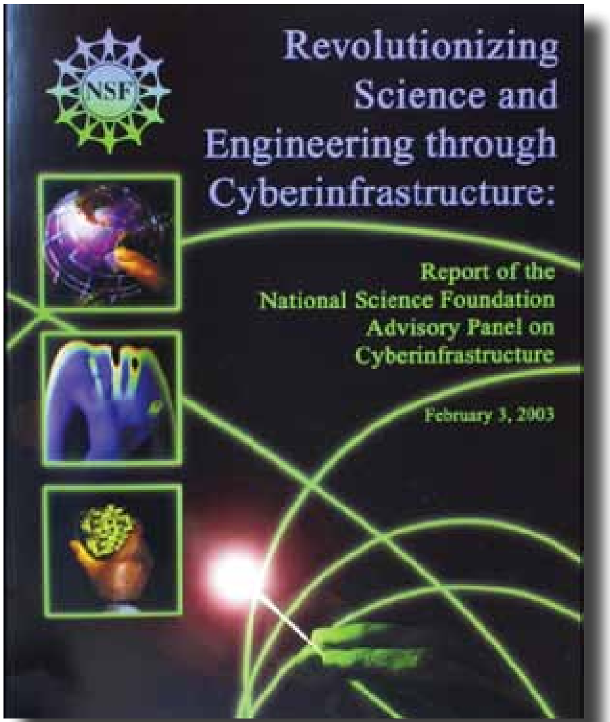
IT-Forum Meeting on "Cyberinfrastructure" at
University of Michigan, Ann Arbor (November 11-12, 2004)

In fall of 2004, the IT Forum met at the University of Michigan to consider the important study by the National Science Foundation Blue Ribbon Advisory Panel on Cyberinfrastructure.

Here "cyberinfrastructure" is the term used to describe hardware, software, ,people, organizations and policies related to information and communications technology. The panel concluded that we are approaching an inflection point in the potential of rapidly evolving information and communications technology to transform how the scientific and engineering enterprise does knowledge work, the nature of the problems it undertakes, and the broadening of those able to participate in research and the related educational activities. To quote the concluding paragraph of its report:

"A new age has dawned in scientific and engineering research, pushed by continuing progress in computing, information, and communication technology, and pulled by the expanding complexity, scope, and scale of today's challenges. The capacity of this technology has crossed thresholds that now make possible a comprehensive 'cyberinfrastructure' on which to build new types of scientific and engineering knowledge environments and organizations and to pursue research in new ways and with increased efficacy. Increasingly, new types of scientific organizations and support environments for science are essential, not optional, to the aspirations of research communities and to broadening participation in those communities. They can serve individuals, teams, and organizations in ways that revolutionize what they can do, how they do it, and who participates. This vision has profound broader implications for education, commerce, and social good."

Clearly, cyberinfrastructure is not only reshaping




Atkins Report on Cyberinfrastructure

but actually creating new paradigms for science and engineering research, training, and application. Once the microprocessor was imbedded in instrumentation, Moore's Law took over scientific investigation. The availability of powerful new tools such as computer simulation, massive data repositories, massively ubiquitous sensor arrays, and high-bandwidth communication are allowing scientists and engineers to shift their intellectual activities from the routine analysis of data to the creativity and imagination to ask entirely new questions. Today, information technology has created, in effect, a new modality of scientific investigation through simulation of natural phenomenon and serving as the bridge between experimental observation and theoretical interpretation. Globalization is a particularly important consequence of the new forms of scientific collaboration enabled by cyberinfrastructure, which is allowing scientific collaboration and investigation to become increasingly decoupled from traditional organizations (e.g., research universities and corporate R&D laboratories) as new communities for scholarly collaboration evolve.

While promising significant new opportunities for scientific and engineering research and education, the digital revolution will also pose considerable challenges and drive profound transformations in existing organizations such as universities, national and corporate research laboratories, and funding agencies. Here it is important to recognize that the implementation of such new technologies involve social and organizational issues as much as they do technology itself. Achieving the benefits of IT investments will require the co-evolution of technology, human behavior, and organizations.

Although the domain-specific scholarly communities, operating through the traditional bottom-up process of investigator-proposed projects, should play the lead role in responding to the opportunities and challenges of new IT-enabled research and education, there is a clear need to involve and stimulate as well those organizations that span disciplinary lines and integrate scholarship and learning. Perhaps the most important such organization is the research university, which despite the potential of new organizational structures, will continue to be the primary institution for educating, developing, and financing the American scientific and engineering enterprise. Furthermore, because the contemporary research university not only spans the full range of academic disciplines but as well as the multiple missions of education, scholarship, and service to society, it can–indeed, it must–serve as the primary source of the threads that stitch together the various domain-focused efforts.

There is a sense among many in the research university community that we will see a convergence and standardization of the cyberinfrastructure necessary for state-of-the-art research and learning over the next several years, built upon open source technologies, standards, and protocols, and that the research universities themselves will play a leadership role in creating these technologies, much as they have in the past. For the IT-driven transformation of U.S. science and engineering to be successful, it must extend beyond the support of investigators and projects in domain-specific science and engineering research to include parallel efforts in stimulating institutional capacity.

National Science Foundation Tutorial

In fall of 2004, members of the IT Forum were invited to conduct a day-long "tutorial" for the leadership of the National Science Foundation concerning the potential impact of information technology on learning, broadly defined. Forum members began by stating their concern that the changing learning needs of our society and the disruptive nature of digital technology may extend well beyond the capacity of our existing learning infrastructure of schools, universities, training programs, and cultural institutions. Approaching the challenge by reforming existing institutions may not be sufficient. After all, "a butterfly is not simply a better caterpillar!" Instead perhaps it was time to explore entirely different types of learning organizations and ecologies.

Today the human resource needs of the nation, an increasingly competitive global, knowledge-driven economy, and the challenge and promise presented by exponentially evolving digital technology presents a new and compelling challenge to NSF to provide leadership and stimulate change in our nation's learning enterprise.

## University Executive Leadership Core Workshops

One of the major concerns voiced in the workshops with the Association of American Universities presidents and provosts was the difficulty in getting universities to recognize the strategic implications of rapidly evolving digital technologies as they reshape the most fundamental aspects of learning and scholarship. Some participants portrayed the challenge to be getting the executive leadership core of the institution–the president, provost, CFO, CIO, director of libraries, key deans–on the same page, communicating with one another rather than simply dumping a diverse array of issues and demands on the CIO and saying, "Handle it!"

To this end they suggested that the IT Forum conduct a series of roundtable workshops around the country, bringing together the executive leadership of several institutions in a facilitated roundtable discussion to compare notes on what they saw as challenges and opportunities. The hope was that engaging in a candid and confidential discussion with peer institutions would force each of the participating teams to get their act together. They would learn from each other and perhaps develop the basis for further collaboration.

Over the course of the 2004-2005 academic year, the IT Forum organized four such workshops:

Cambridge (September 1-2, 2004): CEO-led teams from Carnegie-Mellon University, Cornell University, and Massachusetts Institute of Technology

Chapel Hill (January 24-25, 2005): CEO-led teams from North Carolina State University and the University of North Carolina at Chapel Hill, an Executive Vice Chancellor-led team from Duke University, and individual leaders from Georgia Institute of Technology and the University of Maryland

Austin (March 21-22, 2005): CEO-led teams from Texas A&M University, the University of Arizona, and the University of Texas at Austin, and individual leaders from Arizona State University and Rice University

Irvine (April 25-26, 2005): CEO-led teams from the University of California, San Diego, the University of California, Santa Barbara, and the University of Southern California, an Executive Vice Chancellor-led team from the University of California, Los Angeles, and an individual leader from the University of California, Irvine.

The purpose of these workshops were: i) to help university leadership identify the key challenges and opportunities presented by emerging information technology by comparing perspectives with several peer institutions; ii) to help the executive leadership of a university get on the same page in developing institutional strategies; and iii) to explore how to build stronger coalitions of universities working together to address these challenges.

The workshops were organized in a roundtable format developed by Robert Zemsky, former chair of the Pew Higher Education Roundtable and now director of the Learning Alliance at the University of Pennsylvania, who also served as the moderator for these sessions. Such a roundtable process is particularly effective in encouraging broad and candid engagement of all participants. Each workshop was launched with a working dinner the evening before a day-long workshop, asking each of the presidents to begin the conversation by describing what excited and what scared them about rapidly evolving digital technology. Needless to say, the fears tended to outnumber the hope.

Not surprisingly, several presidents immediately brought up the challenge of managing unbridled expectations for the IT environment. Their faculties believed that "bandwidth should flow like water from a faucet". These university leaders worried that they would be unable to afford the IT investments necessary to stay on the cutting edge of research while meeting ever-expanding student expectations and eventually fall behind, unable to compete for the best faculty and students. Several also expressed concern about the difficulty of making the right decisions on investments, e.g., knowing whether they were headed in the right direction or toward a wall (or a cliff). There was a sense of dread because of the uncertainty and the implications of a bad decision, in terms of cost, the quality of the environment or teaching and research, and even the ability of the institution to function. As one president put it, "I worry that one day I will come into work and find that absolutely nothing works."

Such concerns usually led rapidly to a discussion of the increasing challenge in maintaining the security of the IT infrastructure. Some participants even suggested that a failure in this area could lead to the entire enterprise grinding to a halt, or that a severe attack launched through a university and impacting broader society might result in civil or even criminal liability. Although several of the CIOs agreed that this problem was solvable with sufficient standards and controls, frequently these were incompatible with the diversity–indeed, anarchy–characterizing the many computing environments and student and faculty cultures in the university.

One of these evening dinner discussions was dominated by a conversation on the degree to which students were beginning to use technology both to seize control of their learning environments and to drive change within the institution, much as the IT Forum had found in the workshop at Carnegie-Mellon University. The student social life and learning activities were increasingly structured around always-on, always-in-contact communication (wireless, e-mail, instant messaging). In contrast to the student isolation that some predicted as a consequence of the propagation of technology into the university, there is a zeal for contact and community building among students, demanding not only an ever more sophisticated IT environment, but as well the convenience and responsiveness of university services and instructional activities that students were accustomed to in the commercial arena (Amazon, Google, e-Bay, Travelocity, etc.) Students were beginning to form communities capable of learning on their own and challenging the one faculty member-one course paradigm.

Yet at most institutions, these new IT-based social organizations were quite beyond the comprehension of the faculty, many of whom would just as soon ban wireless connectivity from the classroom and restrict students to using 110 bits-per-second modems to slow things down. While several participants questioned the effectiveness of this highly interactive, multi-tasking, and rapid context switching approach to learning, others suggested it might actually be the best preparation for leadership roles in the very complex, fast- moving social situations of 21st century society. Yet this not only raised the challenge of keeping up with the kids as they became less and less tolerant of traditional approaches to higher education, but it also raised the question of the role that the faculty would play, e.g., leading, lagging, or just staying out of the way.

Such discussions usually converged on recognition that the rapid evolution of digital technology was not only creating a very complex environment for leadership, but that it was characterized by chaos, in which the predictability of decisions and actions became very difficult if not impossible. Efforts to exert the top-down controls demanded by network security and integrity sometimes seemed like trying to close the barn door after the horse had not only already escaped, but the barn itself had fallen down. Several of these evening conversations even suggested that the traditional organization, structure, management, and leadership of the university might be inadequate to deal with such a rapidly evolving and changing technology. At this point, we usually called it an evening, and adjourned to the next day for more in-depth discussions of particular issues of interest to the participants.

## Managing Change

The primary issue arising in discussions of managing the IT environment involved the balance between the centralized control and standardization necessary to achieve adequate connectivity and security, and the inevitable chaos that characterizes the university IT environment because of highly diverse needs and funding sources–particularly in the research arena. There needs to be a balance between infinite customizability and institution-wide standards that protect the organization. There is a need to tolerate freedom–indeed, anarchy–in some domains such as research, while demanding tight control and accountability in others such as telecommunications and financial operations. Of course, this is similar to the struggle between the centralization (security, interoperability) and the decentralization (creativity, unique needs) in all organizations–universities, governments, and corporations.

There was also considerable discussion of just where universities should focus their resources and attention. Some universities felt that the best approach was to outsource the stable infrastructure, including mission-critical services such as finance and telecommunications, and focus attention instead on advanced development efforts, particularly those involving consortia such as Open Knowledge Initiative and Sakai . It is important to select what you can manage, and what you can let go, to pick those areas where you can see strategic opportunities for influence. Outsourcing commodity products and services can allow institutions to free up resources for investing in the future.

Although some institutions were still striving for centralized control, most had recognized that heterogeneity was a fact of life that needed to be both tolerated and supported. It was important to move beyond the contrasts between academic and administrative IT and instead recognize the great diversity of needs among different missions such as instruction, research, and administration as well as among early adopters, mainstream users, and have-nots. The faculty seeks both a reliable platform (a utility) as well as the capacity to support specific needs; researchers would frequently just as soon the administration kept hands off, since their grants are paying for their IT support. The students seek the same robust connectivity and service-orientation that they have experienced in the commodity world, and they will increasingly bring the marketplace onto the campus. In some ways, executive leadership is less a decision issue than a customer relationship management issue.

Several of the workshops featured discussions about the most important IT-related decisions made in the past few years, what issues were involved, who was involved in discussion and decision-making, and what the results were. To our ears, these decisions mainly fell into two categories. The first consisted of seeming "no-brainers," where it was necessary to get presidential approval and mobilize resources to join initiatives that were already moving forward, and where participation was clearly in the institution's long-term interest. The second category consisted of somewhat more difficult decisions where an entrenched interest within the institution had to be taken on in order to conserve resources or achieve other goals for the campus as a whole. There were initiatives that would qualify as visionary, but these were few and far between.

Several participating universities have undergone recent changes in organization or have launched standing councils or committees to address IT issues. Personnel changes have sparked some of these changes. Direct CEO-level involvement in these discussions is uncommon. One long-term trend is the increase in the number and proportion of CIOs who come from industry or other non-academic backgrounds, and the corresponding decrease in the number and proportion of CIOs who emerge from the faculty. Interestingly, participation in decision-making processes did not necessarily map on to the composition of the teams that attended the workshop. Several teams featured department heads and others from academic units, while others consisted entirely of central administrators. Overall, the message we got from all four workshops was that leading research universities believe they are doing a good job managing the IT "here and now"; that they are in control regarding the most important issues; and that a cataclysmic meltdown is not a real possibility.

## The Learning Environment

Although the influence of the net generation of students was raised in early discussions, there was surprisingly little discussion of the use of IT in the instructional environment. To be sure, most participants recognized the way that technologies such as instant messaging, wireless access, and search engines such as

Google were changing both the social interactions and intellectual development of students. Yet there was little discussion of how to harness these new capabilities in the learning environment.

The faculty, by and large, is not as tech savvy as students, and is not aware of the tech-infused culture in which students live and learn. In contrast to the research mission, where the faculty is pushing the boundaries and administrators are forced to respond, in these institutions at least, few faculty members seem involved in cutting-edge use of technology in the instructional domain.

However, this is an arena in which for-profit competition is appearing, where overseas competition might be expected to appear, and where U.S. universities may be in danger of being "Napsterized." The fact that students use one mode of interaction in dealing with faculty because they have to and use another mode when dealing with each other might partially reflect a longstanding intergenerational dynamic. It might also imply that traditional educational institutions are not reaching them, and they are "ripe for the picking" by some new educational institution or instructional mode.

Some participants were confident about the prospects for the optimal uses of technology emerging naturally, while others believed that institutional leaders need to be more proactive in guiding and facilitating. We are left with the questions of how leadership can recognize and leverage strategic opportunities, and how universities can collaborate and learn from one another.

### The Library as the Poster Child of the IT Revolution

To make these discussions less abstract, the impact of information technology on university planning for libraries was introduced in several workshops. In a sense the library has become the poster child for the impact of IT on higher education. Beyond the use of digital technology for organizing, cataloguing, and distributing library holdings, the increasing availability of digitally-created materials and the massive digitization of existing holdings (e.g, the Google project to digitize and put online in searchable format the entire holdings of major research libraries) is driving massive change in the library strategies of universities. While most of the universities in our workshops were continuing to build libraries, many were no longer planning them as repositories (since books were increasingly placed in off-campus retrievable high-density storage facilities) but rather as a knowledge commons where users accessed digital knowledge on remote servers. When pressed, it turned out that the most common characteristic of these new libraries was a coffee shop. They were being designed as a community center where students came to study and learn together, but where books were largely absent. The library was becoming a people place, providing the tools to support learning and scholarship and the environment for social interaction.

What is the university library in the digital age? Is it built around stacks or Starbucks? Is it a repository of knowledge or a "student union" for learning? In fact, perhaps this discussion was not really about libraries at all, but rather the types of physical spaces universities require for learning communities. Just as today every library has a Starbucks, perhaps with massive digitization and distribution of library holdings, soon every Starbucks will have a library–indeed, access to the holdings of the world's libraries through wireless connectivity.

In a sense, the library may be the most important observation post for studying how students really learn. If the core competency of the university is the capacity to build collaborative spaces, both real and intellectual, then the changing nature of the library may be a paradigm for the changing nature of the university itself.

Yet the participants in our workshops also raised the very serious issue concerning the preservation of digital knowledge, now increasing at a rate an order of magnitude larger than written materials. Without a more concerted effort for the standardization of curation, archiving, and preservation of digital materials, we may be creating a hole in our intellectual history. Traditionally this has been a major role of the research university through its libraries. There was a general agreement that research universities need to collaborate more on their responsibilities for the stewardship of knowledge in the digital age.

### Competition vs. Cooperation vs. Collaboration

Another workshop theme was the degree to which information technology was changing the balance between university competition and collaboration. To be sure, the competitive spirit was alive and well in those workshops involving IT leaders (e.g., MIT, Carnegie Mellon, and Cornell) as well as those with both public and private universities (e.g., the University of California and USC). Yet, just as in the earlier workshops held with presidents and provosts, there was recognition that few, if any, institutions had the capacity to go it alone in technology development and implementation, particularly in the face of monopoly pressures from the commercial section.

This growing need to build alliances was particularly apparent in the middleware and networking area. A new set of open educational resources (open- source tools, open content, and open standards) is being created by consortia such as Open Knowledge Initiative, Sakai, and the Open CourseWare project and being made available to educators everywhere. Networking initiatives led by higher education, grid computing, and other elements of cyberinfrastructure are gaining momentum through alliances such as Internet2 and the National Lamba Rail.

Just as in the IT industry itself, there are emerging trends where universities are cooperating in areas such as cyberinfrastructure and instructional computing that allow them to compete more effectively for faculty, students, and resources. The CIOs in our workshops suggested that the growing consensus on nature IT infrastructure of research universities over the next several years–based on open-source standards and outsourcing stable infrastructure–would demand such cooperative efforts.

### Leadership

How does one lead an institution through when key technologies are undergoing such order of magnitude changes? To some participants, the key was empowering the next generation of the faculty. “Our young faculty members generate the best ideas, but traditional academic structures may prevent those ideas from coming to the fore. Therefore, visionary university leadership requires the creation of ad hoc structures that empower young faculty to generate ideas, and focusing presidential attention and resources on the best ones. As long as we can attract the best young faculty, we will be able to stay on the leading edge and innovate.”

While this sounded like an appropriate strategy, and the participating schools could clearly point to a number of important initiatives that have emerged in this way, we were not so convinced. Is there really is such a strong flow of innovative ideas in the IT sphere, even from the top young faculty? And if there is such a strong flow, how do leaders then decide which “horses to back” from among the many worthy candidates?

Other participants conveyed a much more skeptical discussion of leadership and governance, at least as it relates to IT. The leadership ideal expressed by one participant was “make a transformative decision, execute, and repeat.” However, several participants expressed the view that the changing environment has made it difficult if not impossible for individual leaders to reach this ideal with any consistency. For example, it is more difficult than it used to be to generate a significant impact with a relatively small bet. With the current threshold at $10-$20 million, risk aversion may lead to technology investments being made in dysfunctional ways.

Also, in contrast with the faith that some participants expressed in the ideas of individual faculty as a transformative force, others were more inclined to see the faculty as a group or vested interest standing in the path of needed innovation. In this formulation, even new ad hoc structures could not overcome the dead weight of traditional structures that are not working.

Some even suggested that neither university leaders nor even individual institutions could lead through such an era of rapid and profound change. Rather alliances must be created to provide the leadership, or the monopoly-dominated marketplace itself will lead, perhaps in directions antithetical to the nature of the research university. It could well be that it is the leadership structure of the university itself that has become obsolete, and this is the area in most need of change. Here, one participant reminded us, a true revolution replaces all of the leadership of a society.

General Strategies

Here we found a very significant contrast between two approaches to IT management and development: the optimists, who viewed the chaos of the rapidly evolving IT environment as not only inevitable but tolerable–just let it happen, we can adapt, *hakuna matata* –and the pessimists, who believed that the university needed to control and guide the IT revolution. The former group usually consisted of those institutions that had been leaders in IT development and implementation. They were confident while the revolution would continue, their institutions would remain in a leadership role. (One colleague mentioned the old proverb that one needs not outrun a tiger, but only outrun your companion…)

There was, however, general agreement about the unpredictable and occasionally disruptive nature of this technology. Some felt that the biggest threat was the frustration over constant technological change. Others suggest that folks just "get over it", since continuous change is the key characteristic of a knowledge-driven society. The chaos of IT evolution could be an asset if it stimulated more experiment. Since the marketplace might be a more effective and efficient way to allocate resources and determine priorities, some suggested that universities should strive for an ecology of experimentation and alliances.

An Assessment of the Executive Leadership Core Workshops

In looking back over the year of workshops with the executive leadership cores of 18 leading research universities, the IT Forum has several interesting observations. First, it seems clear that while most university presidents are aware of the challenges posed by rapidly evolving digital technology (their world is indeed "flat"), they do not include it high on their lists of priorities for personal attention. Presidents are looking at IT only as a threat, not an opportunity, and they do not believe this is where the wheels are likely to come off the train, as they are in other more critical areas such as state support, private fund-raising, faculty recruiting, demographic changes in the student population, or federal higher education policy where they prefer to focus attention. Besides, if IT is really an area characterized by chaos, there is little that can be controlled anyway.

This *hakuna matata* attitude is the second issue. To be sure, most of the universities involved in our workshop had long histories of adapting readily to change and sustaining leadership in areas such as technology. The richest universities may well be able to ignore these technology trends, pull up the lifeboats, and feel secure with business as usual. Yet the complacency that accompanies past success can be dangerous, as Lou Gertsner pointed out to the AAU presidents from IBM's history.

The third observation is just how difficult it was to steer these discussions in a more strategic direction, attempting to look over the horizon at the challenges and opportunities that could arise as this technology continued its inevitable progression, a 100 or 1,000 fold over the next decade. While participants would nod their heads, they soon regressed into a "we're positioned well for whatever comes, so lets get back to taking about the details of today's issues". The discussions kept coming back to concern "this is what bothers us now" rather than "where be might be ten years from now".

There was remarkably little conversation about the major changes occurring in scholarship and learning, driven in part by technology. Although there was recognition about the new IT-based communities that were evolving for faculty (e.g., cyberinfrastructure-based, global research communities) and students (e.g., social learning communities based on instant messaging), there was little discussion about how the university could take advantage of this in their educational and research missions.

There was also little evidence that these leaders understood just how rapidly this technology is driving major structural changes in other sectors such as business and government. Today an industry's CIO's life is challenged to reduce IT costs for given productivity by factors of 10 every few years. While university leaders were aware of the productivity gains enabled by a strategic use of technology in industry, they found it difficult to imagine the structural changes in the university capable of delivering such improvement.

To some degree, this unwillingness to think more deeply about the strategic implications of a technology evolving at a Moore's Law pace is evidence again of the complacency characterizing leading research universities. Their perch atop the higher education food chain and their relative wealth leads them to continue doing things the same old way. The real challenge is to pry the leadership away from near-term decisions to focus instead on long-term strategies, on "what" you do rather than "how" you do it.

## The Future of Discovery, Learning, and Innovation

In October of 2012, the National Science Foundation sponsored a workshop at the University of Michigan to assess the impact of rapidly evolving information and communications technology (i.e., cyberinfrastructure) on the activities of discovery, learning, and innovation. This workshop convened an unusually diverse group of thought leaders from multiple disciplines and venues to consider the changing nature of learning and discovery in broad terms, spanning learning at all levels and discovery for all forms including research, development, innovation, invention, design, and creativity. The objectives of the workshop included: i) suggesting key research questions, likely game-changers, and possible paradigm shifts, ii) framing an interdisciplinary research agenda for the next decade, and iii) identifying possible research programs, experiments, and organizational structures that would best meet the needs of the nation in this rapidly changing environment. In simpler terms, the goals of the workshop were to set an agenda for the exploration how to transform the what, the how, and who participates in discovery and learning; to personalize and broaden participation in discovery and learning; and to accelerate discovery and the transfer from discovery to innovative use.

More specifically, the topics considered by the workshop considered the impact of powerful technologies such as always-on, ubiquitous connectivity (anywhere, anytime, everyone); social networking, crowd sourcing, collaborative learning and discovery, functionally complete cyberinfrastructures, emerging learning paradigms such as massively open online courses (MOOCs), cognitive tutors, gaming, immersive experiences; big data, data-intensive discovery, learning analytics, intelligent software agents: and possible surprises such as cognitive implants. Of particular concern were the impact of emerging technologies on both learning institutions and learning paradigms? Similarly consideration was given to the way in technology was transforming research paradigms (e.g., data centers (clouds), big data (analytics), crowd sourcing, and open knowledge resources) In particular, the roundtable of participants was challenged to suggest a framework for the conduct of research concerning the impact of possible emerging technologies on the conduct of scientific research, technological innovation, and STEM education. Of particular interest was the identification of possible advances in technology that could radically transform the existing paradigms for these activities.

### Organization of the Workshop

The workshop was organized as a series of moderated roundtable discussions captured by both experienced rapporteurs and video in a special studio that allowed multiple HD cameras and directional sound systems capable of recording the dialog among various participants for later distribution over the Internet. The workshop was organized into four specific sessions:

Changing Needs for Discovery and Learning: Here the focus was on the rapidly changing needs of society for workforce learning and skills, new knowledge, research, innovation, and creativity in a world increasingly integrated and transformed by digital technology. The differing priorities for learning and discovery were examined at the level of individuals, organizations, nations, and the world. The impact of demographic change (from baby boomers to Millennials to Gen Z), workplace needs (adaptive, ubiquitous, and lifelong learning opportunities), and learning structures (explicit, tacit, and intuitive knowledge) were considered. Different forms of discovery were also considered, e.g., transformational to translational to entrepreneurial R&D, as well as differing needs at the organization level (business, industry, government, OECD, emerging economics, and the developing world). The key question facing the group was: "Scientific and technology-enabled workspaces will soon be enormously different. How can we prepare our citizens–researchers, workers, and leaders–for this future?"

The Duderstadt Center at the University of Michigan

The Future Evolution of Digital Technology: Here the topics included the emergence of always-on, ubiquitous connectivity (anywhere, anytime, everyone); social networking, and collaborative learning and discovery, collaboratories; four-quadrant paradigms (i.e., same place/same time; same place/different times; different places as the same time; and different places at different times) and functionally complete cyberinfrastructures; emerging learning paradigms such as intelligent tutors, gaming, immersive experiences; big data, data-intensive discovery, visual analytics, intelligent software agents: and possible surprises such as cognitive implants. The key question: "We will have amazing tools. How can we use them in the service of learning and discovery?"

Possibilities, Game-Changers, and Paradigm Shifts: This session addressed questions such as: How might these emerging technologies transform learning institutions (schools, colleges, workplace training, lifelong learning, open learning) and paradigms (from learning to know, to learning to do, to learning to become)? How are research paradigms likely to change (Pasteur's Quadrant, citizen scientists, crowd sourcing, open knowledge)? Could these drive major social transformations such the Renaissance and Enlightenment that appeared during earlier eras of major changes in discovery and learning. The key question: "The environments for discovery and learning face transformative change. What must learning institutions do to enable this change?"

Paths to the Future of Discovery and Learning: The final session focused on specific findings and recommendations for consideration of federal agencies, educational institutions, industry, foundations, and other organizations and communities concerned with scientific discovery, innovation, and learning. In particular, the roundtable was be challenged to suggest a framework for the conduct of research concerning the impact of possible emerging technologies on the conduct of scientific research, technological innovation, and STEM education. Here the panel included expertise in learning sciences and cognitive science, selected in particular to help uncover how the new possibilities can build on the past half-century of research on how people learn. For example, how does our understanding of human memory and information processing inform the design of new interfaces to extend human capability? How do we design learning and discovery environments that emphasize "21st Century Skills" while ensuring that learners at all levels achieve necessary mastery of core topics? Of particular importance here was the identification of possible advances in technology that could radically transform the existing paradigms for discovery and learning activities (e.g., "Watson in your pocket"). Here the roundtable was asked to suggest new research programs, experiments, and organizational structures that could augment or replace existing discovery, innovation, and learning paradigms. In addition, consideration was given to the social and orga-

Participants

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nizational challenges in exploiting the power of these technologies.

## Session One: The Changing Need for Discovery and Learning

### Demographic Challenges

The first set of discussions concerned the radically different demographics charactering developed and developing economies. For example, the populations of most developed nations in North America, Europe, and Asia are aging rapidly where over the next decade the percentage of the population over 60 will grow to over 30% to 40%. Half of the world's population today lives in countries where fertility rates are no longer sufficient to replace their current populations. In sharp contrast, developing nations in Asia, Africa, and Latin America are characterized by young and growing populations in which the average age is less than 20. The number of students enrolled in higher education by 2030 is forecast to rise from 100 million in 2000 to 400 million in 2030 – an increase of 314%. Here the demand for education is staggering since in a knowledge economy, it is clear to all that this is the key to one's future security. Unless developed nations step forward and help address this crisis, billions of people in coming generations will be denied the education so necessary to compete in, and survive in, the knowledge economy.

Today we see a serious imbalance between educational need and educational capacity–in a sense, many of our universities are in the wrong place, where populations are aging and perhaps even declining rather than young and growing. This has already triggered some market response, with the entry of for-profit providers of higher education (e.g., Laureate, Apollo) into providing higher education services on a global basis through acquisitions of existing institutions or distance learning technologies. But more significantly, meeting this demand will require new forms of technology-enabled learning such as Massively Open Online Courses (MOOCs) and the Open Learning Initiative. Yet, even if market forces and technology-enabled learning paradigms are successful in addressing the urgent educational needs of the developing world, there are also concerns about whether there will be enough jobs to respond to a growing population of college graduates in many of these regions.

### The Educational Needs of 21st-Century Citizens

It is estimated over 80 percent of the new jobs created by our knowledge-driven economy require education at the college level, and for many careers, a baccalaureate degree will not be enough to enable graduates to keep pace with the knowledge and skill-level required for their careers. The knowledge base in many fields is growing exponentially. In some fields such as engineering and medicine the knowledge taught to students becomes obsolete even before they graduate! Hence a college education will serve only as a stepping-stone to a process of lifelong education. The ability to continue to learn and to adapt to—indeed, to manage—change and uncertainty are among the most valuable skills of all to be acquired in college.

Both young, digital-media savvy students and adult learners will likely demand a major shift in educational methods, away from passive classroom courses packaged into well-defined degree programs, and toward interactive, collaborative learning experiences, provided when and where the student needs the knowledge and skills. There will be a shift from "just in case" learning, in which formal education is provided through specific degree programs early in one's life in the hope that the skills learned will be useful later, to "just in time" lifelong learning, in which both informal and formal learning will be expected to occur throughout one's life, when it is relevant and needed to "just for you" learning, highly customized to the needs and styles of the learner. This suggests that most of one's learning will occur after the more formal K-16 experience, either in the workplace or other learning environments. The increased blurring of the various stages of learning throughout one's lifetime–K-12, undergraduate, graduate, professional, job training, career shifting, lifelong enrichment–will require a far greater coordination and perhaps even a merger of various elements of our knowledge infrastructure.

### The Changing Nature of Learning

Yet while learning and teaching in higher education is changing, both those driving change and those who




Discussions of the NSF Workshop on the Impact of IT on Discovery, Learning, and Innovation

need to change (professors/instructors) do not always know how. Learning is happening outside formal structures like the classroom, through hands-on engagement, internships and apprenticeships. It has become life-long and life-wide. The physical spaces where learning happens on campus can be more or less facilitative of learning, and universities have the power to create such spaces, if they recognize the need and value the craft aspects of learning. Part of the challenge here is to understand better how the learning experiments around the edges of learning institutions is challenging and changing traditional forms of pedagogy.

Should educational institutions challenge these characteristics of today's youth, such as multiprocessing homework, texting, gaming and music or capability for rapid context switching, increasingly both created by and necessary to master emerging technologies? Or should we allow our students to adapt naturally to the power of communication using mobile devices and social networks that enable learning through online interactions, particularly among peers, rather than the more structured classroom curriculum charactering today's institutions. Perhaps we have not thought sufficiently about connecting the dots of all the learning options that students have these days!

Lifelong Learning

In a global economy increasing driving by rapidly evolving knowledge and technology, a nation's workforce will require ever more sophisticated and sustained education and training to sustain its competitiveness.

Today's graduates will change careers many times during their lives, requiring additional education at each stage. Furthermore, with the ever-expanding knowledge base of many fields, along with the longer life span and working careers of our aging population, the need for intellectual retooling will become even more significant. Even those without college degrees will soon find that their continued employability requires advanced education. Hence opportunities for lifelong education will become a necessity for a knowledge-driven world.

Unfortunately, with the exception of a few of the professional schools such as medicine, business, and law, there is ample evidence that most faculty members have not been very interested in developing the paradigms necessary for adult education, e.g., the short courses and training programs that will help with new skills. Trying to find a way for the university to incorporate more of the educational apparatus to equip people for lifelong issue is a very big issue, and we have not dealt with it well. Fortunately recently emerging technology-based learning paradigms such as MOOCs and open learning seem particularly well suited to providing lifelong learning opportunities for adult students, since their strong emphasis on both synchronous and asynchronous online education and social networks to build huge learning communities address particularly well the constraints faced by working adults.

It was noted that the flipside of lifelong learning is that students do not have to wait until later in life to learn about the workplace. In fact, most want to get out of universities faster, since these are expensive, and there are plenty of other learning opportunities beyond the campus. Students are already well into their lives when they arrive on campus, and they are taking control of their educational experiences. They are using technology to access learning opportunities beyond the formal curriculum, using digital knowledge resources such as Google, Wikipedia, and digital libraries and building learning communities with other students. We have to understand that the university is no longer the warden for student learning, if it ever was. Instead we have to take advantage of the "life-wide" nature of student learning, just as we have to prepare them for livelong learning activities.

### The Changing Nature of Research and Scholarship

The evolution of powerful cyberinfrastructure is driving significant change in the paradigms for discovery and research. With the exploding capacity of sensor technology and data centers, data mining (analytics) as been added to the traditional scientific processes of observation, hypothesis, and experiment, becoming more data correlation driven than hypothesis driven. Both fundamental research and product development are increasingly dependent on simulation from first principles requiring massive supercomputers rather than experimental measurement and testing. If one subscribes to the view that there is a paradigm shift from hypothesis driven to data driven discovery and simulation, then it is clear that the entire conduct and culture of scientific and engineering discovery and innovation is changing as a result of access to data, technology and social networks. We are going to need new models for sharing data, software, and computational resources.

Yet another concern is the degree to which many companies are embracing philosophies of outsourcing the risks of research, encouraging scientists and engineers to leave the "mother ship" of the company to do a start up such as developing a cloud-based software platform, thereby assuming all the risk, but eventually hoping to be reacquired by the old company through de novo financing. Another pragmatic approach is to offshore corporate research to less expensive research centers in countries like India or China.

As a result, little of today's corporate R&D was basic in nature but rather consisted of extrapolation of existing knowledge through applied research and development. In fact it was suggest that much of the technology of American industry was largely based on scientific research conducted in the 1950s and 1960s in the Cold War era. There was significant concern expressed about the disappearance of major industrial research laboratories such as Bell Laboratories or the Ford Scientific Laboratory, capable of significant translational research connecting basic research with applied research and development to create new products and processes to be transferred into the marketplace to service society. This suggests that we need a new relationship among universities (where basic research and advanced education occurs), national laboratories (where very large-scale

R&D projects are launched, and industry (where both unique facilities and data sets exist).

### Access to the Tools and Data Necessary for Cutting-Edge Research

Today there are major questions with respect to who has access to and control of scientific data. Much data exists in the private sector and is unavailable to researchers in higher education–a break from the past, even in the Cold War years where there much research was constrained by security classification. We are beginning to see a phenomenon of research going where data is and hence migrating to corporate settings. This is creating a deluge of strange results. Experiments and findings are hard to reproduce because scientists cannot get at underlying data. Conclusions that become folklore rather than rigorously reproduced experiments spread quickly through networks.

There were also concerns expressed by representatives from industry that graduate students were not being adequately trained to meet their needs, in part because of the increasing sophistication of technology required for the analysis and development of industrial processes that was simply unavailable on the campuses. Conversely, students coming out of higher education have values that industry does not always share. The open and collaborative nature of recent graduates butts up against intellectual property and privacy rules as well as existing corporate culture.

It was acknowledged that the responsibility for adequate training in such areas required more intimate partnerships between universities and industry. Yet industry participants also acknowledged their practice of luring talented undergraduates in the areas of software development to leave their studies prior to their degrees. Several industry participants admitted they were eating their own seed corn in pursuit of near term profits.

### Craftsmanship

Several participants noted a structural hole that had appeared in today's learning institutions that could impact innovation. In earlier times, when universities were brilliant at doing ideation, and industry was brilliant at de-risking everything and grinding away, there were places like Bell Labs, Xerox PARC, SRI, etc. that had as many craftspeople as scientists. They could build anything, and they built it well. Those people never got recognition. But in labs themselves, shoulder to shoulder, they had as much reputation as any of the PhD's within the organization. This group built the stuff that enabled a serious conversation with engineering and manufacturing companies about product development.

Yet today we have a situation where there are few institutional mechanisms to do the applied research to take ideas into prototypes because of the rapid payback required by venture capital. Furthermore applied research activities based on craft as much as science, and universities are not that good at keeping people good at craft around for time required for these developments. Other players such as the national laboratories still emphasis craft in their major activities, but their cultures and infrastructure are directed at major project work rather than product-oriented R&D needed by industry.

Several European nations such as Germany and Switzerland are much better at creating and valuing craftsmanship. They understand the importance of craft and have developed both the educational structures (e.g., Fachhohenschulen for learning in the applied sciences and the Fraunhofer Institutes for applied technology research) and the reward system to encourage and sustain it. Fortunately today in the United States there are early signs such as the "maker" movement that suggest that young people are becoming very interested once again in making things. A culture of wanting to build stuff is beginning to appear again, but higher education is not geared up for this yet.

### Industry Views of the University

One of the great challenges facing the American research university is the lack of understanding of their broad mission as the nation's key asset for the conduct of basic research (providing over 50% of the national effort), producing the next generation of scientists and scholars, and knowledge professionals (engineering, medicine, law, etc.), providing state-of-the-art health (university medical centers), and attracting global talent (both students and faculty). Hence it was surprising–indeed, alarming– that several of the participants from high-tech industry stressed that the primary purpose of these institutions should be to provide the low-cost mass education and training specific to meeting the immediate needs of industry. In fact, some participants even discounted the value of campus-based research, arguing that in today's economy, it is more efficient to outsource R&D to small spinoff companies or cheaper offshore providers. Another surprise from the discussions was the belief that university research and education were becoming less and less relevant to the information technology industry. There seemed to be a confidence that IT companies, particularly those in software development, could get all the R&D help they need by either outsourcing it to small spinoff companies, offshore it to low cost economies), or simply pluck an outstanding student or faculty member out of a university.

This view seems to have colored the current relationship between universities and the computer industry, which today lags many other industries such as pharmaceuticals in the support of campus-based research. This is ironic, since the basic research conducted on the campuses laid the fundamental foundation for computing, e.g., mathematical logic, solid state physics, systems analysis, while the technology needs of faculty members and the innovation from students drove much of the innovation in the industry (e.g., Univac, CDC, DEC, Microsoft, Apple, Google, Facebook, etc.). Furthermore, many of the paradigms characterizing today's technology actually began on the campuses (e.g., digital computing, time sharing, the Internet, search algorithms, data mining, cognitive tutors). Hence the absence of more robust relationships between today's industry and higher education could well become its Achilles heel because of the growing need for basic research in areas such as artificial intelligence, DNA storage, and quantum computing necessary to advance the technology.

## Session Two: The Future Evolution of Digital Technology

### The End of Moore's Law?

Although most characteristics of cyberinfrastructure, e.g., processing power, data storage, network bandwidth continue to increasing at an exponential pace described by Moore's law, various components of the technology do eventually encounter limits and saturation that require major technology shifts. For example, VLSI processors and memories are approaching the limits of miniaturization and hence processing speed. In the near term devices are exploiting multiprocessor architectures, with dozens of processors on a single chip (and millions of processors in supercomputers). But other constraints such as power requirements will soon require new technologies such as DNA storage and quantum computing.

Similar evolution continues to occur in how information is processed. For example, companies such as Google are built around data centers, analyzing and extracting information and knowledge from large data centers (or clouds). Here scale truly matters, with increases of factors of ten in storage and processing speed regularly required and achieved to meet market requirements. Similarly, data concepts have shifted to larger, more abstract structures such as entitles, concepts, and knowledge, that require enormous increases in data storage and processing speed. They also require more sophisticated software for data processing to enable rapid searches for abstract concepts through petabytes of data.

### The Human Interface

One of the most rapidly changing characteristics of this technology involves the human interface. Although we look back at the transition from text to image to video to 3D immersive displays, there are other characteristics such as mobility, size, and context that also change rapidly. For example, the development of software agents that rely on natural interactions such as speech and context awareness are already transforming both mobile phones (e.g., Apple's Siri) and interfaces with the physical world (e.g., imbedding computing into eyeglasses to assist in context analysis).

Similarly, there is great interest in the evolution of the Internet into a network of objects such as ubiquitous sensors, the rise of contextual data, and the ability to do predictive models of individual behavior. The need for accessibility raises the issue of digital inclusion in the broadest sense. How does one design technology to assist physically challenged individuals, aging populations, those with limited literacy skills, indeed, providing a global population of 10 billion with robust digital access.

## The Evolution of the IT Industry

The history of the computing and communications industry has followed Schumpeter's process of creative destruction. Each major technology turn has been accompanied by the emergence of new companies that frequently destroy the old. While new companies such as Facebook, Google, and Amazon have exploited new paradigms such as social network, big data, clouds, and data mining to rapidly rise to global prominence, they may also be following the evolutionary pattern of earlier market leaders such as Control Data Corporation, Digital Equipment Corporation, and the Bell System.

One interesting scenario is long-term status of the United States IT ecosystem. As an example of how this is evolving consider mobile devices. Remember here that most of mobile phone users on the planet are not from Europe and not from North America but rather from Asia and increasingly Latin America. That will forever more be true. That ratio only continues to expand. For most of these people the mobile phone is their definition of computing. It is not just their primary computer device but usually their only technology. Yet a second example is the continuing outsourcing of the U.S. silicon ecosystem, the whole mix of captive silicon foundries versus open foundries and open intellectual property. This has major implication for not only national competitiveness but also national security. Currently this migration of hardware development is counter balanced by innovation in the software space. But even here we have already begun to lose our status as a major player.

## The Next Big Paradigm Shift

So, what are the early warning systems for major paradigm shifts? What does one look for? Do you look at the research labs on college campuses? Or do you look at Harvard dormitories for what students are doing before they drop out? Do you try to spot the next Bill Gates, Mark Zuckerberg, or Larry Page? Do you have any tracking systems?

Industry participants responded with "No, we don't look at the campuses until things break out of them. We try to spot activities characterized by hyper exponential growth, things that are growing every year by a factor of two or more. If we spot interesting students or faculty in universities, we try to extricate them as soon as possible. The success model is what escapes not what stays inside."

Again from industry's viewpoint, the elephant in the in room is knowledge creation, not knowledge dissemination. Of course, this is the unique role of the research university, albeit in addition to its other missions of knowledge dissemination (e.g., teaching, service). The stovepipe structure in academia (and NSF itself) is stifling. We have commoditized knowledge generation. We need to be more focused on knowledge creation, integration, synthesis, and dissemination. This involves working to broaden access through libraries, search tools, and push models in education. This is the big opportunity that research universities have to embrace. It is about DIKW: data, information, knowledge, and wisdom. One needs to use cyberinfrastructure together with creation tools, and universities are not stepping up to that.

## Resilience

We need to think more about robustness and resilience of cyberinstructure and our knowledge systems. In rapidly changing environment, the capability of responding and being flexible and making smart choices without planning and thinking in advance become extremely important. The academy does not seem to be preparing students for understanding what "big data" really means. What happens when you start changing orders of magnitude, or when noise becomes signal as you amplify it? In the next few years we will be experiencing exa-data. Yet we have very few data scientists. The universities are not churning them out the people who actually know how to do the analysis. There is a sense that we now have fundamentally new tools that will give payoff, if you really do understand data analytics, the mathematical models, but more so if we also understand math, physics, chemistry, and other sciences and know how to bring them together? After all, the correlations identified through data mining to not necessarily lead to causal explanations.

The mental model of cloud-based knowledge and learning is intrinsically difficult. The fundamental challenge is that industry is actively building new stuff all the time. While this is a benefit for doing something innovative, it is not necessarily a good thing if you have a thousand companies innovating in an incompatible manner. Deleting in this case is non-deleting in that case. It is an ecology problem. We live not in the single system we are building but rather in an ecosystem with multiple providers of multiple things. As participant asked: "Do digital natives have any better mental models of new knowledge paradigms such as clouds? I don't think they have deep computational models or insights. I don't know. I really don't."

## Session Three: Possibilities, Game-Changers, and Paradigm Shifts

The workshop participants were encouraged that in their discussion of possibilities, game-changers, and paradigm shifts in discovery, learning, and innovation, they try to strike a balance between identifying possibilities vs. arguing whether they will occur or not. They were invited to suggest important missing topics that need to get on table. Techies tend to talk about change-change-change. But there is also a need to talk about things that will not change. If there are things that are invariant, protected, and nurtured, we should identify them.

Cyberinfrastructure now allows tools, data, experiments, and other assets to support online knowledge communities, making these functionally complete in any of the four quadrants, that is, with all the resources necessary to handle knowledge flow. Using the scaffolding of cyberinfrastructure, one can dramatically reduce constraints of distance and time. This creates a major disruption in how knowledge work is done, expanding significantly the degrees of freedom.

### New Paradigms for Learning and Teaching

So what are the opportunities presented by cyberinfrastructure for learning and teaching, for example Massively Open Online Courses (MOOCs) or cognitive tutor systems or Carnegie Mellon's Open Learning Initiative. Are these something new? Or is this really just old wine in new bottles? After all, millions of students have been using online learning for decades (estimated today to involve over one-third of current students). There are lots of highly developed models, including the UK Open University and the Mellon Foundation's asynchronous learning paradigms.

Of course today's MOOCs do have some new wrinkles, aside from the massive markets they are able to build through the Internet and their current practice of free access. Their semi-synchronous structure, in which courses and exams are given at a specific time while progress is kept on track, allows them to leverage both grading and advising from more advanced students through social networks. (Here one might think of MOOCs as a clever combination of UK's Open University and Wikipedia!) Furthermore MOOCs, like the far-more sophisticate Open learning Initiative, are able to use data mining (analytics) to gather a large amount of information about student learning experiences. When combined with cognitive science, this provides a strong source of feedback for course improvement.

More broadly, there are many other emerging and rapidly evolving learning technologies:

- E-books, digital libraries, and intelligence clouds of data
- Online synchronous and asynchronous lectures (over all four quadrants)
- Analytics on student performance and new approaches to learning research
- Use of artificial intelligence to create cognitive tutor systems (sans faculty)
- Massively multiplayer gaming (e.g., World of Warcraft or MineCraft)
- Immersive technologies (e.g., Second Life, Enders Game)

So what do we know about these new paradigms? Certainly there is a great deal of hype (e.g. that they will unleash a tsunami upon higher education). But where is the beef? Where are the careful measurements of learning that rigorously compare new paradigms such as MOOCs with classroom, studio, or tutorial-based learning? What are the advantages of technology-based learning? Cost and efficiency? Access to gigantic markets (with significant revenue potential)? Standardization…or customization? Capacity to gather data on learning and improve pedagogy? Quality of the learning experience?

Of course, it eventually leads back to a consideration of the most valuable form of learning and how it occurs? Through formal curricula? Through engaging teachers? Through learning communities? Particularly at the graduate level, centuries of experience suggest that the medieval concept of a Universitas Magistrorum et Scholarium, a gathering of scholars and masters, may not only be the most valuable form of learning, but also the most difficult to automate in a technology-intensive environment.

Knowledge communities fracture in strange and interesting ways. MOOCs are just one example of many new kinds learning technologies appearing that represent efforts to try to take over part of what the university nominally does but doing it better. These are not just flipping the classroom but flipping the entire model of the university. Of course, many of these efforts are driven by the exploding global needs for higher education mentioned earlier. For example, to meet the needs of its population, India would have to build 1.500 new universities just to handle its current number of secondary school graduates. There is no way that is going to happen. Hence there are gigantic markets that raise issues of scale.

Worries were expressed about the hype given MOOCs by the media. Certainly this paradigm is characterized by a powerful delivery mechanism. But it is just one model. It is much more important to focus on improving learning by integrating emerging technology with research about how people learn. We need to keep an open mind. Exploring these opportunities will be good for the learning business. There is no question that there will be transformative aspects of this. But there are also other models to explore and much richer collaboration opportunities to share. Through knowledge creation, we need to embrace new paradigms as a community.

The arc of conversation about technology-enabled learning was interesting. It started with MOOCs and how that paradigm could deliver education more cheaply to gigantic markets of users. Then it moved to speculation about whether these could not only lower the cost of education but perhaps shift learning to a new learning paradigm that would create a tsunami sweeping over universities. Yet it was also observed that 500 years it was thought that the printing press would destroy the medieval university. We would no longer need teachers since students could just read the books. As Clark Kerr's famous quote suggests, the university today remains one of the most enduring social institutions.

We must remember that there are actually students living on a university campus, completely immersed in an exciting intellectual and social physical environment and sophisticated communities where most of the learning occurs far from the classrooms and instead through groups of students and teachers, interacting in diverse environments including laboratories, studios, and clinical settings. On a university campus we hope to have people–not just students but faculty and staff–engaged in learning activities all of their waking hours, and in the case of faculty at least, throughout their lives. MOOCs are interesting, but they are far from the vibrant, immersive environment of a college education, at least as we understand it today. And, as yet, there is little rigorous evidence of their learning effectiveness. Most of the efforts in learning science have not looked small experiments in traditional institutions. Learning science as a field is not ready yet for looking more broadly at more flexible learning communities.

A great thing about universities is that there are so many interesting things going on. Companies such as Google and Microsoft are always so focused. Universities have a breadth of opportunities because by design, they are optimal at driving curiosity and creating serendipity. This is a very important theme to think about. Where is the real value added for university environment.

### The Challenge of Inequity in Learning Opportunities

Here one must keep in mind the following fact characterizing American higher education today: If you are smart and poor (bottom quartile), you have only a 10% chance of earning a college degree. If you are dumb and rich (top quartile), you have a 90% chance. The rapidly changing nature of our world challenges our adherence to the traditional disciplines. This is part of what happens and affects low-income kids. We are teaching kids curriculum in K-12 schools that do not prepare them for the world they are coming from and going to. They are double burdened: both how they have been prepared and where they are going.

One of the findings from large ethnographic studies of the way kids are learning on line speaks to social nature of learning through peer-to-peer interaction. This is incredibly important. In a social world, peer to peer learning, apprenticeship can look a lot of different ways. The way kids find their interest starts off with kids hanging out with each other. What are you doing? What does that look like? That looks interesting. I want to tinker with that. Play with that. I want to mess around with that. I want to go deeper – asking each other how to do it. This is an incredibly efficient form of learning. People finding out how to do things and learning that from each other is efficient as long as we scaffold and construct those spaces. Yet have also learned that in the fear-driven communities, sometimes we do not allow kids to hang out together. We only provide geeking out, collaborative space around STEM education for people to go into specific programs. And universities cannot leverage this. For our youth, we do that in kindergarten, but we lose it for middle school and high school kids. We lose the opportunity to play and innovate. If you separate content from context and you get these didactic approaches that leave out particularly low-income kids. When we start talking about "we need fundamentals, we need core." That's what has been happening to our education system for last decades. We have not been addressing the broader set of learning issues related to how kids behave. Perhaps we need math and physics moms like soccer moms, parents showing kids that it is important? The social incentive to be a geek is not high.

## Is the Paradigm for Basic Research Really Changing?

Are research and scholarship paradigms shifting? How? We all hear the buzzwords: clouds, analytics, convergence, etc. Is the way in which research is changing? What about global competition? Is the world of high-energy physics sustainable where you send people off to only one place CERN to do the work, resulting in a list of authors longer than substance of the papers? Are we moving to a wiki world where crowd sourcing of amateurs becomes important? How important is the role of research and scholarship within universities? Do we need tweaking of tax laws so the translational research of Bell Labs begins to reappear as part of the knowledge ecosystem?

Crowd-sourcing, open software, Wikipedia, and social networking enable certain forms of research to fractionalize. But there are deeper fiscal properties. What about the instrumentation (including distributed sensor technology) necessary to generate data? Have we done all the physical things we need so we need not invest in massive experimental facilities like the Large Hadron Collider or missions to the outer planets? Of course, most scientists would contend that industry is really not talking about basic research anymore. Rather they are basing their activities primarily on the applications of things known. Yet if you ask more broadly what society needs from universities, it clearly needs basic research. No one else is doing generating the new knowledge that applied research flows from. Without that you don't get building blocks for innovative applications.

## A Caution about Change in Universities

We should remember that while many think of the university in medieval terms, that universities change only one grave at a time, in reality universities change very quickly and in profound ways. It is true that the university today looks very much like it has for decades–indeed, centuries in the case of many ancient European universities. They are still organized into academic and professional disciplines; they still base their educational programs on the traditional undergraduate, graduate, and professional discipline curricula; our universities are still governed, managed, and led as they have been for ages.

But if one looks more closely at the core activities of students and faculty, the changes over the past decade have been profound indeed. The scholarly activities of the faculty have become heavily dependent upon digital technology–rather cyberinfrastructure–whether in the sciences, humanities, arts, or professions. Although faculties still seek face-to-face discussions with colleagues, these have become the booster shot for far more frequent interactions over the Internet. Most faculty members rarely visit the library anymore, preferring to access digital resources through powerful and efficient search engines. Some have even ceased publishing in favor of the increasingly ubiquitous digital preprint or blog route. Student life and learning are also changing rapidly, as students bring onto campus with them the skills of the net generation for applying this rapidly evolving technology to their own interests, forming social groups through social networking technology (Facebook, Twitter), role playing (gaming), accessing web-based services, and inquiry-based learning, despite the insistence of their professors that they jump through the hoops of the traditional classroom paradigm.

In one sense it is amazing that the university has been able to adapt to these extraordinary transformations of its most fundamental activities, learning and scholarship, with its organization and structure largely intact. Here one might be inclined to observe that technological change tends to evolve much more rapidly than social change, suggesting that a social institution such as the university that has lasted a millennium is unlikely to change on the timescales of tech turns, although social institutions such as corporations have learned the hard way that failure to keep pace can lead to extinction. Yet, while social institutions may respond more slowly to technological change, when they do so, it is frequently with quite abrupt and unpredictable consequences, e.g., “punctuated evolution”.

It could also be that the revolution in higher education is well underway, at least with the early adopters, and simply not sensed or recognized yet by the body of the institutions within which the changes are occurring. Universities are extraordinarily adaptable organizations, tolerating enormous redundancy and diversity. It could be that the information technology revolution is more of a tsunami that universities can float through rather than a rogue wave that will swamp them.

Admittedly it is also the case that futurists have a habit of overestimating the impact of new technologies in the near term and underestimating them over the longer term. There is a natural tendency to implicitly assume that the present will continue, just at an accelerated pace, and fail to anticipate the disruptive technologies and killer apps that turn predictions topsy-turvy. Yet we also know that far enough into the future, the exponential character of the evolution of Moore’s Law technologies such as info-, bio-, and nano- technology makes almost any scenario possible.

Clearly we have entered a period of significant change in higher education as our universities attempt to respond to the challenges, opportunities, and responsibilities before them. This time of great change, of shifting paradigms, provides the context in which we must consider the changing nature of the university.

## Impact: Whence and Whither the Revolution

The report characterizing the first phase of this study of the impact of information technology on the university was entitled *Preparing for the Revolution*. But what revolution? The university today looks very much like it has for decades, still organized into academic and professional disciplines; still basing its educational programs on the traditional undergraduate, graduate, and professional discipline curricula; still financed, managed, and led as it has been for many years.

Yet if one looks more closely at the core activities of students and faculty, the changes over the past decade have been profound indeed. The scholarly activities of the faculty have become heavily dependent upon digital technology–rather cyberinfrastructure–whether in the sciences, humanities, arts, or professions. Although faculties still seek face-to-face discussions with colleagues, these have become the booster shot for far more frequent interactions over Internet. Most faculty members rarely visit the library anymore, preferring to access far more powerful, accessible, and efficient digital resources. Many have ceased publishing in favor of the increasingly ubiquitous preprint route. Even grantsmanship has been digitized with the automation of proposal submission and review and grant management and reporting by funding agencies. And, as we have noted earlier, both student life and learning is also changing rapidly, as students bring onto campus with them the skills of the net generation for applying this rapidly evolving technology to their own interests, forming social groups, role playing (gaming), accessing services, and learning–despite the insistence of their professors that they jump through the hoops of the traditional classroom paradigm.

In one sense it is amazing that the university has been able to adapt to these extraordinary transformations of its most fundamental activities, learning and scholarship, with its organization and structure largely intact. Here one might be inclined to observe that technological change tends to evolve much more rapidly than social change, suggesting that a social institution such as the university that has lasted a millennium is unlikely to change on the timescales of tech turns–although social institutions such as corporations have learned the hard way that failure to keep pace can lead to extinction. Yet, while social institutions may respond more slowly to technological change, when they do so, it is frequently with quite abrupt and unpredictable consequences, e.g., "punctuated equilibrium". It could also be that the revolution in higher education is well underway, at least with the early adopters, and simply not sensed or recognized yet by the body of the institutions within which the changes are occurring.

Universities are extraordinarily adaptable organizations, tolerating enormous redundancy and diversity. It could be that information technology revolution is more a tsunami that universities can float through rather a tidal wave that will swamp them. One of our participants suggested that perhaps what we should view the transformation of the university as an evolutionary rather than a revolutionary process. Evolutionary change usually occurs first at the edge of an organization (an ecology) rather than in the center where it is likely to be extinguished. In this sense the cyberinfrastructure now transforming scholarship or the communications technology enabling new forms of student learning have not yet propagated into the core of the university. Of course, from this perspective, recent efforts such as the Google project take on far more significance, since the morphing of the university library from stacks to Starbucks strikes at the intellectual soul of the university.

It is certainly the case that futurists have a habit of overestimating the impact of new technologies in the near term and underestimating them over the longer term. There is a natural tendency to implicitly assume that the present will continue, just at an accelerated pace, and fail to anticipate the disruptive technologies and kill apps that turn predictions topsy-turvy. Yet we also know that far enough into the future, the exponential character of the evolution of Moore's Law technologies such as info-, bio-, and nano- technology makes almost any scenario possible.

While perhaps not enabling the level of strategic discussions that we had hoped, the IT Forum certainly reinforced the good-news, bad-news character of digital technology. The good news is that it works, and eventually it is just as disruptive as predicted. The bad news is the same: this stuff works, and it is just as disruptive as predicted.

In this spirit, then, perhaps we should end with a discussion that occurred with the AAU provost's workshop in 2004. While university presidents are reluctant to let speculation about the survival of the university on the table, not so with provosts, who were quite comfortable talking about very fundamental issues such as the values, roles, mission, and even the survival of the university, at least as we know it today. During this discussion it was pointed out during the 19th century, in a single generation following the Civil War, essentially everything that could change about higher education in America did in fact change: small colleges, based on the English boarding school model of educating only the elite, were joined by the public universities, with the mission of educating the working class. Federal initiatives such as the Land Grant Acts added research and service to the mission of the universities. The academy became empowered with new perquisites such as academic freedom, tenure, and faculty governance. Universities increased 10-fold and then 100-fold in enrollments. The university at the turn of century bore little resemblance to the colonial colleges of a generation earlier.

The consensus of our discussions with the provost suggested that we are well along in a similar period of dramatic change in higher education. In fact, some of our colleagues were even willing to put on the table the most disturbing question of all: Will the university, at least as we know it today, even exist a generation from now? Disturbing, perhaps. But certainly a question deserving of very careful consideration, at least by those responsible for leading and governing our institutions, suggesting that perhaps such studies should shift from "the impact of technology on the future of the research university" to "the impact of technology on scholarship and learning, wherever they may be conducted"!

Certainly the monastic character of the ivory tower is certainly lost forever. Although there are many important features of the campus environment that suggest that most universities will continue to exist as a place, at least for the near term, as digital technology makes it increasingly possible to emulate human interaction in all the sense with arbitrarily high fidelity, perhaps we should not bind teaching and scholarship too tightly to buildings and grounds. Certainly, both learning and scholarship will continue to depend heavily upon the existence of communities, since they are, after all, high social enterprises. Yet as these communities are increasingly global in extent, detached from the constraints of space and time, we should not assume that the scholarly communities of our times would necessarily dictate the future of our universities. Even in the near term, we should again recall Christensen's innovators's dilemma , as these disruptive technologies, which initially appear rather primitive, are stimulating the appearance of entirely new paradigms for learning and research that could not only sweep aside the traditional campus-based, classroom-focused approaches to higher education but seriously challenge the conventional academic disciplines and curricula. For the longer term who can predict the impact of exponentiating technologies on social institutions such as universities, corporations, or governments, as they continue to multiply in power a thousand-, a million-, and a billion-fold?

To be sure, there will be continuing need and value for the broader social purpose of the university as a place where both the young and the experienced can acquire not only knowledge and skills, but the values and discipline of an educated mind, so essential to a democracy; an institution that defends and propagates our cultural and intellectual heritage, even while challenging our norms and beliefs; the source of the leaders of our governments, commerce, and professions; and where new knowledge is created through research and scholarship and applied through social engagement to serve society. But, just as it has in earlier times, the university will have to transform itself once again to serve a radically changing world if it is to sustain these important values and roles.

## References

James J. Duderstadt, "Prepare for the Revolution: The Impact of Information Technology on the Future of the Research University", Research Universities, and the Challenges of Globalization, An International Convocation, (Association of American Universities, Washington, 2001) pp. 97-108, 118-126.

James J. Duderstadt (chair), Researchers in the Digital Age (Washington, D.C.: National Academy Press, 2001).

James J. Duderstadt (chair), Preparing for the Revolution (National Academies Press, Washington, D.C., 2005)

James J. Duderstadt, Panel Chair, Issues for Science and Engineering: Researchers in the Digital Age, National Research Council (National Academy Press, Washington, 2001) 57 pp James J. Duderstadt, Daniel E. Atkins, and Douglas Van Houweling, Higher Education Faces the Digital Age: Technology Issues and Strategies for American Colleges and Universities (Praeger Publishers, Westport, CT; American Council on Education, Washington, 2002) 289 pp.

James J. Duderstadt, Wm. A. Wulf, and Robert Zemsky, "Envisioning a Transformed University", Issues in Science and Technology Vol. 22, No. 1, Fall 2005 (National Academy Press, Washington, D.C., 2005) pp. 35-41.

James J. Duderstadt, "NSF Workshop on the Future of Discovery, Learning, and Innovation", NSF Report (National Science Foundation, Washington, D.C., 2014)

# Chapter 9

# Energy Research

There are few contemporary challenges facing our nation–indeed, the world–more threatening than the unsustainable nature of our current energy infrastructure. Every aspect of contemporary society is dependent upon the availability of clean, affordable, flexible, and sustainable energy resources. Yet our current energy infrastructure, heavily dependent upon fossil fuels, is unsustainable. Global oil and natural gas production are expected to peak within the next several decades. While there are substantial reserves of coal and tar sands, the mining, processing, and burning of these fossil fuels poses increasingly unacceptable risk to both humankind and the environment, particularly within the context of global climate change. Furthermore, the security of our nation is threatened by oil addiction and the consequent reliance on foreign energy imports from unstable regions of the world. Clearly if the federal government is to meet its responsibilities for national security, economic prosperity, and social well being, it must move rapidly and aggressively to address the need for a sustainable energy future for the United States.

## Secretary of Energy Advisory Board Study

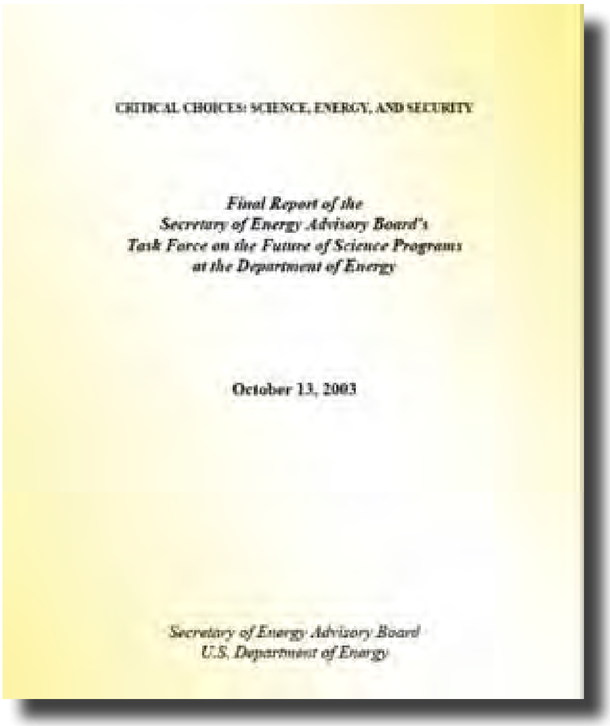
The Department of Energy has a paramount responsibility for keeping American science preeminent in the 21st century. It administers 40of the federal investment in physical science and engineering research. It maintains large, complex, unique and essential scientific and computational infrastructure for the nation through its 17 laboratories and other facilities. Our future economy, security, health and quality of life fundamentally depend on continuing advances in science and technology. Frontier research will determine whether we can produce, store and distribute secure, sustainable, clean and affordable energy, and whether we can develop and produce the new materials, devices, systems and processes that will enable our industries to win in the competitive, knowledge-based, global economy.

Because of the growing importance of this federal agency, in 2002 the Secretary of Energy appointed a blue-ribbon task force of leading scientists and engineers, chaired by Charles Vest, President of MIT, to assess the capacity of the Department of Energy in carrying out its fundamental mission of scientific research. In the preface to its final report, the SEAB Task Force conveyed the following warning:

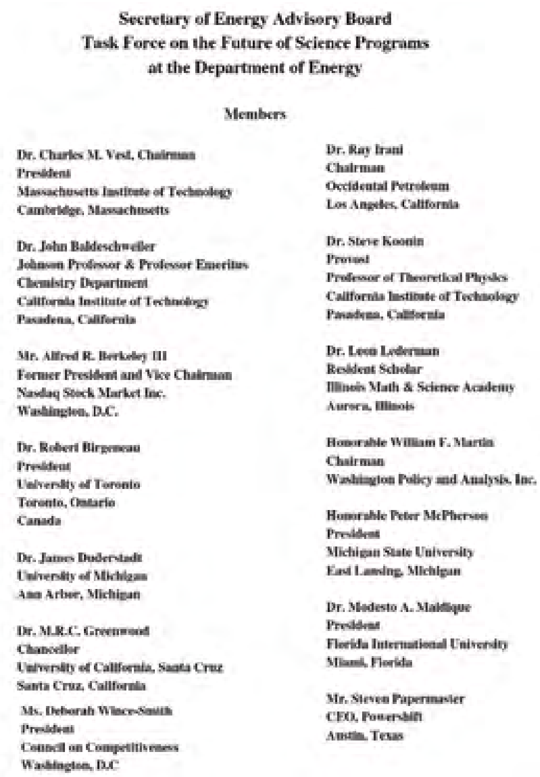
A Warning

In assessing the Department of Energy's science programs the Task Force acknowledged many strengths within the Department of Energy's science programs. In addition, the Task Force reaffirmed the critical role that the Department of Energy and its science programs play in advancing and indeed underpinning the national security, economic security, and energy security of the United States. The Task Force has chosen to focus on those areas where specific recommendations can have the greatest impact on the Department of Energy's achievement of its missions and strategic goals.

Clearly, America cannot retain its freedom, way of life, or standard of living in the 21st century without secure, sustainable, clean, and affordable sources of energy. America is facing its most serious energy shortage since the oil embargoes of the 1970s. As demonstrated clearly and unequivocally in President Bush's National Energy Policy, our projected energy consumption will rapidly outpace our projected energy production as projected at 1999-2000 growth rates. This policy statement challenges the nation to promote energy conservation, modernize our energy infrastructure, and in-




DOE Task Force Report



**Secretary of Energy Advisory Board**
**Task Force on the Future of Science Programs**
**at the Department of Energy**

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crease our supplies in ways that protect and improve the environment.

The Task Force concurs with this challenge, but feared that our nation as a whole has not grasped the seriousness and systemic nature of the problem we face. Energy is fundamental to virtually every human activity in an advanced society – heat, light, climate control, transportation, communication, education, manufacturing, health care, and security. If demand for energy continues to outpace its production, our economy will suffer, the geopolitical situation will become even less stable, our national and economic security will be threatened and our quality of life will degenerate. Furthermore, there will be growing temptations to increase energy production in ways that do not protect the quality of our environment, that increase the gap between the affluent and the poor, or that diminish the hard-earned safety of our energy systems.

The Department of Energy has the primary federal role in providing policy, scientific and technological leadership, vision, and accomplishment to meet this challenge head on. The Task Force believes that there is no other federal agency that has a mission of more fundamental importance to the future of our nation and planet. It is imperative that the DOE's priorities and budgets reflect a sense of urgency commensurate with the seriousness of the increased threat. America can be free, secure and economically strong in the 21st century only if we continue to excel in science and advanced technology.

A vibrant society in the 21st century must be based on the broad development and wise use of scientific and technological knowledge. The economies of the future will literally be knowledge-based. Those nations that excel in discovering, synthesizing, and applying scientific and technical knowledge can prosper and provide security, opportunity, and health for their peoples. Many nations around the globe realize this and are investing and building their scientific and educational infrastructures with a great sense of urgency.

America can meet its energy needs if and only if we make a strong and sustained investment in research in physical science, engineering, and applicable areas of life science, and if we translate advancing scientific knowledge into practice. Today the nation is underinvesting in research in the physical sciences and engineering. This neglect is especially detrimental to our energy future. Our energy future and environmental stewardship cannot be assured by tinkering around the edges of the existing situation. The current mix of energy sources is not sustainable in the long run. Energy conservation and the efficiency and reliability of distribution must be improved. We need to move aggressively now to reevaluate the role of nuclear energy, to understand the complete systems that could comprise a hydrogen economy, and to explore the possibilities of nanotechnology and biological engineering for energy production and storage. All of this requires the generation and careful application of new scientific and technological knowledge.

In other words, research and development, especially aimed at radically improving our ability to efficiently produce, store, and deliver energy, are central and indeed indispensable to the Department of Energy's ability to carry out its mission. The Task Force believes that organizational and budgetary changes must be made to maintain and strengthen the Department's research programs and to ensure that the DOE applications branches access and use the best available scientific knowledge and expertise.

Findings of the SEAB Task Force

The importance of DOE science and facilities to our national, economic and energy security are not well understood by the American public, Congress, or the Executive Branch. Science and technology planners, authorizers, appropriators, and agencies within the government all need to work closely together to ensure that the Nation's research investment encompasses all the fields of research and facilities needed to deliver the 12 technologies upon which the freedom and standard of living of our children and grandchildren will depend. Yet there has been a lack of the close integration and clear communications needed to build understanding and support for Department of Energy and its research and development programs.

The mission of the Department of Energy is widely misunderstood and considered to be unclear and unstable. Outside the research community itself, science is rarely recognized as an essential component of the DOE mission. Like each of the proverbial blind beggars feeling an individual part of an elephant, the public and many federal officials hear about nuclear security, energy security, alternative energy sources, the human genome, environmental cleanup, national laboratories,

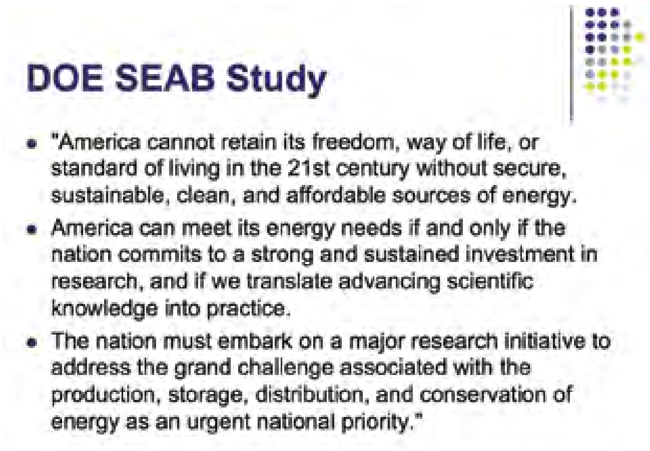
DOE Headquarters (Forrestal Building)

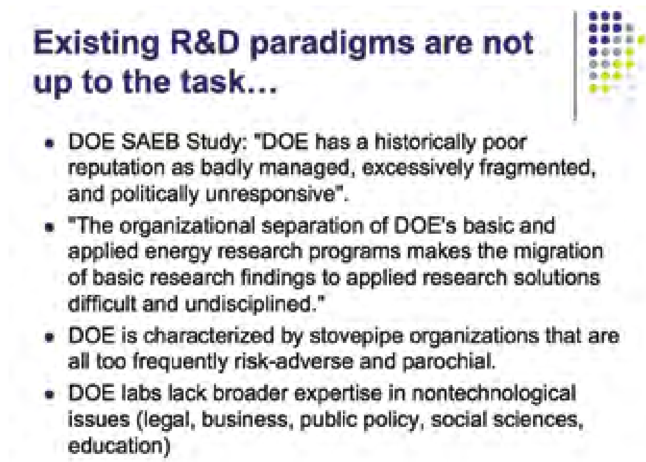
big computers, and nuclear waste disposal. They are left with no sense of an urgent, much less coherent mission, or a sense of integration or synergy. When DOE science is recognized, it is often viewed as strong, but it is nonetheless viewed as somehow separate from any basic Departmental mission.

In order to assess the effectiveness of the Department of Energy's science program, and to identify issues impacting its future, the task force commissioned a large number of confidential interviews with senior staff members across the Administration, Federal agencies, Congress, and the scientific user community. The Task Force found the depth of criticism and concern shocking, consistent, and extremely important to address.

Most problems identified have to do with process, communication, and interaction. They can and must be corrected. The conduct of DOE's public relations and congressional and intergovernmental affairs was widely considered to be lacking. Unfavorable comparisons with the public relations and congressional affairs activities of other agencies were frequently made. Among those interviewed, there is a desire to be supportive of the basic DOE mission and of DOE science, but, as one observer said, this support "must be earned." The Department needs to redouble its efforts to improve the clarity, quality and responsiveness of its communications.

The DOE national laboratories, both multi-user facilities and nuclear weapons facilities, are frequently viewed as powerful independent actors whose associa-




tion with the DOE is sometimes not recognized. Unfortunately, there is no strong perception that these DOE facilities collectively comprise a remarkable national infrastructure for science.

The federal investment in physical science and engineering has been stagnant for over thirty years. During this same period, the Department's national laboratories have suffered from decay and deferred maintenance, and U.S. industry has largely phased out its basic research programs and organizations. As a result, the U.S. is no longer the clear leader in some important areas of science. During the last 30 years, the federal investment in research in the physical sciences and engineering has been nearly stagnant, having grown less than 25 percent in constant dollars. The corresponding investment in life science research has grown over 300 percent. Specifically, in 1970 physical science, engineering, and life science each were funded at an annual level of approximately $5 billion in 2002 dollars. In 2002, physical science and engineering research are funded at approximately $5 billion and $7.5 billion, respectively. The funding for life science is about $22 billion.

Stagnant federal funding of physical science and engineering research is far more damaging than it might appear because of the following externalities:

• These are the fields needed to power the search for both near-term and long-term sources of secure, sustainable, clean, and affordable energy as well as means for their storage and distribution

• American industry has pulled back almost entirely from research with moderate to long time horizons, leaving the federal government as essentially the sole source of support, and universities as nearly the sole performer of such research

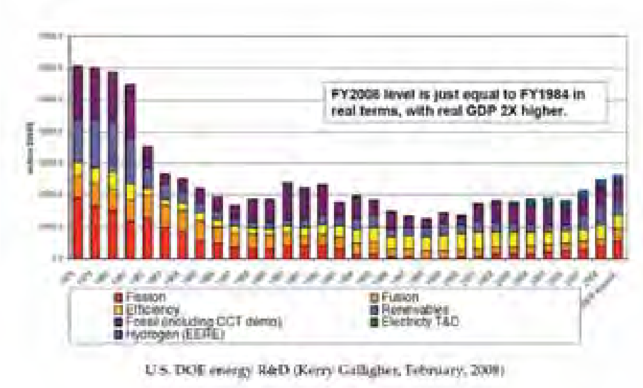
• The number of public and private universities capable of doing excellent research and advanced education in science and engineering has grown substantially

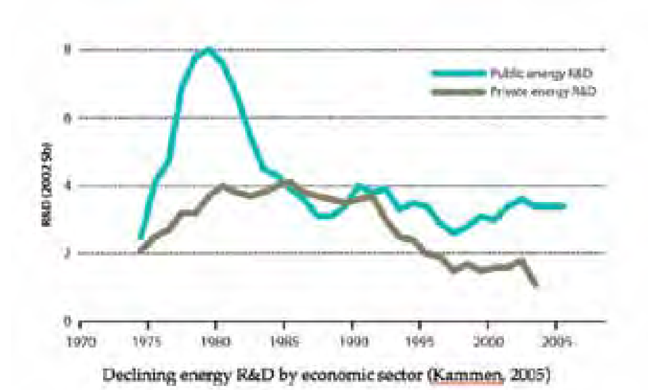
• The complexity and sophistication of most research endeavors have caused their real cost to grow more rapidly than traditional measures of inflation

• Finally, the development and application of physically based technologies and methods is needed to advance the life sciences and medicine.

The underfunding of physical science and engineering research has put U.S. leadership at risk in certain important areas. Examples of critically important fields of science in which we are no longer clearly preeminent are high-energy physics and neutron sources for materials science and biology. When the United States decided to stop construction of the Superconducting Supercollider (SSC) and the European Union moved ahead with construction of the Large Hadron Collider (LHC), U.S. preeminence was diminished in the international effort to explore the boundaries of high-energy physics. If our young scientists want to work at the leading edge of this field, many must now do so in Europe. Many of our universities have, in fact, lost outstanding young faculty members who have emigrated to where the action is. If not addressed through actions like establishing the Next Linear Collider in the United States, our capability to design and develop the most advanced tools in this field will also diminish over time.

For many years, reaching back to the 1950s, U.S. leadership in neutron diagnostics not only advanced our fundamental science but also gave us a great advantage in developing new industries and products de-




By any measure, federal and private funding of energy research is woefully inadequate.

pendent upon a deep understanding of materials. The most obvious example is today's semiconductor industry. Today the most advanced tools are in Europe. This will be corrected to some extent when the Spallation Neutron Source successfully comes on line. But this loss of leadership remains a deep concern because it is important to cutting edge biology and biochemistry, and to the next frontiers of condensed matter physics and materials science and engineering. These are areas of great importance to both industrial and academic user communities.

The budgets of DOE science suffer from the Department's historically poor reputation as badly managed, excessively fragmented, and politically unresponsive. DOE science budgets have not received the priority merited by their importance to our Nation's future energy, security, and economy. Whether or not this reputation is deserved, this perception exists and needs to be addressed.

The Department of Energy is a very large and complex organization, but we believe that the coherence of its programs and communications can and must be improved. Furthermore, we believe that science should be an important integrator of the Department around its central mission. Knowledgeable observers understand that throughout its existence the Department of Energy has hosted and conducted extraordinarily good science and technological research. Nobel Prizes have been won, and generations of outstanding scientists have completed graduate degrees and developed their careers with the support of DOE funding and facilities. Entire fields of science, especially those based on nuclear physics and on the use of radiation sources or accelerators, have been established and driven by the Department.

Personnel of the Office of Science generally get good marks from the scientific community. The DOE has served the nation's defense through the design, production, and stewardship of our nuclear weapons. Nonetheless, there is extensive fragmentation of effort and lack of integration and communication across elements of the Department that are unacceptable as we enter the 21st century facing a historically unparalleled need to develop new means for the production, storage, and distribution of clean energy, to enable better energy conservation, and to deal with many important aspects of both homeland security and international security. These are problems whose solutions require the ability to work across disciplinary boundaries, especially given the promise of emerging applications of life science to engineering and the advent of radical new tools of nanoscale science and technology.

A forward-looking DOE science program must be better integrated across fields, facilities and organizations. In general, the best available science and advanced technologies are not readily making their way into the DOE's application areas. To the extent that such perceptions are justified, weak linkages and interactions with other federal agencies such as the Department of Defense should be recognized and addressed. It is widely perceived that this insularity stems from neglect of explicit interagency bridge building. Cross-agency scientific cooperation by and with DOE, while generally effective, is widely viewed as crisis-driven rather than proactive.

The current organization of the Department is not appropriate to the magnitude and centrality of scientific and advanced technological research in the DOE. It does not ensure that the Department's mission offices responsible for energy, environmental and national security programs benefit from the best available scientific and advanced technological knowledge.

It is also instructive to note that while environmental quality, i.e. programs dealing with nuclear waste and cleanup matters, account for 36 percent of the Department's budget only 4 percent of DOE's R&D portfolio is assigned to that critically important matter. This despite the fact that it is imperative that these operations be well informed by the most up-to-date science available. We also note that advanced computing and computational infrastructure are essential to DOE's mission. The National Laboratories contain the nation's most advanced large scale computers and a wealth of computational expertise. But in part due to their primary use for national security applications, many of these machines are not widely accessible to the user community (whether inside or beyond the Department). The time has come for DOE to be organized and funded to provide major elements of the Nation's cyberinfrastructure for science.

The Department's national laboratories increasingly suffer from decay and deferred maintenance, unpredictable program funding, poorly understood missions, perception of them as independent actors, and the burden of some highly publicized security lapses. The strong political independence of some of the laboratories, coupled with multiple directives from DOE and Congress, is a mixed blessing.

The DOE laboratories, both those directed at national nuclear security and the multi-user scientific facilities, are proud and essential elements of our nation's and world's scientific infrastructure. But they have operated for many years on essentially flat budgets, even as new scientific and technological opportunities and responsibilities have soared. An inevitable consequence of this situation is an unacceptable level of deferred maintenance and decay that is reaching the crisis stage. The situation is more daunting still when the cleanup of former nuclear facilities at some of the labs is considered. The deferred maintenance and attendant issues of safety and laboratory working environment have reached the stage where laboratory directors are cutting already inadequate operating budgets to solve the worst of the problems. The Task Force reviewed various schemes for attracting third party financing of maintenance and construction that, while valiant, strike us as unreasonably complex and inefficient in the long run. It would be better to meet the Department's responsibilities head on.

The lines of accountability for many of the Laboratories are unclear due to the organizational structure of DOE, especially the position of the Office of Science, and oversight by multiple Congressional committees. These factors lead to creep, ambiguity, and fluctuation of mission and leave the Laboratory directors sensing that they have "many masters with conflicting views."

Currently about 15 percent of DOE research is performed by universities (exclusive of support at user facilities), while the rest is done at the DOE laboratories. Expanding the use of objective merit review across the DOE, including in the NNSA national security laboratories, should be considered to ensure that the proportion of research performed by university researchers is appropriate and justified. This is particularly true for a number of emerging, frontier areas, like nanoscale science and technology and life science, where university researchers are not only at the forefront of discovery, but where the economies of scale achieved at national laboratories are not necessary for research performance and success.

The Task Force believes that rigorous merit review of proposed programs and performers, coupled with legitimate institutional concerns, is an important element for generating great science. Many programs in the DOE weapons laboratories are not subjected to such review - either internally or in competition with other potential performers. The merit review processes in the Office of Science are generally viewed as strong. Systematic use of objective merit review should be adopted for the research investments made by other mission programs across the DOE. This would strengthen the quality of the research portfolios and better ensure strong outcomes for the mission needs.

From political and public perspectives, the larger DOE laboratories are viewed as having considerable independence. Frequently, the image and voice of the individual laboratories far outweighs that of the Department of Energy. Although this has some positive aspects, over the years it has led to various Congressional mandates and has not enhanced the sense of the Department's integration and clarity of mission. Finally, we note that the politically explosive issues of real and perceived security lapses is being addressed by the Department of Energy through other avenues but nonetheless has had a real and tangible adverse impact on the Department's reputation which must be rectified.

Recommendations

To recognize the centrality of science to its mission, the Department of Energy should have an Under Secretary for Science. Attendant organizational changes should be made to better accomplish that scientific mission. The organizing and organizational role of science in the DOE should be elevated and expanded in order to clarify that DOE is science agency, better conduct cutting edge research, better conform to the Department's mission, improve DOE application areas' access to and use of the best available scientific knowledge, and better integrate scientific work and knowledge across the Department and across federal agencies. A major step in accomplishing this goal is to establish the position of Under Secretary for Science. The Under Secretary for Science would have both Department-wide and line responsibilities. He or she should serve as the chief science officer for the Department as a whole, overseeing the science officers within Department's missions.

A particularly important responsibility would be to improve the flow of the best available scientific knowledge into those parts of the DOE responsible for applications and policy and to facilitate its effective use. The Under Secretary for Science should have a high-level Science Advisory Board, drawn from academia and industry, to help ensure that the Under Secretary's mission is accomplished. Appointing a high-level Science Advisory Board would enhance the effectiveness and provide the proposed Under Secretary for Science with an independent advisory body to provide advice in response to taskings by the Under Secretary on cross-cutting science issues.

There should be no ambiguity about the threat to our economy, security, health, and way of life associated with the growing imbalance between energy demand and production. The DOE must promulgate a vision and a sustainable path to reliable, efficient, clean, and affordable sources and distribution of energy for the nation. It must also be made clear that without sufficient federal investment in science and advanced technological research, we will not achieve this goal.

It should also be clear that the DOE has a strong and important mission to sustain U.S. leadership in areas of science for which it has stewardship independent of direct application to energy and security. Each Department of Energy research and development initiative should have a regular review to assess whether it is consistent with the Department's 20-year strategy to produce secure, sustainable, clean, and affordable sources of energy, to enhance our national security, and/or to maintain U.S. scientific leadership in areas stewarded by the DOE.

The Secretary of Energy should direct the Under Secretary for Science and the other Under Secretaries to develop a 20-year strategy for their respective mission/strategic goal areas, including scientific leadership. Each Under Secretary should be directed to conduct a regular R&D Portfolio Analysis review of R&D projects and underlying basic science initiatives to assure their continued relevance and contributions to the larger 20-year strategies.

The Department should enhance the quality of research through greater use of merit-based competition, seek the best balance of national laboratory, university, and industrial research, and form partnerships with industry and academia to drive innovation in its mission areas. This Task Force believes that competition and merit review are indispensable if we are to produce the highest quality science to further our national energy needs and scientific leadership. We believe that a critical assessment of the balance between Laboratory and university research must be a key component of strategic planning for DOE and its national laboratories. Indeed, we believe that the Department and its Laboratories must be challenged to increase the use of competitive, peer-reviewed programs in order to enhance creative research and innovation.

The Task Force notes that a strong base of university research is essential to our future. This is our nation's primary mechanism for conducting fundamental scientific and advanced engineering research. It inspires, enables, and financially supports the next generation of scientists, engineers, and leaders of related business and industry. This is of critical importance as the intellectual underpinnings of technology are changing rapidly, especially if the government intends to strengthen the federal investment in physical science and engineering. Despite the differences in basic roles and responsibilities of the three sectors – industry, government, and academia – we will improve our ability to meet our long-term energy goals by forming effective partnerships across these sectors.

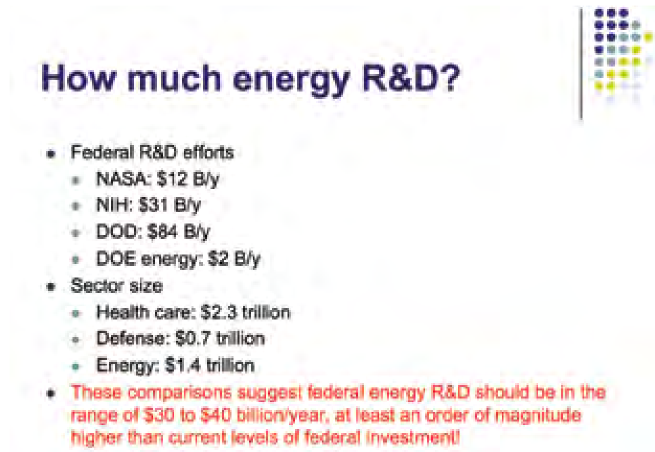
The Department should establish and sustain a program for renewing its laboratories, facilities and infrastructure. It should transfer the funds necessary to achieve this objective from other, non-science accounts. The amount expended annually on maintenance and renewal of DOE laboratory facilities is approximately 0.7 percent of replacement value. By industry standards, this should be on the order of 2-4 percent. The deferred maintenance and the "ticking time bomb" of cleanup of former nuclear facilities at some of the laboratories must be addressed. The Task Force believes that the cost of doing so should not come from the existing operating budgets that have been essentially flat for some years. Either it should be transferred from other DOE accounts or an increment to funding should be requested from Congress.

The Department should embark on three major, highly visible research initiatives in order to promote and meet its mission of leadership in energy, security, and science. One should directly address a basic issue in energy production, storage, distribution, or conservation; one should establish world leadership in the application of advanced computation and simulation to basic scientific problems; and one should provide a frontier research facility for the pursuit of basic science. U.S. leadership in the world community in areas of science that are relevant to the mission of the Department of Energy is important to our future and important to attracting the best and brightest into their pursuit.

We recommend that DOE undertake three highly visible, critically important and inspirational new scientific programs. The first should directly address a grand challenge associated with the production, storage, distribution, or conservation of energy. This will functionally and visibly tie cutting edge science to the crisis facing the nation because of the growing gap between the demand for and production of energy. It should address aspects of this issue in a way that provides for explicit good stewardship of our environment. The second should clearly sustain and leverage U.S. leadership in advanced scientific computation and simulation. Computational modeling and simulation are rapidly becoming indispensable to basic scientific research and advanced technological development. The application of extremely large-scale computation to problems like the climate, the dynamics of biological molecules, combustion processes, and the behavior of complex systems and materials is essential for technological progress. The DOE has much of the nation's expertise and machinery in this area, but it has mostly been developed for the nuclear weapons program and is segregated from use by much of the scientific community. DOE should lead in this area with wide-spread collaboration and access to the scientific and advanced engineering communities in academia and industrial R&D. The third should put America in the lead of a next-generation international program in basic physical science that is relevant to the Department's mission. Scientific, technological, and industrial opportunities arise from the international community that conducts frontier basic science, but there is a clear advantage to the country that hosts the core facilities.

These important initiatives should be a highest priority for the Secretary of Energy and the proposed Under Secretary for Science. They should be shaped with the advice and approval of the proposed Science Advisory Board. Analysis and planning should begin immediately, but to the extent possible, their establishment should be informed by the strategic plans and portfolio analysis recommended in this report.

The Department should strengthen the federal investment in the physical sciences and advanced engineering research. The federal investment across all major agencies that invest in physical science and engineering research in support of their missions – DOE, DOD, NASA, and NSF – has been stagnant for over thirty years. During this same period, the federal investment in life science research, especially through the National Institutes of Health (NIH), has strengthened considerably. Just as NIH is the lead agency for most ar-


eas of biomedical research, and NASA is the lead agency for most space science, the Department of Energy is the lead agency for many areas of physical science and engineering. It therefore should assume a leadership role in elevating understanding of their importance and in establishing stronger federal investment in research and research infrastructure in these fields. The growing crises in energy and environmental quality, and the need to proactively advance U.S. leadership in basic science, must be clearly and effectively addressed by the Department of Energy. The Department of Energy should actively and effectively build support within the Administration and Congress for higher priorities for science and increased budget authorization and appropriations for physical science and advanced engineering research.

The Department should dramatically enhance its role in educating and training future scientists and engineers, drawn from America's diverse population, for careers in DOE-related fields. The Department should establish strong programs of undergraduate, graduate, and postdoctoral fellowships or traineeships in the physical sciences and engineering and should strengthen its outreach at the K-12 level. To provide the science needed to support the basic missions of DOE in areas such as energy, national security, and the environment. Congress has assigned to the DOE Office of Science (DOE-SC) a special responsibility, such as high energy and nuclear physics. DOE-SC is a large science agency, with an excellent record of scientific accomplishment and sole responsibility for important scientific fields such as nuclear physics and high energy physics. It supports and oversees a number of national laboratories that represent an extraordinary national resource and provide unique research facilities to scientists from around the world. It has the capacity to launch and manage scientific research projects on a very large scale (beyond that of other basic research agencies such as NSF and NIH) and to develop and support unique research infrastructure to the scientific community. DOE-SC has strong relationships with research universities, both through the involvement of academic scientists at national laboratories and facilities and through its support of scientific research on the campuses. Its activities have an unusually broad geographical distribution and political footprint.

The continued erosion of funding for DOE-SC threatens not only the national leadership and capacity in key areas of science such as nuclear physics, materials science, and high energy physics, but as well technologies such as particle accelerators that are critical to many fields such as medicine, materials, and biotechnology. Without adequate fundamental research in DOE-SC linked to their activities, many of the more applied R&D programs relevant to DOE missions could find themselves not only without an adequate scientific foundation but as well an inadequate supply of trained scientists and engineers (e.g., nuclear fission technology, which is already hindered by an inadequate research base and the erosion of academic programs and reactor facilities). The dysfunctional organizational structure of DOE will continue to handicap SC and undermine its fundamental scientific missions.

## A National Energy Research Network (A Brookings Institution Study)

Numerous studies from groups such as the National Academies, the President's Council of Advisors on Science and Technology, and the American Association for the Advancement of Science have given the very highest priority to launching a massive federal R&D effort to develop sustainable energy technologies. (National Academies, 2005). In fact, a high level task force created by the Secretary of Energy's Advisory Board (SEAB) stated in the strongest possible terms:

"America cannot retain its freedom, way of life, or standard of living in the 21st century without secure, sustainable, clean, and affordable sources of energy. America can meet its energy needs if and only if the nation commits to a strong and sustained investment in research in physical science, engineering, and applicable areas of life science, and if we translate advancing scientific knowledge into practice. The nation must embark on a major research initiative to address the grand challenge association with the production, storage, distribution, and conservation of energy as both an element of its primary mission and an urgent priority of the United States." (Vest, 2005)

Yet today there is ample evidence that both the magnitude and character of federal energy R&D programs are woefully inadequate to address the urgency of the current energy challenges faced by this nation. The scale of the necessary transformation of our energy infrastructure is immense. It is estimated that over $16 trillion in capital investments over the next two decades will be necessary just to expand energy supply to meet growing global energy demands, compared to a global GDP of $44 trillion and a U.S. GDP of $12 trillion. Put another way, to track the projected growth in electricity demand, the world would need to bring online a new 1,000 MWe powerplant costing $1 billion or more every day for the next 20 years! Clearly this requires a federal R&D effort comparable in scale to the Manhattan Project or the Apollo Program. (Lewis, 2007)

Yet over the past two decades, energy research has actually been sharply curtailed by the federal government (75% decrease), the electrical utility industry (50% decrease), and the domestic automobile industry (50% decrease). (Kammen, 2005) Today the federal government effort in energy R&D is less than 20% of its level during the 1980s in today's dollars! To gain a better sense of the priority given today to energy research, one might compare the roughly $4 B energy federal research budget (see below) with the $13 billion NASA budget, the $30 billion NIH budget, or the $81 billion R&D budget for DOD.

How much should the federal government be investing in energy R&D? A comparison of the size of the energy sector ($1.9 T) compared to health care ($1.7 T) and national defense ($1.2 T) would suggest annual R&D investments in the range of $40 to $50 B, an order of magnitude larger than the current federal investment. Furthermore, there are ample options for funding such a major federal energy R&D effort, both through reallocation of funds from existing federal programs of marginal value (e.g., subsidies for corn-based ethanol production or tax incentives for offshore oil exploration) or from the revenues generated by future programs aimed at constraining greenhouse gas emissions (e.g., the auctions of carbon cap-and-trade certificates or revenues generated by a carbon tax). Clearly, Washington has yet to take the energy crisis seriously at least as measured by its commitment to energy R&D, and as a consequence our nation remains at very great risk.

Beyond scale there are few technology infrastructures more complex than energy, interwoven with every aspect of our society. Large scale deployment of sustainable energy technologies will involve not simply advanced scientific research and the development of new technologies, but as careful attention to complex social, economic, legal, political, behavioral, consumer, and market issues–all characterized as well by complex regional, national, and international relationships. Little wonder that one commonly hears the complaint that "The energy crisis is like the weather; everybody complains about it, but nobody does anything about it!"

Diffusing technology through our social system in a rational and planned way will be as critical to a rapid transformation of our energy systems as the significance of technology itself. Poorly planned introduction of technology has resulted in a history of unintended consequences that often do more to damage the growth of that technology than to help it. With the clock ticking, a major challenge is developing systematic approaches to technology diffusion that avoid the obvious mistakes. A new approach to technology development and deployment is badly needed to avoid costly false starts that the nation cannot afford.

Yet, returning again to the DOE Secretary's Energy Advisory Board (SEAB) Task Force study, there is growing concern that our existing paradigms for federal energy research are just not up to the task. The DOE R&D programs are organized around fuel sources, e.g., coal, oil, gas, nuclear, and renewables, all too characterized by an "energy technology of the year" approach that disrupts longer-term strategic efforts. This also leads to stove-pipe organizations that focus on incremental or discrete technologies as opposed to systems that integrate R&D supply, distribution, and end use needs for the set of energy sources and associated infrastructures required to supply the nation with reliable, affordable, and sustainable energy. The DOE stovepipes then lead to national policies that seriously underestimate threats and consequences and are all too frequently risk-adverse and parochial, tending to seriously misjudge the potential for new high-risk, high-payoff, technologically-enabled opportunities and threats. (ARPA-E Testimony, 2007) The overall result is a complete absence of a comprehensive national energy policy.

The DOE SEAB Task Force concluded further "The federal government alone cannot meet the nation's energy related R&D needs. The Department of Energy must partner with universities, industry, and other federal agencies. It should seek the best balance of national laboratory, university, and industrial research, and form partnerships with industry and academia to drive innovation in its mission areas." (Vest, 2005) More seriously, the DOE laboratories suffer from an insular culture arising from the security constraints of their earlier and ongoing work in atomic energy. Consequently they are too far removed from the marketplace and too focused on their existing portfolios to effectively support "transformational" research targeted at new energy technologies.

To adequately address the nation's energy needs, the capabilities of DOE mission-focused divisions and national laboratories must be significantly supplemented. Since energy challenges have important implications for the nation's scientific and engineering workforce, human capital development has become a particularly critical issue that requires immediate attention. Furthermore, it is well-known that one of the most effective technology transfer mechanism is the knowledge and skills carried by graduates of the nation's research universities. Yet most DOE activities are relatively isolated from education (aside from campus-based programs sponsored by the DOE Office of Science). Furthermore, since the complexity of the nation's energy challenges involve socioeconomic and political issues as much as science and technology, unusually broad multidisciplinary research efforts are required that encompass important areas such as social and behavioral sciences, professional programs in business administration, law, medicine, and public and environmental policy, all areas where national laboratory expertise is limited.

In summary, it is clear that a federal research program adequate to respond to the urgency, scale, and complexity of the nation's needs for a sustainable energy infrastructure will require not only a massive increase in funding. It will also require superseding the existing national laboratory and industrial R&D effort with new research paradigms characterized by highly multidisciplinary scientific research, the development of highly innovative technology commercialization approaches capable and rapid deployment into the marketplace, and great agility to respond to ever changing challenges and opportunities. Such programs must involve an intimate and balanced partnership among multiple players–federal agencies, research universities, established industry, entrepreneurs, and the investment community–from the get-go. A new research culture must be developed based on the nonlinear flow of knowledge and activity among scientific discovery, technological innovation, entrepreneurial business development, and economic, legal, social, and political imperatives, all coordinated across the spectrum of energy technologies contributing to a comprehensive national energy policy.

### Discovery-Innovation Institutes or Hubs

Over the past several years there has been an increasing recognition that U.S. leadership in innovation will require commitments and investments of resources by the private sector, federal and state governments, and colleges and universities. In 2005, the National Academies issued a series of reports suggesting that a bold, transformative initiative, similar in character and scope to initiatives undertaken in response to other difficult challenges (e.g., the Land Grant Acts, the G.I. Bill, and the government-university research partnerships) will be necessary for the United States to maintain its leadership in technological innovation. (Augustine, 2005) The United States will have to reshape its research, education, and practices to respond to challenges in global markets, national security, energy sustainability, and public health. The changes envisioned were not only technological, but also cultural; they would affect the structure of organizations and relationships between institutional sectors of the country.

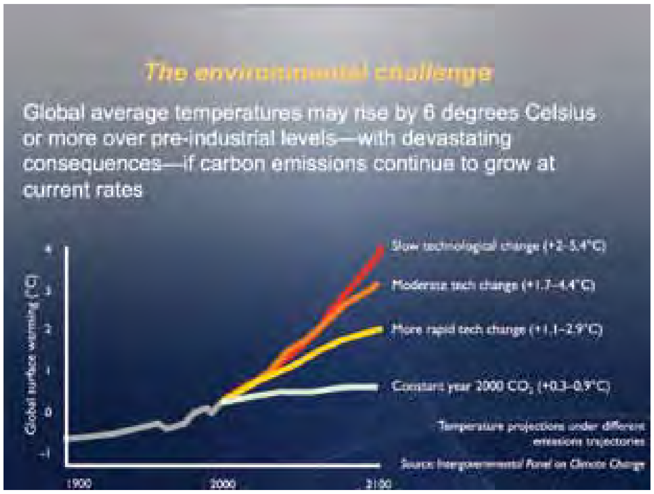
To this end, it was the recommendation of the National Academy of Engineering that a major federal initiative be launched to create translational research centers aimed at building the knowledge base necessary for technological innovation in areas of major national priority. (Duderstadt, 2005) These centers, referred to as *discovery-innovation institutes*, would be established on the campuses of research universities to link fundamental scientific discoveries with technological innovations to create products, processes, and services to meet the needs of society. With the participation of many scientific disciplines and professions, as well as various economic sectors (industry, government, states, and institutions of higher education), discovery-innovation institutes would be similar in character and scale to academic medical centers and agricultural experiment stations that combine research, education, and professional practice and drive transformative change. As experience with academic medical centers and other large research initiatives has shown, discovery-innovation institutes had the potential to stimulate significant regional economic activity, such as the location nearby of clusters of start-up firms, private research organizations, suppliers, and other complementary groups and businesses.

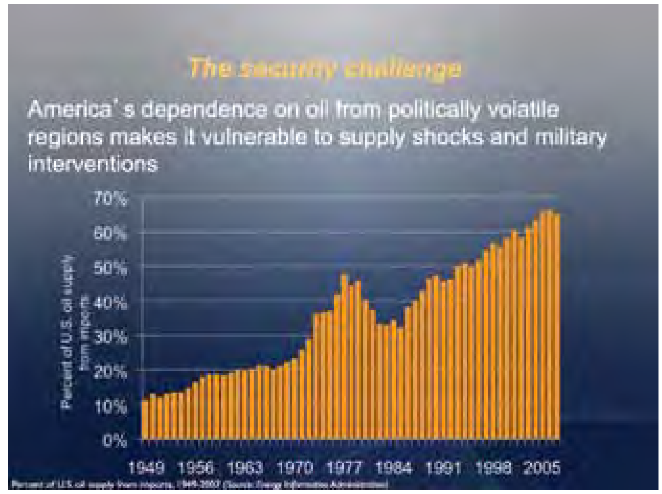
As envisioned here, therefore, the proposed e-DIIs would do the following:

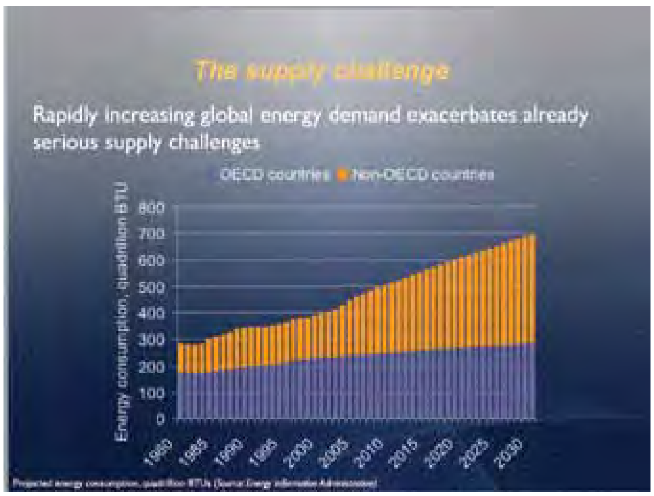
• Organize around a theme, such as renewable energy technologies, advanced petroleum extraction, carbon sequestration, biofuels, transportation energy, carbon-free electrical power generation and distribution, or energy efficiency. Each e-DII would be charged with addressing the economic, policy, business, and social challenges required to diffuse innovative energy technologies of their theme area into society successfully. This mission would require each e-DII to take a systems-approach to technology development and help to transcend the current "siloed" approach common at DOE and its national labs.

• They would foster partnerships to pursue cutting-edge, applications-oriented research among multiple participants, including government agencies (federal, state, and local), research universities, industry, entrepreneurs, and investors. The e-DIIs would encourage a new research culture based on the nonlinear flow of knowledge and activity among scientific discovery, technological innovation, entrepreneurial business development, and economic, legal, social, and political imperatives. In a sense, e-DIIs would create an "R&D commons," where strong, symbiotic partnerships could be created and sustained among partners with different missions and cultures. Building a sustainable energy infrastructure depends as much on socioeconomic, political, and policy issues as upon science and technology. The e-DIIs would encompass disciplines such as the social and behavioral sciences, business administration, law, and environmental and public policy, in addition to science and engineering.

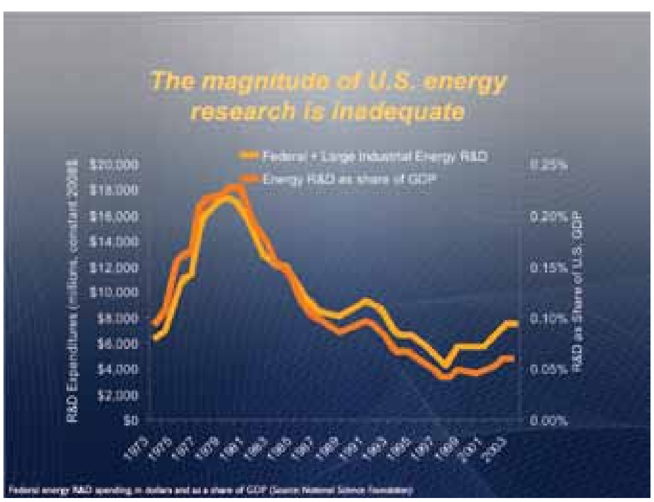
• In addition to institute-based activities, the e-DIIs would act as the hubs of a distributed network, linking together as spokes the basic research programs of campus-based, industry-based, and federal laboratory-based scientists and engineers, research centers, and facilities, to exploit the fundamental character of discovery-innovation institutes to couple fundamental scientific research and discovery with translational research, technology development, and commercial deployment. But the hub-and-spoke network architecture would go further by enabling the basic research group spokes to interact and collaborate among themselves (through exchanges of participants, regularly scheduled meetings, and cyberinfrastructure). Just as the rim of a bicycle wheel greatly strengthens its hub-and-spoke structure, the direct interaction of the basic



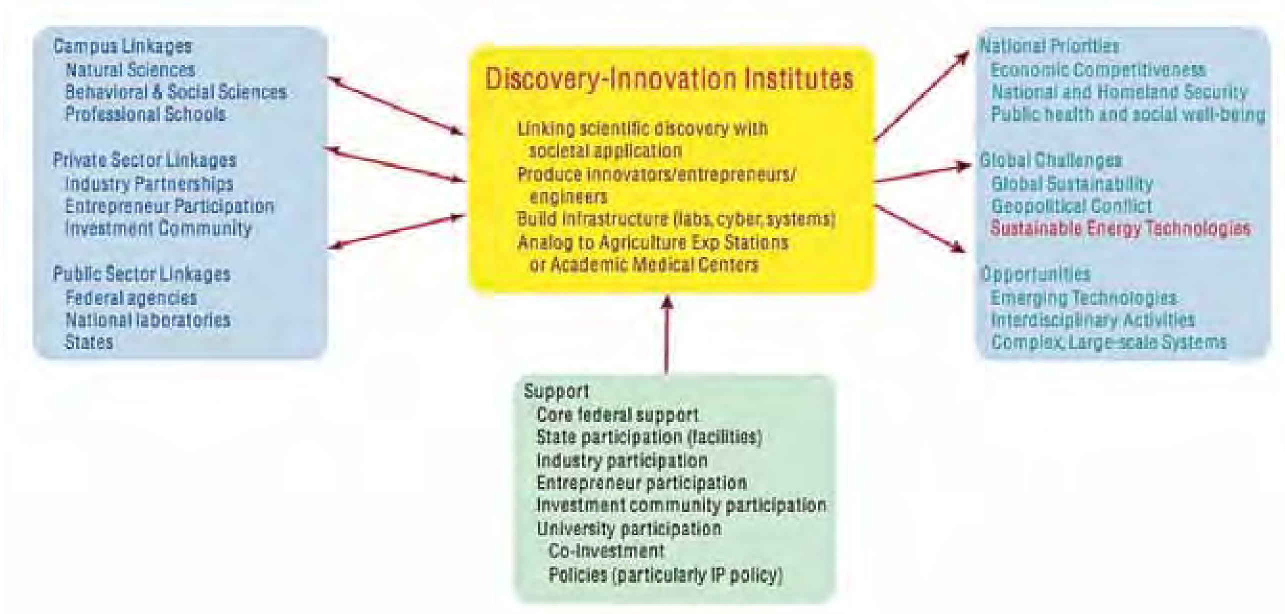









Today's energy challenges suggest that a massive increase in energy research is needed.




The Discovery Innovation Institute Concept

research groups (the spokes) would greatly facilitate collaboration and research progress, creating a basic energy research community greater than the sum of its individual parts and with sufficient flexibility, synergy, and robustness to enable the participation of leading scientists and engineers to address the unusual complexity of the nation's energy challenges.

• Key in the design of (and the awarding of federal support to) each e-DII would be an effective strategy for energy technology development, commercialization, and deployment, working closely with industry, entrepreneurs, and the investment community. For example, this might draw on the experience of major medical centers (the commercialization of translational research through business startups), agricultural and industrial extension programs, federal initiatives for regional economic development, or entirely new paradigms for technology transfer.

• The e-DIIs would build the knowledge base, human capital, and public awareness necessary to address the nation's energy challenges. The e-DIIs are envisioned as the foci for long-term, applications-driven research aimed at building the knowledge base necessary to address the nation's highest priorities. Working together with industry and government, the e-DIIs would also lead to the development of educational programs and distributed educational networks that could produce new knowledge for innovation and educate not only the scientists, engineers, innovators, and entrepreneurs of the future, but learners of all ages, about the challenge and excitement of changing the US energy paradigm. Thus the e-DIIs would have a fundamental educational mission of public education through the involvement of their scientists and engineers in sharing best educational practices and developing new educational programs in collaboration with K-12 schools, community colleges, regional universities, and workplace training that lead to significantly increased public engagement.

• Develop and rapidly transfer highly innovative technologies into the marketplace. The treatment of intellectual property is critical to the rapid and efficient transfer of energy technologies to the marketplace. The e-DIIs should provide a safe zone where intellectual property issues could be worked out in advance. Technology transfer within e-DIIs should be structured to maximize the introduction and positive societal impact of e-DII technologies, learning from successful industry-university partnerships (e.g., BP and the Universities of California and Illinois).


The various partners comprising an energy discovery-innovation institute or hub

• The e-DIIs would encourage regional economic development. With the participation of many scientific disciplines and professions as well as various economic sectors, e-DIIs are similar in character and scale to academic medical centers and agricultural experiment stations that combine research, education, and professional practice and drive transformative change. This organizational form has been successful at generating jobs and stimulating regional economic activity, by the nearby location of clusters of start-up firms, private research organizations, suppliers, and other complementary groups and businesses. The e-DIIs should have an explicit mission to focus, at least in part, on the unique energy needs and opportunities characterizing their home regions, to ensure that new technologies would respond to local challenges and thus could be rapidly deployed.

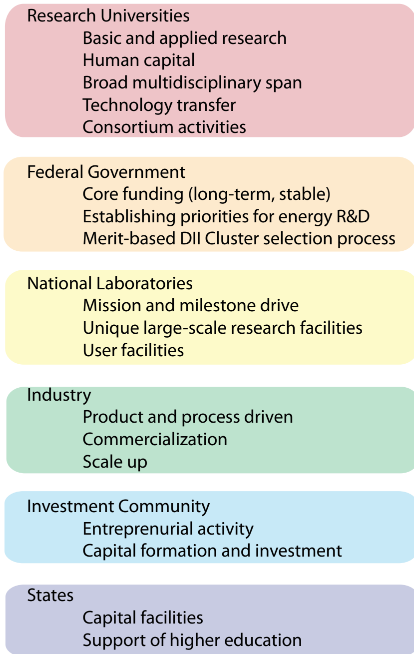
• They would expand the scope of possible energy activities. The partnership character of the e-DII, involving a consortium of universities, national laboratories, industry, investors, state, and federal government, coupled with its regional focus, would give it the capacity to launch projects that are beyond the capability of a national laboratory or industry consortium alone.

To achieve a critical mass of activities, our report recommended the creation over the next several years of a national network of several dozen energy discovery-innovation institutes distributed competitively among the nation's research universities and federal laboratories. A merit-based competitive process would award core federal support ranging from $5 M/y to $10 M/y for modest centers in single institutions to as much as $100 M/y to $200 M/y for large e-DIIs managed by consortia of universities and national laboratories. Federal funding would be augmented with strong additional support and participation from industry, investors, universities, and state governments, for a total federal commitment growing to roughly $6 billion/y (or %25 of the recommended total federal energy R&D goal of $20 to $30 billion/y estimated to be necessary to address adequately the nation's energy challenge.)

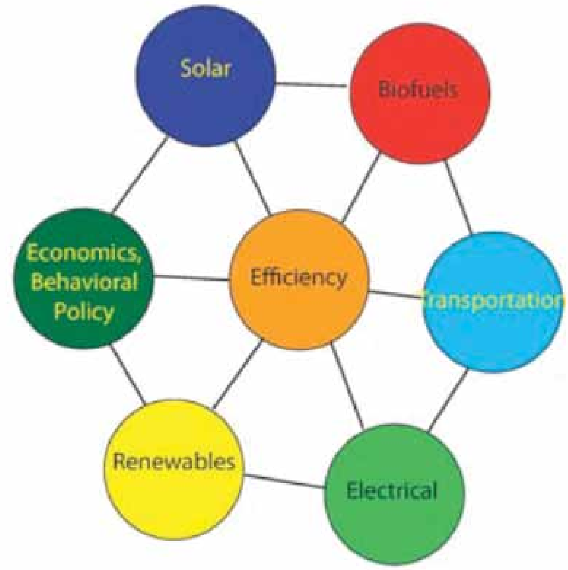
The national network of e-DIIs would consist of several distinct components:

• University-based e-DIIs: Those e-DII's located adjacent to research university campuses would be managed by either individual universities or university consortia, with strong involvement of partnering institutions such as industry, entrepreneurs and investors, state and local government, and participating federal agencies. While most university-based e-DIIs would focus both on research addressing national energy priorities and regional economic development from new energy-based industries, there would also be the possibility of distributed or virtual e-DIIs (so-called "collaboratives") that would link together institutions on regional or national basis. As mentioned earlier, each e-DII would also act as a hub linking together investigators engaged in basic or applied energy research in other organizations.

• Federal laboratory-based e-DIIs: There should be a parallel network of e-DIIs associated with federal laboratories. To enable the paradigm shifts represented




Roles for each of the innovation hub partners




A cluster of energy innovation hubs

by the discovery-innovation institute concept, these e-DIIs would be stood up "outside the fence" to minimize laboratory constraints of security, administration, and overhead and driven by the bottom-up interests of laboratory scientists. Like university-based e-DIIs, their objectives would be the conduct of application-driven translational research necessary to couple the extraordinary resources represented by the scientific capability of the national laboratories with the technology innovation, development, and entrepreneurial efforts necessary for the commercial deployment of innovative energy technologies in the commercial marketplace. A given national laboratory might create several e-DIIs of varying sizes and focus that reflect both capability and opportunities. There might also be the possibility of e-DIIs jointed created and managed by national laboratories and research universities.

• Satellite energy research centers: The large e-DIIs managed by research university consortia or national laboratories would anchor "hub-and-spoke" sub-networks linking satellite energy research centers comparable in scale to DOE's Energy Frontier Research Centers or NSF's Engineering Research Centers, thereby enabling faculty in less centrally-located regions or at institutions with limited capacity to manage the large e-DII hubs to contribute to the nation's energy R&D as an element of the national e-DII network.

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A national network of energy innovation hubs

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In the end, the need to reinvigorate America's economy and place it on a more sustainable footing compels the transformation of U.S. energy policy. Quite simply, the sheer scale, and unprecedented complexity of the nation's "energy problem" requires a new approach—one that rethinks both the magnitude and character of national energy research programs, and places innovation at the center of reform efforts. It is time once again for the federal government to make a major commitment to investing adequately in the energy technologies that will secure prosperity and security for future generations while protecting the sustainability of Planet Earth for humankind. The proposed network of translational energy research centers, comprised of regional energy discovery-innovation institutes, will represent an important element of a broader national effort to achieve a sustainable energy future for both our nation and the world.

## The University of Michigan Energy Research Institute

The University of Michigan convened a committee of university faculty and industry experts charged with conducting a quick scan of various approaches to building a significant research program addressing alternative energy supplies with a particular focus on hydrogen. Key in this effort was to explore the opportunities and challenges (e.g. a SWOT analysis) of various possible initiatives that could then be presented to an industry advisory board.

The committee began with the premise that the critical challenge of the unsustainable nature of the nation's current energy infrastructure. Every aspect of contemporary society is dependent upon the availability of clean, affordable, flexible, and sustainable energy sources–meeting human needs such as sustenance, shelter, employment, transportation, and health; the viability of our economy, in which over 7% of GDP is spent on energy; the fragile nature of our environment, seriously impacted by current technologies for producing and utilizing energy; and the security of our nation, threatened by an our greater reliance on foreign energy imports from unstable parts of the world. One could well make the case that not only should energy research, development, and policy receive the highest priority among national concerns, but such energy research should be a major focus at a leading public research university such as the University of Michigan, which has a strong responsibility to address the most urgent needs of our state, nation, and world.

With this urgency in mind, the committee considered three key criteria in its discussions:

i) achieving national energy independence
ii) minimizing impact on global climate
iii) addressing the particular needs of the transportation industry

Although its initial charge involved assessing possible initiatives concerning roadmaps to a possible future "hydrogen economy", with an emphasis on the use of hydrogen as a transportation fuel, the committee rapidly broadened this discussion to include an array of alternative energy options characterized by zero- or low-hydrocarbon emissions.

Such considerations were embedded in a broader discussion of long-term energy options for both stationary and mobile applications.

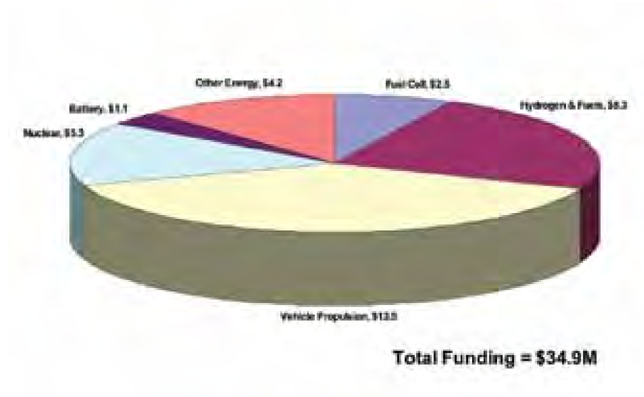
The discussions finally converged on four initiatives at the national, regional, state, and university level:

- At the national level, a major Department of Energy initiative to fund 8 to 10 "Energy Research Centers" on university campuses, organized much along the lines of the NSF Engineering Research Center Program.
- At the regional level, a consortium of university energy research centers focused on the energy needs of the Great Lakes states (e.g., manufacturing and transportation).
- At the state level, the establishment of several major energy research centers with a focus on transportation fuels, along the lines of the major initiatives in California ($300 million supporting R&D centers at UC campuses), Texas (Texas Energy Center) and Ohio ($20 million for its Fuel Cell Consortium), closely coordinated with existing efforts such as NextEnergy and the needs of Michigan industry.
- At the university level, establishing a major Energy Research Institute, aimed at building the University's capacity and presence in a range of scientific, technological, and policy issues involving transportation energy resources.

While each of these initiatives is self-standing, it is important to recognize key linkages that will determine Michigan's role. For example, a rapid and substantial effort is necessary to draw together and expand the University of Michigan's capacity in energy research if it is to have the capability and credibility either to participate in or lead such efforts at the regional or national level. So too, a substantial commitment at the state level (comparable to those in California, Texas, and Ohio) would be necessary for it to lead a Great Lakes consortium. The same linkages are true for participation, since any of these initiatives will eventually require strong collaboration among the University, the state, federal agencies, and Michigan industry.

The study eventually focused its effort on forming

Michigan factory economy is energy intensive.




2005 UM energy research activity

a major Energy Research Institute at the University of Michigan, drawing both on existing capacity and building new capacity to conduct research on a broad range of scientific, technological, and policy issues involving the future of transportation energy systems (with hydrogen-based energy sources as a key focus). Although the startup funding for such an effort would come from University resources, it is anticipated that within 12-18 months, significant federal, state, and industrial support could be achieved.

Here the challenge is both to create a workable organizational structure that provides adequate visibility for existing activities (which are considerable, if out of sight and all too frequently out of mind. See Appendix A) and to make the investments to build new capacity (e.g., attracting lead researchers or programs to the University, much as was done in the high intensity laser field when Gerard Mourou's group was moved from the University of Rochester in the 1980s), invest in facilities.

More specifically, the committee believes that the University should move rapidly to pull together and augment existing energy research in areas designed to achieve greater impact and visibility, while building the credibility for leadership and attracting substantial external resources. Among the possible programs discussed were the following:

• A research center aimed at investigating the interplay between fuel processing and utilization, e.g., the production of hydrogen-based fuels to be utilized in fuel cells for auxiliary or vehicular power units. There has already been considerable industrial interest in working with the University to build the experimental infrastructure on campus to investigate such subjects. In addition, the US Army Tank-armaments Automotive Command (TACOM, Warren, Michigan) has expressed an interest in working with the UM to develop a new facility to conduct fundamental and applied research in decentralized or mobile-platform mounted transportation fuel processing production and reforming systems. This would include research and development of decentralized (or mobile) gas-to-liquid synfuel processes, and of decentralized (or mobile) biomass conversion processes.

• A collaboration with NextEnergy, the state-funded R&D public corporation founded to advance the use of alternative energy technologies by supporting research, design, manufacturing, education, commercialization, and marketing. Many of NextEnergy's initial thrusts align well with the interests of University faculty, plus, NextEnergy already has a well-established industry network which could be use to move technology out of the University. The possibility of collocating expensive experimental facilities and building joint university-industrial-government research programs with NextEnergy umbrella may hold considerable promise.

• The complex interaction between government regulation and market economics is one of the most serious challenges facing the development and implementation of advanced energy sources. The battle on alternative energy sources is likely to be won or lost in the hearing rooms of public regulatory bodies, where technological expertise is limited, and policies tend to be more focused on the political pressures of the moment than the social needs of tomorrow, and muddled regulation strangles technological evolution. The University could pull together its considerable expertise on the technological, legal, economic, and social aspects of energy regulation, working with both government and industry, to develop regulatory policies and structures that more effectively address the urgent energy issues facing our state and nation rather than allowing them to continue being dictated by the old political wars of the past.

• Since biomass energy technology could have significant impact on the economy of agriculture-intensive states such as Michigan, more visionary technologies such as "chemical reactor combines" that simultaneously harvest and process biomass into synfuels should be explored.

More generally, the committee believes that the University of Michigan can play a significant leadership role and meet its public responsibilities only by a concerted effort to organize, support, and build world-class programs in energy research that align with the needs of our state and our nation. In this effort it should move rapidly to executive the following steps:

1. Conduct a comprehensive survey of existing energy research activities on our campus.

2. Develop a plan to build and strengthen linkages with other state and federal initiatives such as NextEnergy

3. Create a University-wide organizational structure for such interdisciplinary energy research activities.

4. Begin a series of investments in particular projects (such as those mentioned above) while seeking external support from state, federal, and industrial sources.

5. Commit itself to achieving leadership in energy research in areas of importance to the state (particularly transportation and manufacturing) with a five year period.

Such steps will be a necessary precursor for effective University leadership of any of more comprehensive initiatives at the state, regional, and federal levels considered by our committee.

## Assessment of Impact

These energy studies have had very significant impact. The Department of Energy has responded by creating a number of energy innovation hubs spanning a range of transformational research areas including nuclear reactors (CASL, the Coalition for Advanced Simulation of Light Water Reactors; JCAP, the Joint Coalition for Artificial Photosynthesis, CMI, the Critical Materials Institute; and JCESR, the Joint Center for Energy Storage Research.

Furthermore the University of Michigan has responded to its energy study by first renovating the Phoenix Memorial Laboratory to enable research on hydrogen energy sources and then building a new complex to house the Michigan Energy Institute.

## References

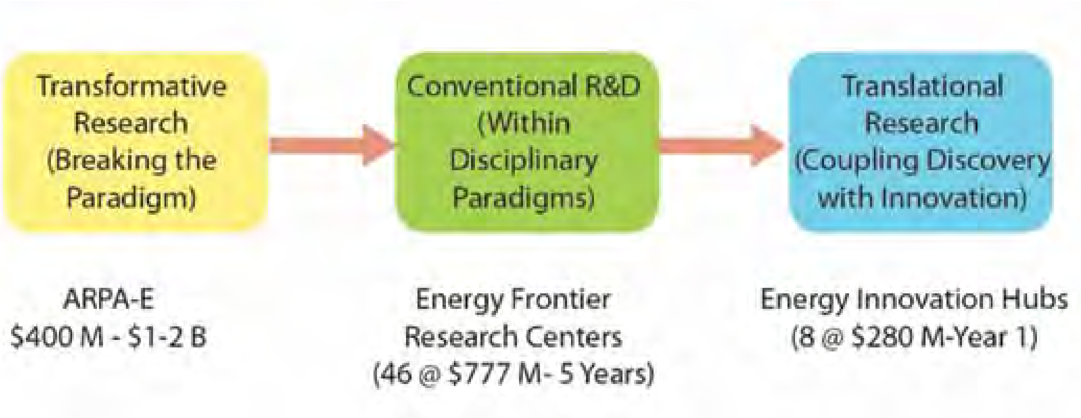
Vest, Charles M. (Chair), Critical Choices: Science, Energy, and Security, Final Report of Secretary of Energy Advisory Board, U.S. Department of Energy, Washington, D.C., 2003

Duderstadt, James J. (Chair), Final Report of the Hydrogen Committee, University of Michigan, 2004

Duderstadt, James J., Mark Muro, and Sarah Rahman, Hubs of Transformation: Leveraring the Great Lakes Research Complex for Energy Innovation (Brookings Institution, Washington, D.C., 2010)

Duderstadt, James J. , et. al., Energy Discovery-Innovation Institutes: A Step Toward America's Energy Sustainabilitiy (Brookings Institution, Washington, D.C., 2009)

Duderstadt, James J., "Global Sustainability: Timescales, Magnitudes, Paradigms, and Black Swans", VIII Glion Colloquium (Economica, Paris, 2011)




How the energy innovation hubs compare to other Department of Energy research paradigms


CASL DOE Energy Innovation Hub


JCAP DOE Energy Innovation Hub


CMI DOE Energy Innovation Hub


JCESR DOE Energy Innovation Hub


Renovation of Phoenix Lab for hydrogen research

Michigan Energy Institute

# Chapter 10

# Nuclear Energy

## Early Activities

Although I was certainly not involved in a leadership role, early in my career I had the opportunity to work on two exciting long-range projects at national laboratories: the Rover Project at Los Alamos Scientific Laboratory, with the goal of developing nuclear-powered rocket engines for long-range space exploration, and the laser-fusion project (Q Division) at the Lawrence Livermore National Laboratory, developing the technology to use the world's most powerful lasers to compress and heat tiny pellets of deuterium and tritium fuels to trigger thermonuclear fusion.

The Rover Project was intended to develop and test rocket engines powered by nuclear fission reactors that would be required for a manned mission to Mars. During the mid-1960s, it was felt that the Mars mission would likely follow rapidly after the successful completion of the Apollo program to land a man on Mars–perhaps as early as 1980. In fact, by the late 1960s there was a plan for a two spacecraft manned mission to Mars in the late 1970s based on Los Alamos nuclear rocket technology.

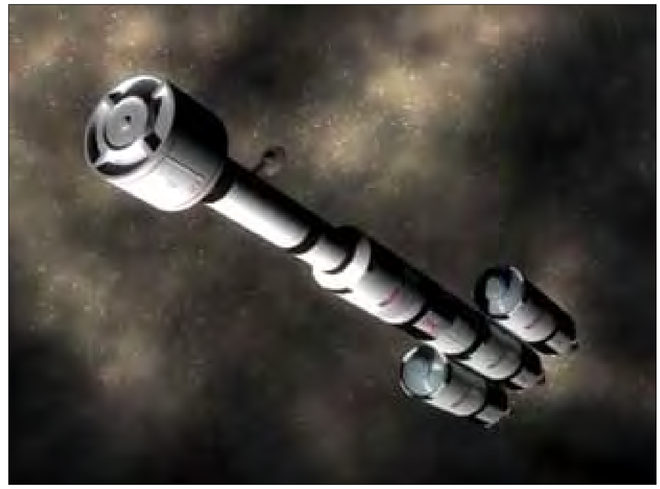
The basic idea was to flow hydrogen as a propellant through channels in very high energy density nuclear reactors, heating it to temperatures of 2,000 C or higher before existing through nozzles for propulsion. The initial test reactors, Kiwi, were rated at 1,000 megawatts, and the next generation of Phoebus reactors, rated at 5,000, were essentially the modules intended for the Mars mission. My work involved simulating the various thermal-hydraulic processes that were used to static test these engines at the Nevada Test Site. Unfortunately, even as the actual rocket engines themselves were built and static tested in the follow-on NERVA program (nuclear energy for rocket vehicle applications), the Apollo program completed its final sequence of missions, and the U.S. space program abandoned further human exploration of the moon and beyond in favor of building the space shuttle and focusing on low earth orbit activity. Needless to say, it was frustrating to have seen such an exciting program achieve its goals only to have it put on the shelf when the U.S. space program abandoned exciting goals such as manned spaceflights to Mars and beyond

Los Alamos was successful in designing, building, and static-testing a sequence of nuclear rocket engines at their Nevada test site–the Kiwi engine rated at 1,000 megawatts and the Phoebus engine rated at 5,000 megawatts (five times the power of a nuclear power plant). I worked on the test programs for these engines, and through this gained a strong interest both in nuclear power and spaceflight.

During the early 1970s I returned to laboratory work, working in the top-secret Q-Division at the Lawrence Livermore Laboratory, attempting to develop the technology of laser-driven thermonuclear fusion. My role was to use supercomputers to model the very complex physical processes characterizing using extremely intense laser beams to heat and compress tiny pellets of hydrogen isotopes to temperatures and pressures sufficient to ignite thermonuclear ignition and burn. Unlike the Los Alamos nuclear rocket project, this project has continued to evolve to today's massive National Ignition Facility at LLNL, which hopes to achieve breakeven fusion (where target fusion energy released exceeds laser energy on the target).

One more experience in the nuclear area: since I usually produced copious lecture notes for each of each of the courses, I soon shifted to writing textbooks

Los Alamos Scientific Laboratory



Artists conception of nuclear powered Mars miaaion

The Phoebus 2A Nuclear Rocket

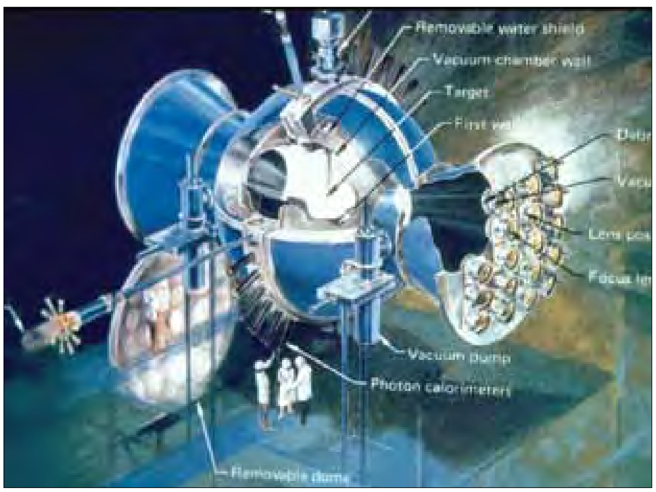
President Kennedy visiting Project Rover

The test firing control room

Testing of the Phoebus nuclear rocket enginee

Lawrence Livermore National Laboratory

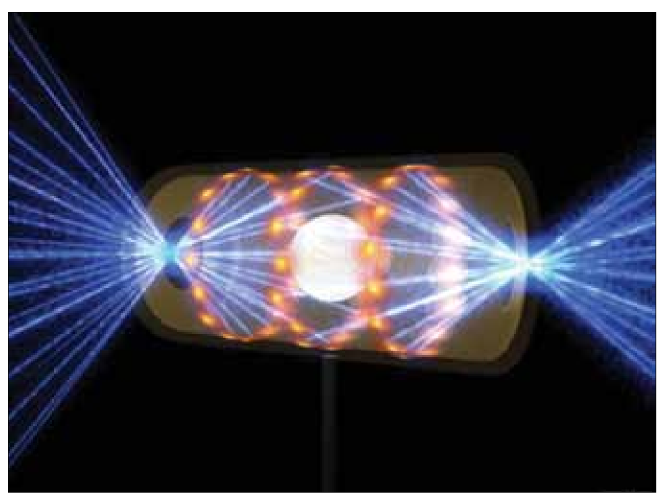
The massive Shiva laser




The laser target chamber

The fusion target...in the eye of a needle

The cylinder containing the target pellet



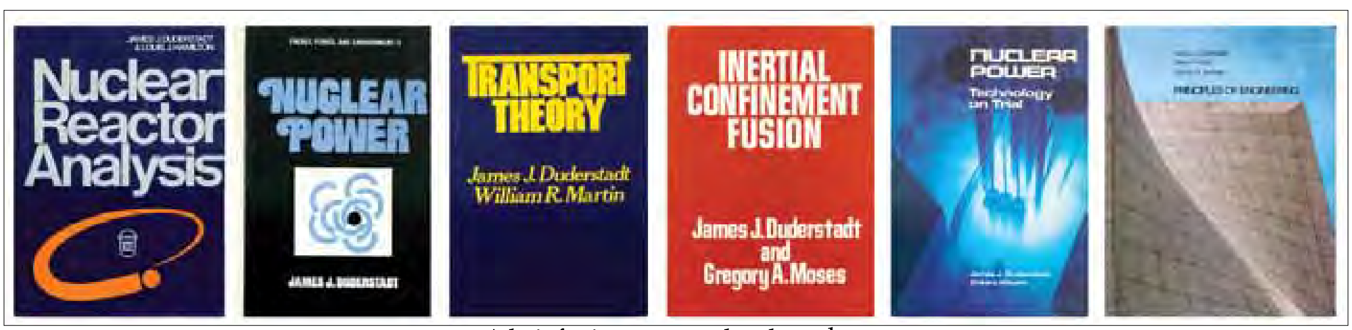
Laser illumination compressing the target

Nuclear Engineering faculty colleagues

Into the classroom

Notes for the many courses I taught

Nuclear Engineering students (with my first textbook)




A brief stint as a textbook author

to expand my pedagogical efforts. The first of these, Nuclear Reactor Analysis, was written with another junior faculty member, Louis J. Hamilton, and covered most of the material required for both the B.S. and M.S. in nuclear engineering. It turned out to be wildly successful, soon becoming a dominant textbook in the field. In fact today (2014), almost 40 years later, it remains one of the most important textbooks in this field. (I've always suspected that the fact that it has remained at the top of the list, even though it has never been updated, reveals just how stagnant the progress in nuclear reactor engineering has been since Three Mile Island!) This led to a series of other textbooks, usually written with faculty colleagues or former graduate students, as indicated by the book covers in the illustration below.

The great interest in nuclear power during the 1970s pulled me into other areas, including a major

The Three Mile Island nuclear plan


The "Nuclear Power and You" TV Series

television series, Nuclear Power and You, produced by the University of Michigan Television System for nationwide broadcast. Unfortunately, it was scheduled to first appear on WABC in New York the week of Three Mile Island, so we had to do a last-minute re-taping of the program on nuclear reactor safety.

This television experience led to another major project in the 1980s where I led an effort to develop an entire undergraduate degree program for the nuclear power industry utilizing studio-produced videotape: ten courses with 40 hour-long lectures for each course, along with problem sets and other references. Here I might note today that this unusual effort would be identified as a MOOC, a "massively open online course"…actually ten courses in this case. However, with the sensitivity about the proliferation of nuclear technology to rogue states seeking to develop nuclear weapons technology, we have decided not to circulate our online curriculum on a global level.

## Nuclear Energy Policy Studies

During the 1990s, the nation's research programs in peaceful uses of atomic energy had decayed rather significantly. Key programs such as the Advanced Light Water reactor program and the Integral Fast Breeder Reactor were completed or phased out. In fact, by 1997, it had dropped essentially to zero. The President's Council of Advisors or Science and Technology warned that the future of this technology in the United States was in considerable doubt.

"Fission's future expandability is in doubt in the United States and many other regions of the world because of concerns about high costs, reactor-accident risks, radioactive-waste management, and potential links to the spread of nuclear weapons. We believe that the potential benefits of an expanded contribution from fission in helping address the carbon dioxide challenge warrant the modest research initiative proposed here (the Nuclear Energy Research Initiative), in order to find out whether and how improved technology could alleviate the concerns that cloud this energy option's future. To write off fission now as some have suggested, instead of trying to fix it where it is impaired, would be imprudent in energy terms and would risk losing much U.S. influence over the safety and proliferation resistance of nuclear energy in other countries. Fission belongs in the R&D portfolio."

Of related concern was the erosion in academic programs and facilities necessary to produce the human resources needed by the nation's nuclear industry and nuclear defense programs. Over the past decade the number of nuclear engineering programs in this country have declined by half (from 80 to 40), the number of university research and training reactors by two-thirds (from 76 to 28), and enrollments have dropped by almost 60% (from 3,440 to 1,520). As noted in a recent planning study:

"Nuclear engineering programs in the United States are disappearing. Without concerted action by DOE, supported by OMB and the Congress, most of the existing nuclear engineering programs will soon evaporate or be absorbed and diffused in other engineering disciplines."

In particular, PCAST recommended that the Department of Energy establish a high-level advisory committee e to provide independent advice on what was necessary to prefer the nation's nuclear energy option.

## The Nuclear Energy Research Advisory Committee (NERAC)

NERAC was established in 1998 to provide independent advice to the U.S. Department of Energy (DOE) on complex science and technical issues that arise in the planning, managing, and implementation of DOE's nuclear energy program. NERAC assisted DOE by reviewing the research and development (R&D) activities of the Office of Nuclear Energy, Science and Technology (NE) and providing advice and recommendations on long range plans, priorities, and strategies to effectively address the scientific and engineering aspects of these efforts. In addition, the committee provides advice on national policy and scientific aspects on nuclear energy research issues as requested by the Secretary of Energy or the Director of the Office of Nuclear Energy. The committee had a diverse membership with a balance of disciplines, interests, experiences, points of view, and geography from academia, industry, and national laboratory communities.

In particular, the Secretary of Energy requested that NERAC assist the Department in developing a long-term nuclear energy R&D plan, identifying priorities and possible programs along with an assessment of funding and infrastructure needs. Furthermore, the Committee was also tasked to evaluate DOE's physical infrastructure for nuclear energy research (e.g., research reactors, hot cells, and accelerators) in light of the needs suggested by the long range nuclear energy R&D plan. In addition, NERAC was asked to assess the current crisis in university nuclear engineering programs and campus-based research facilities in light of the growing human resources needs of the nation.

To conduct these long range planning activities and provide timely advice concerning ongoing or proposed DOE programs in nuclear energy research, NERAC works through a series of subcommittees:

Long-Range Nuclear Technology Research and Development Plan
Nuclear Science and Technology Infrastructure Roadmap Committee
Long Term Isotope Research and Production Plan Subcommittee
NERAC Blue Ribbon Panel on the Future of University Nuclear Engineering Programs and University Research Reactors
Technology Opportunities for Increasing the Proliferation Resistance For Civilian Nuclear Power Systems (TOPS) Task Force
Accelerator Transmutation of Waste Subcommittee
Operating Nuclear Power Plant Research, Coordination, and Planning Subcommittee

Longer Range Planning Activities

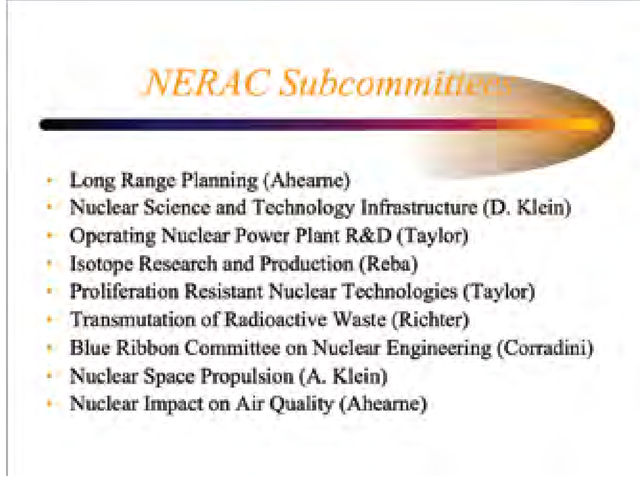
Although these planning efforts are intended to be ongoing and evolutionary, they do provide a strong sense of priorities for DOE/NE in the years ahead. Put simply, the reports stress the importance of adequate investment in ideas (research), people (education), and tools (facilities):

Ideas: There is an urgent sense that the nation must rapidly restore an adequate investment in basic and applied research in nuclear energy if it is to sustain a viable United States capability in the 21st Century. The Long Range Planning Study has recommended a set of program and funding priorities ramping to a level of over $500 million by FY2005, including a growth in funding of the Nuclear Energy Research Initiative (NERI) to achieve the goals set by PCAST. NERAC believes that such funding levels are not only necessary but realistic in view of the funding provided other DOE research programs such as fossil energy ($293 M), renewable energy ($410 M), nuclear physics ($370 M), and high energy physics ($715). It is also recommended that at least a part of this program accommodate investigator-initiated basic research projects, selected on the basis of scientific merit rather than confined to DOE programmatic needs.

U.S. Department of Energy Headquarters


NERAC Charge


NERAC Membership




NERAC Subcommittees

People: The report of the Long Range Planning Subcommittee reflects the views both of the other committees and NERAC membership when it states: "Perhaps the most important role for DOE/NE in the nuclear energy area at the present time is to insure that the education system and its facility infrastructure are in good shape." It is clear that United States nuclear engineering programs and university reactor facilities are at great risk and require immediate and concerted attention in DOE funding priorities. The NERAC Blue Ribbon Panel has made a number of important recommendations concerning the nature of DOE programs and support necessary to preserve and strengthen these important national resources. In particular, the Panel recommends an increase of the Nuclear Engineering Educational Research (NEER) program to $20 M/y, a new competitive research grant aimed at sustaining university research reactors at a level of $15 M/y, and a graduate fellowship/traineeship program at $5 M/y. The Panel believes that the plight of nuclear engineering education in this nation is sufficiently serious that the Department should take substantial steps in its FY2002 budget request to move toward these targets.

Tools: Finally, the Long Range Planning subcommittee, Infrastructure Roadmapping Subcommittee, and the Isotope Subcommittee stress the need for DOE facilities to sustain the nuclear energy research mission in the years ahead. Of particular need over the longer term are dependable sources of research isotopes and reactor facilities providing high volume flux irradiation for nuclear fuels and materials testing. NERAC recog-

Growth in DOE nuclear research

nizes the serious funding and policy issues associated with such facilities (including the use of existing facilities such as FFTF). However it is also important to state NERAC's view that without an adequate investment in basic and applied research programs and in human resource development, such expensive facilities will be useless. Again put most simply, the tools are useless without the people and ideas to make use of them. NERAC believes that these priorities should–indeed, must–guide the Department of Energy's and Administration's funding requests for DOE/NE.

It is important to recognize that these reports represent the efforts, consideration, and wisdom not only of NERAC committee members but as well of the hundreds of members of the broader scientific and engineering community who participated in the various workshops and drafting sessions associated with these studies. As such we believe that the Department of Energy, the Administration, and the Congress should give careful consideration and significant weight to the recommendations in these reports as they frame the programmatic planning and funding requests for the nuclear energy research activities of the Department of Energy.

Largely as a consequence of this planning effort, the nation began to expand its investment in nuclear research to the point where it reached over $240 million a year during my tenure as chair of NERAC.

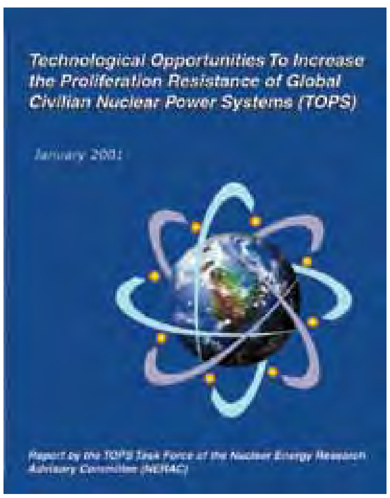
## Consortium for Advanced Simulation of Light Water Reactors (CASL): An Energy Innovation Hub

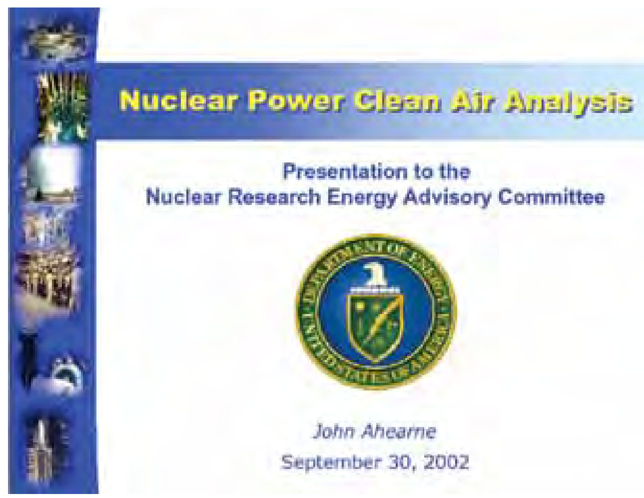
Nuclear energy is a tremendous technological success story for the U.S. A mere 25 years passed between English physicist James Chadwick's corroboration of the neutron's existence to the first full-scale atomic nuclear-powered electrical production plant at the Pennsylvania Shippingport Atomic Power Station in 1957—just four years after President Eisenhower gave his historical Atoms for Peace speech to the United Nations envisioning commercial nuclear power. Accelerated and translational R&D, from fundamental discovery to commercialized technology, has nevertheless proven challenging for nuclear energy; innovations are challenging in an enterprise that that is inherently conservative and regulatory-driven.

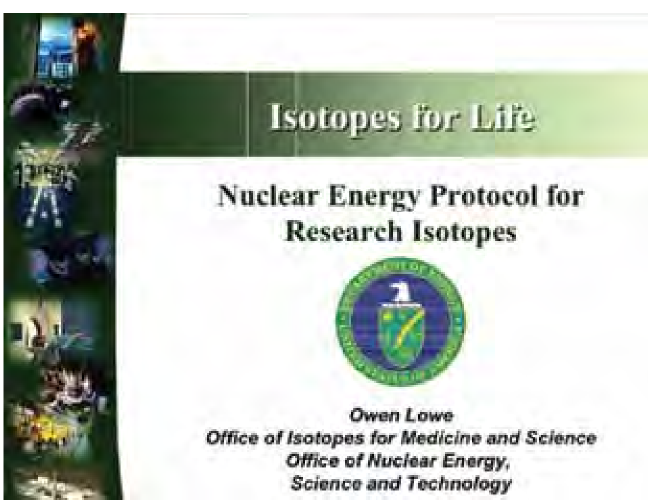
Translational research—a high return proposition for nuclear energy—is exactly what Energy Innovation Hubs established by the U.S. Department of Energy (DOE) strive to enable and accelerate. Hubs bring together teams of top scientists and engineers from academia, industry, and government to collaborate and overcome critical known barriers to achieving national climate and energy goals that have proven resistant to solution via the normal R&D enterprise. Hubs focus on a single topic, with the objective of rapidly bridging the gaps between basic research, engineering development, and commercialization through a close partnership with industry. To achieve this goal, the Hubs necessarily consist of large, highly integrated and collaborative creative teams working to solve priority technology challenges.

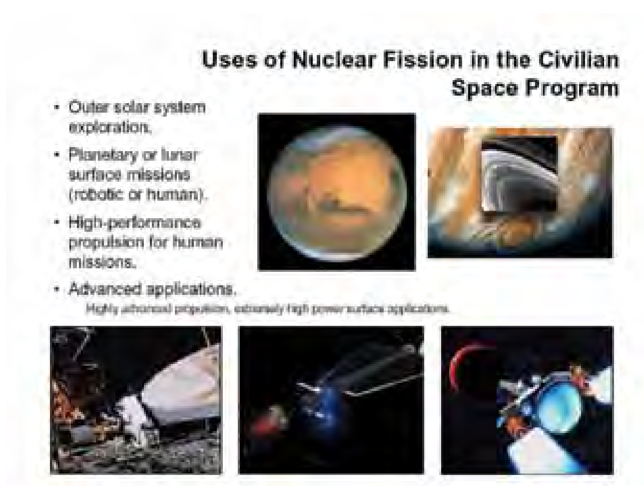
For the Consortium for Advanced Simulation of Light Water Reactors (CASL), awarded as the first Hub by the DOE Office of Nuclear Energy (NE) in July 2010, the focus is on innovating commercial nuclear power generation, specifically the modeling and simulation (M&S) of nuclear reactors. CASL not only strives to bring innovation to the nuclear energy enterprise but also to help retain and strengthen U.S. leadership in two DOE mission areas: HPC-enabled M&S and nuclear energy. CASL is currently completing its fourth year






NERAC Programs


Vision

*Predict, with confidence, the performance of nuclear reactors through comprehensive, science-based modeling and simulation technology that is deployed and applied broadly throughout the nuclear energy industry to enhance safety, reliability, and economics.*

CASL will address, through new insights afforded by its modeling and simulation (M&S) technology, key nuclear energy industry challenges to furthering power uprates, higher burnup, and/or lifetime extension while providing higher confidence in enhanced nuclear safety. CASL will deploy a technology step change (VERA) that supports today's nuclear energy industry and accelerates future advances in the development of this cleaner energy source. CASL M&S technology will become the leading nuclear energy industry M&S capability for supporting advanced nuclear steam supply system (NSSS) and nuclear fuel research, development, and deployment. By making VERA accessible to the nuclear energy community as early as possible, CASL will demonstrate – through industry acceptance, adaption, and licensing – that its M&S technology proactively targets the right industry problems.

CASL Vision Statement

of a five-year Phase 1 execution and has been granted the opportunity by DOE to submit a proposal (herein) for a second five-year Phase 2 (2015–2019) of execution.

Nuclear energy is by far the largest clean-air energy source in the U.S. and the only source that produces large amounts of electricity around the clock. It is a secure source not subject to changing weather conditions, unpredictable fuel cost fluctuations, or over-dependence on foreign suppliers. Nuclear energy facilities produce no air pollution and do not emit greenhouse gases. As the U.S. moves toward a clean-energy, low-carbon economy, nuclear energy must continue to be a part of the energy mix. And yet many challenges remain for nuclear energy—both for the existing U.S. fleet as well as for new reactors; improvements must be made in economics and performance. The future of the commercial nuclear power industry hinges upon furthering power uprates, realizing higher fuel burnup, and operating the existing plants for longer lifetimes—all while providing higher confidence in enhanced nuclear safety.

M&S technology is a mainstay in the nuclear industry. It informs consequential nuclear power operational and safety decisions. The slow evolution of commercial nuclear technology and its strong dependence on M&S are driven by the industry's limited ability to perform frequent full-scale irradiated experiments due to cost, safety and feasibility, and economic uncertainties. Even industry's advanced light water reactors (e.g., ESBWR, AP1000, EPR, SMR) rely on the current nuclear industry M&S technology, which, though continuously improved and central to the industry's evolution, has not sufficiently capitalized on the benefits that more precise predictive simulation and fundamental understanding offer. Opportunities for reduced uncertainties in design and operating margins, as well as operating cost reductions and plant lifetime extension, are lost due to the lack of technology progression and leadership in the industry's M&S.

CASL's mission is to recapture the benefits of leadership in M&S for nuclear technology by providing coupled, high fidelity, usable capabilities needed to address light water reactor (LWR) operational and safety performance-defining phenomena. CASL's unique partnership of government, academia, and industry possesses unparalleled collective institutional knowledge, nuclear science and engineering talent, computational science leadership, and LWR design and regulatory accomplishments. CASL has several key elements: clear deliverables and products that solve industry issues and are driven by a well-defined yet dynamic plan for executing on deliverables; a strategy of delivering prototype products early and often; defined customers and users, with "industry pull" ensured by an Industry Council with over 20 members from the nuclear en-


CASL partners


CASL Organization

ergy and M&S communities; regular engagement with all levels of the U.S. Nuclear Regulatory Commission (NRC), from the research branch to the Commissioners; peer (equal) private-public partnership in management, leadership, and execution under one "virtual" roof; a lead institution (ORNL) with resource allocation authority and responsibility; an independent Science Council to review and advise on quality and relevance of its science and technology (S&T); and a Board of Directors providing oversight and advice on management, plan, and S&T strategy—chaired during its first two years by Ernest Moniz, current Secretary of Energy, and at present chaired by Dale Klein, former Chairman of the NRC.

At the end of Phase 2 (2019), CASL will have developed, assessed, applied, and broadly deployed a comprehensive collection of M&S technologies—in one integrated virtual environment for reactor applications (VERA)—capable of addressing many current and emerging challenges and opportunities for the nuclear industry. With more detailed analyses now possible due to advances in HPC, science-based M&S models will support enhanced understanding for improved designs and materials. Proactive extensions of VERA to PWRs, BWRs, and iPWRs will have been realized and deployments to nuclear vendors and utilities as well as the M&S and HPC communities will have taken place. Through these applications and deployments, the CASL technology will demonstrate its capability to improve the cost-effectiveness of nuclear energy generation via design efficiencies, decreased design-iteration cycle time, and enhanced engineering creativity. By early adoption and tech transfer to the nuclear energy community via Test Stand and broad releases, CASL M&S technology—able to execute on computer platforms ranging from small computing clusters to DOE's largest advanced future exascale-class platforms—is envisioned as a transformative technology leading and informing nuclear energy industry capability.

The strategic selection of Phase 1 and Phase 2 challenge problems (CPs) provide motivation not only for capability development and demonstration, but also for industry interest and adoption of VERA. The value of CASL's capabilities for simulation of the CPs can be measured in part by past and current industry investments to address them (through resolution or avoidance): hundreds of millions of dollars to date and tens of millions of dollars annually. In Phase 1 CASL developed M&S capability for simulation of the in-vessel performance of PWRs as motivated by the selected CPs: CRUD, grid-to-rod-fretting, pellet cladding interactions, departure from nucleate boiling, fuel cladding integrity during a loss of coolant accident, and a reactivity insertion accident. The basic formulation of VERA developed in Phase 1 provides for current applicability and the flexibility to address yet unknown simulation needs. Thus, in Phase 2, the capability can be efficiently broadened with CPs addressing a range of current LWR designs, including PWRs, BWRs, and iPWRs. Further, deepening of VERA's capabilities allows more range in addressing all operating conditions. The broadening and deepening of CASL's Phase 1 technology provides for pervasive applicability, resulting in used and useful tools providing an expansive return on the DOE investment. A structured, industry-informed process helped define the technical scope and plan for Phase 2. The selection rationale included consideration for other DOE programs addressing non- LWR reactor designs, building upon the capabilities developed in Phase 1, engaging the nuclear industry through the existing and expanded partnership, addressing important current and near-term nuclear energy issues, and the provision for equitable government-industry support. To support the development and deployment of VERA in Phase 2, CASL will further engage the nuclear through an expansion of its industry partnership to include other nuclear fuel and design vendors and utilities.

The strategic vision for CASL in Phase 2 and beyond sees its M&S technology evolving into the nuclear enterprise community model for nuclear reactor and power plant M&S technology. Early adoption and technology transfer to the nuclear energy community throughout Phase 1 and 2 in the form of Test Stands, the post-CASL entity, M&S working group, and broad release of VERA will demonstrate industry acceptance, integration and adaption. Broad engagement of the nuclear community allows CASL to build interest, trust, confidence, and acceptance. CASL will expand its funded industry partnership (beyond its founding industry partnership) to include other nuclear fuel and design vendors and utilities as a required step in expanding the range of applicability of its M&S technology. CASL will continue its Education Program and expand its reach to universities outside of the CASL partnership. CASL will also continue to seek guidance from its Science and Industry Councils. CASL's engagement goal goes beyond building acceptance of CASL-developed M&S capabilities, but strives to build an appreciation for the benefits to be derived from the use of and reliance upon predictive M&S capabilities. Sustainability of CASL-developed technologies will be assured through a proactive Phase 2 plan to establish a stable and long-lived post-CASL entity—an innovation center for nuclear energy M&S and a vibrant M&S working group—to assume and carry on CASL's technology by bringing together and engaging leading experts from academia, federal agencies, and industry. This supports CASL's vision to predict, with confidence, the performance of nuclear reactors through comprehensive, science-based M&S technology that is deployed and applied broadly throughout the nuclear energy industry to enhance safety, reliability, and economics.

CASL's Phase 1 execution has generated tangible products and innovations that support the four performance metrics in the DOE NE Energy Innovation Hub Renewal Plan: (1) measurable progress and delivery of milestones (541 to date) and the commensurate ability of VERA to demonstrably address nuclear reactor phenomena; (2) proactive response to findings and recommendations provided by three prior annual DOE NE reviews of CASL; (3) substantial scientific productivity, measured in part by high-quality, peer-reviewed publications, technical and milestone reports, invited presentations (over 1300 and counting); and (4) early and aggressive deployment of its M&S technology (VERA) to the nuclear energy and broader science and technology communities. A limited release of VERA is now available and three VERA Test Stands have been deployed (with more planned): at Westinghouse for AP1000 PWR startup analysis; at EPRI for fuel performance analysis, and at TVA for CFD-based analyses of flows in the reactor's lower plenum. The executed milestone plan has differed somewhat from that proposed plan that was not specific enough to meet the objectives and expected deliverables. The executed path evolved as CASL technology was being developed, with new avenues of research opening as the team discovered novel solutions and overcame roadblocks. The executed milestones provided focused direction that resulted in better requirements-based outcomes.

## References

Duderstadt, James J. and Chihiro Kikuchi, *Nuclear Power: Technology on Trial* (University of Michigan Press, Ann Arbor, 1979)

Duderstadt, James J., Testimony to Congress on the Nuclear Energy Research Advisory Committee, U.S.

Department of Energy, 2000

Vest, Charles M. (Chair), Critical Choices: Science, Energy, and Security, Final Report of Secretary of Energy Advisory Board, U.S. Department of Energy, Washington, D.C., 2003

National Laboratories and Universities, Report of a Workshop, National Research Council, 2003

Duderstadt, James J., "Global Sustainability: Timescales, Magnitudes, Paradigms, and Black Swans", VIII Glion Colloquium (Economica, Paris, 2011)

CASL Program Plan (Coalition on Advanced Simulation of Light Water Reactors), U.S. Department of Energy, 2012

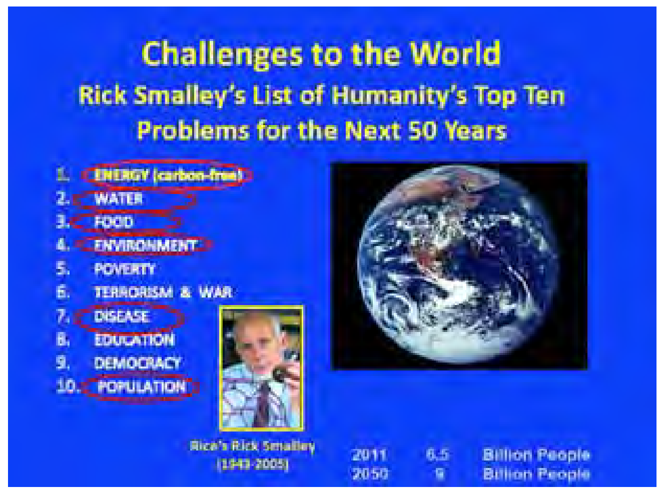
CASL Program Plan Phase 2 (Coalition on Advanced Simulation of Light Water Reactors), U.S. Department of Energy, 2014

# Chapter 11

# Global Sustainability

History has always been characterized by periods of both change and stability–war and peace, intellectual progress and decadence, economic prosperity and contraction_but today the pace and magnitude of such changes have intensified, driven by the powerful forces of globalization, changing demographics, rapidly evolving technologies and the expanded flows of information, technology, capital, goods, services and people worldwide. Economies are pushing the human exploitation of the Earth's environment to the limits; the military capacity of the great powers could destroy the world population many times over, business corporations have become so large that they can influence national policies, the financial sector has become so complex and unstable that it has the capacity to trigger global economic catastrophes in an instant, and corrupted regimes leading to failed states still appear in all parts of the world. Many believe that the impact of human activities, ever more intense, globally distributed and interconnected, threatens the very sustainability of humankind on Earth, at least in terms that we currently understand and enjoy.

While the fruits of development and modernity are indisputable, the negative consequences of these recent developments appear to be increasingly serious. For example, there is compelling evidence that the growing population and invasive activities of humankind are now altering the fragile balance of our planet. The concerns are multiplying and intensifying in severity: the destruction of forests, wetlands and other natural habitats by human activities, the extinction of millions of species and the loss of biodiversity; the buildup of greenhouse gases and their impact on global climates; the pollution of our air, water and land. We must find new ways to provide for a human society that presently has outstripped the limits of global sustainability.

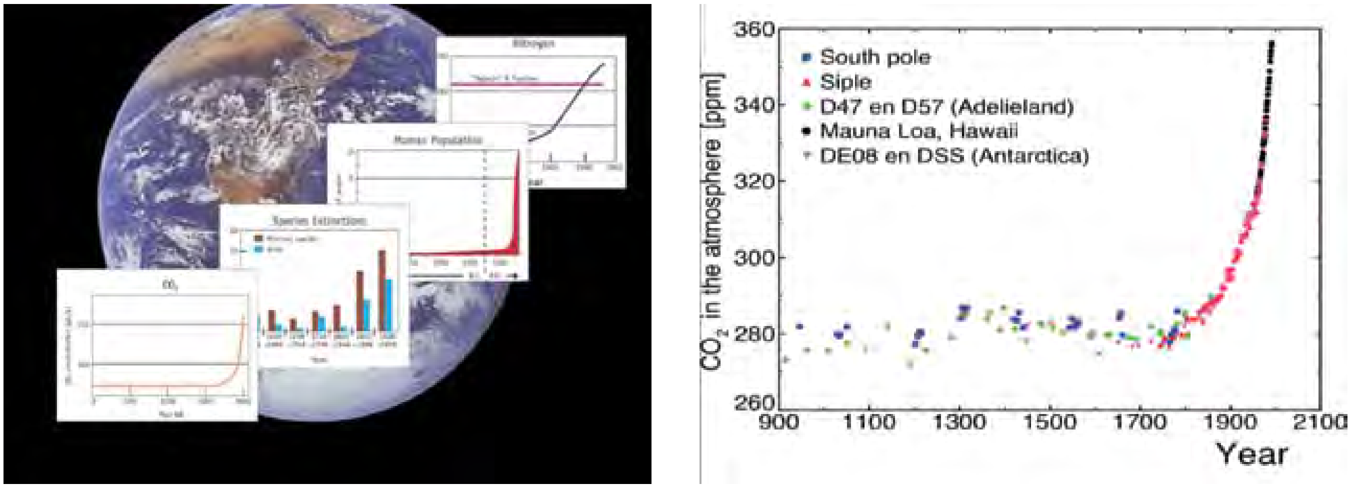



Nobel Laureate Smalley's list of challenges

## National Science Foundation Roundtable on Global Climate Change

In 2010 a roundtable comprised of physical, engineering, and social scientists with considerable experience in higher education and the dynamics of public policy was asked to consider the challenge presented by the growing evidence of global climate change. Concerned that the nation's scientific and policy expertise is not being used either efficiently or expeditiously in the search for a sustainable future, the group came together to seek solutions that can actually be implemented rather than new alarms that need to be sounded. After extensive discussions, they arrived at the statement below:

Amid the controversy that surrounds global warming, it is the question almost never asked: "When the political will has finally been summoned and the necessary funds appropriated, will the nation have the




Scientific measurements suggest a direct correlation between global climate and $CO_2$ concentration.

scientific and technical know-how, the policy smarts, and the educational commitment to meet the challenge ahead?" The answer at the present time is certainly no. Too much of our current knowledge about climate change is sequestered in discrete fields of study, and too little progress has occurred to integrate existing knowledge, implement solutions, or explore what remains unknown or poorly understood.

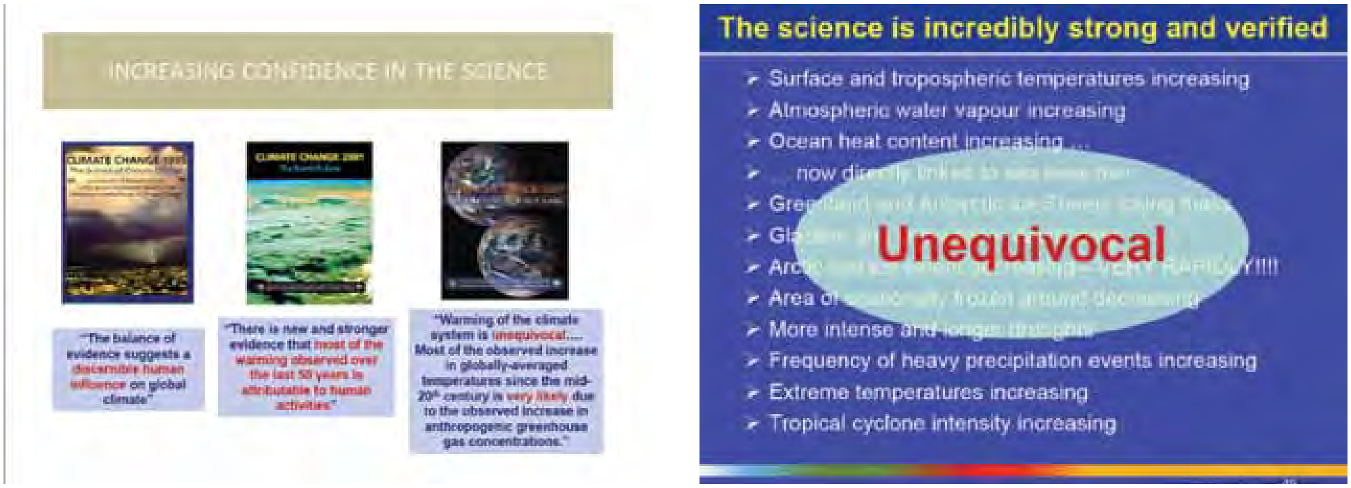
To extricate the nation and the world from this dilemma, we believe—indeed proclaim—that both the research community and the federal agencies that fund climate-related research must rethink their approach to this complex problem. Tackling the embedded issues of climate change and sustainable development requires programs of research and education that are much more open and collaborative. Major steps are needed to convey more effectively the knowledge that currently exists and to develop new knowledge offering solutions to questions still unanswered.

The threats of climate change cannot be allayed either by scientific research or social policy alone. What is required is an integrated community of experts and expertise that is prepared to work together and to work differently. Put bluntly, responding to climate change will require a global community of experts more willing to gamble on new projects that do not promise the discrete, often disconnected discoveries that are the sine qua non of an academic career. What are needed are research and education programs that are more open and collaborative as well as interconnected. That old maxim that the world has problems while universities have departments cannot continue to hold sway.

Like the academic research enterprise that it supports, the often-tangled network of federal agencies, departments, and bureaus responsible for sponsoring climate change research must become a more unified force in support of expanded climate knowledge. Building and conveying to future generations a knowledge base that integrates the products of different academic disciplines and analytic perspectives will require a major retrofit of existing institutions within the federal government—a reframing of agencies to yield greater nimbleness and an increased ability to work together in support of common purposes. There must be an end to bureaucratic silos, to negotiated solutions which are the antithesis of working together, and to the making of the small, almost assured bets that have come to characterize the awarding of federally funded research grants and contracts.

What we face together, and what our children will inevitably face, is a continuing process of mitigation and adaptation focused on making the world less hot and more inhabitable in the future. A major step in meeting the challenge is to establish strong collaborations among researchers, practitioners, and policy-makers who possess a wide range of expertise so that the vast knowledge base that already exists—and the future expansion of that knowledge base—yields the most effective, rapid, and beneficial responses to climate change.

Beyond this step, what is needed is a set of tools and strategies that will reduce vulnerabilities to climate disruption and build the globe's resilience to future chal-




There is overwhelming confidence in both the presence and cause of global warming.

lenges—in effect a Climate Change Toolbox. One step in filling this Toolbox is to launch a more intensive basic research effort to develop the underlying scientific knowledge characterizing climate change. In addition to basic research, the best way to fill a Climate Change Toolbox is to mount a limited number of large-scale and strategically coordinated demonstration projects yielding a broader, better integrated, and more coherent knowledge base, including implementation strategies and practices designed to achieve shared climate goals.

The programmatic investments we urge the nation to consider are of three kinds:

Tools in Support of Policy Development
and Application

• Accelerate the deployment of instruments, models, and techniques for monitoring the health of planet earth—akin to a physical exam, though the measurements would be continuous in real time, and they would track a multitude of climate variations, including such vital signs as water availability and quality, food production, and carbon accumulation. Just as important, such instruments must monitor the health and well-being of the people and societies who inhabit the earth.

• Enhance the capability for massive global modeling and simulations, yielding a combined physical and social earth system model to diagnose and explain causes for observed changes, to project future states of the planet under different developmental scenarios, and to identify scenarios that offer greatest promise for sustainability to inform policy decisions at international, national, and local levels.

Tools from Technology Demonstration Projects

• Make use of the Department of Energy's advanced energy technology development programs—for example, carbon sequestration, biofuels, Generation IV nuclear reactors, smart electrical grids—to identify the critical path and missing knowledge necessary for technology development and deployment, and to drive the necessary scientific and engineering research programs across multiple federal agencies.

Tools for Education and Outreach

• Develop community research and demonstration projects that focus on influencing human culture and behaviors in ways that moderate energy use and resource consumption and support the use of information for adaptation and risk management.

• Develop and implement new curricula and approaches to teaching in K-12 and higher education institutions that provide students with a better understanding of the complex relationships between environmental, economic, and social systems—and that engage both the current workforce and future generations in solving climate problems that threaten the achievement of global well-being.

In the search for a way forward, commentators as

Global Sustainabiity Op-Ed

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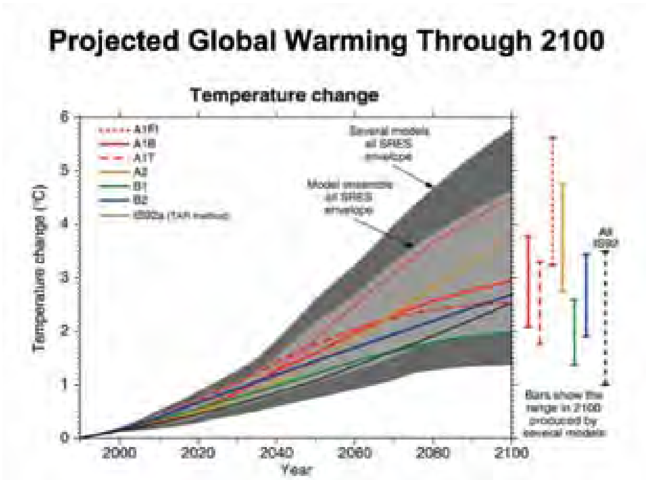



Of most immediate concern is global warming.
well as experts often ask, "What major governmental efforts of the past might serve as models for what needs to be done in the future?" The most compelling example comes from the nineteenth century and the development of land-grant universities in the United States, including agricultural and industrial experiment stations and cooperative extension programs. The success of the Land Grant Acts through the nineteenth and early twentieth centuries attests to the level of scientific, engineering, policy, and educational integration we believe is essential to responding to the challenge of global warming today. What is required is a commitment built on the efforts of the many as opposed to the few—to produce a coherent knowledge base focusing on what is certainly this century's most compelling issue. A climate response program should be funded at a level comparable to other national research priorities of similar urgency such as public health, space, and national defense.

It is time to make more effective use of the knowledge that currently exists, and way past time for smart-thinking investments to be made into better understanding, communicating, and teaching how to respond to the consequences of climate change, as a nation and as a planet.

## Glion Colloquium on Global Sustainability

We live in a time of great change, an increasingly global society, driven by the exponential growth of new knowledge and knitted together by rapidly evolving information and communication technologies. It is a time of challenge and contradiction, as an ever-increasing human population and invasive activities of humankind are now altering the fragile balance of our planet. The concerns are both multiplying in number and intensifying in severity: the destruction of forests, wetlands, and other natural habitats by human activities leading to the extinction of millions of biological species and the loss of biodiversity; the buildup of greenhouse gases such as carbon dioxide and their possible impact on global climates; the pollution of our air, water, and land. A global, knowledge-driven economy places a new premium on technological workforce skills as governments place increasing confidence in market forces to reflect public priorities despite the evidence that they have become increasingly unstable. Shifting geopolitical tensions are driven by the great disparity in wealth and power about the globe, manifested in the current threat to homeland security by terrorism. We are challenged to find new ways to provide for a human society that presently has outstripped the limits of global sustainability.

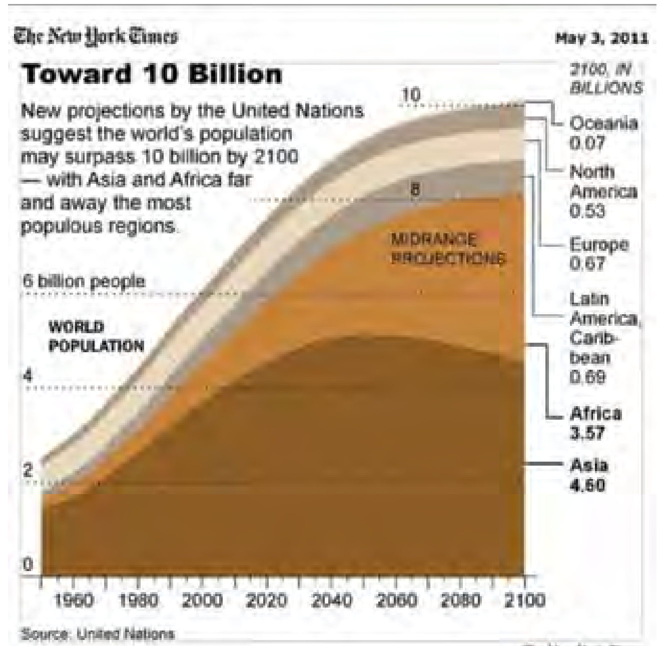
### Some Puzzles

There is ample evidence that the world's climate is changing–and quite rapidly in fact, e.g., the shrinking


...threaten humankind's very existence on Planet Earth

of the Artic ice cap, the melting of glaciers around the world, shifting climates, and more intense storms. Furthermore, the fact that the only things that has changed in a massive way over the last thousand years are the doubling of carbon-dioxide concentrations in the atmosphere produced by the burning of fossil fuels and land-use practices. This strongly suggests this climate change is due to the activities of humankind. The increasing confidence on the part of the vast majority of the scientific community that the activities of humankind are changing the climate of the planet is illustrated by the most recent conclusion of the International Panel on Climate Change: "Warming of the climate system is unequivocal…Most of the observed increase in globally-averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations" (IPCC, 2007). Yet, not only have we made rather feeble attempts to address this, but a substantial part of our population denies the reality of both climate change and human impact.

It is also puzzling that despite the growing evidence that our current energy infrastructure based largely on fossil fuels is no longer sustainable, whether because of limited reserves of oil and gas, the rising costs driven by the imbalance between supply and demand, or environmental impact, we continue on with business as usual–drilling more wells, fracturing more shale deposits for gas, building more coal-fired power plants, and producing more gasoline-guzzling automobiles. Of course, we do hear suggestions that perhaps renew-




Projected global population growth...

ables such as wind or solar power are the answer if only we would just invest in them–although another carbon-free technology, nuclear power, is rarely mentioned as an option.

The past several years has also clearly established the vulnerability of our financial markets, dependent as they are on poorly understood instruments such as derivatives and credit default swaps, guided by abstract theories developed by renegade theoretical physicists, driven by the insatiable greed of traders and gigantic banks, and linked tightly together through computers and networks into highly unstable, nonlinear, and poorly understood systems. Yet, despite the loss of many trillions of dollars and the livelihood of millions of people as these systems collapsed in 2008, pulling down our economies with them, we seem unwilling to take steps to regulate these dangerously unstable markets or discipline those who have made billions from speculative activities. Any engineer could warn that removing constraints (e.g., friction) from an intrinsically unstable system will lead to catastrophe!

Finally, I remain puzzled by how our society views the great tragedy this past year in Japan, hit by a massive tsunami triggered by one of the largest earthquakes in history. Although this natural disaster has destroyed cities and claimed tens of thousands of lives, we instead seem more concerned by the impact the tsunami caused to a 40-year old nuclear power plant, that while seriously damaged, has yet to have a measureable impact on public health, although it seems likely to have thrown seriously off course the global effort to expand nuclear power as the only currently viable major source of carbon-free electricity generation.

Of course, there are a lot of explanations to these puzzles. To be sure, people tend to believe what they want to believe. They tend to seek simple solutions to complex problems such as global climate change. So too, greed can be a very powerful destabilizing force, and the wrong incentives can stimulate taking excessive risks, whether in financial markets or the design of complex technology (e.g., BP's deepwater drilling). There are also problems in the way that experts describe these issues to the lay public (Bierbaum, 2011). Of course, it is not surprising that people do not believe what scientists try to tell them. Climate change can be both complicated and counterintuitive, for example, explaining why global warming could lead to major snowstorms. Furthermore, the scientific community can appear arrogant and cavalier at times (e.g., the "Climategate" scandal that led to cries of conspiracy and hoax). But to disregard Mother Nature is another matter.

We should have learned the dangers of benign neglect from a 20th century characterized by two world wars, the threat of nuclear holocaust, the impact of global pandemics (e.g., the influenza pandemic of 1918), the havoc caused by dictators and failed states, and the list goes on. The forces we face today are somewhat different, but no less threatening and challenging. Our current inability to generate sufficient concern and action to address the challenge of global sustainability may suggest that something more fundamental may be involved: the difficulty we have in comprehending the timescales, magnitudes, and paradigm shifts characterizing the challenges threatening global sustainability. There is one more characteristic that complicates this even further: the degree to which our world is being reshaped by "Black Swan" events (a term to be explained later).

## Timescales

We usually think in terms of the timescales characterizing our own experiences. For example, businesses tend to function on timescales determined by quarterly earnings statements–little wonder here, since this is how Wall Street estimates the value of their stock. Public policy evolves on timescales of election cycles, in the U.S. typically two-year cycles corresponding to state and federal elections. (Of course, dictatorships tend to function on timescales determined by the lifetimes of their leaders, as vividly being demonstrated today in the Middle East and Africa.) We tend to think of natural phenomena, such as climate change or biological evolution operating on very long timescales, thousands or even millions of years. But all of this is changing, with serious implications for global sustainability.

As we have noted, evidence of global warming is now incontrovertible–increasing global surface and air temperatures, receding glaciers and polar ice caps, rising sea levels, and increasingly powerful weather disruptions–all confirm that unless the utilization of fossil fuels is sharply curtailed, humankind could be seriously threatened. There are several timescale issues here. In the near term (meaning decades), if the current rate of growth of fossil fuel combustion continues, atmospheric carbon dioxide concentrations that have been in the range of 200 to 300 ppm by volume for 400,000 years and have already increased to current levels of 390 ppm are projected to rise even further to 550 ppm by 2050 (Lewis, 2007). Although human adaptation could probably occur at this level, it would be in a radically different world in which biodiversity would be seriously threatened (e.g., the coral reefs would die), and the seas would rise by 1-2 meters, flooding much of the world's lowlands. A world that continued to be primarily dependent upon fossil fuels could see carbon dioxide concentrations of 800 ppm by 2100, approaching the point at which even more serious events, such as the melting of the ice masses in Greenland or Antarctica could raise sea levels by several meters, or the methane in the Artic tundra could be released, triggering a possible runaway greenhouse process (think Venus).

Unfortunately, the lifetime of carbon dioxide in the atmosphere is very long. Even if current emissions could be eliminated, it would take thousands of years for concentrations to decay back to acceptable levels. Hence, we have only a few decades to address this problem before reaching the point of no return. As Nate

Lewis of Caltech suggests, we are currently conducting the biggest experiment with Planet Earth that humankind has ever performed by tinkering with our climate, "We get to do this experiment exactly once. And there is no tomorrow, because in 20 years that experiment will be cast in stone. Within the next 20 years, we either solve this problem or the world will never be the same!" (Lewis, 2007)

However, the success of this "experiment" depends on facing up to a second challenge: Our current energy infrastructure, heavily dependent upon fossil fuels, is unsustainable, particularly within the context of global climate change, but also because of possible mismatch between supply and demand (particularly for oil that may already have reached a peak in production). Clearly, if nations are to meet their responsibilities for national security, economic prosperity, and environmental impact, the world must move rapidly and aggressively to address the need for a sustainable energy future. Yet, time is not on our side.

The energy industry and its markets are the world's most massive, most indispensable, most expensive, and most complex, in which major technological change occurs on a timescale measured in decades, not years (Smil, 2010). As Lewis points out, new energy sources, such as renewable energy technologies, are a "substitution" product that require first, fostering a marketplace where the technology can come to scale and compete (Lewis, 2007). Hence, even with strong government involvement in developing new energy technologies and intervention in the marketplace, it will take decades for sustainable technologies to have major impact. Yet, the clock continues to tick, carbon dioxide levels continue to rise, and the climate continues to change.

As yet another example of shifting timescales, we might consider the recent experiences of our financial markets, now not only coupled together electronically about the world, but with supercomputers instantaneously solving the complex equations developed by mathematicians and physicists ("quants") to determine key trading decisions, rather than the more deliberate decisions of analysts and brokers on the trading floor. Here the timescale issue involves new technologies driving such profound changes in our world such as information technology are characterized by an exponential pace of evolution in which characteristics such as computing speed, memory, and network transmission speeds for a given price increase by a factor of 100 to 1000 every decade. Scientists and engineers today believe that the exponential evolution of these technologies is not only likely to continue for the conceivable future, but, in fact, the pace may be accelerating

Magnitudes

In sharp contrast to the rapidly contracting timescales characterizing exponential technologies such as computers and networks, other activities critical for determining global sustainability are more constrained by their scale or magnitude. For example, producing energy, distributing it to society, and transforming it into useful functions requires a massive and expensive infrastructure. The scale of the necessary transformation of our energy infrastructure is immense. It is estimated that over $16 trillion in capital investments over the next two decades will be necessary just to expand energy supply to meet growing global energy demand driven by the energy needs of developing economies (compared to a global GDP of $44 trillion and a U.S. GDP of $14 trillion). Put another way, to track the projected growth in electricity demand, the world would need to bring online a new 1,000 MWe powerplant every day for the next 20 years! (Lewis, 2007) Moreover, the International Energy Agency estimates that to keep carbon dioxide emissions below 450 ppm (and global temperature increases below 2 degrees C) would require an investment of $12 trillion in low-carbon energy technologies and energy efficiency by 2030 (Smil, 2011).

Yet, there is another important magnitude issue here. Unfortunately, most renewable energy sources such as wind, biofuels, and solar, are very dilute. MacKay demonstrates this by comparing the land mass requirements for each energy source by comparing power densities: windpower: 2.5 watts/m2; biofuels: 1.5 watts/m2 (in Brazil); solar: 6 watts/m2 to meet the needs of the UK population, 1.5 watts/m2, concluding that a renewable energy economy would take most of the UK land mass. He goes on to note that to meet the needs of Europe with solar energy would take a region of solar collectors about the size of Germany (MacKay, 2009).

A second example of just how magnitudes influence global sustainability is demographics. The United

Nations has recently updated its projection of world population growth to 9.3 billion by 2050 and to over 10 billion by 2100 (United Nations, 2011). This raises the logical question: Can we sustain a population of such magnitude on Spaceship Earth? In fact, the basic premise of the free market system, which relies on steady growth in productivity and profits, based in part on similar growth in consumption and population, must be challenged by the very serious problems that will result from a ballooning global population, such as energy shortages, global climate change, and dwindling resources. The stark fact is that our planet simply cannot sustain a projected population of 10 billion with a lifestyle characterizing the United States and other developed nations with consumption-dominated economies.

To be sure, there are some signs of optimism here: a slowing population growth in much of the world (although not in Africa), the degree to which extreme poverty appears to be receding, both as a percentage of the population and in absolute numbers, and the rapid economic growth of developing economies in Asia and Latin America. During the past several decades, technological advances, such as the "green revolution" in agriculture, have lifted a substantial portion of the world's population from the ravages of extreme poverty. In fact, some nations once burdened by overpopulation and widespread poverty, such as India and China, now are viewed as economic leaders in the 21st century.

Yet today, there remain substantial and widening differences in the prosperity and quality of life of developed, developing, and underdeveloped regions; between the North and South Hemisphere; and within many nations (including the deplorable level of poverty tolerated in my own country, the richest on the planet). It is estimated that roughly one-sixth of the world's population, 1.5 billion people, still live in extreme poverty–defined by Jeffrey Sachs as "being so poor you could die tomorrow", mostly in sub-Saharan Africa, parts of South America, and much of central Asia. Sachs states this in even stronger terms, "More than 8 million people around the world die each year because they are too poor to stay alive. Malaria, tuberculosis, AIDS, diarrhea, respiratory inflections, and other diseases prey on bodies weakened by chronic hunger, claiming more than 20,000 lives each day" (Sachs, 2005).

Paradigm Shifts

Looking back over history, one can identify certain abrupt changes, discontinuities in the nature, the fabric, of our civilization. Clearly, we live in just such a time of very rapid and profound social transformation, a transition from a century in which the dominant human activities involved the exploitation of natural resources to manufacture and transport goods to one in which communication technology has become paramount, from economies based upon cars, planes, and trains to one dependent upon computers and networks. We are shifting from an emphasis on creating and transporting physical objects such as materials and energy to knowledge itself; from atoms to bits; from societies based upon the geopolitics of the nation-state to those based on diverse cultures and local traditions; and from a dependence on government policy to an increasing confidence in the marketplace to establish public priorities. A radically new system for creating wealth has evolved that depends upon the creation and application of new knowledge and hence, upon educated people and their ideas and institutions such as research universities, corporate R&D laboratories, and national research agencies where advanced education, research, innovation, and entrepreneurial energy are found (Drucker, 1995).

Whether through travel and communication, through the arts and culture, or through the internationalization of commerce, capital, and labor, or our interconnectedness through common environmental concerns, the globally community is becoming increasingly integrated. The liberalization of trade and investment policies, along with the revolution in information and communications technologies, has vastly increased the flow of capital, goods, and services, dramatically changing the world and our place in it (National Intelligence Council, 2005). Today, globalization determines not only regional prosperity but also national and homeland security. Our economies and our companies are international, spanning the globe and interdependent with other nations and other peoples.

It is also becoming increasingly clear that we are approaching an inflection point in the potential of information and communications technologies to radically transform knowledge work. When we think of digitally mediated human interactions, we generally think of the awkwardness of e-mail or televideo conferences or the instantaneous interaction with text messaging or video Skype. More recently, we have seen the power of social networking through software, such as Facebook and Twitter, to link together millions of people, not only building new communities but empowering social movements, such as the Arab Spring of 2011.

Beyond acknowledging the extraordinary and unrelenting pace of evolution of such technologies, it is equally important to recognize their disruptive nature. The impact on social institutions such as corporations, governments, and learning institutions is profound, rapid, and quite unpredictable. As Clayton Christensen explains in The Innovators Dilemma, while many of these new technologies are, at first, inadequate to displace today's technology in existing applications, they later explosively displace the application as they enable a new way of satisfying the underlying need (Christensen, 1997). If change is gradual, there will be time to adapt gracefully, but that is not the history of disruptive technologies.

Black Swans

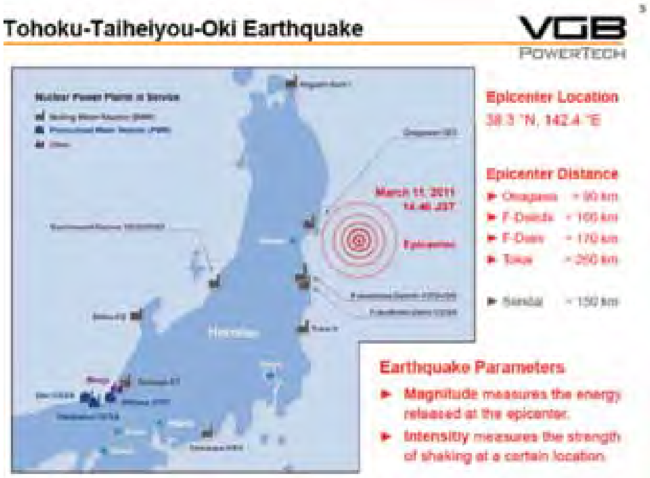
During the past year, the world has been rocked by unanticipated events such as the failure of the BP Deepwater Horizon drilling platform in the Gulf of Mexico and the Fukushima Daiichi nuclear power plant accident resulting from a massive tsunami hitting the coast of Japan. It seems appropriate here to adopt the terminology of "black swan" introduced by Nassim Taleb to refer to an event that is "outside of regular expectations; carries an extreme impact; and makes us concoct explanations for its occurrence after the fact, making it explainable and predictable" (Taleb, 2007). The name arises from a 16th century conjecture that since all swans were presumed at that time to be white, and black swans were then presumed not to exist, if one were found it would disprove the impossibility of this presumption. (Actually, black swans did exist, but in Australia. Today they have also been imported into Europe.)

Taleb suggests that Black Swan events are increasing as our world becomes more complex and integrated, and today they may be more important than ordinary events in determining issues like global sustainability. "Black Swan logic makes what you don't know far more relevant that what you do know. Since Black Swans are unpredictable, we need to adjust to their existence (rather than naively trying to predict them). We need to consider the extremes, improbable or not, particularly if they carry an extraordinary cumulative effect. We need to invest more in prevention than in treatment." (Taleb, 2007)

Are all European swans white?

Not these I photographed in France!

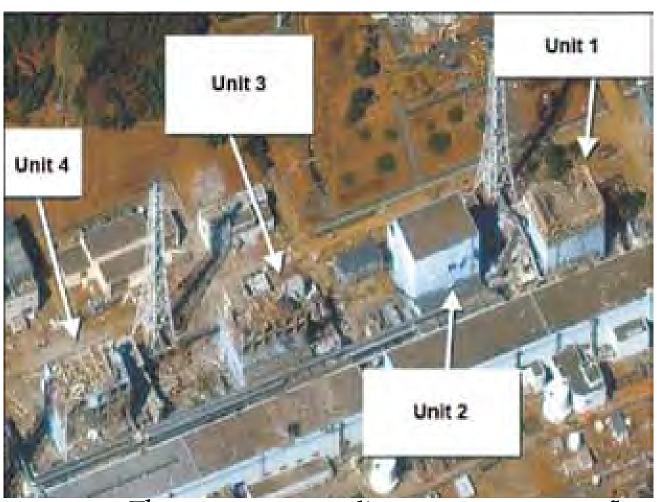
The tsunami-driven accident at the Fukushima Daiichi nuclear plant in Japan was just such an event. Here the driving cause was a gigantic tsunami, over 35 m in height, created by a massive 9.0 quake that was several times the size of the maximum event deemed possible in the design of the Fukushima nuclear power plant. So what was the consequence? To be sure, there was





A massive 9.0 earthquake occurred off the coast of Japan in 2011


The size of the resulting tsunami was far above the seawall design of the Fukushima nuclear power station.




The emergency cooling generators were flooded leading to hydrogen explosions in the plant.

The flooding and subsequent meltdown of the Fukushima reactors was a "black swan" event.

catastrophic damage to the plant as it lost all electrical power and cooling for an extended period of time, allowing the fuel to overheat and partially melt and releasing radioactivity to the environment. Yet, the impact on public health has been minimal (at least to this point). As noted by The Economist, despite being hit by a natural disaster of biblical proportions causing immense damage to the plant, there was little damage to the environment beyond the plant's immediate vicinity or to public health (Economist, 2011).

In fact, the most serious impact is likely to be the erosion of public confidence in nuclear power, ironically a carbon-free technology that today provides 14% of the world's electricity with a 50-year safety record in which only one nuclear plant accident has occurred with a major consequence for public safety (Chernobyl). As observed by The Economist, "Fear and uncertainty spread faster and farther than any nuclear fallout" (Economist, 2011).

A second example is the failure of the BP Deepwater Horizon drilling platform in the Gulf of Mexico last year. Unlike Fukushima, the BP accident has caused many deaths and vast damage to the Gulf environment. And unlike the Japan incident, which was triggered by a natural disaster of biblical proportions, the BP Deepwater Horizon accident was clearly the result of human error–inadequate design, operation, and response. Yet, it was also a Black Swan event, thought to be impossible, of major consequence, yet clearly understandable and explainable in retrospect.

Clearly, such Black Swan events threaten global sustainability. The impact of major environmental events, such as the melting of the Arctic tundra and release of massive amounts of methane could trigger runaway global greenhouse instability. The rapid melting of the ice sheets in Greenland or the Antarctic could raise sea levels by several meters inundating coastal cities and populations. In fact, one can imagine Black Swan events that today seem of such remote possibility that they currently exist only in science fiction. Clearly, phenomena such as machine consciousness, contact by extraterrestrial intelligence, or cosmic extinction from a wandering asteroid are Black Swan "possibilities" for our civilization, but just as clearly they should neither dominate our attention nor our near-term actions. Indeed, the most effective way to prepare for such unanticipated events is to make certain that our descendants are equipped with education, wisdom, and foresight of the highest possible quality.

## The Roles of Universities in Addressing the Challenges of Global Sustainability

In summary then, the forces driving change in our world–anthropogenic driven changes in our environment (climate change, declining biodiversity), changing demographics (aging populations, migration, increasing ethnic diversity), environmental impact (climate change, biodiversity), globalization (economic, geopolitical, cultural), and disruptive technologies (info-bio-nano technologies)–are likely to require very major changes in post-secondary education as a global knowledge economy demands a new level of knowledge, skills, and abilities on the part of our citizens. It will also require research universities capable of discovering new knowledge, to develop innovative applications of these discoveries, transfer them into society through entrepreneurial activities, and educate those capable of working at the frontiers of knowledge and the professions.

Yet, there are broader responsibilities beyond national interests–particularly for developed nations–in an ever more interconnected and interdependent world. Global challenges, such as crippling poverty, health pandemics, terrorism, and global climate change, require both commitment and leadership. So, what are the implications of these shifting timescales, magnitudes, paradigms, and emerging Black Swans characterizing a rapidly changing world for the future of the university? To be sure, the traditional roles of the university will continue to be important. But our educational programs must be characterized by both the depth and breadth to prepare our graduates for a world of constant and ever accelerating change. For example, an increasingly complex and rapidly changing world requires "T" graduates, capable of both depth in a particular discipline as well as intellectual breadth (Donofrio, 2009). Our research activities must evolve to develop the intellectual tools to address the challenges of a world increasingly threatened by humankind. And we must become more engaged with society beyond our campus to shape both public understanding and action. Whether motivated by the economic desire to create new markets or the more altruistic motives of human welfare, our universities have a responsibility to address global issues. Globalization requires thoughtful, interdependent and globally identified citizens. Educational institutions must think more concertedly about their role in promoting both individual and civic development.

But we must also recognize that a changing world demands a change in the university itself. Social computing will empower and extend learning communities beyond the constraints of space and time. Open knowledge and education resources will clearly expand enormously the knowledge resources available to our institutions. Immersive environments will enable the mastery of not only simply conventional academic knowledge, but as well tacit knowledge, enabling our students to learn not only how "to know" and "to do", but actually how "to be"– whether scholars, professionals, or leaders–but above all, contributing citizens of the emerging global community (Thomas, 2011).

But there is a possibility even beyond these. Imagine what might be possible if all of these elements merge, i.e., Internet-based access to all recorded and then digitized human knowledge, augmented by powerful search engines; open source software, open learning resources, and open learning institutions (open universities); new collaboratively developed tools (Wikipedia II, Web 3.0); immersive environments (World of Warcraft, Second Life); social networking (Facebook, Twitter); and ubiquitous information and communications technology (digital appliances such as smart phones and iPads). In the near future, it could be possible that anyone with even a modest Internet or cellular phone connection will have access to the cyberspace cloud containing all recorded knowledge of our civilization along with ubiquitous learning opportunities and social networking communities throughout the world.

Imagine still further the linking together of billions of people with limitless access to knowledge and learning tools enabled by a rapidly evolving scaffolding of cyberinfrastructure, which increases in power one-hundred to one thousand-fold every decade. This hive-like culture will not only challenge existing social institutions–corporations, universities, nation states–that have depended upon the constraints of space, time, laws, and monopoly but it will also enable the spontaneous emergence of new social structures as yet unimagined. Just think of the early denizens of the Internet such as Google, Wikipedia, Facebook, Twitter …and, unfortunately, Al Qaeda. In fact, we may be on the threshold of the emergence of a new form of civilization, as billions of world citizens interact together, unconstrained by today's monopolies on knowledge or learning opportunities.

Perhaps this, then, is the most compelling vision for the future of knowledge and learning organizations such as the university, no longer constrained by space, time, monopoly, or archaic laws, but rather responsive to the needs of a global, knowledge society and unleashed by technology to empower and serve all of humankind.

## References

Killeen, Timothy, A Declaration on Global Climate Change, Op-Ed, New York Times, 2009

Duderstadt, James J., "Global Sustainability: Timescales, Magnitudes, Paradigms, and Black Swans", VIII Glion Colloquium (Economica, Paris, 2011)

Duderstadt, James J. and Luc Weber, Global Sustainability, VIII Glion Colloquium (Economica, Paris, 2011)

## Chapter 12

# National Commission on the Future of U.S. Higher Education

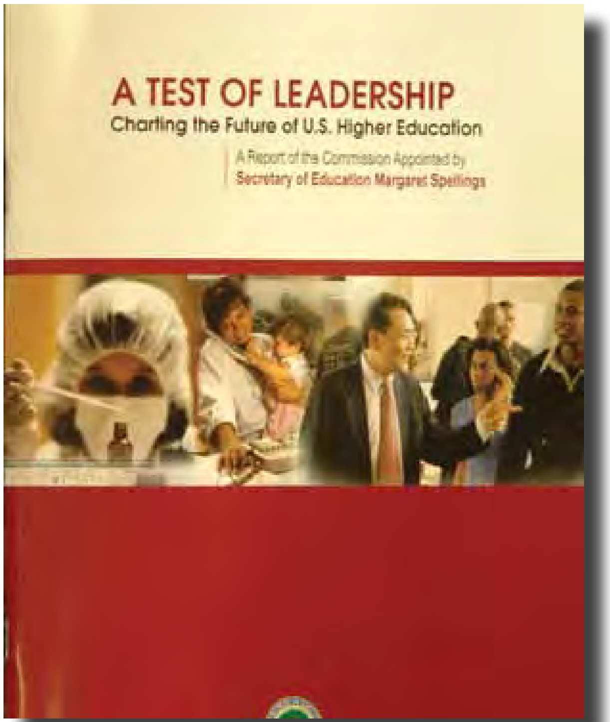
Today the United States faces a crossroads, as a global knowledge economy demands a new level of knowledge, skills, and abilities on the part of our citizens. We have entered an era in which educated people, the knowledge they produce, and the innovation and entrepreneurial skills they possess have become the keys to economic prosperity, public health, national security, and social well-being. Hence the strength, prosperity, and leadership of a nation in a global knowledge economy will demand highly educated citizenry and hence upon a world-class system of postsecondary education. It will also require leading research universities, capable of discovering new knowledge, developing innovative applications of these discoveries, transferring them into society through entrepreneurial activities, to educate those capable of working at the frontiers of knowledge and the professions.

More generally, it is clear that today the United States must demand and be prepared to sustain a world-class system of postsecondary education capable of meeting the changing educational, research, and service needs of the nation. Yet this goal faces many challenges, including an increasing stratification of access to (and success in) quality higher education based on socioeconomic status, questionable achievement of acceptable student learning outcomes (including critical thinking ability, moral reasoning, communication skills, and quantitative literacy), cost containment and productivity, and the ability of institutions to adapt to changes demanded by the emerging knowledge services economy, globalization, rapidly evolving technologies, an increasingly diverse and aging population, and an evolving marketplace characterized by new needs (e.g., lifelong learning), new providers (e.g., for-profit, cyber, and global universities), and new paradigms (e.g., competency-based educational paradigms, distance learning, open educational resources).

It was with these challenges in mind that in 2005 the U.S. Secretary of Education, Margaret Spellings, created a Commission on the Future of Higher Education in America (later known as "The Spellings Commission"). The Commission began with two premises: First the good news: "Whether America's colleges and universities are measured by their sheer number and variety, by the increasingly open access so many citizens enjoy to their campuses, by their crucial role in advancing the frontiers of knowledge through research discoveries, or by the new forms of teaching and learning that they have pioneered to meet students' changing needs, these postsecondary institutions have accomplished much of which they and the nation can be proud."

But it followed this with the bad news: "Despite these achievements, however, the Commission believes U.S. higher education needs to improve in dramatic ways. As we enter the 21st century, it is no slight to the successes of American colleges and universities thus far in our history to note the unfulfilled promise that remains. Our year-long examination of the challenges facing higher education has brought us to the uneasy conclusion that the sector's past attainments have led our nation to unwarranted complacency about its future.

"We have seen ample evidence that some form of postsecondary instruction is increasingly vital to an individual's economic security. What we have learned over the last year makes clear that American higher education has become what, in the business world, would be called a mature enterprise: increasingly risk-averse, at times self-satisfied, and unduly expensive. It is an enterprise that has yet to address the fundamental issues of how academic programs and institutions must be transformed to serve the changing educational needs



Report of the Spellings Commission

of a knowledge economy. It has yet to successfully confront the impact of globalization, rapidly evolving technologies, an increasingly diverse and aging population, and an evolving marketplace characterized by new needs and new paradigms."

In summary, the Commission found ample evidence to suggest two areas of particular concern: social justice and global competitiveness:

Social Justice: For close to a century now, access to higher education has been a principal – some would say the principal – means of achieving social mobility. Much of our nation's inventiveness has been centered in colleges and universities, as has our commitment to a kind of democracy that only an educated and informed citizenry makes possible. Yet today too many Americans just aren't getting the education that they need – and that they deserve.

Global Competitiveness: The world is becoming tougher, more competitive, less forgiving of wasted resources and squandered opportunities. In tomorrow's world a nation's wealth will derive from its capacity to educate, attract, and retain citizens who are to able to work smarter and learn faster – making educational achievement ever more important both for individuals and for society writ large. Yet again numerous recent studies suggest that today's American college students are not really learning what they need to learn. As Derek Bok summarized it, the education provided today by many of our colleges and universities is "not good enough and getting worse."

To address these concerns, the Commission set as its goals the following:

1. A world-class higher-education system that creates new knowledge, contributes to economic prosperity and global competitiveness, and empowers citizens.

2. A system that is accessible to all Americans, throughout their lives.

3. Postsecondary institutions capability of providing high-quality instruction while improving their efficiency in order to be more affordable to the students, taxpayers, and donors who sustain them.

4. A higher-education system that gives Americans the workplace skills they need to adapt to a rapidly changing economy.

5. Postsecondary institutions capable of adapting to a world altered by technology, changing demographics and globalization, in which the higher-education landscape includes new providers and new paradigms, from for-profit universities to distance learning.

For much of its work the Commission held hearings across the nation to hear from many constituencies–students and parents, business and industry, leaders of college and universities, and many others with strong interest or concerns. A series of background papers were prepared by consultants on many topics such as the cost of higher education, student learning outcomes, and student financial aid, while many individuals and organizations provided their own thoughtful analysis. In early spring the commissioners moved into their own deliberations to begin to converge on key findings and possible recommendations.

However, the study suffered a bit of a setback when

Secretary of Education Margaret Spellings

Members of the Spellings Commission

a group of consultants was asked to prepare an early draft of the report of the Commission without adequate consultation. This report, which bore little relation to the views of the commissioners or the hearings that had conducted, for that matter, largely reflected the highly negative and opinionated views of the consultants and unfortunately set higher education on edge when it was released prematurely.

After a minor revolt, in which the commissioners essentially repudiated the consultant draft, the Commission resumed its work and eventually came up with its own findings and recommendations, at least at the 100,000 foot level. Of course, the devil is always in the details, and the final draft of the report represented considerable negotiation and word-smithing. While all of the commissioners supported the final recommendations at the broadest level, each could point to areas of the report where there was still disagreement.

## Findings of the Spellings Commission

In today's knowledge-driven society, higher education has never been more important. America's national capacity for excellence, innovation and leadership in higher education will be central to our ability to sustain economic growth and social cohesiveness. Our colleges and universities will be a key source of the human and intellectual capital needed to increase workforce productivity and growth. They must also continue to be the major route for new generations of Americans to achieve social mobility. The benefits of higher education are significant both for individuals and for the nation as a whole. Over a lifetime, an individual with a bachelor's degree will earn an average of $2.1 million – nearly twice as much as a worker with only a high school diploma. Furthermore, the transformation of the world economy increasingly demands a more highly educated workforce with postsecondary skills and credentials. Ninety percent of the fastest-growing jobs in the new information and service economy will require some postsecondary education.

Too few Americans prepare for, participate in, and complete higher education – especially those underserved and nontraditional groups who make up an ever-greater proportion of the population. The nation will rely on these groups as a major source of new workers as demographic shifts in the U.S. population continue.

The Commission found that access to higher education in the United States is unduly limited by the complex interplay of inadequate preparation, lack of information about college opportunities, and persistent financial barriers. While the proportion of high school graduates who immediately enter college has risen in recent decades, unfortunately, it has largely stalled at around 60 percent since the late 1990s. The national rate of college completion has also remained largely stagnant. Most important, and most worrisome, too many Americans who could benefit from postsecondary education do not continue their studies at all, whether as conventional undergraduates or as adult learners furthering their workplace skills. While there are important actions that can be taken both by colleges and universi-

Members of the Spellings Commission with Secretary of Education Spellings

ties and by their patrons (state and federal government, private support) to improve access at the margin, major gains are not likely without a sustained improvement in secondary education. Dismal high school achievement rates nationwide have barely budged in the last decade. Close to twenty-five percent of all students in public high schools do not graduate – a proportion that rises among low income, rural, and minority students.

We are especially troubled by gaps in college access for low-income Americans and ethnic and racial minorities. Notwithstanding our nation's egalitarian principles, there is ample evidence that qualified young people from families of modest means are far less likely to go to college than their affluent peers with similar qualifications. Only 8% of the bottom quartile will graduate from a four-year institution, compared to 75% of the top quartile. To quote Chuck Vest: "In American higher education today it is better to be dumb and rich than to be smart and poor."

Shortly after our report, the Education Trust, headed by Commissioner Kati Haycock, released a scathing report labeling flagship public research universities as "Engines of Inequality" by "choking off college access and upward mobility for the poor by shifting away from the traditional need-based financial aid to merit-based programs that heavily favor affluent students, thereby abandoning their historical role as engines of social mobility through providing educational opportunities to students from low-income and minority populations." (The words were taken from a NYT editorial condemning this practice.) Nearly 40 percent of today's postsecondary students are self-supported; more than half attend school part-time; almost one-third work full-time; 27 percent have children themselves. But we are not expanding capacity across higher education to meet this demand. Just as dismaying, low-income high school graduates in the top quartile on standardized tests attend college at the same rate as high-income high school graduates in the bottom quartile on the same tests. Only 21 percent of college-qualified low-income students complete bachelor's degrees, compared with 62 percent of high-income students.

Our higher-education financing system is increasingly dysfunctional. State subsidies are declining; tuition is rising; and cost per student is increasing faster than inflation or family income. Affordability is directly affected by a financing system that provides limited incentives for colleges and universities to take aggressive steps to improve institutional efficiency and productivity. Public concern about rising costs may ultimately contribute to the erosion of public confidence in higher education.

There is no issue that worries the American public more about higher education than the soaring cost of attending college. Yet because students and families only pay a portion of the actual cost of higher educa-

Meetings at the Watergate

Meetings of the Spellings Commission

tion, affordability is also an important public policy concern for those who are asked to fund colleges and universities, notably federal and state taxpayers, but also private donors. The rapid increase in the price of a college education, driven in part by cost shifting from tax support to tuition in public institutions, by inefficiency and stagnant productivity gains, and by unbridled competition for the best students, faculty, resources, and reputations, is undermining public confidence in higher education. From 1995 to 2005, average tuition and fees at private four-year colleges and universities rose 36 percent after adjusting for inflation. Over the same period, average tuition and fees rose 51 percent at public four-year institutions and 30 percent at community colleges.

One of the reasons tuition and fees have increased is that state funding has fallen to a 25 year low, dropping to less than 20% of the operating costs of the nation's public colleges and universities, on the average. Although the Commission strongly encouraged states to continue their historic and necessary commitment to the support of public higher education, it realized that this could prove difficult in view of the priorities of an aging baby boomer population which will emphasize health care, retirement, safety from crime, and tax relief rather than education for their tax dollars. The bottom line is that state funding for higher education was not likely to grow enough to support enrollment demand without higher education addressing issues of efficiency, productivity, transparency, and accountability clearly and successfully.

College and university finances are complex and are made more so by accounting habits that confuse costs with revenues and obscure production costs. The lack of transparency in financing is not just a problem of public communication or metrics. It reflects a deeper problem: inadequate attention to cost measurement and cost management within institutions. Next to institutional financial aid, the greatest growth has been in administrative costs for improvements in student services. A significant obstacle to better cost controls is the fact that a large share of the cost of higher education is subsidized by public funds (local, state and federal) and by private contributions. These third-party payments tend to insulate what economists would call "producers" – colleges and universities – from the consequences of their own spending decisions, while "consumers" – students – also lack incentives to make decisions based on their own limited resources. In addition, colleges and universities have few incentives to contain costs because prestige is often measured by resources, and managers who hold down spending risk losing their academic reputations. Another little-recognized source of cost increases is excessive state and federal regulation. Specifically, institutions of higher education must comply with more than 200 federal laws – everything from export administration regulations to the Financial Services Modernization Act.

The entire financial aid system – including federal, state, institutional, and private programs – is confusing, complex, inefficient, duplicative, and frequently does not direct aid to students who truly need it. Need-based financial aid is not keeping pace with rising tuition.

There are at least 20 separate federal programs providing direct financial aid or tax benefits to individuals seeking postsecondary education. The system is overly complicated and its multitude of programs sometimes redundant and incomprehensible to all but a few experts. This complexity has the unfortunate effect of discouraging some low-income students from even applying to college. Unmet financial need among the lowest-income families (those with family incomes below $34,000 annually) grew by 80 percent from 1990 to 2004 at four-year institutions, compared with 7 percent for the highest-income families. The Advisory Committee on Student Financial Assistance estimates that in the first decade of the new century, financial barriers will keep nearly 2 million low- and middle-income college qualified high school graduates from attending college. Nearly three-quarters of undergraduate students in private, non-profit institutions graduate with some debt, compared with 62 percent in public institutions. According to the most recent College Board figures, median debt levels among students who graduated from four-year institutions were $15,500 for publics and $19,400 for private, non-profits.

At a time when we need to be increasing the quality of learning outcomes and the economic value of a college education, there are disturbing signs that suggest we are moving in the opposite direction. As a result, the continued ability of American postsecondary institutions to produce informed and skilled citizens who are able to lead and compete in the 21st century global marketplace may soon be in question.

While U.S. higher education has long been admired internationally, our continued preeminence is no longer something we can take for granted. The rest of the world is catching up, and by some measures has already overtaken us. When compared to the 30 OECD nations, the U.S. has fallen to 9th in higher education attainment, 16th in high school graduation rates, and 24th in learning proficiency for 15 year olds. It has dropped to 12th in the fraction of its population with college degrees. It is also notable that U.S. public expenditures per student have been flat at about the OECD average, while most other nations have been increasing their investment in recent years (although strong private support keeps the U.S. at the head of the pack in 2.5% of GDP spent on higher education).

There is inadequate transparency and accountability for measuring institutional performance, which is more and more necessary to maintaining public trust in higher education. Traditionally, institutional quality is measured primarily through financial inputs and resources. In today's environment, these measures of inputs are no longer adequate, either within individual institutions or across all of higher education. Despite increased attention to student learning results by colleges and universities and accreditation agencies, parents and students have no solid evidence, comparable across institutions, of how much students learn in colleges or whether they learn more at one college than another. Colleges and universities can also use more comparable data about the benchmarks of institutional success – student access, retention, learning and success, educational costs (including the growth in administrative expenses such as executive compensation), and productivity – to stimulate innovation and continuous improvement. Accreditation, the large and complex public-private system of federal, state and private regulators, has significant shortcomings.

There was some disagreement among the commissioners on the prospects for enhanced public support. Some believed that an aging population will simply have higher priorities–e.g., health care, retirement, safety from crime, national security, tax relief. Others believed that in the knowledge economy, since education determines these other goals, the public will support further investment. However, most believed it was only prudent to expect that markets will increasingly drive (if not dominate) public policy.

The likelihood that the private sector will be the primary source of additional resources to meet the growing higher education needs of the nation, coupled with the highly decentralized and competitive nature of the postsecondary education enterprise, suggest that market forces will be more effective than public policy and regulation in stimulating and enabling higher education to respond to the needs of the nation. Moreover, market pressure and competition should drive not only quality and productivity but also stimulate innovation and responsiveness. The challenge therefore is to enable the postsecondary education market to function efficiently and effectively, by empowering more informed consumers of educational services, eliminating unnecessary market constraints and monopolies, and providing the additional incentives and investments necessary for innovation and change. Key in this effort will be the adoption of standards for institutional disclosure and transparency of information such as learning outcomes, student flows (unit record tracking), financial data, and other measures of institutional impact (R&D, public service) aimed at providing both consumer information and evidence of public accountability.

American higher education has taken little advantage of important innovations that would increase institutional capacity, effectiveness and productivity. Government and institutional policies created during a different era are impeding the expansion of models designed to meet the nation's workforce needs. In addition, policymakers and educators need to do more to build America's capacity to compete and innovate by investing in critical skill sets and basic research.

Institutions as well as government have failed to sustain and nurture innovation in our colleges and universities. Reports from those working at the grassroots level in fields such as teacher preparation and math and science education indicate that the results of scholarly research on teaching and learning are rarely translated into practice. Little of the significant research of the past decade in areas such as cognitive science, neurosciences, and organizational theory is making it into American classroom practice, whether at the K-12 level or in colleges and universities. With the exception of several promising practices, many of our postsecondary institutions have not embraced opportunities for innovation, from new methods of teaching and content delivery to technological advances to meeting the increasing demand for lifelong learning. Accreditation and federal and state regulations, while designed to assure quality in higher education, can sometimes impede innovation and limit the outside capital investment that is vital for expansion and capacity building. It is fundamental to U.S. economic interests to provide world-class education while simultaneously providing an efficient immigration system that welcomes highly educated individuals to our nation.

## Recommendations of the Spellings Commission

While there was unanimous agreement on the general recommendations, there was more diversity of opinion on their many details.

1. REMOVING THE BARRIERS TO ACCESS AND SUCCESS: Every student in the nation should have the opportunity to pursue postsecondary education. The recommended, therefore, that the U.S. commit to an unprecedented effort to expand higher education access and success by improving student preparation and persistence, addressing non-academic barriers and providing significant increases in aid to low-income students.

While there are important actions that can be taken both by colleges and universities and by their patrons (state and federal government, private support) to improve access at the margin, major gains are not likely without a sustained improvement in secondary education. A high school degree should signify that a student is college and/or work ready. States must adopt high school curricula that prepare all students for participation in postsecondary education and should facilitate seamless integration between high school and college.

2. RESTRUCTURE FINANCIAL AID: To address the escalating cost of a college education and the fiscal realities affecting government's ability to finance higher education in the long run, we recommend that the entire student financial aid system be restructured and new incentives put in place to improve the measurement and management of costs and institutional productivity.

Here the key is to focus financial aid at the national, state, and institutional level primarily to address need, rather than subsidize the well-to-do (as much of it does today through "merit" aid and tax benefits). The Commission proposed replacing the current maze of financial aid programs, rules and regulations with a system more in line with student needs and national priorities. That effort would require a significant increase in need-based financial aid and a complete restructuring of the current federal financial aid system. The recommendations call for consolidating programs, streamlining processes, and replacing the FAFSA with a much shorter and simpler application.

The federal government, states and institutions should significantly increase need-based student aid. To accomplish this, the present student financial aid system should be replaced with a strategically oriented, results-driven system built on the principles of (i) increased access, or enrollment in college by those students who would not otherwise be likely to attend, including non-traditional students; (ii) increased retention, or graduation by students who might not have been able to complete college due to the cost, (iii) decreased debt burden, and (iv) eliminating structural incentives for tuition inflation. Federal grant programs should be consolidated to increase the purchasing power of the Pell Grant. Whatever restructuring of federal financial aid takes place, the Pell Grant will remain the core need-based program.

Policymakers and higher education leaders should develop, at the institutional level, new and innovative means to control costs, improve productivity, and increase the supply of higher education. At the same time, the Commission opposes the imposition of price controls. Federal and state policymakers and accrediting organizations should work to eliminate regulatory and accreditation barriers to new models in higher education that will increase supply and drive costs down. Federal and state policymakers should relieve the regulatory burden on colleges and universities by undertaking a review of the hundreds of regulations with which institutions must comply and recommend how they might be streamlined or eliminated.

3. TRANSPARENCY, ACCOUNTABILITY, AND PUBLIC PURPOSE: To meet the challenges of the 21st century, higher education must change from a system primarily based on reputation to one based on performance. The Commission urged the creation of a robust culture of accountability and transparency throughout higher education. Every one of its goals, from improving access and affordability to enhancing quality and innovation, will be more easily achieved if higher education institutions embrace and implement serious accountability measures.

To restore public trust and confidence, it suggest that higher education should emulate the capital markets through transparency and accountability that demonstrates their public purpose, e.g., agreeing on how to measure costs, prices, and values (analogous to FASB) and full public disclosure of both learning outcomes and financial performance (analogous to Sarbanes-Oxley). To this end the Commission recommended the creation of a consumer-friendly information database on higher education with useful, reliable information on institutions, coupled with a search engine to enable students, parents, policymakers and others to weigh and rank comparative institutional performance. In addition to this new consumer-oriented database, more and better information on the quality and cost of higher education is needed by policymakers, researchers and the general public.

The faculty must be at the forefront of defining educational objectives for students and developing meaningful, evidence-based measures of their progress toward those goals, but the philanthropic community and other third-party organizations are urged to invest in the research and development of instruments measuring the intersection of institutional resources, student characteristics, and educational value-added. Furthermore, accreditation agencies should make performance outcomes, including completion rates and student learning, the core of their assessment as a priority over inputs or processes.

4. INVESTING IN INNOVATION: With too few exceptions, higher education has yet to address the fundamental issues of how academic programs and institutions must be transformed to serve the changing needs of a knowledge economy. The Commission recommended that America's colleges and universities embrace a culture of continuous innovation and quality improvement by developing new pedagogies, curricula, and technologies to improve learning, particularly in the area of science and mathematical literacy.

It encouraged broad federal support of innovation in higher education from multiple agencies (Departments of Education, Energy, Labor, Defense, and Commerce; the National Science Foundation; the National Institutes of Health; and the National Aeronautics and Space Administration) in order to align and coordinate federal investment of innovation in higher education. The Commission encourages the creation of incentives to promote the development of information-technology-based collaborative tools and capabilities at universities and colleges across the United States, enabling access, interaction, and sharing of educational materials from a variety of institutions, disciplines, and educational perspectives. Both commercial development and new collaborative paradigms such as open source, open content, and open learning will be important in building the next generation learning environments for the knowledge economy.

5. LIFELONG LEARNING: America must ensure that our citizens have access to high quality and affordable educational, learning, and training opportunities throughout their lives. The Commission recommended the development of a national strategy for lifelong learning that helps all citizens understand the importance of preparing for and participating in higher education throughout their lives.

This is one of our most important recommendations! Just as in earlier critical moments in our nation's history when federal initiatives expanded the role of education, e.g. the Land Grant Acts in the 19th century to provide higher education to the working class, universal access to secondary education in the early 20th century, and the G. I. Bill enabling the college education of the returning veterans of World War II, today a major expansion of educational opportunity could have extraordinary impact on the future of the nation. The Commission believes it is time for the United States to take bold action, completing in a sense the series of these earlier federal education initiatives, by providing all American citizens with universal access to lifelong learning opportunities, thereby enabling participation in the world's most advanced knowledge and learning society. The Secretary of Education, in partnership with state and other federal agencies, should develop a national strategy to develop such an effort.

6. RESPONDING TO THE IMPERATIVES OF A GLOBAL, KNOWLEDGE ECONOMY: The United States must ensure the capacity of its universities to achieve global leadership in key strategic areas such as science, engineering, medicine, and other knowledge-intensive professions. We recommend increased federal investment in areas critical to our nation's global competitiveness and a renewed commitment to attract the best and brightest minds from across the nation and around the world to lead the next wave of American innovation.

The Commission supports increasing federal and state investment in education and research in critical areas such as the STEM fields, teaching, nursing, biomedicine, and other professions along the lines recommended by the American Competitiveness Initiative, Rising Above the Gathering Storm, and the National Innovation Initiative. Moreover, in an effort to retain the best and brightest students and professionals from around the world, the federal government must address immigration policies specifically aimed at international students. It recommended that these international students who graduate with an advanced STEM degree from a U.S. college or university should have an expedited path to an employer-sponsored green card and also be exempted from the numerical cap for green cards.

To summarize these recommendations:

1. Demand (and assist) K-12 education in preparing every student for post-secondary education.
2. Refocus federal, state, and institutional financial aid programs on need-based aid.
3. Disclosure and transparency requirements.
4. Stimulate more innovation in higher education.
5. Make a national commitment to lifelong learning.
6. Endorse other major federal initiatives aimed at creating a knowledge economy.

## The Quality Subcommittee of the Spellings Commission

Much of the work of the Commission occurred through various subcommittees, comprised of a subset of Commission members and staffed by the Department of Education. Of particular importance here was the work of the Subcommittee on Quality in American Higher education. (Membership: James Hunt, former Governor of NC; Rick Stephens, Senior VP, Boeing; Nicholas Donofrio, Executive VP, IBM; Robert Mendenhall, President, Western Governors University; Charles Vest, President, MIT; James Duderstadt, President Emeritus, University of Michigan, Chair) Although the conclusions of this subcommittee were similar in many ways to those of the full Commission, there were some significant differences. Like the Commission's Report, the Quality Subcommittee agreed with the goals of demanding, building, and sustaining a truly world-class system of higher education by achieving an optimum balance between market forces and public policy; addressing those factors that have created a strong dependence of access and success in higher education upon socioeconomic status; shifting the education paradigm to stress the critical thinking and lifelong learning skills necessary to cope with uncertainty and change; stressing the importance of measuring, characterizing, and coordinating the activities of the postsecondary education enterprise in the United States; stimulating and sustaining the knowledge creation role of higher education (research and innovation); and engaging with the public to re-establish an adequate understanding of the public purpose of higher education in America while earning its understanding, trust, and confidence through bold initiatives aimed at addressing public concerns.

Yet it added to these one more objective. Today the United States faces a crossroads, as a global knowledge economy demands a new level of knowledge, skills, and abilities on the part of our citizens. Just as in earlier critical moments in our nation's history when federal initiatives expanded the role of education, e.g. the Land Grant Acts in the 19th century to provide higher education to the working class, universal access to secondary education in the early 20th century, and the G. I. Bill enabling the college education of the returning veterans of World War II, today a major expansion of educational opportunity could have extraordinary impact on the future of the nation. The Commission believes it is time for the United States to take bold action, completing in a sense the series of these earlier federal education initiatives, by providing all American citizens with universal access to lifelong learning opportunities, thereby enabling participation in the world's most advanced knowledge and learning society. Most important, was the following recommended statement for the Commission:

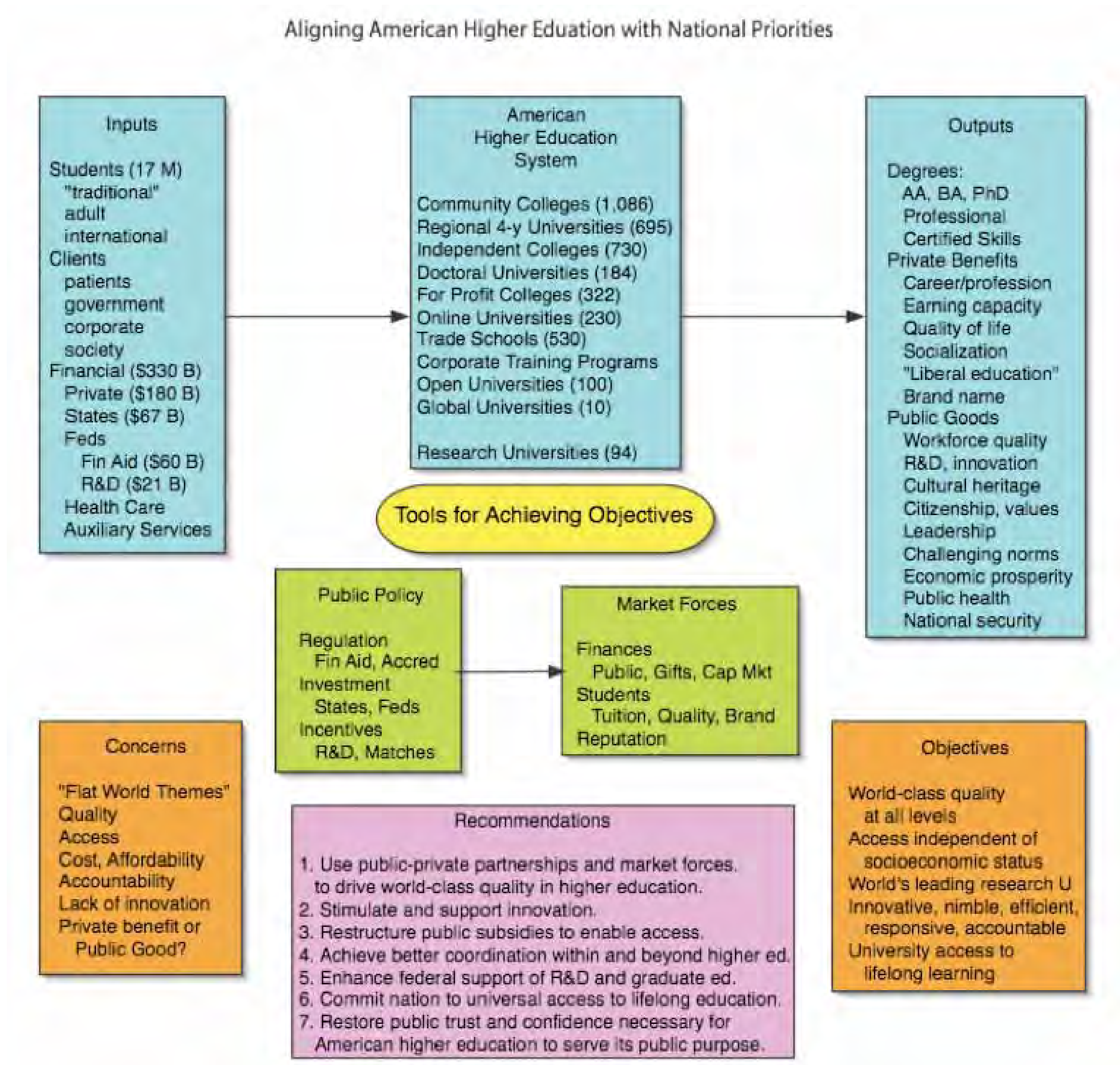
*The Commission recommends that the nation accept a responsibility as a democratic society to enable all of its citizens to take advantage of the educational, learning, and training opportunities they need and deserve, throughout their lives, thereby enabling both individuals and the nation itself to prosper in an ever more competitive global economy. While the ability to take advantage of educational opportunity always depends on the need, aptitude, aspirations, and motivation of the student, it should not depend on one's socioeconomic status. Access to livelong learning opportunities should be a right for all rather than a privilege for the few if the nation is to achieve prosperity, security, and social well-being in the global, knowledge- and value-based economy of the 21st century.*

Recommendations and Possible Strategies

It is clear that today the United States must demand and be prepared to support a world-class system of postsecondary educational institutions capable of meeting the changing educational, research, and service needs of the nation.

Yet this goal faces many challenges, including an increasing stratification of access to (and success in) quality higher education based on socioeconomic status, questionable achievement of acceptable student learning outcomes (including critical thinking ability, moral reasoning, communication skills, and quantitative literacy), cost containment and productivity, and the ability of institutions to adapt to changes demanded by the emerging knowledge services economy, globalization, rapidly evolving technologies, an increasingly diverse and aging population, and an evolving marketplace characterized by new needs (e.g., lifelong learning), new providers (e.g., for-profit, cyber, and global universities), and new paradigms (e.g., competency-based educational paradigms, distance learning, open educational resources).

While there is strong evidence that American research universities continue to provide the nation with global leadership in research, advanced education, and knowledge-intensive services such as health care, technology transfer, and innovation, this leadership is threatened today by rising competition from abroad, by stagnant support of advanced education and research in key strategic areas such as physical science and engineering, and by the complacency and resistance to change of the American research university.




The recommendations of the Spellings Quality Subcommittee for the nation

To address these issues, the Commission proposes a vision, identifies challenges, and suggests possible strategies in each of seven areas: quality, innovation, access, coordination, research and graduate education, lifelong learning, and public purpose.

1. Quality

The United States must demand and be prepared to support a world-class higher education system, utilizing market forces shaped by incentives, public-private partnerships, and requirements for evidence-based assessment of educational effectiveness to drive all elements of postsecondary toward higher quality, efficiency, innovation, and nimbleness.

Vision: The nation must demand that its postsecondary education enterprise (e.g., colleges and universities, proprietary schools, industry education training programs, and new paradigms such as distance learning and global universities) achieve world-class standards in all important areas, e.g., quality, learning outcomes, access, efficiency, innovation, and responsiveness to changing societal needs. While colleges and universities should be responsive to the projected needs of students, their employers, and the nation, it is also essential that they launch the major transformations of educational programs necessary to prepare students for a much different world, providing them with the knowledge and skills necessary for the jobs of tomorrow and the abilities to face future problems not yet even identified.

Challenges: While some elements of American higher education are clearly world-class, such as its research universities, the Commission is less sanguine about the quality and performance of our total postsecondary education enterprise. There are numerous valid concerns about graduation rates, time to degree, learning outcomes, performance, and responsiveness of various elements of postsecondary education in America that could threaten its capacity to serve the needs of the nation. The limited capacity of the enterprise to innovate and adapt to changing needs and conditions, coupled with the lack of transparency concerning costs, prices, and value also raise concerns about quality.

Part of the challenge is the reluctance of higher education to accept accountability for learning outcomes. Few institutions provide clear and measurable educational objectives for their academic programs. Even less effort is demand evidence-based assessment of educational effectiveness, although some accreditation agencies are moving in this direction. While there are numerous tools available for such assessment, including comprehensive examinations, capstone courses, senior portfolio and dissertation requirements, and recent developments in testing deeper cognitive abilities (e.g., the Collegiate Learning Assessment tests developed by the RAND Corporation), there is limited incentive for faculties to develop and apply such assessment methods. Hence, current measures of academic quality tend to focus more on inputs such as student selectivity, resource expenditure, or reputation than on the value-added provided by an academic program.

Public policy alone is unlikely to be effective in stimulating higher education to become more responsive to national needs. Traditional policy tools such as regulation have proven relatively ineffective in driving substantive change in the American higher education system. Furthermore public funds at both the state and federal level may be limited for at least a generation by the priority given the needs of an aging population (Medicaid, Medicare, Social Security), national security, and tax relief and will likely be insufficient to meet the growing need for lifelong access to postsecondary education for the majority of our population. Unlike most other nations, American higher education is supported by comparable balance of public and private resources (roughly 45% public and 55% private). Although strong public support of higher education from both the states and the federal government will be essential in maintaining broad access to quality postsecondary education, the possibility of new resources available in the private sector through capital markets and intergenerational wealth transfer will likely intensify even further the market forces on colleges, universities, and other elements of the postsecondary education sector.

Beyond this, academia and government must be open to new ways of leveraging industry and private-sector resources to address national priorities. Business experience with open source, standards-based methods and service-oriented architectures could prove invaluable to universities in developing new approaches to enhancing institutional performance and standards for learning outcomes. New partnerships among higher education, business and industry, and state and federal government should be established and sustained to achieve world-class quality in the American postsecondary education enterprise.

Yet it is also clear that if markets are allowed to dominate and reshape the higher education enterprise without constraint, some of the most important values and roles of the university will likely fall by the wayside. Creating an effective market requires thoughtfully structured strategic interventions and enlightened public policy to ensure that the market is a force supporting the broader public purposes of higher education.

Possible Strategy: In its pursuit of the vision of a world-class system of postsecondary education better aligned with national needs, the United States should rely heavily upon market forces shaped by public policy and investment and public-private sector partnerships rather than government regulation. This is consistent with our assumption of constrained public funding and the long and effective decentralization and diversity in American higher education. It is our belief that if market constraints such as unnecessary regulation at the state and federal level, monopoly and predatory practices, and inadequate consumer information are addressed, then market forces will drive institutions toward best practices in educational quality, cost containing, productivity, and innovation. Market competition within higher education should be strongly encouraged and facilitated by removing unnecessary regulation and bureaucracy at the state and federal level, challenging monopolistic practices, providing information to better educate consumers of educational services, and providing incentives for institutions to develop or adopt best practices in areas such as cost containment, productivity, the assessment of student learning outcomes, and innovative academic programs.

However for market forces to be effective in driving quality improvement, we believe it essential to challenge institutions (and their faculty) to develop clear objectives for their academic programs and then provide to the marketplace (students, parents, employers, governments, media) evidence-based assessment of how well their educational programs are performing in achieving these goals. While federally or state-mandated use of specific assessment mechanisms such as standardized tests is unlikely to be effective because of the great diversity of the American higher education system, we do believe that the broad requirement of evidence-based assessment of educational effectiveness through processes such as accreditation could trigger not only institution-based efforts to measure learning outcomes but also stimulate the development and implementation of new assessment tools.

New partnerships among higher education, business and industry, and government will be important in developing best practices in achieving learning performance objectives, quality, and cost-effectiveness (e.g., student unit records systems to track student access and progress, consumers reports on institutional quality and performance, and more sophisticated mechanisms to measure student learning outcomes). Moreover such partnerships will be important in identifying changing educational needs (e.g., the skills required by a services economy or by globalization) and restructuring academic programs accordingly. However such a market-focused approach to the achievement of quality and responsiveness will also require enlightened public policies and investment to ensure that the market forces do not distort the broader public purposes of higher education.

More specifically, institutions should be provided with the flexibility to compete for students, faculty, and resources from both public and private sources on the basis of quality, price, and value. Consumers of educational services (students, employers, governments) should be provided with sufficient information to readily make comparisons among and between institutions (e.g., prices, benefits, job placements, quality of learning, socioeconomic distribution of students, student learning outcomes, and the scale and scope of other activities such as research and public service. Both industry and the federal government could provide assistance in collecting and distributing such information.

2. Innovation

To support American innovation, the nation's colleges and universities must embrace innovation themselves, by developing new learning pedagogies, academic paradigms, and educational forms that are more responsive to national priorities. This will require a very substantial increase in the support of research and development associated with learning and education by the federal government and higher education institutions.

Vision: Leadership in innovation–the transformation of knowledge into products, processes, and services–is critical to competitiveness, long-term productivity growth, and the generation of wealth and hence to United States prosperity and security. Institutions of higher learning must collaborate with industry and government to create a national educational climate and culture that enables innovation to thrive. Not only is this a challenge to our colleges and universities to provide the graduates capable of innovation and adaptation to change, but it also demands that American higher education also develop and demonstrate the capacity for continuous innovation and quality improvement at both the institution and enterprise level. In fact, we believe that innovation (in the use of technology, learning paradigms, organization of learning institutions and systems, financing, and governance) will be both the strongest driver and enabler of change in higher education in the years ahead.

Challenge: There is increasing agreement that the prosperity and security of all Americans will depend on our nation's enduring and evolving capacity to learn, inspire, create, and innovate. Today American leadership in innovation is challenged not only by a global, knowledge-driven economy, but by the need for college graduates capable of applying technology, talent, and capital in new ways, with deep analytical skills and the ability to manage ambiguity, to meet business and societal demands. Here part of the challenge is the changing nature of innovation itself; it is far more open; it spans virtually all disciplines; and it is increasingly global. And it arises not in the isolated laboratory but in the marketplace, the workplace, the community, and the classroom. It requires the development of new academic disciplines such as services systems management, increasingly multidisciplinary research and instruction across the traditional disciplines, and continual learning opportunities to keep abreast of the fast-changing dynamic nature of work. Clearly, sustaining the nation's leadership in innovation will require institutions of higher learning capable of embracing innovation as key both to their quality and capacity to serve the changing needs of our society.

Yet today many segments of American postsecondary education are currently not well positioned to meet the changing needs of the nation. Although there are bright spots of innovation, by and large American higher education is a mature industry that has become increasingly risk-adverse, and frequently complacent and ponderous. Furthermore, much of the enterprise has yet to address the fundamental issues of how academic programs and institutions must be transformed to serve the changing educational needs of a knowledge economy. It is not enough simply to intensify current stimuli, policies, and management strategies and make incremental improvements to organizational structures and curricula.

Changing market pressures such as the high cost of education and the educational needs of adults, coupled with the rapid evolution of information and communications technology stimulating new forms of higher education such as virtual universities, e-learning, and distributed learning models. New paradigms such as open-source and open-content, as manifested in initiatives such as Open CourseWare, the Open Knowledge Initiative, the Sakai Project, and the Google Book project, hold out the potential of providing universal access to both knowledge and higher education. Furthermore, the considerable progress in cognitive and neurosciences research over the past two decades holds great promise for very significant improvements in learning methods and productivity. Yet this will only occur with adequate investment at both the federal and institutional level in R&D concerning learning, pedagogy, technology, and curriculum development.

Possible Strategy: Working closely with business and industry, higher education must give greater priority to the support of the nation's leadership in innovation through new academic programs in areas such as services science, greater multidisciplinary instruction and research, and key involvement in regional innovation economies. To stimulate the necessary level of innovation and institutional transformation within higher education, the federal government should launch a major interagency federal R&D program concerning learning and education, comparable in both approach and funding level to DOD's DARPA, capable of tapping the new knowledge (brain research, cognitive science, organizational science) and technologies (information, communications, and systems technology) capable of stimulating innovation in learning methods, pedagogy, and educational institutions. Key would be efforts to stimulate similar commitments on the part of colleges and universities to substantial internally funded R&D activities associated with improving learning, scholarship, and institutional performance.

3. Access

Access to higher education should receive the highest priority for public funding, whether through financial aid, state appropriations to colleges and universities, or tax policy (e.g., "tax expenditures"). Public funds should be targeted to those students with greatest need.

Vision: The nation and the states must address and remove those factors that have created a strong dependence of access and success in higher education upon socioeconomic status. We should aspire to the ideal where family income is nearly irrelevant to the ability of a student to attend the college or university best matched to his or her talents, objectives, and motivation.

Challenges: Education has become a key determinant of one's personal standard of living and quality of life. The breakpoint between those who succeed in college and those who fail is perhaps the most critical decision point in one's life. Yet many studies have revealed the degree to which access to higher education in America has become increasingly stratified according to student financial circumstances, thereby undercutting the fundamental principles of equity in providing educational opportunities for a democratic nation. Today even the most academically talented students in the lowest economic quartile are significantly less likely to have access to the benefits of higher education than the least qualified students in the top quartile–a situation clearly intolerable for a democratic society. Furthermore, more students are borrowing larger amounts at higher interest rates to pay for college than ever before, with debt burdens that are not only influencing student career choices (e.g., high paying rather than socially-beneficial careers) but discouraging many low income students from even attempting a college education.

Part of the challenge arises from the patchwork character of current federal, state, and institutional financial aid programs, designed more to address political objectives and benefit the commercial loan industry than address the needs of students in a strategic fashion. Here a key public policy issue is how public funds for higher education should be allocated among students from differing socioeconomic circumstances and among institutions of differing missions. Today a very significant fraction of public funds, whether allocated directly to public institutions to enable low tuition, or through state and federal financial aid programs, go primarily to benefit affluent students with modest economic needs, at a time when close to a quarter of Americans are disproportionately and severely deprived of educational opportunity at colleges and universities.

Possible Strategies: Although both the states and the federal government have many objectives in providing public funding to higher education, e.g., regional economic development, public health, national security, or, more pragmatically, voter support, the widening gap between the educational opportunities available to affluent students and those of modest means compels the Commission to recommend that access to higher education, regardless of socioeconomic circumstance, should receive the highest priority for public funding. While the principle of low tuition in public institutions has a long-standing precedence, this subsidy of the educational costs for affluent students should not come at the expense of adequate financial aid programs for those of modest means.

Furthermore, while merit scholarship programs may be appropriate for stimulating student interest in key strategic areas (e.g., science, engineering, and mathematics), these must not come at the expense of need-based financial aid programs. Publicly funded financial aid should rely primarily on need-based rather than merit-based programs, with grants as the preferred mechanism for the lowest income quartile of students, while loans and tax benefits are the preferred mechanisms to assist students from more affluent backgrounds with access to postsecondary education and lifelong learning opportunities ("higher and further education").

In particular, the current system of federal financial aid programs requires major overhaul–if not total replacement–to achieve a strategic program of grants, loans, and tax benefits that adequately and efficiently addresses in an accountable and transparent fashion goals such as enhanced student access, retention, and reduced student debt burden. Such a program should be strategically-oriented, results-driven, efficient in the utilization of taxpayer dollars, and demonstrably effective.

4. Coordination

Mechanisms such as a federally managed student record system and more direct involvement by colleges and universities in education at the secondary level should be used to achieve greater coordination both within the higher education system and the broader American education enterprise to better serve students and society.

Vision: Both students and the nation could be well served by a higher degree of coordination, particularly in facilitating the transition among various levels (e.g., K-12, community college, undergraduate, graduate, professional, lifelong learning) and elements (public, private, for-profit, corporate training) of higher education. Key to this effort will be the development of a federally managed student record system capable of statistically tracking the flow and progress of students throughout postsecondary education, as well as the development of incentives at the state and federal level for institutional coordination and cooperation among all elements of the American education sector.

Challenge: The Commission strongly agrees with the recent survey in The Economist that concluded, "America's system of higher education is the best in the world. That is because there is no system!" Yet it is also the case that the absence of coordination and articulation agreements can be a serious hurdle to students attempting the transition from one education level or institution to another. While competition among institutions is important, particularly in a marketplace increasingly funded from private sources, so too is sufficient coordination to allow a smooth, transparent transitions from one stage or institution to the next in a future increasingly dependent upon lifelong learning. Put another way, postsecondary education needs to be better coordinated and integrated vertically, while preserving the strong market competition horizontally.

Furthermore, higher education needs to be far more tightly coupled to primary and secondary education. Recent studies have revealed the ill-preparedness of high school graduates for college work, along with poor success of higher education in addressing student deficiencies in written and quantitative literacy.

Possible Strategies: The federal government, working closely with the higher education community, should develop and maintain a student unit record system capable of describing the general flow of students throughout the postsecondary education enterprise. There is also a need on the part of students for more specific and confidential information about their own standing and academic progress, particularly should a lifelong education system become available. However this objective requires further study to design a system with appropriate protection of confidential information and privacy rights.

Colleges and universities need to work closely with K-12 education, aligning high school curricula with college standards and providing feedback to prospective students about their readiness for college work. In particular, the senior year of high school (12th grade), currently regarded as an educational wasteland by many, should be used by colleges and secondary schools both to introduce advanced students to college-level work while providing the remedial education necessary to repair deficiencies in student preparation for further study. It should also be observed here that the commitment to lifelong learning (Recommendation 6) could provide yet additional opportunities for addressing the diversity in K-12 learning experiences and student learning readiness that today leads to all-too-frequent failure at the college level.

5. Research and Graduate Education

The United States should implement strategies such as the American Competitiveness Initiative proposed by the President to enable higher education to increase the talent pool and knowledge base in key strategic disciplines such as the physical sciences, mathematics, and engineering.

Vision: The United States must sustain the capacity of its research universities to achieve global leadership in key strategic areas such as science, engineering, medicine, and other knowledge-intensive professions and attract talented students and faculty from across America and around the world through adequate public and private investment and stimulating institutional innovation and change. Research universities, government, and industry should strive to create effective mechanisms for ensuring that the new knowledge developed on the campuses serves society through technology transfer, innovation, and entrepreneurial activities.

Challenges: There are growing concerns that the scientific and technological building blocks of the nation's economic leadership and national security are eroding at a time when many other nations are gathering strength. Federal support of R&D as a fraction of GDP has dropped in half over the past three decades (from 2% to less than 0.8% of GDP), while the nation's research portfolio has become heavily skewed in favor of biomedical research at the expense of research in physical science and engineering, keys to the nation's technological strength. Numerous studies have suggested that the nation's strategic and economic security is threatened by its current course, living on incremental improvements to past developments and gradually conceding technological leadership to international competitors. Instead it is critical the United States invest in the necessary research, producing the world-class graduates, stimulating the innovation, and creating the high-skill, high-value jobs that define a prosperous nation in a knowledge-driven global economy.

Possible Strategy: The federal government must restore a level of research funding adequate to support its most urgent priorities including national defense, homeland security, health care, energy security, and economic competitiveness, with special attention directed to physical science and engineering. Federal and state governments and industry should invest in upgrading and expanding university laboratories, equipment, and information technologies and meeting other infrastructural needs of research universities such that the national capacity to conduct world-class research in key strategic disciplines is sufficient to address national priorities. Government and industry should also invest in scholarships, fellowships, curriculum development aimed at enhancing student interest in science, mathematics, engineering, and technology at all educational levels, with particular attention given to encouraging the participation of women and underrepresented minorities, while recruiting talented students from around the world.

6. Lifelong Learning

The nation should commit itself to the goal of providing universal access to lifelong learning opportunities for all citizens, thereby enabling participation in the world's most advanced knowledge society. This will not only require a significant increase in the capacity and quality of postsecondary education in America, but also the development of new types of institutions, funding mechanisms, and public-private partnerships.

Vision: Today the United States faces a crossroads, as a global knowledge economy demands a new level of knowledge, skills, and abilities on the part of our citizens. In earlier critical moments in our nation's history federal initiatives aimed at expanding the role of education had great impact on America, e.g. the Land Grant Acts in the 19th century to provide higher education to the working class, university access to secondary education in the early 20th century, and the G. I. Bill enabling the college education of the returning veterans of World War II. Today, as our nation undergoes a transition from an industrial to a knowledge-based economy, the Commission believes it is time for the United States to take bold action, completing in a sense the series of these earlier federal education initiatives, by providing all American citizens with universal access to lifelong learning opportunities, thereby enabling participation in the world's most advanced knowledge society. The nation would accept its responsibility as a democratic society in an ever more competitive global, knowledge driven economy to provide all of its citizens with the educational, learning, and training opportunities they need, throughout their lives, whenever, wherever, and however they need it, at high quality and affordable costs, thereby enabling both individuals and the nation itself to prosper.

Challenge: The needs for lifelong learning opportunities in a knowledge society are manifold. The shelf life of education early in one's life, whether K-12 or higher education, is shrinking rapidly in face of the explosion of knowledge in many fields. Today's students and tomorrow's graduates are likely to value access to lifelong learning opportunities more highly than job security, which will be elusive in any event. They understand that in the turbulent world of a knowledge economy, characterized by outsourcing and off-shoring to a global workforce, employees are only one paycheck away from the unemployment line unless they commit to continuous learning and re-skilling to adapt to every changing work requirements. Furthermore, longer life expectancies and lengthening working careers create additional needs to refresh one's knowledge and skills through. Even today's college graduates expect to change not simply jobs but entire careers many times throughout their lives, and at each transition point, further education will be required–additional training, short courses, degree programs, or even new professions. And, just as students increasingly understand that in a knowledge economy there is no wiser personal investment than education, many nations now accept that the development of their human capital through education must become a higher priority than other social priorities, since this is the only sure path toward prosperity, security, and social well-being in a global knowledge economy.

Of course, establishing as a national goal the universal access to lifelong learning would require not only a very considerable transformation and expansion of the existing postsecondary education enterprise, but it would also require entirely new paradigms for the conduct, organization, financing, leadership, and governance of higher education in America. For example, most of today's colleges and universities are primarily designed to serve the young–either as recent high school graduates or young adults early in their careers. Yet achieving the objective of universal access to lifelong learning would expand enormously the population of adult learners of all ages. Traditional university characteristics such as residential campuses designed primarily to socialize the young with resources such as residence halls, student unions, recreational facilities, and varsity athletics would have marginal value to adult learners with career and family priorities. Such universal lifelong learning could change dramatically the higher education marketplace, providing for-profit institutions already experienced in adult education with significant advantages. Furthermore it seems likely that the only way that such ubiquitous access can be provided to lifelong learning to adults with career and family responsibilities will be through technology-mediated distance learning.

Possible Strategies: One approach would be to utilize a combination of transportable education savings accounts and loans, perhaps indexed to future earnings much like Social Security by mandatory earmarking of a portion of an individual' earnings over their careers as a source of funds for their education. Here, in contrast to Social Security that amounts to saving over a career for one's relatively unproductive golden years, instead one would be borrowing and investing on the front-end to enhance their personal productivity and hence prosperity throughout their lives through future education. By making such education savings accounts mandatory, again like Social Security, one would create a sense of ownership on the part of the students, thereby making it more likely that they would seek to take advantage of the educational opportunities provided by their account. A variation on this theme would be to access the capital markets by using the government (either federal or state) to borrow money at low interest rates to be loaned to students, and then provide strong tax incentives to employers to assist students in paying off these loans during employment. Note employer participation would bring another very important consumer to the table, since clearly employers (private or public) would want to demand high quality learning experiences in disciplines of importance to their enterprise if they are going to pay off the student loans of their employees.

A second approach would be an analog to the Land Grant Acts of the 19th Century that assisted the nation in evolving from an agrarian frontier society into an industrial nation. One might imagine a Learn Grant Act for the 21st Century to assist the United States in evolving still further to respond to the challenges of a global knowledge economy. It would focus on developing our most important asset, our human resources, as its top priority, along with the infrastructure necessary to sustain a knowledge-driven economy. Patterned after the Land Grant Acts, the Learn Grant Act would involve a partnership among the federal government, the states, and the higher education enterprise in which the federal government would provide assets comparable to the land grants (e.g., the funds resulting from the sale or lease of the digital spectrum), the states would commit to providing base support necessary to ensure access to postsecondary education for their populations, and higher education institutions would commit to the major transformations necessary to provide life-long learning opportunities of high quality, affordable cost, and necessary flexibility (asynchronous and ubiquitous learning), along with the other knowledge services needed by our society. However, since the growth in the learning population enabled by universal access to lifelong learning would be financed primarily from private sources, this would also require a partnership among students (learners and borrowers), employers (financiers), and government (facilitator).

7. Public Purpose

Higher education must take decisive action to address current concerns about quality, efficiency, capacity, and accountability if it is to earn the necessary level of public trust and confidence to enable it to pursue its public purpose.

Vision: While higher education provides important private benefits to graduates, clients, and industry, in reality it is primarily a public good, created and support by society to serve a public purpose.

Challenges: Like so many other institutions in our society, higher education today finds itself roundly criticized from the right, the left, and the center—indeed, even from within by many of our own faculty, students, and staff—for flaws large and small, fundamental and trivial, real and imagined. Little wonder that at times the academy feels under siege: criticized by parents and students for the uncontrolled escalation of tuition; attacked by state legislators and governors for insufficient attention to state needs; criticized by Washington and indeed our own faculties for rising administrative costs; challenged across the political spectrum for the quality and nature of undergraduate education; and generally blasted by the media in essentially any and all of our activities, from teaching to health care to intercollegiate athletics.

Among this array of criticisms, there is one that stands out in particular: the growing frustration of society with the hesitancy or reluctance of the university to face up to the challenge of change. A rapidly evolving world has demanded profound and permanent change in most, if not all, social institutions. Corporations have undergone restructuring and reengineering. Governments and other public bodies are being overhauled, streamlined, and made more responsive. Individuals are increasingly facing a future of impermanence in their employment, in their homes, and even in their families. The nation-state itself has become less relevant and permanent in an ever more interconnected world.

Unlike many other institutions, at least according to our critics, the university has responded to the needs of a changing society largely by defending the status quo. To be sure, change has always occurred in higher education on glacial time scales—not surprising since the typical career of a tenured faculty member spans three or more decades. But at a time when our society, our nation, and the world itself are changing rapidly, the university still tends to frame its contemporary roles largely within traditional paradigms. It resists major changes in curricula or pedagogy. Students continue to be evaluated and credentialed relative to "seat time" rather than learning outcomes. The technology that is revolutionizing our world has largely bypassed the classroom, which continues to function largely as it has for decades, if not centuries. Tenure is seen not as a protection for academic freedom but rather as a perquisite that shields the faculty from accountability and change. And higher education tends to respond to resource constraints by raising funds from other sources rather than prioritizing programs or increasing productivity.

Possible Strategies: While market forces are likely to dominate public investment and public policy, at least for the foreseeable future, it is essential for higher education to retain its public purpose rather than simply responding to the market demands of the moment. After all, it has been a public good of immense importance throughout the history of the nation, and it must remain so. Here, however, it should be recognized and acknowledged that for higher education to regain the necessary degree of public trust and confidence, institutions will have to first listen more attentively to the concerns of its various and diverse constituencies (e.g., students, parents, employers, public and private patrons) and then respond to these concerns through bold institutional actions and transformation consistent with their public purpose.

Two Remaining Caveats

Caveat 1: The strength of American higher education depends upon characteristics such as:

- The great diversity among institutions and missions.
- The balance among funding sources (private vs. public, state vs. federal).
- The influence of market forces (for students, faculty, resources, reputation).
- Its global character (attracting students and faculty from around the world)
- The absence of a centralized system that leads to highly decentralized, market-sensitive, and agile institutions, students, and faculty.
- Supportive policies (academic freedom, institutional autonomy, tax and research policies).
- The research partnership between universities, the federal government, and industry.

These characteristics must be preserved in any effort to better align higher education with the changing needs of the nation.

Caveat 2: As the nation pursues the objective of building and sustaining a world-class system of postsecondary education capable of meeting its changing education, research and service needs in an ever more competitive world, it is also important that it bear in mind the long-standing history and purpose of higher education in western societies. As Frank Rhodes has observed,

"For a thousand years the university has benefited our civilization as a learning community where both the young and the experienced could acquire not only knowledge and skills, but also the values and discipline of the educated mind. It has defended and propagated our cultural and intellectual heritage, while challenging our norms and beliefs. It has produced the leaders of our governments, commerce, and professions. It has both created and applied new knowledge to serve our society. And it has done so while preserving those values and principles so essential to academic learning: the freedom of inquiry, an openness to new ideas, a commitment to rigorous study, and a love of learning." (Rhodes, 1999).

There seems little doubt that these broader roles of higher education will continue to be needed by our nation. Hence, while responsiveness to the needs of a 21st nation in an intensely competitive global, knowledge economy, so too is the need to preserve these more fundamental roles, values, and public purposes of higher education in America.

## Assessment of Impact

The Spellings Commission was launched to address the themes of access, affordability, and accountability in American higher education. (Actually there was a fourth theme–quality–but it seems to have been set aside during much of the subsequent study and discussion.) The Commission issued a series of sweeping recommendations to better align higher education with the needs of the nation, including 1) reaffirming America's commitment to provide all students with the opportunity to pursue postsecondary education; 2) restructuring student financial aid programs to focus upon the needs of lower income and minority students; 3) demanding transparency, accountability, and commitment to public purpose in the operation of our universities; 4) adopting a culture of continuous innovation and quality improvement in higher education; 5) greatly increasing investment in key strategic areas such as science, engineering, medicine, and other knowledge-intensive professions essential to global competitiveness; and 6) ensuring that all citizens have access to high quality educational, learning, and training opportunities throughout their lives through a national strategy to provide lifelong learning opportunities at the postsecondary level.

Because of the cacophony of criticism and speculation surrounding the release of the Commission's report, it is also important to note here what were NOT included as recommendations: no standardized testing, no tuition price fixing, no national (federal) accreditation process, and no federalization of American higher education, which constitutionally remains the responsibility of the states and the private sector.

Perhaps due to controversial language used in the report itself and the press of other issues, the Commissions recommendations were not given high priority by the Bush administration. Its work has largely sank beneath the waves today. Yet, at least in spirit, the current administration and Congress have taken a number of important steps to address the basic concerns of the Commission, e.g., ramping up investments in the Pell Grant program to broaden access, restructuring the federal loan programs both to achieve efficiency while address student debt concerns , reauthorizing the America COMPETES Act to address concerns about innovation and STEM education, and setting a bold national goal of achieving world leadership in college degree attainment.

Hence while some skepticism is appropriate concerning the impact of the Spellings Commission itself, the Obama administration has taken important steps to strengthen American higher education in many of the ways we had hoped!

## References

Duderstadt, James J. and Farris W. Womack. *The Future of the Public University in America: Beyond the Crossroads*. Baltimore, MD: Johns Hopkins University Press, 2002.

Duderstadt, James J., An Issue Framing Paper for the Spellings Commission, Millennium Project, University of Michigan, 2004.

Duderstadt, James J., Report of the Quality Subcommittee of the Spellings Commission, Millennium Project, University of Michigan, 2005.

Miller, Charles (chair). *A Test of Leadership: Charting the Future of U.S. Higher Education.* National Commission on the Future of Higher Education in America ("The Spellings Commission"). Washington, DC: Department of Education, 2006.

Duderstadt, James J., "Raising the Bar: America's Challenge to Higher Education", Center for the Study of Higher and Postsecondary Education, The University of Michigan, 2007

Zemsky, Robert, "The Rise and Fall of the Spellings Commission", Chronicle of Higher Education, 2007.

Duderstadt, James J., "Aligning American Higher Education with a Twenty-first-century Public Agenda". Higher Education in Europe, Vol 34, No. 3-4, 2009.

# Chapter 13

# Public Research Universities

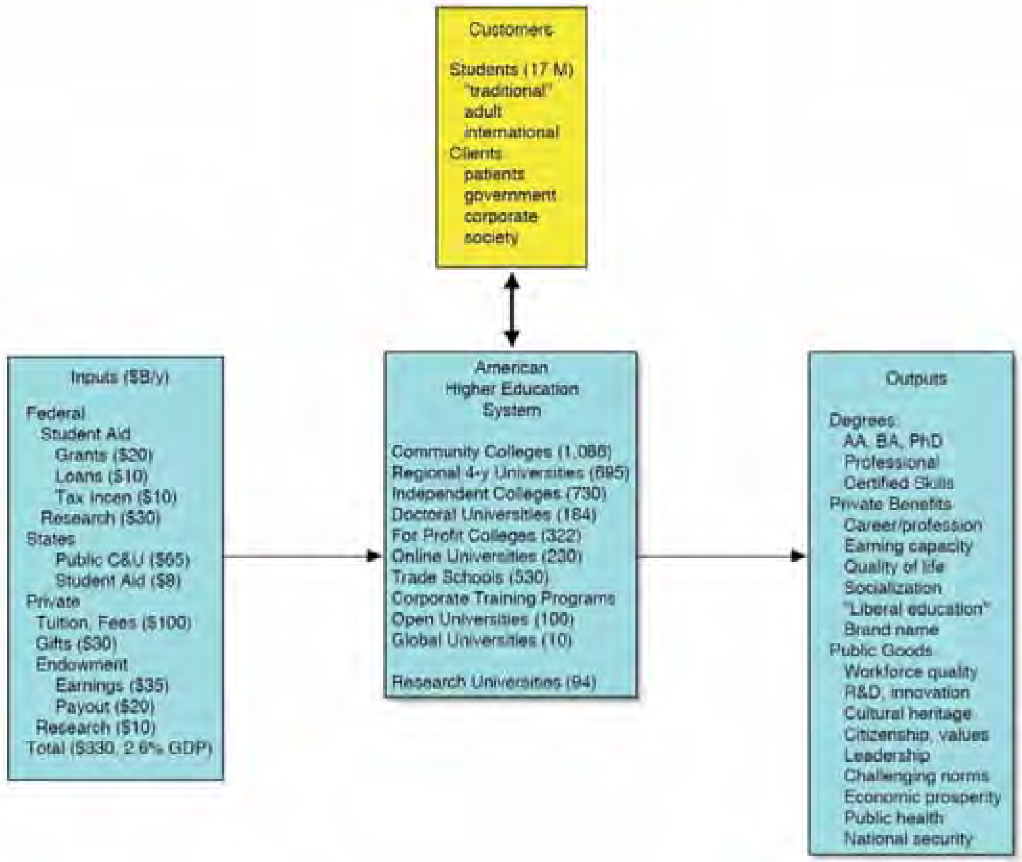
America's public research universities are the backbone of advanced education and research in the United States today. They conduct most of the nation's academic research (62%) while producing the majority of its scientists, engineers, doctors, teachers, and other learned professionals (70%). They are committed to public engagement in every area where knowledge and expertise can make a difference: basic and applied research, agricultural and industrial extension, economic development, health care, national security, and cultural enrichment (McPherson, 2009).

Ironically, America's great pubic research universities were not created by the states themselves but instead by visionary federal initiatives. During the early days of the Civil War, Congress passed the Morrill Land Grant Act (1862) that provided revenues from the sale of federal lands to forge a partnership between the states and the federal government aimed at creating public universities capable of extending higher education opportunities to the working class while conducting applied research to enable American agriculture and industry to become world leaders.

Some eighty years later, in the closing days of World War II, a seminal report, drafted by wartime research director Vannevar Bush persuaded the nation to invest heavily in campus-based research and graduate education through new federal agencies such as the National Science Foundation (Bush, 1945). Once again, the key theme was sustaining a close partnership between the federal government, the states, universities, and industry for the conduct of research in the national interest. This shaped the evolution of the American research university as we know it today (Cole, 2009).

The public research universities created by these two federal initiatives have become key assets in providing the steady stream of well-educated people, scientific knowledge, and technological innovations central to our robust economy, our vibrant culture, our vital health enterprise, and our security in a complex, competitive, and challenging world. In fact, it was the public research university, through its land-grant tradition, its strong engagement with society, and its commitment to educational opportunity in the broadest sense, that was instrumental in creating the middle class, transforming American agriculture and industry into the economic engine of the world during the 20th century, and defending democracy during two world wars. Today, public research universities must play a similarly critical role in enabling America to compete in an emerging global economy in which educated citizens, new knowledge, and innovation are key.

Yet today, despite their importance to their states, the nation, and the world, America's public research universities are at great risk. Many states are threatening both the quality and capacity of their public research universities through inadequate funding and intrusive regulation and governance. Rising competition from generously endowed private universities and rapidly evolving international universities threaten their capacity to attract and retain talented students and faculty. While the current budget difficulties faced by the states are painfully apparent, and the highly competitive nature of American higher education is one of its strongest features, it is also important to recognize that public research universities are critical national assets, key to the nation's economic strength, public welfare, and security. It would be a national disaster if the crippling erosion in state support and predatory competition among institutions were to permanently damage the world-class quality of the nation's public research universities.



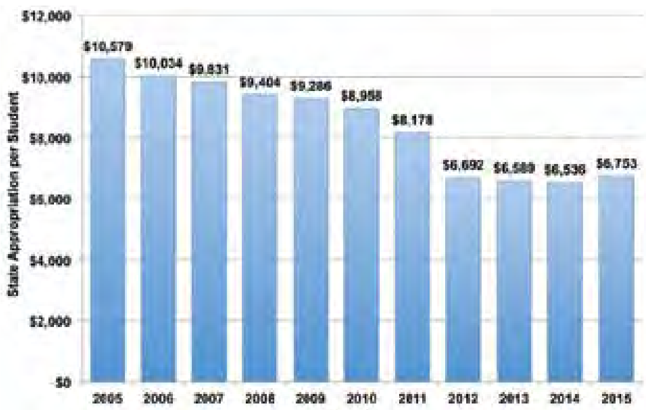

U.S. Higher Education by the numbers

## Today's Challenges Facing Public Research Universities

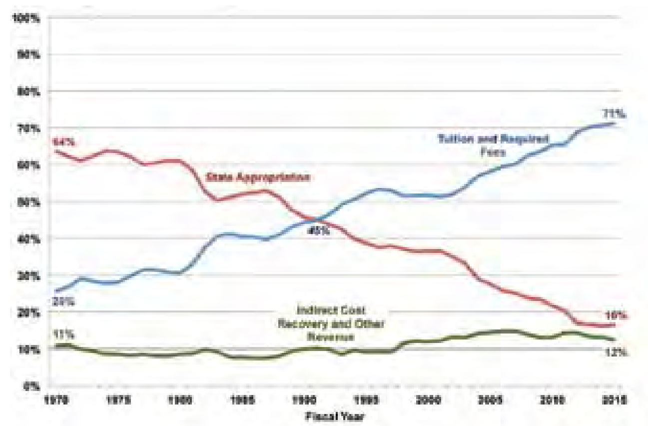
### Challenge 1: Shifting Public Priorities

Today the nation's public research universities face urgent and at times contradictory marching orders. They are challenged by their states to expand participation in higher education significantly and to increase baccalaureate degree production in an effort to enhance workforce quality. At the same time, the nation depends upon them to produce both the world-class research and the college graduates at all levels necessary to sustain an innovation-driven and globally competitive national economy. Aging populations are increasingly dependent upon the clinical services of their medical centers. Local economies depend both on their talented graduates and their entrepreneurial spinoff of companies to market their research achievements. In an increasingly fragmented and hostile world, the nation continues to depend, for its security, on the science and technology developed on their campuses. Meeting these myriad challenges is increasingly difficult as state support of higher education erodes and political constraints on public institutions multiply.

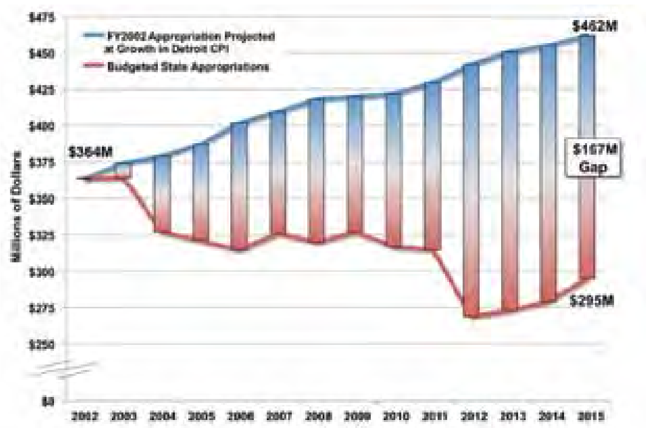
There is ample evidence from the past three decades of declining support that the states are simply not able–or willing–to provide the resources to sustain growth in public higher education, at least at the rate experienced in the decades following World War II. Despite the growth in enrollments and the demand for university services such as health care and economic development, most states will be hard pressed to sustain even the present capacity and quality of their institutions. In the wake of the recent global financial crisis, many states have already enacted drastic cuts in state appropriations, ranging from 20% to 50% (SHEEO, 2011). In this budget-constrained climate, public support of higher education and research is no longer viewed as an investment in the future but rather as an expenditure competing with the other priorities of aging populations, e.g., health care, retirement security, safety from



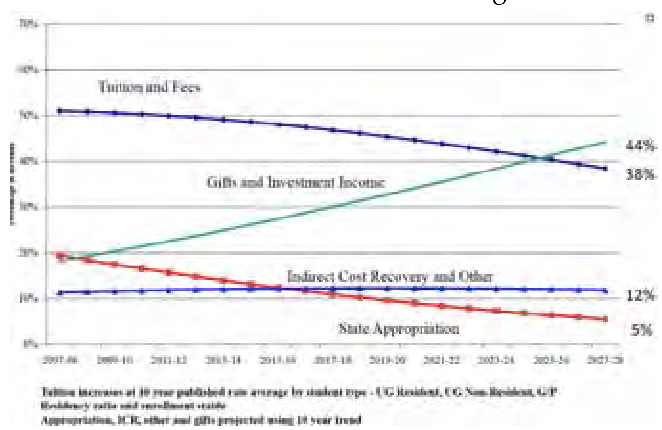

State Appropriations per student




General contribution of state support to the UMAA General Fund budget




The "Jaws" diagram showing the erosion in state support compared to the CPI



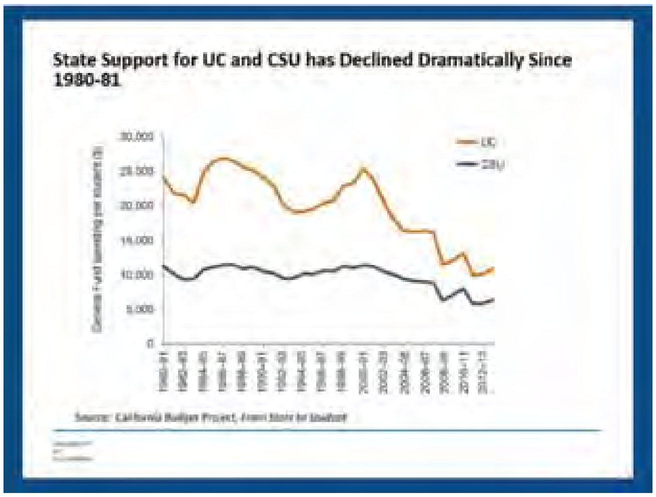

An optimistic extrapolation of the General Fund over the next decade (Hanlon)

crime, and tax relief. Instead, state governments are urging their research universities to wean themselves from state appropriations by developing and implementing strategies to survive what could be a generation-long period of state support inadequate to maintain their capacity, quality, and reputation.

### Challenge 2: The Changing Relationship between Universities and Government

Ironically, even as state support has declined, the effort to regulate universities and hold them accountable has increased. To some degree, this is evidence of governments attempting to retain control over the sector through regulation even as their financial control has waned. Most state governments and public university governing boards tend to view their primary roles as oversight to ensure public or political accountability rather than as stewardship to protect and enhance their institutions so that they are capable of serving both present and future generations. Furthermore, many public research universities today find themselves constrained by university systems, characterized both by bureaucracy and system-wide policies for setting tuition levels and faculty compensation that fail to recognize the intensely competitive environment faced by research universities.

Yet something more fundamental is occurring. While it was once the role of governments to provide for the purposes of universities, today it is now the role of universities to provide for the purposes of government. As costs have risen and priorities for tax revenues have shifted to accommodate aging populations, governments have asked more and more stridently, what are universities for? The imperatives of a knowledge-driven global economy have provided a highly utili-




California provides a vivid demonstration of how much state support has declined.


California also demonstrates that corrections and health care are now the top priorities.

tarian answer: to provide the educated work-force and innovation necessary for economic competitiveness. Governments, in other words, increasingly regard universities as delivery agencies for public policy goals in areas such as economic development and workforce skills that may be tangential to their primary responsibilities of education and scholarship (Newby, 2011).

While it is certainly true that cost-containment and accountability are important issues, it is also the case that most public universities can rightly argue that the main problems for them today is that they are both seriously underfunded through state appropriations and seriously overregulated by state policies in areas such as employment, financial affairs, tuition control, and open meetings requirements. Little wonder that public university leaders are increasingly reluctant to cede control of their activities to state governments. Some institutions are even bargaining for more autonomy from state control as an alternative to restoration of adequate state support, arguing that if granted more control over their own destiny, they can better protect their capacity to serve the public.

### Challenge 3: A Rapidly Changing Competitive Environment

The highly competitive nature of higher education in America, where universities compete aggressively for the best faculty members, the best students, resources from public and private sources, athletic supremacy, and reputation, has created an environment that demands achievement. However, while competition within the higher education marketplace can drive quality, if not always efficiency, it has an important downside. When serious imbalances arise in available funding, policy restrictions, and political constraints, such competition can deteriorate into a damaging relationship that not only erodes institutional quality and capacity, but also more seriously threatens the national interest. It can create an intensely Darwinian winner-take-all ecosystem in which the strongest and wealthiest institutions become predators, raiding the best faculty and students of the less generously supported and more constrained public universities and manipulating federal research and financial policies to sustain a system in which the rich get richer and the poor get devoured (Duderstadt, 2005).

This ruthless and frequently predatory competition poses a particularly serious challenge to the nation's public research universities. These institutions now find themselves caught with declining state support and the predatory wealthy private universities competing for the best students, faculty, and support. Of course, most private universities have also struggled through the recent recession, though for some elite campuses this is the first time in decades they have experienced any bumps in their financial roads. Yet their endowments and private giving will recover rapidly with a recovering economy, and their predatory behavior upon public higher education for top faculty and students will resume once again.

## What to Do? Institutional Strategies for the Near Term

### Streamlining, Cost-Containment, Productivity Enhancement

Clearly, in the face of the impact of aging populations and the global financial crisis on state and federal budgets and hence on support for higher education, the nation's public research universities must intensify their efforts to increase efficiency and productivity in all of their activities. In particular, they should set bold goals for reducing the costs of their ongoing activities. Many companies have found that cost reductions and productivity enhancement of 25% or greater are possible with modern business practices such as lean production and total quality management. While universities have many differences from business corporations–for example, cost reductions do not drop to the bottom line of profits–there is likely a very considerable opportunity for process restructuring in both administrative and academic activities (ITS, 2010).

Of course, in the face of deep cuts in state appropriations, most public research universities have already been engaged in intense cost-cutting efforts, particularly in non-academic areas such as financial management, procurement, energy conservation, competitive bidding of services, and eliminating unnecessary regulation and duplication. They have cut hundreds of millions of dollars of recurring costs from their budgets. But it is now time to consider bolder actions that require restructuring of academic activities as well. Some obvious examples include:

- Moving to year-round operation to maximize use of campus facilities
- Working with peer institutions to develop better metrics and accounting practices to achieve efficiency and productivity
- Making more extensive use of information technology (e.g., online learning, research collaboration among institutions, and sharing of expensive research facilities)
- Exploring model programs to reduce time to degree (e.g., three-year BA/BS and five-year PhD)
- Developing new models for junior faculty development and senior faculty retirement

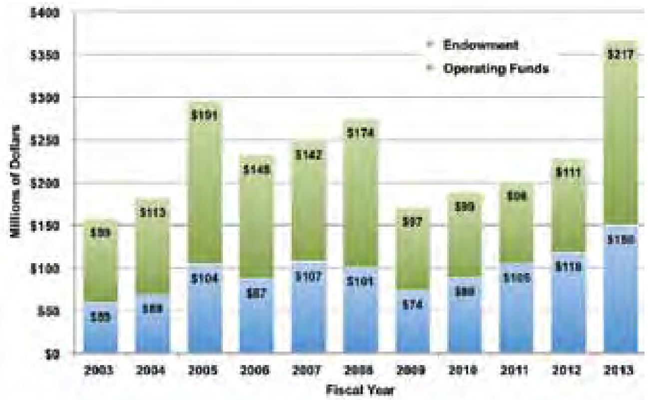

Michigan demonstrates that the actual cost of a public university education has remained stable.

In fact, it might even be time to take on third rail issues such as faculty tenure by reconsidering the appropriate balance between the role of tenure in protecting academic freedom and providing the security of career-long employment, particularly in professional schools such as medicine and engineering where professional practice is comparable to faculty scholarship in determining both faculty contributions and compensation.

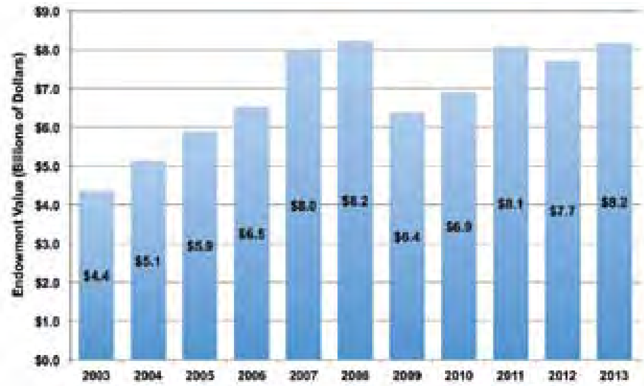
Clearly, current financial models for most American research universities are unsustainable and must be restructured (Zemsky, 2005, 2009). Yet, while efficiency, streamlining, cost reductions, and productivity enhancement are all necessary, eventually stakeholders of American higher education must address the dramatic decline in research university support through investments from all sources–federal government (particularly for graduate education), states, private sector, and students (tuition). As any business executive knows all too well, relying entirely on cost-cutting and productivity enhancement without attention to top line revenue growth eventually leads to Chapter 11!

### Privatizing the Public University

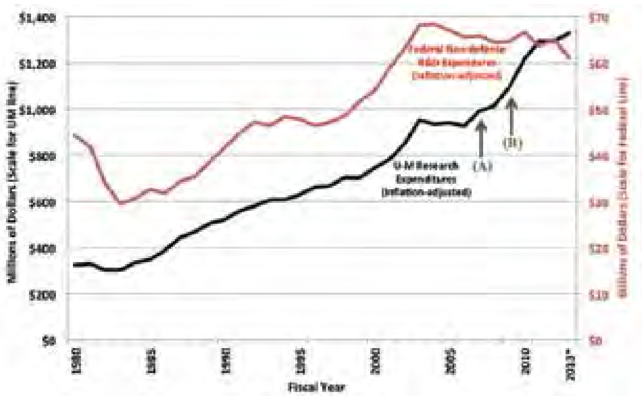
Declining state support is driving many public research universities to emulate their private counterparts in the development of an entrepreneurial faculty culture and in the manner in which priorities are set and assets are managed (Ehrenberg, 2006). In such uni-



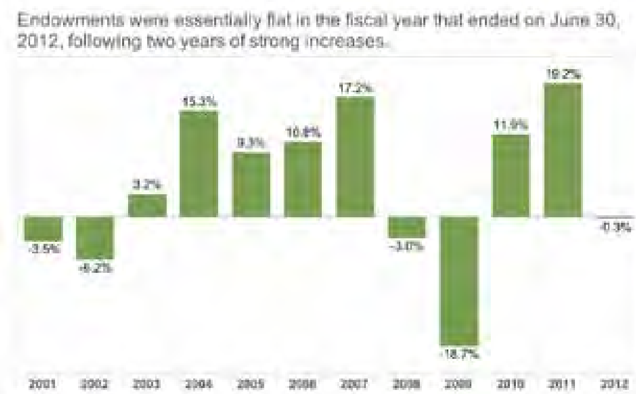

Gifts to the University




Endowment Growth




Growth in research expenditures



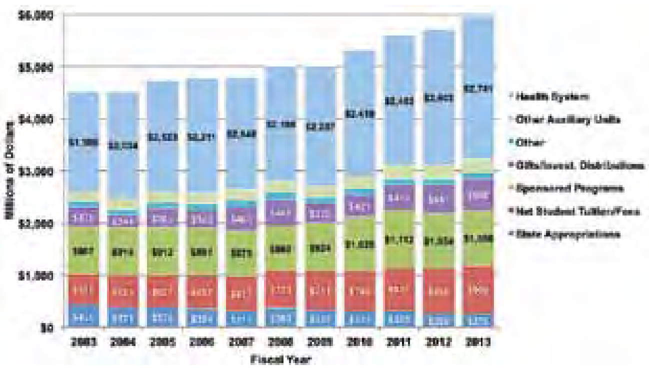

Endowment returns over past decade

versities, only a small fraction of operating or capital support comes from state appropriation. Like private universities, these institutions depend on tuition, federal grants and contracts, private gifts, and revenue from auxiliary services such as health care for most of their support.

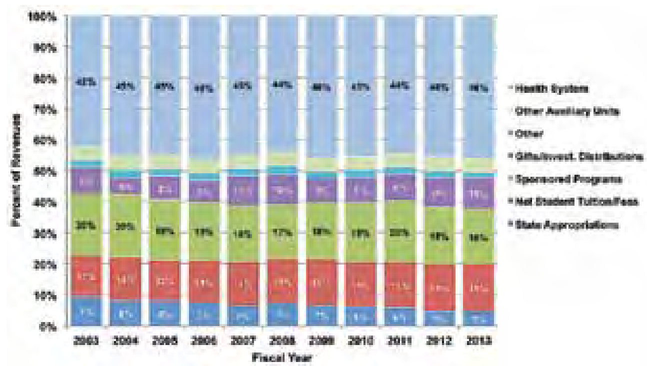
In fact, many states are encouraging their public universities to reduce the burden of higher education on limited state tax revenues by diversifying their funding sources, e.g., by becoming more dependent upon tuition–particularly that paid by out-of-state students–by intensifying efforts to attract gifts and research contracts, and by generating income from intellectual property transferred from campus laboratories into the marketplace. Some states are even encouraging experimentation in creating a more differentiated higher education structure that better aligns the balance between autonomy and accountability with the unique missions of research universities. Examples include Virginia's effort to provide more autonomy in return for accountability for achieving negotiated metrics, Colorado's voucher system, performance funding in South Carolina, and cohort tuition in Illinois (Breneman, 2005).

Yet, such efforts to "privatize" the support of public universities through higher tuition or increasing out-of-state enrollments can also encounter strong public and political opposition, even though there is ample evidence that to date tuition increases at most public institutions have not been sufficient to compensate for the loss in state appropriations (Desrochers, 2011). Furthermore, since state support is key to the important public university mission of providing educational opportunities to students regardless of economic means, shifting to high tuition funding, even accompanied by increased financial aid, usually leads to a sharp decline in the socioeconomic diversity of students (Haycock, 2008, 2010).

The privatizing strategy is flawed for more funda-

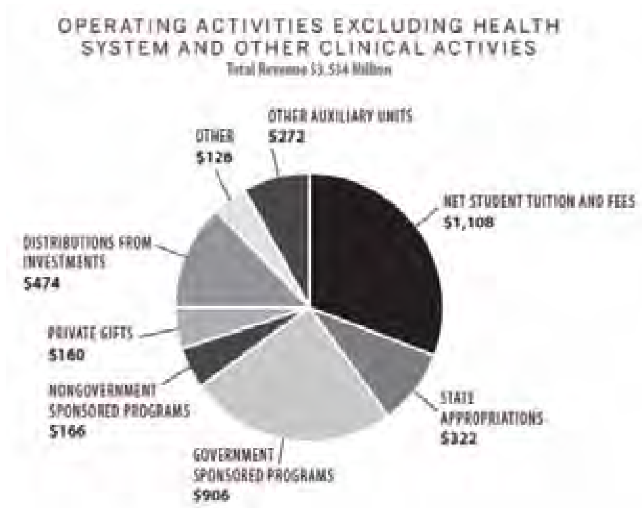



Operating Revenues (inc Hospitals)

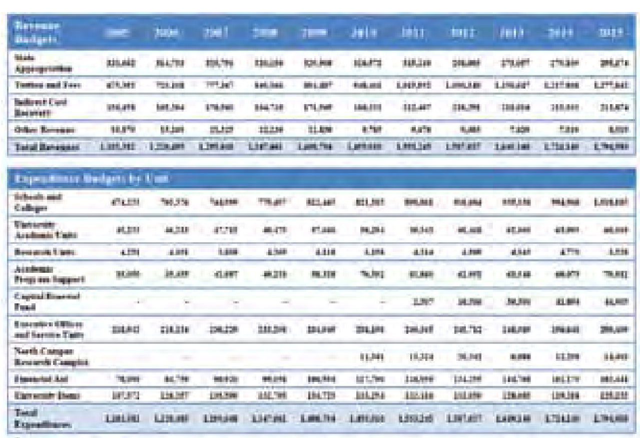



Operating Revenues (w/o Hospitals)

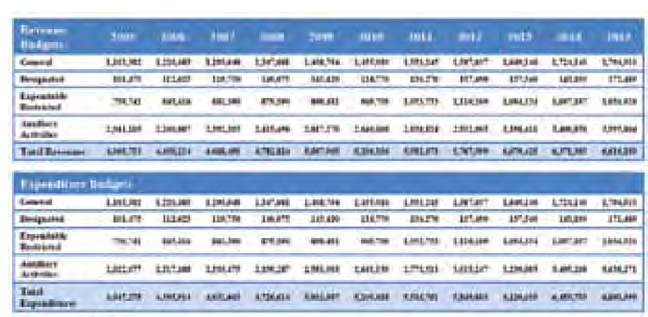

UM Total Budget (including hospitals)




UM Academic Budget (without hospitals)



UM Budget Revenue (2014)



UM Budget Planned Expenditures (2014)

The University of Michigan demostrates well the paradigm
of a “privately supported but publicly committed university!

mental reasons. The public character of state research universities runs far deeper than financing and governance and involves characteristics such as their large size, disciplinary breadth, and deep engagement with society through public service. These universities were created as, and today remain, public institutions with a strong public purpose and character. Hence the issue is not whether the pubic research university can evolve from a "public" to a "private" institution, or even a "privately funded but publicly committed" university. Rather, the issue is a dramatic broadening of the "publics" that these institutions serve, are supported by, and become accountable to, as state support declines to minimal levels.

#### Extending the Land-Grant Paradigm to a New Century

The success of the land-grant university suggests that this model could serve as the platform for the further evolution of the public research university. For example, both the role of research universities in contributing to the innovation necessary to compete in a knowledge-driven global economy and the changing nature of the research necessary to stimulate breakthrough discoveries and transfer into the marketplace may require new research paradigms. In particular, with the disappearance of many of the nation's leading industrial research laboratories (e.g., Bell Labs), there is a need for new university-based paradigms to conduct translational research, capable of building the knowledge base necessary to link fundamental scientific discoveries with the technological innovation necessary for the development of new products, processes, and services.

To fill this gap, the federal government has recently launched a series of "innovation hubs" involving research universities, national laboratories, and industry designed to link fundamental scientific discoveries with technological innovations (Duderstadt, 2010). However, in reality, this is simply the repurposing of the land-grant agricultural and industrial experiment stations established by the Hatch Act of 1887, a partnership involving higher education, business, and state and federal government that developed and deployed the technologies necessary to build a modern industrial nation for the 20th century while stimulating local economic growth. The highly successful model of land-grant experiment stations and cooperative extension services can clearly be broadened beyond agriculture and industrial development as an expanded mission for land-grant and other public universities to address major national challenges such as building a sustainable energy infrastructure, providing affordable health care for aging populations, and developing new, globally competitive manufacturing industries. In fact, one might even imagine shifting the 19th and 20th century land-grant priorities from developing the vast natural resources of a young nation to instead focusing on the key resources of the 21st century knowledge economy: the skills, knowledge, innovation, and entrepreneurial spirit of our people. The field stations and cooperative extension programs–perhaps now as much in cyberspace as in a physical location–could be directed to regional learning and innovation needs.

The land-grant model of linking federal and state investment and interest with higher education and business to serve national and regional needs, while initially intended for agriculture and industry, remains a very powerful paradigm for the conduct of both basic and applied research aimed at a very broad range of contemporary needs and priorities.

### What to Do? The State Role

#### Balancing Governance, Autonomy, and Accountability

Many of the most powerful forces driving change in higher education come from the marketplace, driven by new societal needs, the limited availability of resources, rapidly evolving technologies, and the emergence of new competitors such as for-profit ventures. Clearly, in such a rapidly changing environment, agility and adaptability become important attributes of successful institutions.

Unfortunately, the governance of public universities, whether at the level of state government or institutional governing boards, is more inclined to protect the past than prepare for the future. Furthermore, all of higher education faces a certain dilemma related to its being far easier for a university to take on new missions and activities in response to societal demand than to shed missions as they become inappropriate, distracting, or too costly. This is a particularly difficult matter for public universities because of intense public and political pressures that require these institutions to continue to accumulate missions, each with an associated risk, without a corresponding capacity to refine and focus activities to avoid risk. Examples here would include pressures to launch expensive new academic programs in areas such as medicine or engineering without adequate resources or to embark on high-risk economic development activities through university-business partnerships that may be incompatible with the academic culture. Furthermore there are many demands from state and federal government, governing boards, and public opinion for increasing accessibility, decreasing costs, and accountability for learning outcomes. All of these forces have long constrained the agility of public universities (Miller, 2006).

Little wonder that one finds an increase in the efforts of public research universities to free themselves from the constraints of politically-determined governing boards, the tyranny of university systems, and the intrusive regulation of state government in the hope of achieving the autonomy and agility to adapt to a future with limited state support. Steps should be taken to ensure that during a time of great financial stress on flagship public universities, they are provided with the autonomy and agility to restructure their operations to enable them to survive with their quality intact what is likely to be a generation-long period of inadequate state support. After all, should the states intentionally allow their public research universities to decline significantly in quality and capacity, it would be a major blow to the nation's prosperity and security since public universities are the primary source of advanced degrees and basic research for the United States. Put another way, states should be warned not to add insult to injury by strangling their research universities with unnecessary regulation or intrusion on sensitive political issues such as climate change or gay rights, even as they starve them with inadequate support.

## Mission Differentiation and Profiling

It is apparent that the great diversity of higher education needs, both on the part of diverse constituencies (young students, professionals, adult learners) and society more broadly (teaching, research, economic development, cultural richness), demands a diverse higher education ecosystem of institutional types. Key is the importance of mission differentiation, since the availability of limited resources will allow a small fraction of institutions to become globally competitive as comprehensive research institutions (Duderstadt, 2009).

Although most states have flagship state research universities, they also have many other public colleges and universities that aspire to the full array of missions characterizing the comprehensive public research university. Community colleges seek to become four-year institutions; undergraduate colleges seek to add graduate degree programs; and comprehensive universities seek to become research universities. Since all colleges and universities generally have regional political representation, if not statewide influence, they can frequently build strong political support for their ambitions to expand missions. Even in those states characterized by "master plans" such as California, there is evidence of politically driven mission creep, leading to unnecessary growth of institutions and wasteful overlap of programs.

A differentiated system of higher education helps to accomplish the twin goals of enhancing educational opportunity and conducting research of world-class quality. But it assigns different roles in such efforts for various institutions. Clearly, limited resources will allow only a small fraction of institutions to become globally competitive as comprehensive research institutions.

So how many world-class research universities can a state–or the nation, for that matter–really afford? This is a highly charged question that usually engenders strong political rhetoric. But perhaps here we can rely upon (or blame) a calculation once made by David Ward, former president of the American Council of Education and chancellor of the University of Wisconsin, Madison. He estimated that supporting a public world-class research university with an annual budget in excess of $1 billion or more requires the tax base of a population of five million or greater. Ward's calculation would suggest that nationwide we could probably afford 60 of these comprehensive flagships. But here it is also very important to add the caveat that many a university that possesses neither the resources nor the scale to become a comprehensive research university has demonstrated the capacity to mount world-class research and graduate programs in more narrowly defined areas. By focusing resources, many regional universities and independent colleges have managed to create peaks of excellence that make significant contributions in particular areas of scholarship.

## What to Do? The Federal Role

### The Importance of a National Strategy

Nations around the world have recognized the importance of world-class research universities and are rapidly strengthening their institutions to compete for international students and faculty, resources, reputation, and the impact of university-driven research and advanced education on economic prosperity (Weber, 2008, 2010). Yet currently the United States stands apart with no comprehensive policy for enhancing and sustaining its research universities in the face of growing international competition from abroad. In fact, many current federal policies and practices actually harm the competitiveness of American universities, e.g., the failure to cover the full costs of federally-funded research projects (indirect cost recovery, cost sharing requirements), a research appropriations process that favors political influence rather than national priorities, and regulatory constraints that discourage the recruiting of international students and faculty. There is an urgent need to develop a framework of national policies and funding goals capable of sustaining the nation's research universities at world-class levels, embedded in a broader federal R&D policy that addresses national priorities (Augustine, 2005).

Within the broader framework of United States innovation and R&D policies, it is essential that the nation develop specific goals for sustaining the strong academic research, doctoral education, and research universities key to the nation's capacity to compete, prosper, and achieve national goals for health, energy, the environment, and security in the global community of the 21st Century. These goals should include a framework of supportive federal funding and public policies adequate to maintain university research and graduate education at world-class levels (Berdahl, 2010; McPherson, 2010).

### Fixing the Flaws

While the federal government continues to be the key sponsor of campus-based research, there is an urgent need for the federal government to end damaging fluctuations in research appropriations and research policy and instead provide steady, sustainable, predictable support for university research over the longer term. This would enable universities to plan their own investments in research facilities and staffing, and it would en-able federal research expenditures to become more effective and efficient.

During the past two decades, an era during which external support of campus-based research by federal and industrial sponsors remained at relatively constant levels (at \$32 B/y and \$2.5 B/y, respectively), there has been a very significant growth in research supported from internal university funds that now amounts to over \$10 B/y (Berdahl, 2010). While some of this university-sponsored research has supported scholarship in important areas such as the humanities and social sciences where external sponsorship is limited, much of the growth in university research expenditures has also been driven by the serious underfunding, cost-sharing requirements, and regulatory burden of the research grants and contracts commissioned from universities by government, industry, and foundations. In fact, the present financial burden associated with research grants from federal agencies is estimated by some universities to be as much as 25% of the grant amount. Since the only way for most institutions to subsidize such unsupported costs of federal and industrial research grants is through the reallocation of student tuition revenue or clinical income from patients, universities have been forced into a very awkward and politically volatile position by current federal research policies.

There is an urgent need for federal government to move over the next several years to cover the full cost of the research projects it funds at academic institutions, and it should do so across all federal agencies and universities in a consistent and transparent manner. Private foundations and industrial sponsors should also be advised not to pressure universities to waive or reduce administrative cost rates below actual expenses. In fact, research universities should actively discourage research grants and contracts characterized by inadequate funding or excessive cost-sharing that would require unreasonable subsidies from other university revenue sources such as tuition, clinical income, or donor-specified gifts.

Earlier it was noted that a serious competitive imbalance has arisen in the marketplace for the best faculty, students, and resources, with private research universities now spending almost three times as much to educate each student and 30% more for faculty salaries (McPherson, 2009). This is due, in part, to the degree to which current federal and state policies in areas such as tax benefits, student financial aid, research funding, and regulation tend to preferentially benefit and subsidize the high-cost nature of private institutions. Since one of the great strengths of American higher education is the presence of a balanced system of world-class public and private research universities, it is important that federal and state policies treat both public and private universities in an equitable manner to achieve quality, diversity, and balance in America's higher education system rather than drive damaging predatory behavior.

### Restructuring the Support and Conduct of Graduate Education

The erosion of state support of graduate education and research, particularly in areas of science and technology critical to national interests, suggest that the federal government must play a more significant role in graduate student support. In particular, the federal government should become the primary patron of advanced education in areas key to national priorities such as economic prosperity, public health, and national security, just as it accepted this responsibility for the support of campus-based research in the decades following WWII. Federal support of graduate education should be allocated to universities based on a combination of merit and impact. For example, competitive graduate traineeship programs might be used in some disciplines, while grants for other fields might be based on graduation rates or the size of graduate faculties or student enrollments (much like the capitation grants used in the health sciences). Other grants could be designed to stimulate and support newly emerging disciplines in areas of national priority such as nanotechnology or sustainable energy. A key objective would be a better balance in the support among student fellowships, traineeships, and research assistantships.

For their part, research universities should commit to correcting the current flaws in doctoral education and postdoctoral training. Numerous studies confirm a strong consensus that by conducting graduate education in the same institutions where a large portion of the nation's basic research is done, our research universities have created a research and training system that is one of the nation's greatest strengths—and the envy of the rest of the world. Yet it is not surprising that during these times of challenge and change in higher education, the nature and quality of graduate education have also come under scrutiny. The current highly specialized form of graduate education no longer responds to the needs of many students nor of society, as evidenced by the difficulty many recent PhDs have in finding employment. Attrition in many graduate programs has risen to intolerable levels, with more than 50% of those who enroll in PhD programs failing to graduate (compared to attrition rates in law and medicine of less than 5%), while time to degree has lengthened beyond five years, only to be followed by required post-doctoral service for many disciplines. These factors have eroded the attractiveness of further graduate study for many talented undergraduates who now prefer to enroll in professional programs such as law, medicine, and business characterized by more predictable duration, completion, and compensation. It is time to launch a serious reform of graduate education in American universities comparable to those occurring in other areas of graduate and professional education (e.g., the Flexner Report in medicine).

### Jump-Starting the Rebuilding of the Nation's Research Faculty During a Time of Financial Stress

There are compelling needs to replenish the faculties of the nation's research universities with new perspectives and capabilities. Yet it is also the case that many institutions are limited in their ability to add young faculty members by serious financial constraints, particularly in public universities now experiencing serious reductions in state appropriations. Furthermore, the recent recession has shaken the confidence of senior faculty enrolled in defined contribution retirement programs, delaying their decision to retire and resulting in a rapidly aging and heavily tenured faculty cadre without the turnover necessary to open up positions for new junior faculty hires. To address this current challenge, likely to last for the next decade, the National Academies has recently proposed a federal program of matching grants to establish endowments for the support of faculty positions, modeled after highly successful programs at the University of California Berkeley and in Canada (Birgeneau, 2009; Canada Research Chairs, 2011).

### For the Longer Term: Broadening the Concept of the Public Research University

The American university has changed quite considerably over the past two centuries and continues to evolve today. Colonial colleges have become private research universities; religious colleges formed during the early 19th century gradually became independent colleges; junior colleges have evolved into community colleges and then into regional universities. Today public research universities continue to evolve to adapt to changes in students (from state to national to global), support (from state to national, public to private), missions (from regional to national to global), and perception (from education as a public good to a private benefit). They are rapidly expanding their public purpose far beyond the borders of their states since the more mobile the society and global the economy, the broader the "publics" served by the university.

This broadening of the public purpose of the public research university is not only mandated by national and global needs for its services, but is also a consequence of the changing motivation of the states to invest in world-class institutions. At a time when the strength, prosperity, and welfare of nations demand a highly educated citizenry and institutions with the ability to discover new knowledge, develop innovative applications of discoveries, and transfer them into the marketplace through entrepreneurial activities, such vital national needs are no longer top state priorities (Courant, 2010). The model of state-based support of graduate education and research made sense when university expertise was closely tied to local natural resource bases such as agriculture, manufacturing, and mining. But today's university expertise has implications far beyond state borders. Highly trained and skilled labor has become more mobile and innovation more globally distributed. Most of the benefits from the graduate training and research conducted at state research universities are public goods that provide only limited returns to the states in which they are located.

Hence it should be no surprise that today many states, caught between the financial pressures of weakened economies and the political pressure of Tea Party activists, have concluded that they cannot, will not, and probably should not invest to sustain world-class quality in graduate education and research, particularly at the expense of other priorities such as broadening access to baccalaureate education or addressing the needs of aging populations. Unfortunately, today not only is state support woefully inadequate to achieve state goals, but state goals no longer accumulate to meet national needs.

While the declining priority that states have given to public higher education may be politically acceptable in the near term, though not certainly for their long-term prosperity, such a strategy could have disastrous consequences for the nation. The scientists and engineers, physicians and teachers, humanists and artists, and designers, innovators, and entrepreneurs produced by public research universities are absolutely vital to national prosperity, security, health, and quality of life in the global, knowledge-driven economy. It is clear that the production of these critical assets can no longer be left dependent on shifting state priorities and declining state support. It is essential to realign responsibilities for support of America's public research universities such that advanced graduate and research programs of major importance to the nation are both supported by and held accountable to the needs of key stakeholders beyond state borders. Here it should be noted that both the unusually broad intellectual needs of the nation and the increasing interdependence of the academic disciplines provide compelling reasons why such federal support should encompass all areas of scholarship including the natural sciences, the social sciences, the humanities, the arts, and professional disciplines such as engineering, education, law, and medicine.

More specifically, one might consider a hybrid structure for the public research university that is better distributed for both support and governance among the states, students, the federal government, industry, and private donors:

• The states, consistent with their current priorities for enhancing workforce quality, would focus their limited resources on providing access to quality education at the associate and baccalaureate levels, augmented by student tuition and private philanthropy.

• Students (and parents) would continue to provide support through tuition and fees, although perhaps increasingly augmented by need-dependent financial aid grants and income-contingent student loans.

• The federal government, in addition to being the leader in supporting university research, would become the primary patron of advanced education at the graduate level (i.e., master's and doctoral degree programs) across all academic disciplines (natural and social sciences, humanities, and the arts) through a coordinated system of fellowships, traineeships, and graduate student assistantships.

• Professional schools enabling high-income careers such as law, business administration, and medicine would become predominantly privately supported through high tuition (enabled by strong financial aid/loan programs) and private giving, similar to private universities.

• Foundations and individual donors would continue to play a major role in the support of both education and scholarship in selected areas while enabling the broader roles of the university such as the preservation of knowledge and culture and serving as an informed critic of society. Yet it should also be acknowledged that while such private support will become increasingly important, for most public institutions it will provide only the margin of excellence on a funding base primarily dependent upon state support and student tuition.

Of course, such an approach would require a new social contract to reflect not only the interests of the states but those of the expanding array of stakeholders providing support for such hybrid institutions. Clearly, not only the governance but the statutory responsibility and authority of these emerging institutions would need to be renegotiated. In view of the likely inability of the states to sustain the essential contributions of their research universities at a world-class level, such an evolutionary path seems not only possible but perhaps inevitable.

## The Future of the Public Research University in America

An important theme throughout the history of American higher education has been the evolution of the public university. The nation's vision and commitment to create public universities competitive in quality with the best universities in the world were a reflection of the democratic spirit of a young America. With an expanding population, a prosperous economy, and imperatives such as national security and industrial competitiveness, the public was willing to make massive investments in higher education. While elite private universities were important in setting the standards and character of higher education in America, it was the public university that provided the capacity and diversity to meet our nation's vast needs for postsecondary education and research.

Today, however, in the face of limited resources and the pressing social priorities of aging populations, this expansion of public support of higher education has slowed. While the needs of our society for advanced education and research will only intensify as we continue to evolve into a knowledge-driven global society, it is not evident that these needs will be met by further expansion of our existing system of state universities. The terms of the social contract that led to these institutions are changing rapidly. The principle of general tax support for public higher education as a public good and the partnership between the states, the federal government, and the universities for the conduct of basic research and education, established in 1862 by the Morrill Act and reaffirmed a century later by post-WWII research policies, are both at risk.

These forces are already driving major change in the nature of the nation's public research universities. One obvious consequence of declining state support has been the degree to which many leading public universities may increasingly resemble private universities in the way they are financed, managed, and governed, even as they strive to retain their public character. Public universities forced to undergo this privatization transition–or, in more politically acceptable language, "self-sufficiency"–in financing must appeal to a broader array of constituencies at the national—indeed, international—level, while continuing to exhibit a strong mission focused on state needs. In the same way as private universities, they must earn the majority of their support in the competitive marketplace, that is, via tuition, research grants, and private giving, and this will require actions that come into conflict from time to time with state priorities. Hence, the autonomy of the public university will become one of its most critical assets, perhaps even more critical than state support for many institutions.

In view of this natural broadening of the institutional mission, coupled with the increasing inability (or unwillingness) of states to support their public research universities at world-class levels, it is even possible to conclude that the world-class "state" research university may have become an obsolete concept. Instead, many of America's leading public research universities may evolve rapidly into "regional," "national," or even "global" universities with a public purpose to serve far broader constituencies than simply the citizens of a particular state who no longer are able or willing to provide sufficient support to sustain their programs at world-class levels. In fact, one might well argue that states today would be better off if they encouraged their flagship public research universities to evolve into institutions with far broader missions (and support), capable of accessing global economic and human capital markets to attract the talent and wealth of the world to their regions.

How might institutions embark on this path to serve far broader public constituencies without alienating the people of their states—or risking their present (albeit low) level of state support? One constructive approach would be to attempt to persuade the public—and particularly the media—that public research universities are vital to states in a far more multidimensional way than simply education alone—through health care, economic development, pride (intercollegiate athletics), the production of professionals (doctors, lawyers, engineers, and teachers), and so forth. The challenge is to shift the public perception of public research universities from that of a consumer to that of a producer of state resources. One might argue that for a relatively modest contribution toward their educational costs, the people of their states receive access to the vast resources, and benefit from the profound impact, of some of the world's great universities. It seems clear that we need a new dialogue concerning the future of public higher education in America, one that balances both its democratic purpose with economic and social imperatives.

Today we face the challenges of a hypercompetitive global, knowledge-driven society in which other nations have recognized the positive impact that building world-class public universities can have. America already has them. They are one of our nation's greatest assets. Preserving their quality and capacity will require not only sustained investments but also significant paradigm shifts in university structure, management, and governance. It also will likely demand that public research universities broaden their public purpose and stakeholders far beyond state boundaries. Preserving the quality and capacity of the extraordinary resource represented by our public research universities must remain a national priority, even if the support required to sustain these institutions at world-class levels is no longer viewed as a priority by our states.

## References


Berdahl, Robert. "Maintaining America's Competitive Edge: Revitalizing the Nation's Research University". Testimony to the National Academies Committee on Research Universities. Washington, DC: Association of American Universities, 2010.

Birgeneau, Robert J. and Frank D. Yery. "Rescuing Our Public Universities". The Washington Post, September 27, 2009.

Breneman, David. "Are the States and Public Higher Education Striking a New Bargain?", Public Policy Paper Series. Washington, DC: Association of Governing Boards and Colleges, 2005.

Courant, Paul N, James J. Duderstadt, Edie N. Goldenberg. "Needed: a National Strategy to Preserve Public Research Universities". Chronicle of Higher Education, A36, January 8, 2010.

Duderstadt, James J. and Farris W. Womack. *Beyond the Crossroads: The Future of the Public University in America.* Baltimore, Md: Johns Hopkins University Press, 2005.

Courant, Paul, James J. Duderstadt, Edie Goldenberg, "Needed: A National Strategy to Preserve Public Research Universities", Chronicle of Higher Education, 2010.

Duderstadt, James J., "Aligning American Higher Education with a Twenty-first-century Public Agenda". Higher Education in Europe, Vol 34, No. 3-4, 2009.

Duderstadt, James J., "Creating the Future: The Promise of Public Research Universities for American, Association of Public and Land Grant Universities Volume Celebrating the 150th Anniversary of the Morrill Act, 2012

Ehrenberg, Ronald G., "The Perfect Storm and the Privatization of Public Higher Educaion". Change, January/February 2006, p. 47

Haycock, Kati and Danette Gerald. *Engines of Inequality.* Washington, DC: Education Trust, 2008.

Haycock, Kati. *Opportunity Adrift.* Washington, DC: Education Trust, 2010.

McPherson, Peter and David Schulenberger. "Competitiveness of Public Research Universities and Consequences for the Country: Recommendations for Change". Washington, DC: Association of Public and Land-Grant Universities, 2009.

Miller, Charles (chair). A Test of Leadership: Charting the Future of U.S. Higher Education. National Commission on the Future of Higher Education in America ("The Spellings Commission"). Washington, DC: Department of Education, 2006.

Zemsky, Robert, William Massey and Gregory Wegner. *Remaking the American University: Market-Smart and Mission Centered*. New York, NY: 2005.

Zemsky, Robert. *Making Reform Work: The Case for Transforming American Higher Education*. Rutgers, NJ: University of Rutgers Press, 2009.

# Chapter 14

# University Leadership and Governance

Higher education in the United States is characterized both by its great diversity and an unusual degree of institutional autonomy–understandable in view of the limited role of the federal government in postsecondary education. As The Economist notes, "The strength of the American higher education system is that it has no system." (The Economist, 2005) More generally, the strength of American higher education depends upon characteristics such as:

- The great diversity among institutions and missions.
- The balance among funding sources (private vs. public, state vs. federal).
- The influence of market forces (for students, faculty, resources, reputation).
- Its global character (attracting students and faculty from around the world)
- A limited federal role that leads to highly decentralized, market-sensitive, and agile institutions, students, and faculty.
- Supportive public policies (academic freedom, institutional autonomy, tax and research policies).
- The research partnership between universities, the federal government, and industry.

As a consequence the contemporary university is one of the most complex social institutions of our times. For example, the manner in which American higher education is supported is highly diverse, complex, and frequently misunderstood. In the simplest sense, today the United States spends roughly 2.6% of its GDP on higher education ($330 B), with 55% of this ($185 B) coming from private support, including tuition payments ($90 B), philanthropic gifts ($30 B), endowment earnings ($35 B on the average), and revenue from auxiliary activities such as clinics and athletics ($30 B). Public sources provide the remaining 45%: the states provide 24% ($75 B) primarily through appropriations directly to public colleges and universities; the federal government provides the remaining 21% ($70 B) through student financial aid, subsidized loans, and tax benefits ($40 B) and research grants ($30 B). This very large dependence on private support–and hence the marketplace–is unique to the United States, since in most other nations higher education is primarily supported (and managed) by government (90% or greater). It is the major reason why on a per student basis, higher education in America is supported at about twice the level ($20,545 per year) as it is in Europe. (OECD, 2008) There is a caveat here, however, since roughly half of this cost is associated with non-instructional activities such as research, health care, agricultural extension, and economic development–missions unique to American universities. The actual instructional costs of American higher education are quite comparable to many European nations.

The university's external constituencies are both broad and complex, and include as clients of university services not only students but also patients of its hospitals; federal, state, and local governments; business and industry; and the public at large. The university is, however, not only accountable to this vast base of present stakeholders, but it also must accept a stewardship to the past and a responsibility for future stakeholders. In many ways, the increasing complexity and diversity of the modern university and its many missions reflect the character of American and global society. Yet this diversity—indeed, incompatibility—of the values, needs, and expectations of the various constituencies served by higher education poses a major challenge.

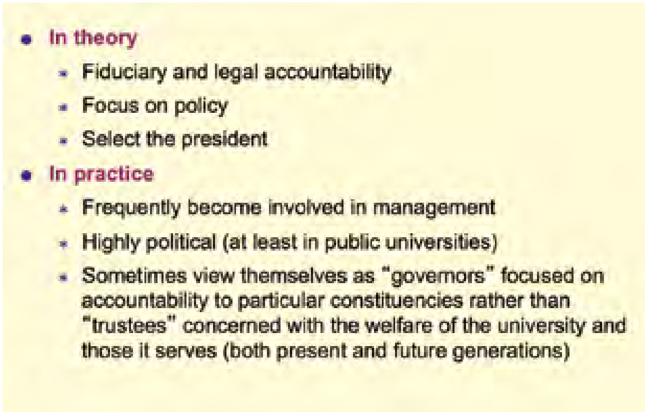
## Governance

The importance of the university to our society, its myriad activities and stakeholders, and the changing nature of the society it serves, all suggest the importance of experienced, responsible, and enlightened university leadership, governance, and management. Here we should distinguish between leadership and management at the institution or academic unit level, as exercised by administrative officers such as presidents, deans, and department chairs, and the governance of the institution itself as exercised by governing boards, statewide coordinating bodies, or state and federal government. The governance of public colleges, universities, and higher education systems is particularly complex, involving the participation and interaction of many organizations with responsibilities for not only the welfare of the institution but also for funding and regulating its activities and ensuring its public accountability. At the most basic level, the principles embodied in the Constitution make matters of education an explicit state assignment. State governments have historically been assigned the primary role for supporting and governing public higher education in the United States. The states have distributed the responsibility and authority for the governance of public universities through a hierarchy of governing bodies including the legislature, state executive branch agencies, higher education coordinating boards, institutional governing boards, and institutional executive administrations.

American colleges and universities have long embraced the concept of institutional governance involving public oversight and trusteeship by lay boards of citizens. Although these boards have both a legal status as well as fiduciary responsibility, their limited knowledge of academic matters leads them to delegate much of their authority to the university's administration for executive leadership and to the faculty for academic matters. Because of their lay character university governing boards face a serious challenge in their attempts to understand and govern the increasingly complex nature of the university and its relationships to broader society. They must be attentive to the voluntary culture (some would say anarchy) of the university that responds far better to a process of consultation, communication, and collaboration than to the command-control-communication process familiar from business and industry. This is made even more difficult by the politics swirling about and within governing boards, particularly in public universities, that not only distract boards from their important responsibilities and stewardship, but also discourage many experienced, talented, and dedicated citizens from serving on these bodies. The increasing intrusion of state and federal government in the affairs of the university, in the name of performance and public accountability, but all too frequently driven by political opportunism, can trample upon academic values and micromanage institutions into mediocrity. Furthermore, while the public expects its institutions to be managed effectively and efficiently, it weaves a web of constraints through public laws that make this difficult. Sunshine laws demand that even the most sensitive business of the university must be conducted in the public arena, including the search for a president. State and federal laws entangle all aspects of the university in rules and regulations, from student admissions to financial accounting to environmental impact.

Leadership and governance

The great diversity of university governance–state government, coordinating boards, boards of trustees, faculty senates–suggests that the most appropriate governance structure likely involves a unique consideration of history and constraints for each institution. Yet while this collegial style of governance has a long history both in this country and abroad, the extraordinary expansion of the roles and mission of the university over the past century has resulted in a contemporary institution with only the faintest resemblance to those




Respoonsibilities of governing boards

in which shared governance first evolved. Despite dramatic changes in the nature of scholarship, pedagogy, and service to society, the university today is organized, managed, and governed in a manner little different from the far simpler colleges of the early twentieth century. This is particularly true, and particularly questionable, for the contemporary public university facing an era of significant challenge and change.

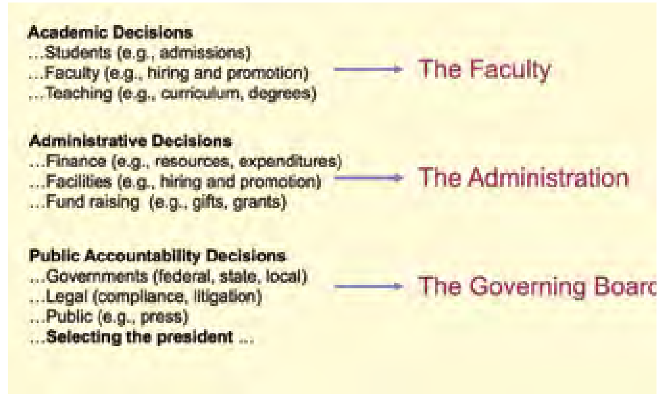
While it may be impolitic to be so blunt on the campus, the simple fact of life is that the contemporary university is an extremely important and complex public corporation that must be governed, led, and managed with competence and accountability to benefit its diverse stakeholders. These public and private interests can only be served by a governing board that functions with a structure and a process that reflect the best practices of corporate boards, comprised of members with expertise commensurate with their fiduciary obligations, albeit with a deep understanding of the academic culture and values characterizing the university. And, like corporate boards, the quality and performance of university governing boards should be regularly assessed and their members should be held accountable for their decisions and actions through legal and financial liability. This suggests the need for considerable restructure of university governing boards, as illustrated in the diagram below:

## Leadership

It is interesting to note that both the report of the Spellings Commission, A Test of Leadership: Charting the Future of U.S. Higher Education, and the report of the AGB Task Force on the State of the University Presidency, The Leadership Imperative, stressed the importance of "leadership". Both recognized that for higher education to play the role it must during a period of challenge, opportunity, and responsibility, it must establish a stronger sense of trust and confidence on the part of the American public. Key in earning and sustaining this trust and confidence are university presidents, working in concert with their governing boards and faculties. No leader comes to personify an institution in the way a president does. A president must provide academic leadership at the same time he or she must assimilate and tell the institution's story to build pride internally and support externally. The president has primary responsibility for increasing public understanding and support for the institution as a contributor to the nation's continued vitality and well being. (AGB, 2006)

Yet the ability to be an effective spokesperson for higher education in America is strongly dependent upon the support provided by governing boards and faculties (or at least their tolerance) for the voice of the president. Many universities find that the most formidable forces controlling their destiny are political in nature—from governments, governing boards, or perhaps even public opinion. Unfortunately, these bodies are not only usually highly reactive in nature, but they frequently either constrain the institution or drive it away from strategic objectives that would better serve society as a whole and in the long run. Many university presidents—particularly those associated with public universities—believe that the greatest barrier to change in their institutions lies in the manner in which their institutions are governed, both from within and from without. Universities have a style of governance that is more adept at protecting the past than preparing for the future. An earlier AGB effort highlighted these concerns when it concluded that the governance structure at most colleges and universities is inadequate. "At a time when higher education should be alert and nimble, it is slow and cautious instead, hindered by traditions and mechanisms of governing that do not allow the responsiveness and decisiveness the times require." (AGB, 1996) The Commission went on to note its belief that many university presidents were currently unable to lead their institutions effectively, since they were


University governance (in theory)




Shared governance (also in theory)

forced to operate from "one of the most anemic power bases of any of the major institutions in American society."

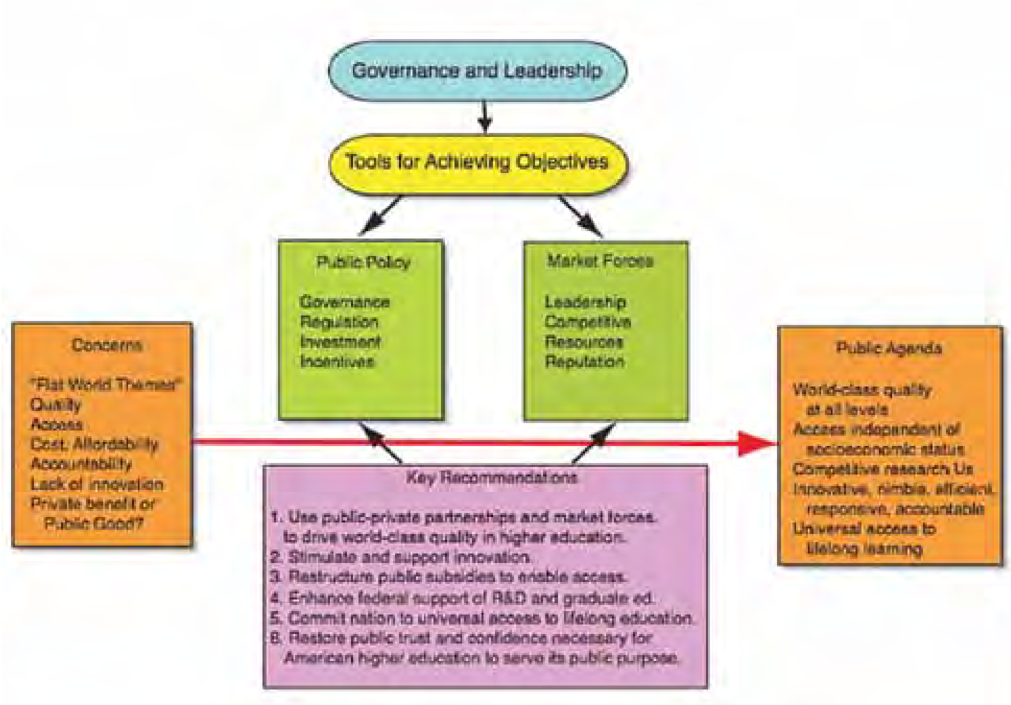
A decade later the AGB Task Force on the university presidency found that the presidents of American colleges and universities continue today to face impediments in their efforts to provide capable leadership, particularly on important national issues. (AGB, 2006) The university presidency is all too frequently caught between these opposing forces, between external pressures and internal campus politics, between governing boards and faculty governance. Today there is an increasing sense that neither the lay governing board nor elected faculty governance has either the expertise nor the discipline–not to mention the accountability–necessary to cope with the powerful social, economic, and technology forces driving change in our society and its institutions. The glacial pace of university decision-making and academic change simply may not be sufficiently responsive or strategic enough to allow the university to control its own destiny. To strengthen the voice of the presidency and secure the ability to provide the necessary leadership during a period of considerable change, challenge, and opportunity, the task force set out three imperatives:

1. To reconnect the president with the core academic mission of the university, i.e., learning and scholarship. It is important to resist the tendency to view the presidency as simply just another CEO role, dominated by fund-raising or lobbying, and instead re-establish academic leadership as a president's highest priority.

2. To urge boards, faculties, and presidents themselves to view the university presidency not as a career or a profession in and of itself, but rather as a calling of immense importance, similar to those of other forms of public service, rather than seeking personal compensation and benefits far removed from the academy.

3. To seek to establish what the AGB Task Force termed integral leadership: "A new style of collaborative but decisive leadership. A president must exert a presence that is purposeful and consultative, deliberative yet decisive, and capable of midcourse corrections as new challenges emerge. Integral leadership succeeds in fulfilling the multiple, disparate strands of presidential responsibility and conceives of these responsibilities as parts of a coherent whole. Leadership of this sort links the president, the faculty, and the board together in a well-functioning partnership purposefully devoted to a well-defined, broadly affirmed institutional vision." (AGB, 2006)

In summary, today there remain many concerns about the governance and leadership of higher education, particularly for public colleges and universities. Many governing boards have become overly politicized, focusing more on oversight and accountability than on protecting and enhancing the capacity of their university to serve the changing and growing educational needs of our society. While faculty governance is critical in sustaining the consultative character of the university, it can also become cumbersome and possibly even irrelevant to either the nature or pace of the issues facing the contemporary university. University




The challenge of governance and leadership

leadership, whether at the level of chairs, deans, or presidents, has insufficient authority to meet the considerable responsibilities engendered by powerful forces of change on higher education. And nowhere, either within the academy, at the level of governing boards, or in government policy, is there a serious discussion of the fundamental values so necessary to the nature and role of the public university.

To be sure, the contemporary university has many activities, many responsibilities, many constituencies, and many overlapping lines of authority, and from this perspective, shared governance models still have much to recommend them: a tradition of public oversight and trusteeship, shared collegial internal governance of academic matters, and, experienced administrative leadership. But it also seems clear that the university of the twenty-first century will require new forms of governance and leadership capable of responding to the changing needs and emerging challenges of our society and its educational institutions. Governing board members should be selected for their expertise and commitment and then held accountable for their performance and the welfare of their institutions. Faculty governance should focus on those issues of most direct concern to academic programs, and faculty members should be held accountable for their decisions. Our institutions must not only develop a tolerance for strong presidential leadership; they should demand it.

## Remaining Questions, Concerns, and Caveats

Today American higher education faces many challenges, including an increasing stratification of access to (and success in) quality higher education based on socioeconomic status; questionable achievement of acceptable student learning outcomes (including critical thinking ability, moral reasoning, communication skills, and quantitative literacy), cost containment and productivity; and the ability of institutions to adapt to changes demanded by the emerging knowledge services economy, globalization, rapidly evolving technologies, an increasingly diverse and aging population, and an evolving marketplace characterized by new needs (e.g., lifelong learning), new providers (e.g., for-profit, cyber, and global universities), and new paradigms (e.g., competency-based educational paradigms, distance learning, open educational resources). Furthermore, while American research universities continue to provide the nation with global leadership in research, advanced education, and knowledge-intensive services such as health care, technology transfer, and innovation, this leadership is threatened by rising competition from abroad, by stagnant support of advanced education and research in key strategic areas such as science and engineering, and by the complacency and resistance to change of the academy.

Yet there remain many questions for those responsible for governing, supporting, leading, and providing higher education services to society. For example:

• What do people expect from higher education? Are these reasonable expectations or do they arise from a lack of understanding of the broad role of higher education? Perhaps more germane to a public agenda is the question of what people really need from higher education–including roles such as social criticism that are rarely valued at the time.

• To whom is the university responsible? To whom should it be held accountable? Students? The public? The taxpayer? The politicians? The media? How about responsibility and accountability to society at large? States? The nation? The world? Or framed in a different way, how would one prioritize accountability to respond to the needs of the present with being a responsible steward for past investments and commitments or the responsibilities to preserve and enhance our college and universities to serve future generations?

• Who should be held accountable for the performance and quality of higher education? Elected public officials such as governors and legislators? Governing boards? University faculties? University presidents? Football coaches (at least at some institutions…)?

• How does one persuade an aging population, most concerned with issues such as retirement security, health care, safety from crime and terrorism, and tax relief, that both their own welfare and their legacy to future generations depends on investing public resources in the strong support of higher education?

• In recent years there has been a trend toward expanding the role of state governments in shaping the course of higher education. Many of these accountability movements call on universities to narrow their goals to focus on near-term imperatives, e.g., more efficient classroom instruction, increased undergraduate enrollments, limiting tuition increases even as state support deteriorates. Rarely are the broader purposes of higher education–e.g., creating the educated citizenry necessary for a democracy, preserving cultural assets for future generations, enabling social mobility, and being a responsible social critic–acknowledged as public priorities by state leaders.

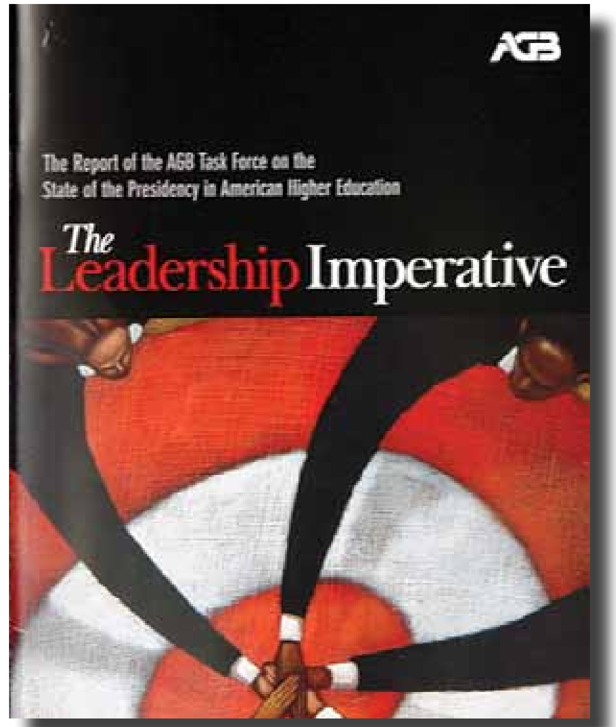
• The eroding support and increasingly intrusive regulation directed toward public higher education raises a serious question as to whether state government can continue as a responsible steward for public colleges and universities, which are also critical assets for broader society and the nation itself. Term-limited legislators and governors, political parties controlled by narrow special interest groups, and a body politic addicted to an entitlement economy have ceased to be reliable patrons of higher education in several states. Little wonder that governing boards are seeking more autonomy over decisions such as admission, tuition and fees, faculty and staff compensation, procurement, and other areas sometimes micromanaged by state government.

• What role should the federal government play in setting and achieving the public agenda for American higher education? While the states have primary responsibility for sustaining public higher education, federal policies have frequently provided the primary stimulus for change through initiatives such as the Land Grant Acts, the GI Bill, the government-research partnership, and the extension of educational opportunities through the Higher Education Acts. What is a national agenda for higher education appropriate to prepare America for tomorrow?

So what are state governments, boards of trustees, and university leaders to do, as their academic institutions are buffeted by such powerful forces of change, and in the face of unpredictable futures? It is important to always begin with the basics, by considering carefully those key roles and values that should be protected and preserved during a period of transformation. For example, how would an institution prioritize among roles such as educating the young (e.g., undergraduate education), preserving and transmitting our culture (e.g., libraries, visual and performing arts), basic research and scholarship (e.g., graduate and professional education), and serving as a responsible critic of society? Similarly, what are the most important values to protect? Clearly academic freedom, an openness to new ideas, a commitment to rigorous study, and an aspiration for the achievement of excellence would be on the list for most institutions. But what about values and practices such as lay governing boards, shared governance, and tenure? Should these be preserved? At what expense?

Of course, we all aspire to excellence, but just how do we set our goals? There is an increasing sense that the paradigm characterizing many elite institutions, which simply focuses more and more resources on fewer and fewer, does not serve the broader needs of our society. Rather, the premium will be on the development of unique missions for each of our institutions, missions that reflect not only their tradition and their unique roles in serving society, but as well their core competency. If such differentiation occurs, then far greater emphasis should be placed on building alliances with other institutions that will allow them to focus on core competencies while relying on alliances to address the broader and diverse needs of society.

It is important for university leaders to approach issues and decisions concerning institutional transformation not as threats but rather as opportunities. True, the status quo is no longer an option. However, once we accept that change is inevitable, we can use it as a strategic opportunity to control our destiny, while preserving the most important of our values and our traditions. Creative, visionary leaders can tap the energy created by threats such as the emerging for-profit marketplace and technology to engage their campuses and to lead their institutions in new directions that will reinforce and enhance their most important roles and values.




Association of Governing Boards Report

The Leadership Imperative

Executive Summary

At the outset of the 21st century, colleges and universities face an array of daunting challenges. To name a few: intense global competition, rapid technological advancements, changing demographics, increasing demand for education and training, new ways of delivering instruction, greater pressures for accountability, and shrinking public funds to achieve societal purposes. In the face of these challenges, there is a critical need to create the human and intellectual capital to ensure the nation's continued social, civic, and economic well-being. America's higher education institutions must be the engines of society's transformation.

Ten years ago, the Association of Governing Boards (AGB) issued a report, *Renewing the Academic Presidency: Stronger Leadership for Tougher Times.* Several of its most pointed recommendations called on higher education institutions to free themselves from processes of excessive internal consultation—in effect, to empower presidents to be purposeful decision makers.

A decade later, the AGB Task Force on the State of the Presidency in American Higher Education finds


AGB TASK FORCE ON
THE STATE OF THE PRESIDENCY
IN AMERICAN HIGHER EDUCATION

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that colleges and universities continue to face impediments in their efforts to achieve effective governance and sustain capable leadership. Indeed, some argue that we are in a governance crisis. Regardless, the obstacles are traceable to the intensity and range of conflicting pressures a president must confront—and from the fact that presidents receive uneven guidance, support, and oversight from their governing boards. Failure to address these issues will diminish the strength of our colleges and universities and undermine the public's trust in higher education.

No leader comes to personify an institution in the way a president does. A president must provide academic leadership at the same time he or she must assimilate and tell the institution's story to build pride internally and support externally. The president has primary responsibility for increasing public understanding and support for the institution as a contributor to the nation's continued vitality and well-being.

The looming questions are whether colleges and universities will continue to attract high-caliber leaders to the presidency—and whether higher education as a whole will continue to earn the public trust. The Task Force asserts that the partnership of the president and governing board is an essential factor not just in the success of a college or university presidency but also in higher education's success in meeting the challenges of the global century. The Task Force report calls for presidential leadership that links the president and governing board closely together in an environment of support, oversight, and accountability.

The Task Force contends that a new style of collaborative but decisive leadership—integral leadership—is the key to addressing these issues. A president must exert a presence that is purposeful and consultative, deliberative yet decisive, and capable of course corrections as new challenges emerge. Integral leadership succeeds in fulfilling the multiple, disparate strands of presidential responsibility and conceives of these responsibilities as parts of a coherent whole. Leadership of this sort links the president, the faculty, and the board together in a well-functioning partnership purposefully devoted to a well-defined, broadly affirmed institutional vision.

In that spirit, the report addresses several aspects of the leadership imperative from the standpoint of a board's responsibility: (1) the support a board provides for effective leadership, (2) the search for a president, (3) the presidential evaluation and compensation process, (4) board accountability, (5) presidential renewal and succession, and (6) advocacy for higher education. The report's recommendations call on presidents to seek the active support of their boards while demonstrating effective academic leadership that engages the faculty in a shared vision of the institution's future.

This report primarily addresses college and university governing boards and their presidents, but it also will be relevant to public officials and others concerned with higher education's continued ability to achieve success and secure the public's support. Although the report's language generally refers to the chief executives and governing boards of individual public and private institutions, its principles apply to the leaders of public university systems as well.

Recommendations

To Governing Boards

Support Presidential Leadership

1. Charge the president with fulfilling the institutional vision and hold the president accountable.

2. Charge the president with responsibility for developing a strategic plan, in conjunction with faculty, the executive leadership team, and other constituents including public stakeholders.

3. Encourage the president to build a capable and effective leadership team.

4. Help the president chart a course of action that respects the prevailing institutional culture while carrying it forward to meet new challenges.

5. Support the president in the task of confronting difficult and controversial issues.

6. Focus on policy rather than administration.

Presidential Search

1. Before beginning a presidential search, be certain the board is proceeding from a thorough understanding of the institution's needs, now and in the course of the next decade.

2. Constitute a search committee that is united around the institution's vision.

3. Do not allow search consultants to supplant the board's thinking about the qualities needed in the next president.

4. Eliminate the conditions that often work against internal candidates for the presidency.

5. Exercise caution in considering candidates whose past experiences suggest that they view the presidency as a transportable profession.

6. Ensure that the process used to select a president is widely regarded as fair and legitimate.

Evaluation and Compensation

1. Periodically evaluate a president's performance based on clearly defined, mutually agreed-upon performance goals.

2. Calibrate a president's compensation package based on transparent and justifiable internal and external benchmarks as well as on the marketplace for accomplished chief executives.

3. Avoid "hidden enhancements" to presidential compensation from private sources.

4. Ensure that the process of establishing the president's compensation package is appropriately transparent.

Board Accountability

1. Recognize the link between a board's accountability and a president's ability to lead.

2. Respect and adhere to the legal principles of fiduciary responsibility.

3. Establish clear ethical guidelines and enforce conflict-of-interest policies for all board members.

4. Recognize the board's responsibilities to diverse constituencies.

5. Evaluate the board's performance and enhance its competence in areas where evaluation has shown it to be deficient.

Presidential Renewal and Succession

1. Support and nurture the president and provide opportunities for constructive feedback and positive reinforcement.

2. Encourage new presidents to seek a network of mentors to ease the leadership transition.

3. Assess the impact of the duties of the presidency on the well-being of the president and his or her family.

4. Assist in bringing a successful presidency to a graceful end.

5. Charge the president with developing opportu-

nities and pathways for leaders to advance within the institution.

Fulfill the Leadership Imperative

1. Support the president as an advocate for higher education.

To Presidents

1. Actively engage the board in meeting its responsibilities to the institution and to the public trust.

2. Unite the board, faculty, and other constituents in developing a vision for the institution and enlist the support required to lead the institution in meeting future challenges.

3. Cultivate a deep understanding of the institution and build on its unique character, history, and values.

4. Do not allow daily managerial tasks to detract from meeting the institution's long-range strategic challenges.

5. Create an environment that encourages leadership development within the institution.

6. Exemplify in actions and words the contributions higher education makes to the nation's capacity for productive engagement in a global age.

7. Use the planning process and the performance review as occasions to clarify goals for the institution and the presidency.

To State Policymakers

1. Provide a sustained level of financial support that allows colleges and universities to meet community, regional, statewide, and national goals.

2. Make merit, skill, and experience the chief criteria for trustee selection.

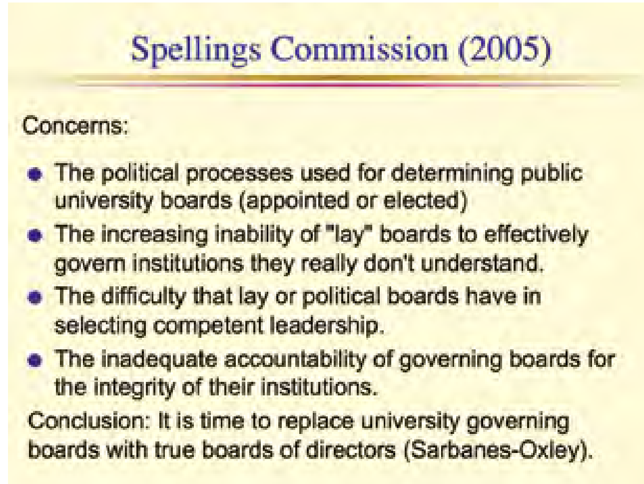
3. Insist that board members understand and accept their responsibilities as stewards of the institution's mission and financial resources.

4. Promote board development.

5. Engage trustees and regents as partners in advocating the value of public and private higher education.

To the Association of Governing Boards

1. Develop and widely disseminate a Statement on




An assessment of goerning boards

Board Accountability and Fiduciary Oversight that boards may use as a model.

2. Continue to advance the association's leadership in strengthening governing boards by developing guidelines for setting presidential compensation and new programs for presidents that focus on higher education governance, finance, and president-board relationships.

3. Seek new opportunities to serve as advocates for stronger trustee voices in support of strategic investments in the value of higher education.

## More General Observations

Structural Issues

While it is probably impolitic to be so blunt, the simple fact is that the contemporary university is a public corporation that must be governed, led, and managed with competence and accountability to benefit its various stakeholders. Its broad responsibilities can best be served by a governing board that is comprised and functions as a true board of directors. Like the boards of directors of publicly-held corporations, the university's governing board should consist of members selected for their expertise and experience, as well as their loyalty to the institution. They should govern the university in ways that serve both the long term welfare of the institution as well as the more immediate interests of the various constituencies it serves.

The academic tradition of extensive consultation, debate, and consensus building before any substantive decision can be made or action taken is yet another challenge. To be sure, the voluntary culture (some would say anarchy) of the university responds better to a process of consultation, communication, and collaboration than to the command-control-communication process familiar from business and industry. However this process is simply incapable of keeping pace with the profound changes facing effective governance of the public university. Not everything is improved by making it more democratic.

The leadership of the university must be provided with the authority commensurate with its responsibilities. Academic leaders, whether at the level of department chairs, deans, vice-presidents, or even the president, should have the same degree of authority to take actions, to select leadership, to take risks and move with deliberate speed, that their counterparts in both the corporate world and government enjoy. The challenges and pace of change faced by the modern university no longer allow the luxury of "consensus" leadership, at least to the degree that "building consensus" means seeking the approval of all concerned communities before action is taken. Nor do our times allow the reactive nature of special interest politics to rigidly moor the university to an obsolete status quo, thwarting efforts to provide strategic leadership and direction.

While academic administrations generally can be drawn as conventional hierarchical trees, in reality the connecting lines of authority are extremely weak. In fact, one of the reasons for cost escalation in higher education is the presence of a deeply ingrained academic culture in which leaders are expected to "purchase the cooperation" of subordinates, to provide them with positive incentives to carry out decisions. For example, deans expect the provost to offer additional resources in order to gain their cooperation on various institution-wide efforts. Needless to say, this "bribery culture" is quite incompatible with the trend toward increasing decentralization of resources. As the central administration relinquishes greater control of resource and cost accountability to the units, it will lose the pool of resources that in the past was used to provide incentives to deans, directors, and other leaders to cooperate and support university-wide goals.

Hence, it is logical to expect that both the leadership and management of universities will need increasingly to rely on lines of true authority just as their corporate counterparts. That is, presidents, executive officers, and deans will almost certainly have to become comfortable with issuing clear orders or directives from time to time. So, too, throughout the organization, subordinates will need to recognize that failure to execute these directives will likely have significant consequences, including possible removal from their positions. Here I am not suggesting that universities adopt a top-down corporate model inconsistent with faculty responsibility for academic programs and academic freedom. However, while collegiality will continue to be valued and honored, the modern university simply must accept a more realistic balance between responsibility and authority.

Clearly an effort should be made to rebuild leadership strength at middle levels within the university, both by redesigning such positions to better balance authority and responsibility, and by providing leadership development programs. This may involve some degree of restructuring the organization of the university to better respond to its responsibilities, challenges, and opportunities.

### Restructuring Governing Boards

Needless to say, such accountability starts at the top, at the level of the university's governing board. Nothing is more critical to the future success of higher education than improving the quality and performance of boards of trustees.

For public boards the need is particularly urgent. As long as the members of the governing boards of public universities continue to be determined through primarily political mechanisms, without careful consideration of qualifications or institutional commitment, and are allowed to pursue political or personal agendas without concern for the welfare of their institution or its service to broader society, the public university will find itself increasingly unable to adapt to the needs of a rapidly changing society.

As the contemporary university becomes more complex and accountable, it may be time to set aside the quaint American practice of governing universities with boards comprised of lay citizens, with their clearly inadequate expertise and all too frequent political character, and instead shift to true boards of directors similar to those used in the private sector. Although it may sound strange in these times of scandal and corruption in corporate management, it is nevertheless my belief that university-governing boards should function with a structure and a process that reflects the best practices of corporate boards. Corporate board members are selected for their particular expertise. They are held accountable to the shareholders for the performance of the corporation. Their performance is reviewed at regular intervals, both within the board itself and through more external measures such as company financial performance. Clearly directors can be removed either through action of the board or shareholder vote. Furthermore, they can be held legally and financially liable for the quality of their decisions–a far cry from the limited accountability of the members of most governing boards for public universities.

While it is important to provide board members with sufficient tenure to develop an understanding of the university, it is also important to avoid excessively long tenures. It is probably wise to limit university board service to a single term, since this would prevent members from "campaigning" during their tenure for future appointment or election to additional terms.

Again drawing on the experience of corporate boards, let me make the more radical suggestion that university presidents in universities should have some influence over the selection of board members, just as their colleagues in private universities and CEOs in the corporate sector. Here I am not proposing that university presidents actually nominate or select board members. But consideration should be given to their right to evaluate and possibly veto a proposed board member if the individual is perceived as unduly political, hostile, or just simply inexperienced or incompetent.

It is my belief that all university governing boards, both public and private alike, would benefit greatly from the presence of either active or retired university presidents, senior administrators, and distinguished faculty members from other institutions among their membership. Since the experience of most lay board members is so far removed from the academy, it seems logical to suggest that boards would benefit from the experience such seasoned academicians might bring. After all, most corporate boards find it important to have experienced business leaders, either active or retired, among their membership. University boards should do the same.

An equally controversial variation on this theme would be to provide faculty with a stronger voice in true university governance by appointing faculty representatives as members of the governing board. This would be similar, in a sense, to the practice of some corporate boards in providing a seat for a representative from organized labor. However, there would need to be a clear sense of accountability and liability in such an appointment, so that the faculty board members would not simply become advocates for the faculty position and instead be responsible to the entire institution.

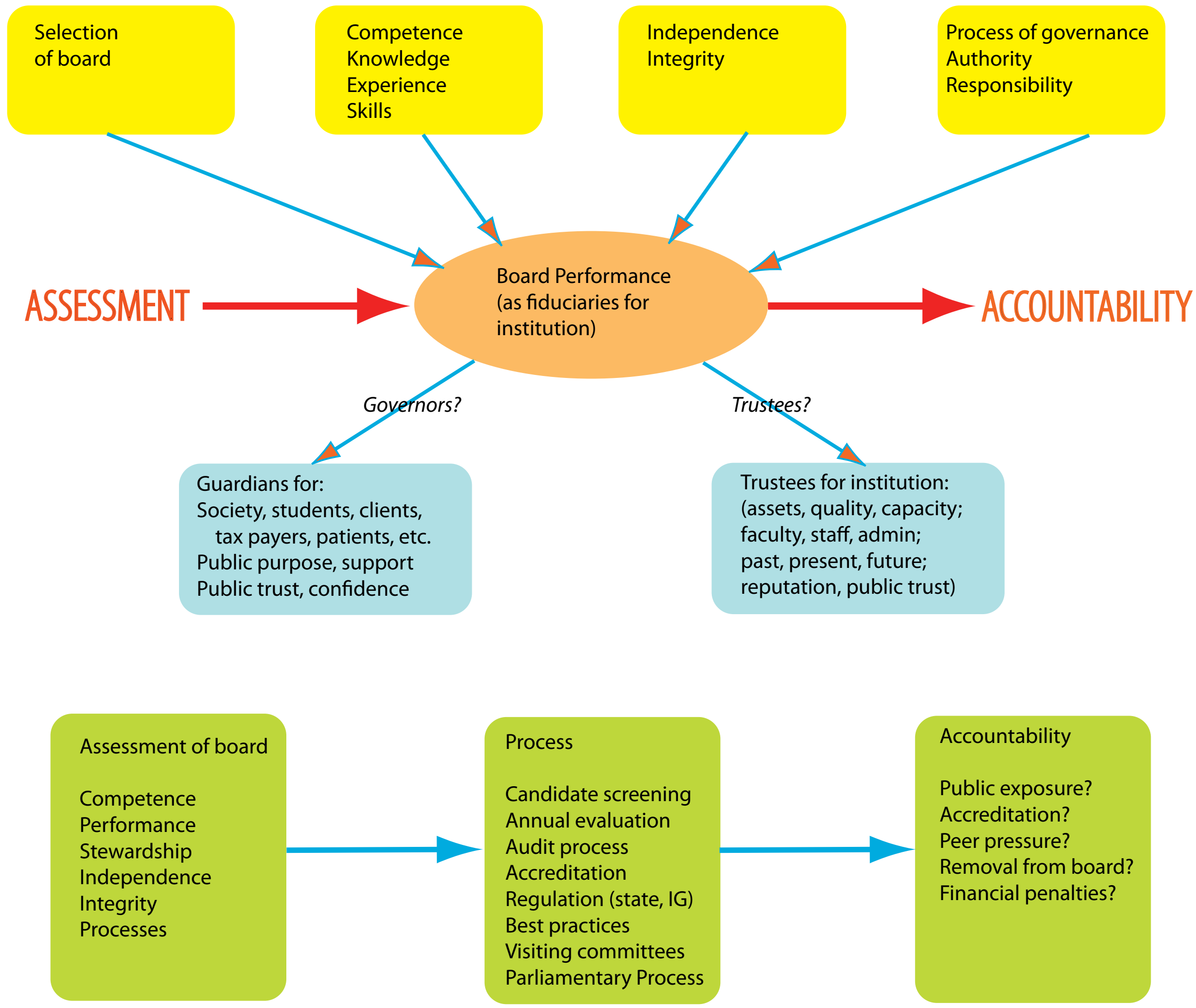
Every effort should be made to convince leaders of state government that politics and patronage have no place in the selection of university governing boards or efforts to determine their administrative leadership. Quality universities require quality leadership. Even as public university governing boards have become increasingly political and hence sensitive to special interests, they have also become increasingly isolated from accountability with respect to their quality and effectiveness. Not only should all boards be subject to regular and public review, but also the quality and effectiveness of governing boards should be an important aspect of institutional accreditation.

## Some Proposals for Strengthening Faculty Governance

Perhaps the simplest approach to identifying possible reforms in faculty governance is to examine where it seems to work well and why.

From my own experience—as a faculty member, a former member of faculty governance at both the academic unit and university level, and a has-been university president–faculty governance seems to work best when focused upon academic matters such as faculty searches, promotion and tenure decisions, and curriculum decisions.

Why? Because the rank and file faculty members understand clearly that not only do they have the authority to make these decisions, but that these decisions are important to their academic departments and likely to affect their own teaching and research activities. As




A roadmap for strengthening university governing boards

a result, the very best faculty members, namely those with strongest reputations and influence, are drawn into the academic governance process, either through formal election or appointment to key committees (hiring, promotion, tenure, curriculum, executive) or at least consulted for influential opinions in their role as department "mandarins".

In sharp contrast, most active faculty members view university-wide faculty governance bodies such as faculty senates as primarily debating societies, whose opinions are invariably taken as advisory by the administration and the governing board. Hence, rare is the case when a distinguished faculty member will spare the time from productive scholarship, teaching, or department matters for such university service. Of course there are exceptions, but more common is the squeaky wheel syndrome, where those outspoken faculty members with an axe to grind are drawn to faculty politics, frequently distracting faculty governance from substantive issues to focus instead on their pet agendas.

Hence the key to effective faculty governance is to provide faculty bodies with executive rather than merely advisory authority, thereby earning the active participation of the university's leading faculty members. Advisory bodies, paid only lip service by the administration or the board of trustees, will rarely attract the attention or engage the participation of those faculty most actively engaged in scholarship and teaching.

### A Balance of Interests and Influence

Shared governance is, in reality, an ever-changing balance of forces involving faculty, trustees, and administration. Yet at a deeper level, it represents the effort to achieve a balance among academic priorities and values, public responsibility and accountability, and financial, management, and political realities.

But different universities achieve this balance in quite different ways. For example, at the University of California a strong tradition of campus and systemwide faculty governance is occasionally called upon to counter the political forces characterizing the governing board, examples being the loyalty oath controversy of the 1950s, the Reagan takeover of the UC Board of Regents in the 1960s, and the debates over the use of affirmative action in student admission during the 1990s.

In contrast, at the University of Michigan, campuswide faculty governance has historically been rather weak, at least compared to faculty influence through executive committee structures at the department, school, and college level. Hence the tradition has been to develop a strong cadre of deans, both through aggressive recruiting and the decentralization of considerable authority to university's schools and colleges, and then depend upon these academic leaders to counter the inevitable political tendencies of the university's regents from time to time.

Where is the influence of the university administration¬–and particularly the president–in this balancing act? Usually out of sight or perhaps out of mind. After all, senior administrators including the president serve at the pleasure of the governing board and are also mindful of faculty support since they may be only one vote of no confidence away from receiving their walking papers. While it has always been necessary for the American university president to champion the needs of the academic community to the board and the broader society while playing a role in ensuring that the academic community is in touch with society's interests and needs, it is also not surprising that the administration is usually quite reticent to get caught publicly in skirmishes between the governing board and the faculty.

The danger of such a bilateral balance of power arises when one party or the other is weakened. When the faculty senate loses the capacity to attract the participation of distinguished faculty members, or when a series of poor appointments at the level of deans or executive officers weaken the administration, a governing board with a strong political agenda can move into the power vacuum. Of course there have also been numerous examples of the other extreme, in which a weakened governing board caved into unrealistic faculty demands, e.g. by replacing merit salary programs with cost-of-living adjustments or extending faculty voting privileges to part-time teaching staff in such as way as to threaten faculty quality.

## It All Comes Back to Values

University leadership and governance, management and decision-making should always reflect the fundamental values of the academy, e.g., freedom of inquiry, an openness to new ideas, a commitment to rigorous study, and a love of learning. Yet, these processes should also be willing to consider and capable of implementing institutional change when necessary to respond to the changing needs of our society. In any consideration of how our universities are governed and led, it is important to always begin with the basics, to launch a careful reconsideration of the key roles and values of the university that should be protected and preserved during a period of change.

For example, how would an institution prioritize among roles such as educating the young (e.g., undergraduate education), preserving and transmitting our culture (e.g., libraries, visual and performing arts), basic research and scholarship, and serving as a responsible critic of society?

Similarly, what are the most important values to protect? Clearly academic freedom, an openness to new ideas, a commitment to rigorous study, and an aspiration to the achievement of excellence would be on the list for most institutions. But what about values and practices such as shared governance and tenure? Should these be preserved? At what expense? We need to act in such a way as to preserve our core missions, characteristics, and values.

Only a concerted effort to understand the important traditions of the past, the challenges of the present, and the possibilities for the future can enable institutions to thrive during a time of such change.

Today the complexity of the contemporary university and the forces acting upon it have outstripped the ability of the current shared governance system of lay boards, elected faculty bodies, and inexperienced academic administrators to govern, lead, and manage.

Farr too many colleges and universities find that the most formidable forces controlling their destiny are political in nature—from governments, governing boards, public opinion, and, at times, even faculty governance bodies.

Many of my university president colleagues—particularly those associated with public universities—believe that the greatest challenge and threat to their institutions arises from the manner in which their institutions are governed, both from within and from without. Universities have a style of governance that is more adept at protecting the past than preparing for the future.

It seems clear that the university of the twenty-first century will require new forms of governance and leadership capable of responding to the changing needs and emerging challenges of our society and its educational institutions. To be sure, shared governance models still have much to recommend them, at least in theory if not in practice. The contemporary university has many activities, many responsibilities, many constituencies, and many overlapping lines of authority that are well addressed by the tradition of public oversight and trusteeship, shared collegial internal governance of academic matters, and, experienced administrative leadership.

Yet the increasing politicization of governing boards, the ability of faculty senates to use their powers to promote special interests, delay action, and prevent reforms; and weak, ineffectual, and usually short-term administrative leadership all pose risks to the university. While shared governance may have much to recommend it, it must be adapted to a new time and new challenges.

Governing board members should be selected for their expertise in areas related to the nature of higher education and the contemporary university and commitment to the welfare of the institution. Trustees should be challenged to focus on policy development rather intrude into management issues. Their role is to provide the strategic, supportive, and critical stewardship for their institution and to be held clearly publicly, legally, and financially accountable for their performance and the welfare of their institutions.

The faculty senate should become a true participant in the academic decision process rather than simply a watchdog on the administration or defenders of the status quo. Faculty governance should focus on those issues of most direct concern to academic programs, and faculty members should be held accountable for their decisions. Faculties also need to accept and acknowledge that strong leadership, whether from chairs, deans, or presidents, is important if their institution is to flourish during a time of significant change.

Our institutions must not only develop a tolerance for strong leadership; they should demand it. The contemporary American university presidency also merits a candid reappraisal and likely a thorough overhaul.

The presidency of the university may indeed be one of the more anemic in our society, because of the imbalance between responsibility and authority, the cumbersome process used to select university leaders, and the increasing isolation of "professional" academic administrators from the core teaching and scholarship activities of the university. Yet it is nevertheless a position of great importance, particularly from the perspective of the long-term impact a president can have on an institution.

In conclusion, it is simply unrealistic to expect that the governance mechanisms developed decades or even centuries ago can serve well either the contemporary university or the society it serves. To assign the fate of these important institutions to inexperienced and increasingly political lay governing boards isolated from accountability is simply not in the public interest. Furthermore, during such times of dramatic change, we simply must find ways to cut through the Gordian knot of shared governance, of indecision and inaction, to allow our colleges and universities to better serve our society.

To blind ourselves to these realities is to perpetuate a disservice to those whom we serve, both present and future generations.

## Finally, A Caution about Institutional Integrity

A final priority both for leadership and governance are those values and ethical principles under girding institutional integrity. As Mark Yudolf, form President of the University of California (and Chancellor of the

University of Texas, has observed: "This is the era of Enron; this is the era of disclosure. This wave has already swept over the public schools, and now it is approaching higher education. Either you help to shape this accountability revolution so that it is done in an intelligent way, or you're going to get swept over by it."

Of course, part of the problem here is the very complexity of the issues and ethical incidents. To be sure, there are obvious cases that amount essentially to criminal activity, for example the cases with Enron, Tyco, and Worldcom. But what about more subtle business practices such as the predatory behavior of Microsoft to prevent competitors from accessing their operating system, or the American automobile industry's efforts to block enhanced fuel economy, or pharmaceutical companies ignoring the needs of children for vaccinations and instead focusing drug development to the far more lucrative market of aging baby boomers?

The same is true in higher education that has its own list of high profile ethical lapses: the loss of life in clinical trials conducted by faculty with interests in associated spinoff companies; the blatant conflict of interest of trustees cutting business deals with one another at their institutions' expense; college sports scandals involving sexual assault and substance abuse; or a host of extreme cases of faculty misbehavior in areas such as scientific integrity, sexual harassment of students, and so forth.

But here, too, there are more subtle issues that raise serious ethical questions: The "management" rather than the "avoidance" of conflict of interest in intellectual property commercialization that is clearly distorting the scientific enterprise, limiting publication and even the cooperation among investigators; the tolerance of the abysmal graduation rates of college football and basketball players, now well under 50%, that clearly represent exploitation of these young students at a time when their coaches' compensation has soared to truly obscene levels; and exposing our students to credit-card scams and other predatory commercial practices on our campuses.

Just as with the business community, lapses in ethical behavior can cause very great damage to the reputation and integrity of the university and higher education more generally, undermining its privileged place in our society. Note that when one institution stumbles, we all get tarnished as public opinion surveys clearly indicate! It all comes down to the need to make judgments and decisions on increasingly complex cases. This requires a solid foundation of institutional values that frequently goes beyond what the law would require. It also requires an extensive program of education about fundamental institutional and social values for students, faculty, and staff, not just a focus on the laws. Put another way, just as with the business community, universities are at increasing risk if they lack a clearly understood and accepted code of ethics and along with a process both for educating the university community and continually reviewing and revising when necessary both the code of ethics and the policies and guidelines for its implementation.

So where are the key areas of concern? Clearly, we must include those areas that relate directly to the fundamental education and scholarly mission of the university such as academic integrity and research accountability. But universities are also places charged with developing human potential and serving society. Hence there are also concerns such as faculty-student relationships, exploitation of students, and the protection of human subjects. Since universities are places where the young are not only educated but socialized, there are also issues such as student disciplinary policies, substance abuse concerns, sexual harassment and assault, and a host of "isms" such as racism, sexism, elitism, and extremism to confront. Finally, since many of our institutions are multi-billion global conglomerates, higher education also faces most of the same challenges with business practices characterizing any publicly-traded corporation.

Today there are many factors that are intensifying both the importance and complexity of ethical behavior in higher education. For example, the soaring commercialism of intellectual property, the increasing university dependence on business activities (e.g., endowment management), the faculty dependence upon external compensation (consulting, publishing, equity interests), and the increasing pressures on auxiliary activities such as hospitals and intercollegiate athletics all raise serious conflict-of-interest and business practice issues comparable to those addressed by the Sarbanes-Oxley Act in the corporate setting. As mission creep continues to expand the complexity and scope of universities with new enterprises, it also entails new risks, such as the equity interests associated with technology transfer, real estate ventures, expansion of health care systems, international activities, and technology (software piracy). Driving it all is the increasingly Darwinian nature of the competitive environment in higher education, for the best faculty and students, for research grants and private gifts, for winning athletic programs, and for reputation.

More fundamentally, in an era in which the marketplace is replacing public policy in determining the nature of higher education in America, one must question the degree to which financial gain is replacing public purpose in determining the actions of universities and their faculty, staff, students, and governing boards. It is my belief that we have reached a tipping point that requires more rigorous attention to institutional values and ethical practices in higher education. Clearly the privileged place of universities demands higher standards that those simply required by law or public perception. After all, values are far more important than laws. There is a very significant difference between legal behavior and ethical behavior. The law provides very little guidance as to what is or is not ethical behavior, particular in an academic institution where values such as academic freedom, scholarly, rigorous inquiry, and openness simply require higher standards than those merely tolerated by the law.

The lesson of the past several years of corporate misbehavior–Enron, Worldcom, etc.–involves the importance of both process and transparency. The corrective medicine of Sarbanes-Oxley demands that corporations and their boards of directors not only have to be fiscally accountable, but they also have to be able to prove it! Some universities such as the University of Texas have already adopted such reforms as best practices. There are increasing calls to strengthen financial controls at colleges not simply by government, but also by credit-rating agencies, accounting and law firms, and private foundations. But while these may pose challenges–albeit necessary–the call for greater accountability and transparency may also present important opportunities.

Here governing boards must be particularly attentive, since they will increasingly be held to the same standards as the boards of directors of publicly traded corporations, both in their own competency and the processes they utilize for assuring institutional integrity. Furthermore, governing boards must be more scrupulous in their oversight both of the compensation and expenditures of senior university administrators, with particular attention paid to the university president. In public universities this extends to transparency, since the failure to disclose key aspects of presidential compensation or expenditures can be just as damaging politically as the inappropriate nature of these decisions.

Finally, achieving public trust and confidence in higher education may require some reform of the academy itself. The academy claims to be a profession, much like law, medicine, and engineering. Members of such learned profession agree to maintain high standards of performance, to restrain self-interest, and to promote ideals of public service in the areas of responsibility. In return, society grants them substantial autonomy to regulate themselves.

Many of the recent scandals in business practices resulted from professionals such as accountants, lawyers, bankers, security analysts, and corporate officers allowing self-interest and greed to trump integrity. Rather than acting as a constraint against excess, they facilitated unrestrained self-interest. As a result, these professions are increasingly losing their autonomy, as government steps in to provide through laws such as the Sarbanes-Oxley Act strict regulations for professional practice largely because the professions have lost the sense of public trust.

There is an important lesson here for higher education. Like other professions, the professoriate is granted the autonomy of academic freedom as long as it is able to demonstrate that it has the capacity to set and enforce standards for ethical behavior. Yet, in all candor, it has failed to do so. Ethical codes such as those adopted by the American Association of University Professors and various disciplinary societies are largely vague and toothless. The evidence suggests that most faculty members fail to set high standards for the behavior of their colleagues, frequently tolerating the most blatant misbehavior of colleagues. The academy's credibility to students is undermined by inattention to teaching, exploitation of student relationships, and numerous examples of conflict of interest (e.g., scholarly ethics).

As a result of its benign neglect of professional ethics, the professoriate could find itself facing the same intrusion of regulation and constraint now characterizing the legal, accounting, and business professions should the public lose confidence that it is upholding its end of the social contract that provides academic freedom and autonomy. Trustees need to act to hold the professoriate more accountable for maintaining its end of the social compact. They should require orientation programs for new faculty and include substantial material on ethics and values in graduate education (key to producing the next generation of professors).

More specifically, the increasing demand for institutional accountability and integrity may provide an important opportunity to re-insert the subject of values and ethics into the curriculum. Key to institutional integrity is an understanding and acceptance of those values and traditions that under gird an institution. Some of these are fundamental academic values such as academic freedom, scholarly integrity, and openness. Others trace back to the institutional saga, the history and culture, of the particular institution. But unfortunately all such discussion of such values seems to be missing in action from the campus these days. Presidential and trustee leadership can fill some of the gap created by faculty reluctance to discuss moral values with students.

Today's climate of increasing public scrutiny and accountability may present an opportunity. It is easier to make the case that it is time for universities to take strong action to stimulate a dialog concerning and a commitment to embracing fundamental values and ethics into their activities–certainly their practices, but perhaps even more so their fundamental activities of teaching and scholarship.

## References

Baililes, Gerald (Chair), *The Leadership Imperative, ABF Task Force on the State of the Presidency in American Higher Education*, Association of Governing Boards, 2006

Baililes, Gerald, *Aligning American Higher Education with a 21st Century Public Agenda*, Miller Center of Public affairs, University of Virginia, 2008

Duderstadt, James J., *The View from the Helm: Leading the American University during an Era of Change* (Ann Arbor, MI: University of Michigan Press, 2006) 400 pp.

## Chapter 15

# Financing Higher Education

### The Myth

As fall approaches, the headlines of newspapers across the states join the din of politicians complaining about the increases in tuition at public universities. "Tuition to soar for state undergraduate students, with increases of 12%, 13%, and 18% respectively at UM, MSU, and WSU". The Governor joins in, "These increases are unacceptable. Universities must figure out a way to streamline, to tighten their belts the way the state has done." And parents and students worry about whether they will be able to afford a college education.

In Michigan, a state cursed with a weak economy, a dysfunctional state budget, and a state government that ranks higher education at the bottom of its priority list, this feeding frenzy has become an annual occurrence. Of course it is rarely mentioned that the proposed tuition increases are far below what would be necessary to compensate for the loss of state support, roughly 25% over the past several years. The cacophony of complaints also ignores the fact that the tuition cost net financial aid  born by most families has actually decreased at many public universities over the past decade. But newspapers and politicians adhere to the same dictum: "Never let the truth stand in the way of a good story…or a possible vote!"

The real issue here is way that public policies and market pressures are reshaping the relationship among the cost, price, and value of a college education. While perhaps not as attention-getting as a politician's charge of price-gouging in public higher education, it is important to distinguish myth from reality to understand the current plight of public higher education in America.

### The Reality

Let's begin with a few interesting facts. First, the good news:

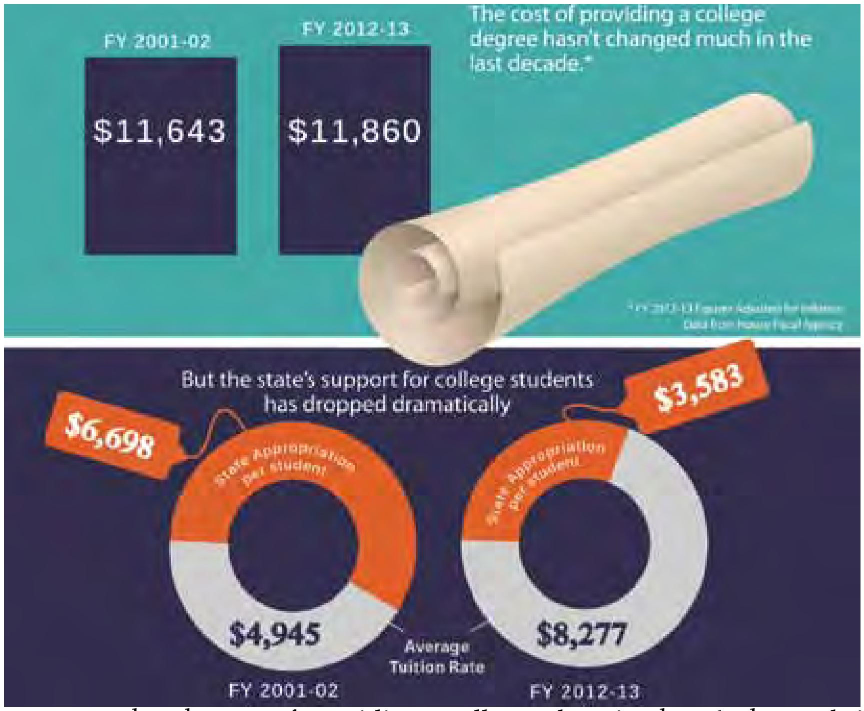
1. The actually cost of a college education at public universities has remained remarkably stable over the past 30 years.

2. Nationwide tuition covers, on the average, only one-third of the costs of a college education in a public university. (

3. When financial aid is taken into account, many students (and parents) pay only a fraction of the stated tuition, the sticker price–about 45% on the average in Michigan, for example.

4. Access to higher education today is greater than ever before in our nation's history, both because of the availability of financial aid programs and the great multiplicity and diversity of colleges and universities, ranging from local community colleges and regional four-year institutions to small liberal arts colleges and proprietary (for-profit) institutions to elite private universities and massive public research universities. A larger proportion of the population goes on to higher education that in most other countries including a greater share of nontraditional students (adults, women, minorities), although this ranking is erodingtoday with declining public support.

5. American higher education remains the envy of the rest of the world, both as measured by the preference of international students to seek education in the United States and by the reputation of our top universities. As a recent major study by *The Economist* put it, "America's system of higher education is the bet in the world. It has the monopoly on the world's best universities and also provides access to higher education



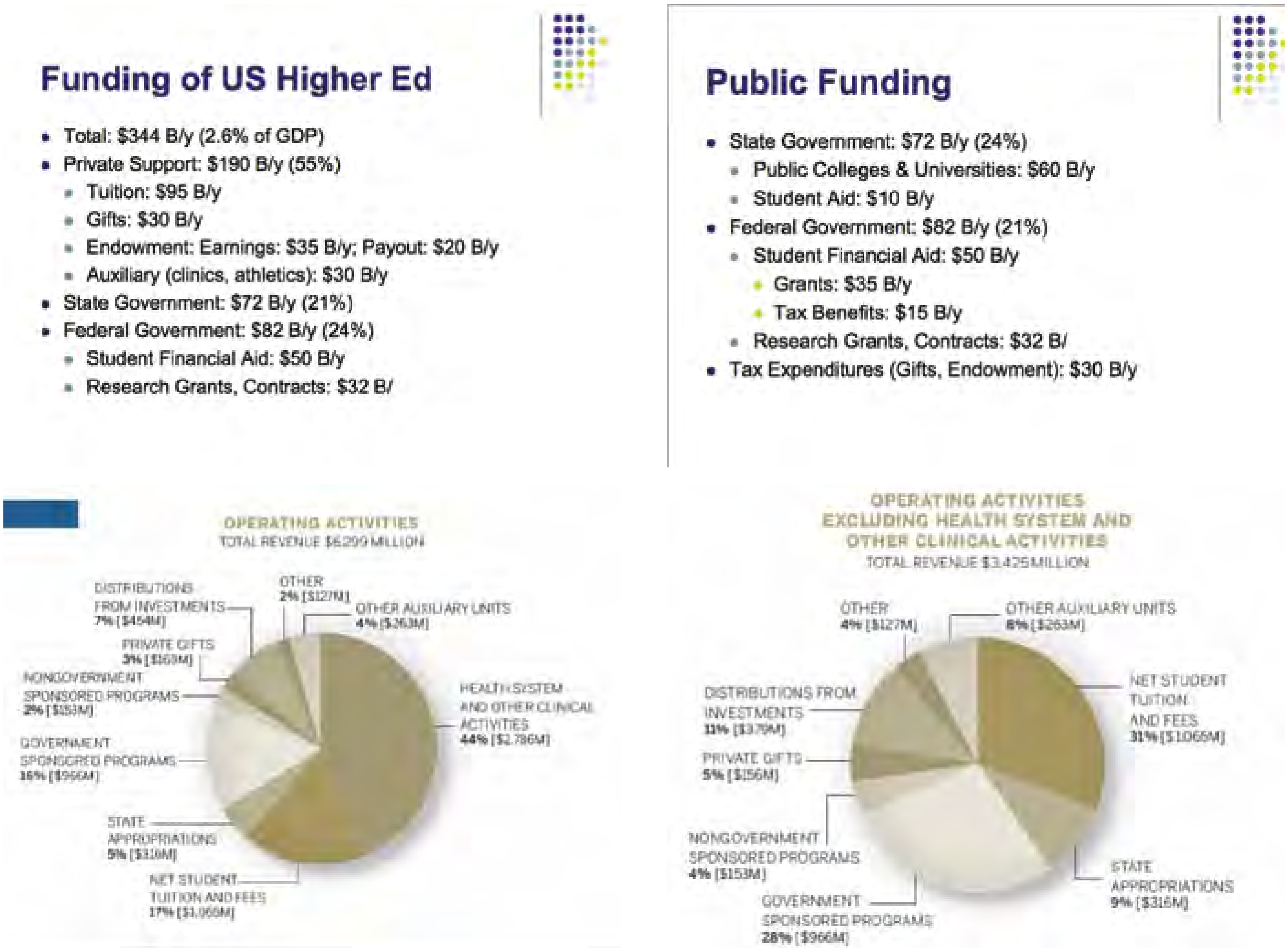
Michigan demonstrates that the cost of providing a college education hasn't changed since the 1990s.

to the bulk of those who deserve it." In international rankings, 17 of the top 20 universities (and 35 of the top 50) are American, employing 70% of the world's Nobel Prize winners. (The Economist, 2005)

Again to quote *The Economist*, "The main reason for America's success lies in organization. The federal government plays a very limited role. America does not have a central plan for its universities. Instead universities have a wide range of patrons, from state governments to religious bodies, from fee-paying students to generous philanthropists. Universities compete for everything, from students to professors to basketball stars."

More specifically, in the United States, the relationship among the cost of educating college students (to the institution), the price charged to students (tuition), and the value of a college degree (to the student) is determined by three key players: Universities determine both the cost and the value of a college education. States, either directly through regulation or indirectly through subsidy, determine the tuition or sticker price. And the federal government, usually in concert with the universities, determine the real cost to students through financial aid programs that provide "rebates" from the sticker price, based on either student merit or economic need.

In the simplest sense, today the United States spends roughly 2.6% of its GDP on higher education ($330 billion) , with 55% of this ($180 B) coming from private support (e.g., tuition payments, philanthropic gifts, or revenue from auxiliary activities such as college athletics) and 40% from government; the states provide 20% ($72 B), primarily through appropriations directly to institutions; and the federal government provides the remaining 25% ($81 B), through federal financial aid and subsidized loans and tax benefits to students ($60 B), research grants and contracts to universities ($21 B), and other support for specific activities such as health care and agricultural extension. Here, it should be noted that this very large dependence on private support–and hence the marketplace–is unique to the United States since in most other nations, higher education is primarily supported (and managed) by government (90% or greater). It is the major reason why on a per student basis, higher education in America is supported at about twice the level ($20,545 per year) as it is in Europe. (OECD, 2005) There is a caveat here, however, since roughly half of this cost is associated with non-instructional activities such as research, health care, agricultural extension, and economic development–mis-




Funding breakdown both for the nation and for the University of Michigan

sions unique to American universities.

Yet another complexity arises from the hidden subsidies of higher education by both state and federal government through the foregone tax revenues arising from the treatment of university gifts and endowment earnings as charitable gifts and nontaxable income, respectively. To be more specific, when a university receives gifts that are deducted as charitable contributions, other taxpayers subsidize, in effect, these foregone taxes. Similarly, the nonprofit nature of endowment income also make them exempt from the taxes that would apply to for-profit company revenues. It is estimated that foregone tax revenues or "tax expenditures" from charitable gifts and endowment earnings amount roughly $16 B per year (assuming an average 30% tax rate on the $25 B of gifts and $27 B of endowment earnings), which amounts to a federal government subsidy of as much as $40,000 per student at well-endowed private colleges and universities, leading to the ironic situation that when all support, public and private, is accounted for, several of these institutions are among the most "publicly supported" universities in the nation. Of course, one can make a strong case for the appropriateness of some degree of public support of private higher education. Yet these "tax expenditures", while very real and perhaps appropriate burdens on state and federal tax revenues, are rarely included in the total picture of cost, price, and value of a college education, although they would significantly modify the true costs and public subsidy picture of American higher education.

Setting the public subsidy of private higher education in America by beneficial tax policies aside for the moment, let us return to the specific case of public higher education. Recall, that students pay a sticker price, tuition, which is only about one-third of the actual cost of their education, and, in reality, when financial aid is taken into account, pay on the average about one-sixth of the tuition price. In good times, the states provide the appropriations from tax revenues that support this rather substantial price discount from the actual costs of education experienced by institutions. But in hard times, when the states cut back their appropriations, then the discount shrinks, and students either have to pay more or universities have to cut programs. Actually, both usually happen.

Although most public (and political) attention is focused on tuition (price) as the key concern, in reality this has very little to do with either the access or affordability of public higher education. Put most simply, in public universities, the system works as follows:

State government determines the price (tuition).

Governing boards determine the value (quality).

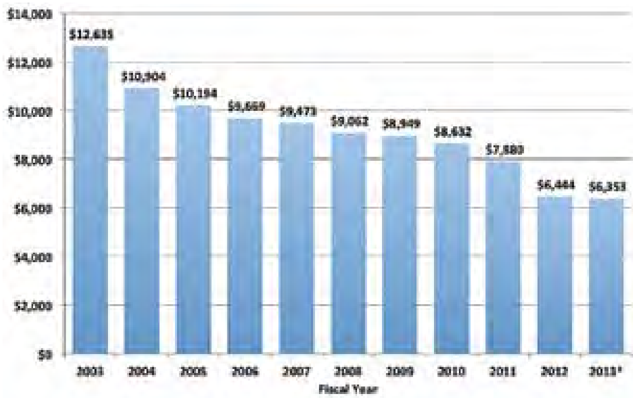
Need-based student financial aid determines the access (affordability).

More specifically, state government determines the price discount from the true cost of education through appropriations and hence the tuition (typically about one-third of the actual cost and usually less than the cost of room and board). If the state cuts appropriations per student, then tuition must rise to replace the lost discount. The governing board determines the quality of the university through its ability to acquire sufficient resources, either through its effectiveness in attracting adequate state appropriations or its willingness to support necessary tuition levels. Need-based financial aid is the key to student access, since this provides not only further discounting of tuition, usually eliminating it all together for students with significant need, but it also helps to cover other costs such as room and board, books, travel, and other expenses. Ironically, failure to set tuition sufficiently high to compensate for inadequate state support can erode both quality and access, since it constrains the resource base necessary for both quality academic programs and adequate financial aid, while providing unnecessary educational subsidies to students from more affluent backgrounds.

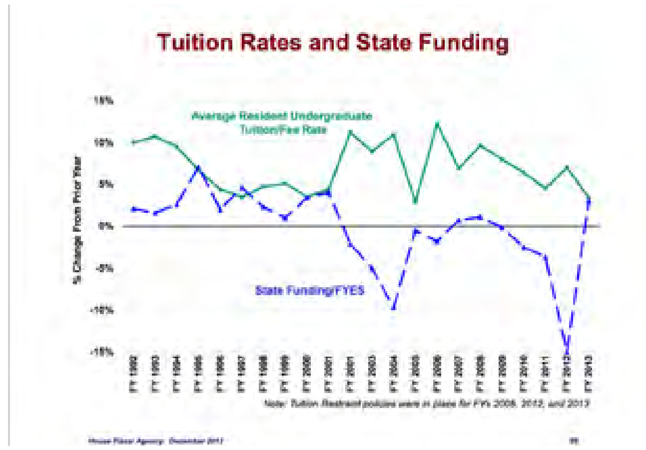
Now for the bad news: Public support of higher education has been dropping for the past three decades. The State of Michigan provides an excellent example of the dilemma faced by public universities. Over the past decade years, Michigan's public universities have suffered massive cuts in state appropriations, with most universities seeing reductions in state support per student over 50% during this period, ironically at a time when enrollments have been increasing. More specifically, appropriations to Michigan's public universities have declined from $1.62 billion in FY2002 to $1.43 billion in FY2005, with further budget cuts on the horizon in FY2014. State appropriations per studentshave dropped from $7,000 to $4,500 over this period, amounting to a 50% loss in state support when inflation adjusted. In fact, over the past two years alone, the state has cut $260 million from the higher-education budget, an amount equal to the combined support of seven state universities, forcing the elimination of 2,000 university jobs and denying the opportunity for a college education to many thousands of students.

During much of this period, state universities strained to hold tuition increases in check.Unfortunately state government abrogated an earlier agreement to restore funding cuts if the universities would hold tuition increases below inflation. The universities honored their end of the bargain; the state did not and cut appropriations still further, amounting over a four-year period to 25% to 40% on an inflation-adjusted, per student basis. Hence the universities had no choice in 2005 but to begin to raise tuition levels at double-digit rates.

At the national level, state appropriations have fallen from $8.50 per $1,000 of personal income to $7,000, a decline of 20% during the 1980s and 1990s. Funding of higher education dropped from 7.2% of state expenditures in 1977 to 5.3% in 1997, a 27% drop (Kane, 2003). The share of public university budgets provided by the states have dropped from 50% in 1979 to 35% in 2000, and in the wake of a weak economy, have dropped even further. Among Big 10 universities, state support now covers less than 20% of operating costs, and at the University of Michigan, state appropriations now have dropped below 7% of the total operating budget and 12% of its academic budget.




UM state support received per student



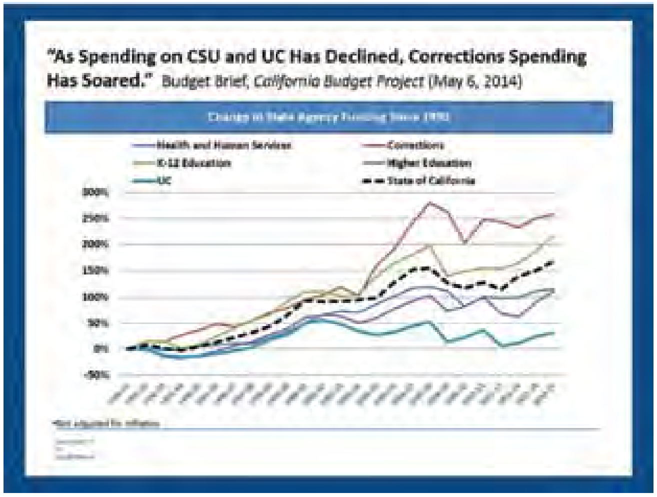

UM tuition is determined largely by state suport...

In fact, the National Conference of State Legislatures reports that between 2002 and 2014 higher education was the ONLY major function of state government that took such large cuts in state funding. Although universities have had no alternative but to increase tuition as state support has dropped–at least if they had the opportunity–this has NOT been sufficient to cover the reduction in state funding. The combination of the decline in state appropriations and the political restrictions on raising tuition at public institutions has produced a particularly marked decline in educational and general spending per student at public relative to private colleges and universities.

Today there are many signs that the quality of public higher education in America is beginning to suffer, at just that moment when the challenges of a global, knowledge-driven economy have positioned our universities as among our most important assets in securing economic prosperity, social well-being, and national security. Student-to-faculty ratios and workloads have been increasing, eroding not only the quality of classroom instruction but also constraining research university faculty from conducting the research critical to economic development in a knowledge economy increasing dependent upon technological innovation. Faculty salaries at public universities have fallen 20% behind those at private universities (compared to 1980 when they were roughly even), leading to a migration of some of the best professors from public to private institutions. Other erosion has occurred in the value of pension plans, medical benefits, life insurance, housing, and other benefits key to faculty recruiting and retention. The number of public universities listed among the top 25 national universities in U.S. News & World Report's rankings has declined from 7 in 1987 to 3 in 2004 (and these three, UC-Berkeley, U Michigan, and U. North Carolina are ranked 23rd, 24th, and 25th !)

There are also growing concerns about eroding access, as dollars that should be gong into need-based financial aid are going instead to compensate for declining state support. Returning to Michigan as our case study, the actual estimated cost of undergraduate education at the University of Michigan is about $28,000 per year, which also happens to be the tuition charged to students from out-of-state. The University charges an average tuition of about $9,000 to undergraduate Michigan residents, a discount of roughly $19,000. Unfortunately, even if all of UM's state appropriation of $300 million were allocated to support Michigan students (leaving none for research, public service, or other state-related activities), this would amount to only $12,000. Hence the University has to compensate for about $9,000 of unsubsidized costs for each Michigan undergraduate. Where do we get this? From the same discretionary dollars that it would normally use for priorities such as need-based financial aid.

Note here that it has long been a UM policy that the University will provide sufficient financial aid to meet the full need of all Michigan undergraduates. But this policy is now at some risk, in view of the declining state subsidy. There is already some evidence that this is affecting the socioeconomic character of our student




California also demonstrates that corrections and health care are now the top priorities.

body, since the average family income of UMAA undergraduates is now well above $100,000, with more students from high income (> $250,000) than low income families (>$50,000).

As Stanley Ikenberry, the former president of the University of Illinois and the American Council on Education, summarizes the current plight of public higher education in America: "The severity of current cuts, coming after more than two decades of slow but steady relative decline in state support, has forced many education leaders to conclude that the old, often implicit, compacts between the states and their universities–such as ensured access to affordable public universities to the states' high school graduates–have been abandoned." (Ikenberry, 2005).

A recent New York Times editorial put it well: "The United States has moved entire generations into the middle class and beyond by subsidizing public colleges, putting higher education without the reach of many deserving low-income students. The pubic college system is in steep decline, however, because of decades of declining support from states that historically kept educational quality high and tuition low." (NYT, 2004).

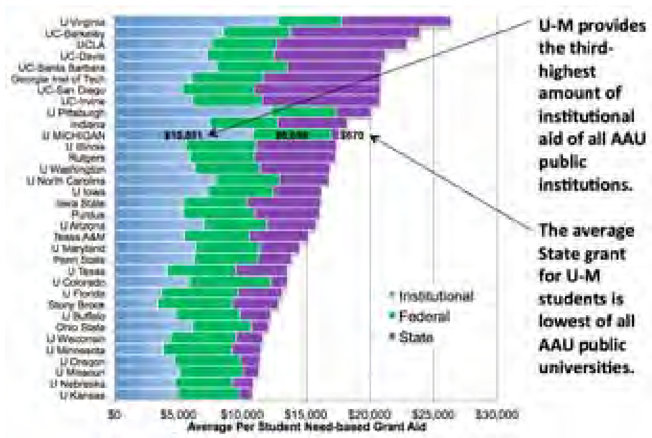
By way of comparison, the federal government spends $45 billion (8.2%) of the $550 billion the nation will invest this year in K-12 education.

## Why Is This Happening?

So why is this happening? Why have the states been methodically disinvesting in public higher education over the past two decades? In part it has to do with other competing priorities for state tax dollars. Most states launched massive prison construction programs during the 1980s in response to poling suggesting voter concerns with crime and mandatory sentencing guidelines, without thinking much about long term costs. Today the state budget for prisons has surpassed the higher education budget in most states. In fact, at an average inmate cost of $30,000 per year, with prisons populated primarily by first-offenders incarcerated for nonviolent offenses such as drug trafficking or petty theft, the corrections system has become a de facto "higher education system" in many states, turning petty crime offenders into hardened criminals at a cost comparable to the tuition charged for a Harvard education.

The blame for myopic planning goes well beyond the states. Unfunded federal mandates have decimated state budgets, diverting dollars for these obligations from discretionary funds used for priorities such as higher education. Of particular concern is the rapidly growing burden of Medicaid, a consequence largely of the federal government's inability to come to grips with a growing uninsured population and the urgent need for universal health care in our nation. As recent studies have suggested, the economic burdens of the unfunded Medicaid mandates passed onto the states by the federal government have now surpassed the entire public education budget (both K-12 and higher education) in the majority of the states. (Kane, 2003).

Tax policy is also a big part of the problem. In the past, the support of public universities always followed the ebb and flow of economic cycles. In bad economic times, state governments and donors cut support, hoping to restore it once again in good times. But during the late 1990s, as the dot-com frenzy drove boom times in the stock market and state tax revenues, state governments chose to cut taxes rather than restore earlier cuts in higher education. A few even locked in these cuts through constitutional amendments such as Colorado's Tax-Payer Bill of Rights (TABOR), restricting not only tax revenues but even the costs of state services such as higher education (e.g., tuition). As one state budget officer observed: "College leaders are fooling themselves if they think the end of this recession will be like all the others. What we're seeing is a systematic, careless with-




...and absence of state-based financial aid programs.

drawal of concern and support for advanced education in this country at exactly the wrong time." (Selingo, 2003)

This is compounded by the obsolete structure of most state tax structures, still designed for a 20th century industrial economy, e.g., taxing manufacturing, rather than for a 21st century knowledge economy increasingly dependent upon knowledge services such as legal, financial, and information services that largely go untaxed. As the boom economy cycled into the post-dot-com bust, state budgets collapsed under the structural deficits created by tax cuts and their inability to tax the economic activities of increasingly knowledge-intensive service economies. Since cutting K-12, corrections, or federal mandates such as Medicaid was politically impossible, the only remaining sacrificial lamb was public higher education.

Finally, many states aggravated this situation even further with misguided higher education policies such as merit scholarship programs that primarily benefited well-off students attending high quality K-12 schools, who needed neither the assistance or incentives to attend college, at the expense of need-based financial aid aimed at those less fortunate students from impoverished backgrounds and weak schools. As we noted earlier, this was also compounded by tuition constraints that required universities to subsidize low prices for affluent students at the expense of need-based financial aid programs. In this sense, low tuition and state-funded merit scholarship programs are highly regressive social policies, in effect providing welfare for the rich at the expense of educational opportunity for the poor.

Once again, the federal government has contributed to this shift away from providing support to those students with financial need to subsidizing the college education of more affluent students. As recent studies have indicated, over the past three decades the federal government has provided a disproportionately large share of federal aid to well-endowed private colleges rather than to public colleges, which enroll about 80% of the nation's college students. (Winter, 2004). Federal financial aid programs favor institutions that rely heavily on student tuition, covering about 40% of the costs of high tuition private institutions, allowing them to increase tuition substantially in recent years. In contrast, political constraints and public perceptions have limited most public colleges and universities from taking full advance of such financial aid programs. (Alexander, 2000). This has been aggravated by the shift in federal financial aid away from need-based grants such as the Pell Grant program to subsidized loans and tax benefits that increasingly benefit middle and upper income students.

But there was an even deeper issue. The American university has long been seen as an important social institution, created by, supported by, and accountable to society at large. The key social principle sustaining the university has been the perception of education as a public good–that is, the university was established to benefit all of society. Like other institutions such as parks and police, it was felt that individual choice alone would not sustain an institution serving the broad range of society's education needs. Hence public policy dictated that the university merited broad support by all of society, rather than just by the individuals benefiting from its particular educational programs, through direct tax subsidy or indirect tax policies (e.g., treatment of charitable giving or endowment earnings).

Yet, today, even as the needs of our society for post-secondary education intensifies, we also find an erosion in the perception of education as a public good deserving of strong societal support. State and federal programs have shifted from investment in the higher education enterprise (appropriations to institutions) to investment in the marketplace for higher education services (subsidized loans and tax benefits to students and parents). Whether a deliberate or involuntary response to the tightening constraints and changing priorities for public funds, the new message is that education has become a private good that should be paid for by the individuals who benefit most directly, the students. Government policies that not only enable but encourage the capacity of universities to capture and market the commercial value of the intellectual products of research and instruction represent additional steps down this slippery slope.

All of this points to an alarming shift in public priorities, away from accepting stewardship for the sacrifices of past generations by investing to support future generations. The cavalier disregard for investments in higher education, regarding it as a lower priority, expendable during hard times, is not only irresponsible but foolish in view of the importance of advanced education, research, innovation to economic competitiveness and security in a hypercompetitive global, knowledge-driven economy. But perhaps this is not so surprising, in view of the fact that the baby boomers, who have usually followed the adage "Eat dessert first; life is uncertain!" are now approaching retirement. The aging "me generation" that now dominates public policy demands expensive health care, ever more prisons, homeland security, reduced tax burdens–and apparently to hell with the kids and the future. If this is indeed a consequence of the priorities of a governing generation, then it is also possible that the current inadequacy tax support for public colleges and universities is not a temporary affliction; it is likely to last for several decades!

## What To Do?

Little wonder that after the cavalier treatment public higher education has received from state leaders over the past several years, the governing boards with fiduciary responsibility for the welfare of public universities have begun to lose confidence in state government as a reliable partner in providing adequate support for this critical state and national asset. Term-limited legislators and governors, political parties controlled by narrow special interest groups, and a body politic addicted to an entitlement economy simply cannot be trusted. Instead, governing boards are relying more heavily on the autonomy provided by the state constitution, which gives them control over decisions such as admission, tuition and fees, faculty and staff compensation, procurement, and other areas sometimes micromanaged by state government.

Across the nation numerous experiments are appearing to redefine the nature of public education. Some states such as Virginia and Colorado have created new types of public universities that function more as public corporations or authorities rather than state agencies, allowing universities greater flexibility to draw support from the private marketplace, in return for more visible measures of accountability in areas such as graduation rates and technology transfer. In fact, Colorado has even implemented a voucher system to fund higher education, in which students are provided grants taken with them to the institution of their choice. Other states including South Carolina and also Virginia have allowed the privatization of selected higher education programs, e.g., professional schools such as law and business, or even entire universities. Several states such as Pennsylvania and Washington have moved to performance contracting, in which universities are redefined as state-related rather than state-owned and negotiate a contractual relationship with state government receive state funds for specific services, e.g., educating a certain number of state residents. Perhaps the most interesting experiment is in Ohio, where Miami University has been allowed to set tuition levels for Ohio residents at private levels, then discount it by the state appropriation per student, and still further with need-based financial aid, thereby making quite transparent the relative dependence of tuition on state support. (Breneman, 2005).

In fact, this last approach is increasingly finding favor in many quarters. As an 2004 editorial in the New York Times explained, "With government support so shaky, state colleges are gong to need to raise their rates. A more moderate approach might be to permit tuition to rise to the levels now charged to out-of-state students, while protecting those with less ability to pay [with need-based financial aid programs]." The NYT editorial concludes: "State colleges must find a way to fulfill the mission they were crated to perform. Since the government has taken to starving them, their best hope is to increase tuition for those who can afford to pay." (NYT, 2004)

Although some are concerned that these experiments could lead to a transformation of public higher education in a piecemeal fashion, campus by campus and state by state, without any overarching design (Ikenberry, 2005), in reality they represent highly pragmatic approaches to two important realities: First, it is unlikely that public higher education will command sufficient priority to an aging baby boomer population to merit adequate tax support. Two, we have entered an era in which the marketplace is viewed as a far more accurate reflection of public priorities than the ballot box or public policy. Together these imply that some radical restructuring of public higher education may be in order.

## A National Agenda for Higher Education

The future of public higher education is of immense importance to the United States. Beyond the fact that three-quarters of all college students are enrolled in public universities, the increasing dependence of our nation on advanced education, research, and innovation compel efforts to both sustain and enhance the quality of our public colleges and universities. Yet, as this paper suggests, the traditional structure for financing public higher education may no longer be viable. Traditionally, this has involved a partnership among states, the federal government, and private citizens (the marketplace). In the past the states have shouldered the lion's share of the costs of public higher education through subsidies, which keep tuition low for students; the federal government has taken on the role of providing need-based aid and loan subsidies. Students and parents (and to a much lesser extent donors) pick up the rest of the tab.

Yet this system has become vulnerable as the states face the increasing Medicaid obligations of a growing and aging uninsured population, made even more difficult by the state tax-cutting frenzy during the boom period of the late 1990s. This is likely to worsen as a larger percentage of young people and working adults seek higher education while the tax-paying population ages and health care costs continue to escalate. As Kane and Orzag conclude, "the traditional model of higher education finance in the U.S. with large state subsidies to public higher education and modest means-tested grants and loans from the federal government is becoming increasingly untenable." (Kane, 2003).

Little wonder then that many are calling upon national leaders to articulate a national agenda for higher education in America, similar to other national agendas in K-12 education such as "A Nation At Risk" and "No Child Left Behind". Of course, we have had such national higher education agendas before during times of major national challenge and opportunity. The Land-Grant Acts of the 19th century addressed the needs of an emerging industrial nation and the importance of education to the working class. The government-university research partnership, proposed by Vannevar Bush in 1944 and implemented following WWII, along with the G.I. Bill and the recommendations of the Truman Commission, established the principle of federal support of research and graduate education on the campuses while launching the massification of higher education in America. The National Defense Education Act of the late 1950s and 1960s established investments in higher education as critical to national security during the height of the Cold War.

Yet since that time, for almost four decades, the nation really has had no agenda for higher education in America. Little wonder that at times we appear to be drifting aimlessly, with changing social priorities putting at great risk that the very institutions that earlier generations built and supported so strongly as key to the future of a great nation. Here part of the challenge is a profound misunderstanding of the relationship among the cost, price, and value of a college education by both students and parents and by elected public officials. The funding of higher education by state and federal government support (including tax benefits), philanthropy, and other various revenue streams not only disguise true costs but make pricing, e.g., tuition, largely fictitious, since all students, rich and poor, in public and private institutions receive very substantial subsidies. In some ways the financing of higher education is reminiscent of health care, where third-party payers (insurance companies, Medicare and Medicaid) also decouple the consumer from the marketplace. However in health care, at least one can estimate the costs of medical treatment and patients can assess the value of their health care, in contrast to higher education where true costs are difficult to estimate and the benefit of a college education is usually assessed only many years later.

One might approach this as an appropriate challenge to the federal government. After all, in some ways it was federal inaction that created the current dilemma, crippling state budgets with unfunded federal mandates such as Medicaid, through federal inaction on national priorities such as universal health care, and shifting philosophies of federal financial aid programs. It is also the federal government's responsibility to invest adequately in providing for economic prosperity and national security, particularly in the new flat world characterized by phenomena such as outsourcing and off-shoring characterizing a hypercompetitive, global, knowledge-driven economy increasingly dependent upon knowledge workers, research, and technological innovation. (Friedman, 2005).

Perhaps it would be more constructive, however, to present this as an opportunity: We have entered an age of knowledge in a global economy, in which educated people, the knowledge they produce, and the innovation and entrepreneurial skills they possess have become the keys to economic prosperity, social-well being, and national security. Moreover, education, knowledge, innovation, and entrepreneurial skills have also become the primary determinants of one's personal standard of living and quality of life. Democratic societies–and state and federal governments–must accept the responsibility to provide all of their citizens with the educational and training opportunities they need, throughout their lives, whenever, wherever, and however they need it, at high quality and at affordable prices.

Government leaders could define and embrace a vision for the nation's future that provides citizens with the lifelong learning opportunities and skills they need to live prosperous, rewarding, and secure lives in this world. Perhaps it is time to create an analog to the Land Grant Act or G I Bill for the 21st century–perhaps a Learn Grant Act that would provide every citizen with an entitlement for as much education as they need, wish, or are capable of, throughout their lives. For example, a combination of federal and state programs could provide vouchers or education accounts that could be redeemed at accredited institutions for partial support of education with amounts adjusted to levels (community college, undergraduate degrees, workplace training, professional and graduate degrees, lifelong enrichment) and available at anytime throughout one's life.

This could be financed through mechanisms similar to pensions and health care, e.g., Social Security and Medicare, creating legal and institutional frameworks for universal portability. The key would be to create transparent and transportable benefits and opportunities to enable sufficient mobility and agility to adapt to a changing economy. For example, one could image tax-deferred education savings accounts or perhaps even education accounts paid for through payroll taxes similar to Social Security. In fact, in contrast to paying a tax to support one's retirement (and relatively unproductive) years as in Social Security, the Learn Grant program would instead finance one's capacity to be even more productive through further education and enhanced skills. The use of such accounts would correspond to investing directly in the marketplace rather than in institutions, thereby minimizing public bureaucracy and exerting strong market pressures on educational institutions to align themselves with national needs. The key would be to provide portable benefits and opportunities for lifelong learning so that

While the startup costs of such a program would be considerable (perhaps one-third of the costs of health care), the impact of creating a truly world-class workforce–or better yet a society of learning–capable of competing in a global, knowledge-driven economy would be extraordinary.

### A New Approach to Tuition

In rummaging through my old notebooks, I found an interesting idea several of us dreamed up in 1995 to address the regressive nature of our current approach to instate tuition within a politically acceptable framework. Even our government relations team viewed this alternative approach to the state appropriation, tuition, and financial aid just might work, particularly at a time when the state would be hard pressed to provide adequate support for higher education. The basic idea is to earmark a part of the state appropriation for need-based financial aid and use the real cost/market pricing for tuition.

More specifically, the University would announce that we intend to restructure the way we finance the University to better serve the citizens of the state and make certain they get their money's worth by adopting a more transparent pricing and insisting on cost containment:

i) Restructuring budgeting (the responsibility center budgeting model)

ii) Implementing cost/market-based pricing (tuition)

iii) Restructuring financial aid to maximize access for state residents

We would announce that henceforth we will set our tuition at only one rate—that for outstate students—and this would be determined by our real costs and the national market for each of our programs. (Here we could use the Michigan private colleges such as Kalamazoo or national peers such as Cornell and Penn to set our base UG price at $40,000 or so, with comparable tuition levels for our graduate and professional schools.)

We would then use the state appropriation to provide discounts for all Michigan residents enrolled in our programs, but with two types of discounts being provided:

i) First, an across-the-board discount provided to ALL state residents, regardless of need;

ii) Second, a need based discount for those students that need additional assistance to attend Michigan.

In this effort we would first determine the amount of the state appropriation that would be earmarked for research, public service, and financial aid (say, $100 million). The remaining state appropriation ($220 million) would be spread over all resident students to determine some appropriate discount, say, $10,000 per student, from the retail nonresident price.

Note that this accomplishes a number of objectives:

i) It allows us to get instate tuition up to more realistic levels (my target estimate is 50% of nonresident tuition levels).

ii) It reflects the fact that ALL Michigan residents benefit from a substantial discount because of the state appropriation.

iii) However it also reflects the University's strong commitment to access by allocating a substantial portion of the state appropriation to need-based financial aid, much in the same way that the private colleges in Michigan have gouged $120 million of state tax dollars to do the same for their students.

iv) It would make it clear that we are NOT asking rich families to pay for the support of poor students, since ALL students receive substantial discounts because of state appropriations (and other University funds). Rather we use the state appropriation to provide this financial aid, in the same spirit as the private colleges in the state.

v) This would establish a clear relationship between the state appropriation and our pricing that we could explain. We could even share our calculations with the Legislature and the media, so they could see directly how much an increase in appropriations will affect the discount given to instate state students.

vi) Since the increase of the retail price (nonresident tuition) will be determined by the cost and the marketplace, once we have made this adjustment, we will be back to more moderate tuition increases each year (e.g.,, the CPI plus 1-2%), thereby avoiding the annual tuition bashing.

This approach would give us a solid moral ground for asking more affluent families to pay more of their fair share of the cost of the education for their children, since we could demonstrate directly what discount from the real (retail) tuition their state appropriation dollars are getting for them. If they want a greater discount, they will either have to pay higher taxes or insist that their legislators allocate more of their existing tax dollars to higher education.

Note that a variation on the theme would be to work backward and first subtract from the state appropriation the amount we need for sufficient need-based financial aid to make certain that any Michigan resident accepted to the University can attend, regardless of financial circumstances. Then the remaining appropriation (minus research and public service) would be spread over all students to get to the standard discount. It would be hard for legislators to argue against this, since to do so would put them in the position of publicly supporting subsidy of the rich at the expense of the poor. (Note that the taxes paid by the rich families are only a small fraction of the discount they would receive in any case, most of which comes from all of those citizens who are not participating in higher education.)

In summary, this approach might sweep the tuition debate permanently off the table. The fundamental principles are hard to argue with:

i) We set our "prices" (namely, tuition) based on cost, value, and market—and NOT on politics or necessary budget plugs. More precisely, since the value of a Michigan education is comparable to that of leading private universities such as Cornell and Penn and local privates such as Kalamazoo and Calvin, and since our costs are comparable, our retail price should be similar (about $25,000 in today's market).

ii) We set as a first priority the long-standing principle that no Michigan resident, who qualifies academically and who is admitted will be denied the opportunity for a Michigan education because of financial need. We will meet this need with the first dollars off the top of the state appropriation (plus our own internal financial aid resources).

iii) Since the state created us to do research and public service, in addition to educating Michigan citizens, a portion of the state appropriation should be earmarked for these purposes.

iv) The remaining dollars will be spread across Michigan resident students to provide a net discount in price.

One can almost imagine a tuition bill reading as follows:

| | |
|---|---|
| UM Undergraduate Tuition | $40,000 |
| State resident discount | $ 6,000 |
| Financial aid discount | $14,000 |
| Balance due | $20,000 |

(Note, from a public relations point of view, one could also advertise an "average" instate tuition, taking into account the average financial aid discount, along with a range, e.g.,

Average instate tuition: $20,000 (with a range from 0 to $15,000, based on need)

Finally, note that this approach would also address the instate/outstate enrollment issue, since if the state wanted us to educate more Michigan residents, we would simply spread the state appropriation dollars over more students, thereby providing them with less of a discount (unless the state increased the appropriation). If we enrolled fewer residents, they would each get a larger discount.

A rather simplistic approach, but still worth thinking about…

## Another Approach: Learn Grants

The Challenge: Education has become a key determinant of one's personal standard of living and quality of life. The breakpoint between those who succeed in college and those who fail is perhaps the most critical decision point in one's life. Yet many recent studies have revealed the degree to which access to higher education in America has become increasingly stratified according to student financial circumstances, thereby undercutting the fundamental principles of equity and social justice. Today even the most academically talented students in the lowest economic quartile are significantly less likely to have access to the benefits of higher education than the least academically qualified students in the top quartile–a situation clearly intolerable for a democratic society.

Part of the challenge arises from the patchwork character of current federal, state, and institutional financial aid programs, which have evolved over the years more as a consequence of the political process than any defined purpose or accountability with respect to impact or efficiency in achieving student access or success in higher education. Today a very significant fraction of public funding for post-secondary education go primarily to benefit affluent students with modest economic needs, at a time when close to a quarter of Americans are disproportionately and severely deprived of educational opportunity at colleges and universities.

There has been inadequate effort to integrate and restructure the system into a cohesive policy-driven program, despite the obvious benefits and cost savings. As a consequence, while the current system does benefit affluent students, the lending industry, and political objectives, it is both extraordinarily inefficient and ineffective with respect to key objectives such as higher education access, retention, and debt burden. It needs to be replaced with a strategically-oriented, results-driven, and greatly simplified program of grants, loans, and tax benefits that demonstrably works to serve clearly-articulated goals.

As a consequence of both the inadequacy and complexity of existing financial aid programs, many economically disadvantaged students (and parents) no longer see higher education as an option open to them but rather as a privilege for the more affluent. As a result, these students do not have the incentive to perform well in K-12 (nor do their parents have the incentive to support them), hence falling behind early or dropping out of the college-bound ranks.

The Proposal: To address this alarming injustice and provide strong incentives for college preparation, the idea would be to provide every student with a "529 college savings account", a "Learn-Grant" when they begin kindergarten. Although this account would be owned by the students (although invested in the equity market by the federal government or its agents), its funds could only be used for post-secondary education upon the successful completion of a high school college-preparatory program. Each year students (and their parents) would receive a statement of the accumulation in their account, with a reminder that this is their money, but it can only be used for their college education (or other post-secondary education). An initial contribution of, say, $10,000 (e.g., $5,000 from the federal government with a $5,000 match from the states) would accumulate over their K-12 education to an amount that when coupled with other financial aid would likely be sufficient for a four-year college education at a public college or university.

Beyond serving as an important source of financial aid, the Learn Grants would provide a very strong incentive for succeeding in K-12 and preparing for a college education, since the account would be something students own but would lose if they did not continue their education beyond secondary school (after some appropriate grace period). The program might be funded from any of a number of sources, e.g., from a federal plus state match, the revenue from the auction of the digital spectrum (most analogous to the Land Grant Act), etc. Although the Learn Grants would be provided to all students when entering K-12 (in order to earn broad political support), they could be augmented with additional contributions from public, private, or parental sources during their pre-college years, based on need and/or performance.

As to cost, if we assume roughly 4.5 million children enter K-12 each year (the estimate for 2010), then at $10,000 per student, this would cost $40 billion ($20 billion each to the states and the feds). While this seems immense, it is about the cost of one year of K-12 education (or college education, on the average). It also should be compared to other public expenditures (Medicaid/Medicare, corrections, defense, and even student financial aid). From this broader perspective, it really doesn't seem excessive when viewed both as an investment in social justice and the future of the nation!

It is imperative both as a matter of social justice and economic competitiveness that the nation and the states address and remove those factors that have created a strong dependence of access and success in higher education upon socioeconomic status. America should aspire to the ideal where family income is nearly irrelevant to the ability of a student to attend the college or university best matched to his or her talents, objectives, and motivation. The proposed Learn Grant program would provide a powerful stimulus to building the world-class workforce necessary for America's prosperity and security in an ever more competitive global, knowledge-driven economy.

Assessment of Impact

The efforts to counter the myths characterizing the cost of a college education have long been a priority of university leaders, economists, and educational organizations such as the American Council on Education and the Association of Public and Land Grant Universities. Unfortunately, for every speech or op-ed attempting to explain the costs of higher education there are generally two more propagating the usual myths.

Similarly the particular proposals suggested for addressing the costs and pricing of higher education are also not original. Miami University of Ohio adopted the approach of using a transparent formula to discount the actual cost of a college education by a combination of subsidy by state appropriations and additional need-based financial aid, only to have the Ohio governor respond by attempting to freeze tuition.

Even the "learn grant" proposal is not entirely new, since such investments have long been made to young children through so-called "baby bonds".

Hence, while studies such as those in this chapter are important, they remain only brief skirmishes in a long war to balance "who benefits" with "who pays" in American public higher education.

## References

Duderstadt, James J., Report of the Quality Subcommittee of the Spellings Commission, Millennium Project, University of Michigan, 2005.

Duderstadt, James J., The View from the Helm: Leading the American University during an Era of Change (Ann Arbor, MI: University of Michigan Press, 2006) 400 pp.

Duderstadt, James J., Aligning American Higher Education with a Twenty-first-century Public Agenda". Higher Education in Europe, Vol 34, No. 3-4, 2009.

Courant, Paul, James J. Duderstadt, Edie Goldenberg, "Needed: A National Strategy to Preserve Public Research Universities", Chronicle of Higher Education, 2010.

## Chapter 16

# Diversity, Inclusion, and Public Purpose

The University of Michigan was established in 1817 in the village of Detroit by an act of the Northwest Territorial government and financed through the sale of Indian lands granted by the United States Congress. (Since it benefited from this territorial land grant, the new university was subject to the enlightenment themes of the Northwest Ordinance guaranteeing civil rights and religious freedom. Envisioned by the people of our state as truly public, Michigan became the first university in America to successfully resist sectarian control. We can be proud that, buoyed by committed students, faculty, staff, and the citizens of our state, the University of Michigan has consistently been at the forefront of higher education, grappling with the difficult issues of plurality and promoting equality.

In many ways, it was at the University of Michigan that Thomas Jefferson's embrace of the principles of the Enlightenment in his proposition for nation, "We hold these truths to be self-evident: That all men are created equal", was most fully embraced and realized. Whether characterized by gender, race, religion, socioeconomic background, ethnicity, or nationality–not to mention academic interests or political persuasion–the university has always taken great pride in the diversity of its students, faculty, and programs.

Particularly notable here was the role of Michigan President James Angell in articulating the importance of Michigan's commitment to provide "an uncommon education for the common man" while challenging the aristocratic notion of leaders of the colonial colleges such as Charles Eliot of Harvard. Angell argued that Americans should be given opportunities to develop talent and character to the fullest. He portrayed the state university as the bulwark against the aristocracy of wealth. However the journey to achieve Angell's vision of the University's public purpose did not come easily, however.

President James Angell

As with most of higher education, the history of diversity at Michigan is complex and often contradictory. There have been many times when the institution seemed to take a step forward, only to be followed by two steps backward. Michigan was one of the earliest universities to admit African-Americans and women in the late 19th century. At our founding, we attracted students from a broad range of European ethnic backgrounds. In the early 1800s, the population of the state swelled with new immigrants from the rest of the country and across the European continent. It took pride in its large enrollments of international students at a time when the state itself was decidedly insular. By 1860, the Regents referred "with partiality," to the "list of foreign students drawn thither from every section of our country." Forty-six percent of our students then came from other states and foreign countries. Today more than one hundred nations are represented at Michigan.

In contrast, our record regarding Native Americans has been disappointing. In 1817, in the treaty of Fort Meigs, local tribes became the first major donors when they ceded 1,920 acres of land for "a college at Detroit." A month later the Territorial Legislature formed the "university of Michigania," and accepted the land gift in the college's name. Today, although the number of Native American students enrolled is very low, they continue to make vital cultural and intellectual contributions to the University.

The first African American students arrived on campus in 1868, without official notice. In the years following Reconstruction, however, discrimination increased. Black students joined together to support each other early in the century and staged restaurant sit-ins in the 1920s. It was not until the 1960s that racial unrest finally exploded into campus-wide concerted action.

Michigan's history with respect to gender is also very mixed. Michigan was the first large university in America to admit women. At the time, the rest of the nation looked on with a critical eye. Many were certain that the "experiment" would fail. The first women who arrived in 1869 were true pioneers, the objects of intense scrutiny and resentment. For many years, women had separate and unequal access to facilities and organizations. Yet, in the remaining decades of the 19th Century, the University of Michigan provided strong leadership for the nation. Indeed, by 1898, the enrollment of women had increased to the point where they received 53 percent of Michigan's undergraduate degrees. However, during the early part of the 20th Century, and even more with the returning veterans after World War II, the representation of women in the student body declined significantly. It only began to climb again during the 1970s and 1980s and, for the first time in almost a century, once again exceeded that of men in 1996. During the past several decades, the University took a number of steps to recruit, promote, and support women staff and faculty, modifying University policies to better reflect their needs. True equality has come slowly, driven by the efforts of many courageous and energetic women.

## The Michigan Mandate

The effort of the University of Michigan to bring diverse racial and ethnic groups more fully into the life of the university in the 1980s provides an excellent example of the moral leadership that can be exerted by a university president. This process of institutional transformation was guided by a strategic plan known as the Michigan Mandate, which achieved very significant progress toward the objective of social diversity and led eventually to a landmark decision by the U.S. Supreme Court in 2003.

As with most of higher education, the history of diversity at Michigan is complex and often contradictory. There have been many times when the institution seemed to take a step forward, only to be followed by two steps backward. Michigan was one of the earliest universities to admit African Americans and women in the late nineteenth century. It took pride in its large enrollments of international students at a time when the state itself was decidedly insular. Yet it faltered as minority enrollments languished and racial tensions flared in the 1960s and 1970s, only to be jolted occasionally into ineffective action by student activism—the Black Action Movement in the 1970s and the United Coalition against Racism in the 1980s. Nonetheless, access and equality have always been central goals of the institution. Michigan has consistently been at the forefront of the struggle for inclusiveness in higher education.

When I became provost and then president in the late 1980s, it had become apparent that the university had made inadequate progress in its goal to reflect the rich diversity of our nation and our world among its faculty, students and staff. In assessing this situation, we concluded that although the University had approached the challenge of serving an increasingly diverse population with the best of intentions, it simply had not developed and executed a plan capable of achieving sustainable results. More significantly, we believed that achieving our goals for a diverse campus would require a very major change in the institution itself.

It was the long-term strategic focus of our planning that proved to be critical, because universities do not change quickly and easily any more than do the societies of which they are a part. Michigan would have to leave behind many reactive and uncoordinated efforts that had characterized its past and move toward a more strategic approach designed to achieve long-term systemic change. Sacrifices would be necessary as traditional roles and privileges were challenged. In particular, we understood the limitations of focusing only on affirmative action; that is, on access, retention, and representation. The key would be to focus instead on the success of underrepresented minorities on our campus, as students, as faculty, and as leaders. We believed that without deeper, more fundamental institutional change these efforts by themselves would inevitably fail–as they had throughout the 1970s and 1980s.

The challenge was to persuade the university community that there was a real stake for everyone in seizing the moment to chart a more diverse future. People needed to believe that the gains to be achieved through diversity would more than compensate for the necessary sacrifices. The first and most important step was to link diversity and excellence as the two most compelling goals before the institution, recognizing that these goals were not only complementary but would be tightly linked in the multicultural society characterizing our nation and the world in the future. As we moved ahead, we began to refer to the plan as The Michigan Mandate: A Strategic Linking of Academic Excellence and Social Diversity.

The mission and goals of the Michigan Mandate were stated quite simply:

1. To recognize that diversity and excellence are complementary and compelling goals for the university and to make a firm commitment to their achievement.

2. To commit to the recruitment, support, and success of members of historically underrepresented groups among our students, faculty, staff, and leadership.

3. To build on our campus an environment that sought, nourished, and sustained diversity and pluralism and that valued and respected the dignity and worth of every individual.

A series of carefully focused strategic actions was developed to move the University toward these objectives. These actions were framed by the values and traditions of the University, an understanding of our unique culture characterized by a high degree of faculty and unit freedom and autonomy, and animated by a highly competitive and entrepreneurial spirit. The strategy was both complex and pervasive, involving not only a considerable commitment of resources (e.g., fully funding all financial aid for minority graduate students) but also some highly innovative programs such as our Target of Opportunity program for recruiting minority faculty. It also was one of those efforts that we believed required leadership on the front lines by the president, since only by demonstrating commitment from the top could we demand and achieve comparable commitments throughout the institution.

By the mid 1990s Michigan could point to significant progress in achieving diversity. The representation of underrepresented minority students, faculty, and staff more than doubled over the decade-long effort. But, perhaps even more significantly, the success of underrepresented minorities at the University improved even more remarkably, with graduation rates rising to the highest among public universities, promotion and tenure success of minority faculty members becoming comparable to their majority colleagues, and a growing number of appointments of minorities to leadership positions in the University. The campus climate not only became more accepting and supportive of diversity, but students and faculty began to come to Michigan because of its growing reputation for a diverse campus.

Perhaps most significantly, as the campus became more racially and ethnically diverse, the quality of the students, faculty, and academic programs of the University increased to their highest level in history. This latter fact reinforced our contention that the aspirations of diversity and excellence were not only compatible but, in fact, highly correlated. By every measure, the Michigan Mandate was a remarkable success, moving the University beyond our original goals of a more diverse campus.

Even while pursuing the racial diversity goals of the Michigan Mandate, we realized we could not ignore another glaring inequity in campus life. If we meant to embrace diversity in its full meaning, we had to attend to the long-standing concerns of women faculty, students, and staff. Here, once again, it took time–and considerable effort by many women colleagues (including my wife and daughters)–to educate me and the rest of my administration to the point where we began to understand that the university simply had not succeeded in including and empowering women as full and equal partners in all aspects of its life and leadership.

In faculty hiring and retention, despite the increasing pools of women in many fields, the number of new hires of women had changed only slowly during the late twentieth century in most research universities. In some disciplines such as the physical sciences and

Student Access and Success
- Undergraduate Student Access
  - Wade McCree Incentive Scholarship
  - King/Chavez/Parks Program
  - Summer programss (e.g., DAPCEP)
  - Collegee Day visitation for families
  - Tuition grants to all Native American students from Michigan.
- Special Undergraduate Programs
  - Undergraduate Research Opportunity Program
  - 21st Century Program
  - CRLT Programs
  - Leadership 2017
  - Office of Academic Multicultural Initiatives
- Graduate Student Support
  - Fully funding minority graduate support
  - Rackham Graduate Merit Fellowship Program

Special Programs
- Tapped grass-roots creativity and energy using $ 1 M/yf Presidential Initiatives Funds tor competitive proposals from faculty and student groups.

Results
- Enrollments:
  - 83% increase in students of color (to 28%)
  - 90% increase in underrep min (to 15%)
  - 57% increase in AA (to 2,715 or 9.1%)
  - 126% increase of Latinos (to 4.3%)
  - 100% increase in Native Americans (to 1.1%)
- Graduation rates for African Americans highest among public universities.
- UM ranked 27th in nation in minority BA/BS
  - 8th for M.S. degrees, 7th for PhD degrees
  - 1st in African American PhDs (non HBCU's)
- Graduate education
  - Increased minority fellowships by 118%
  - Of 734 Rackham Fellows in 1994,
    - 51% were African American,
    - 29% were Latino
- Professional Schools:
- Business: 12% AA, 28% color
- Medicine: 11% AA, 39% color
- Law: 10% AA, 21% color

Faculty
- Target of Opportunity Program
- Faculty Development (Faculty Awards Program for minority faculty)
- Cluster hiring
- Creating a welcoming and supportive culture (networks, centers, surveys)
- Enlarging candidate pool by increasing PhD enrollments

Results
- +62% for African Americans (128)
- +117% for Latinos (52)
- +75% for Native Americans (7)
- Senior academic leadership (URM): from 14 to 25

Staff
- Demanded accountability in hiring and promotion
- Human Resources and Affirmative Action programs
- Consultation and Conciliation Services

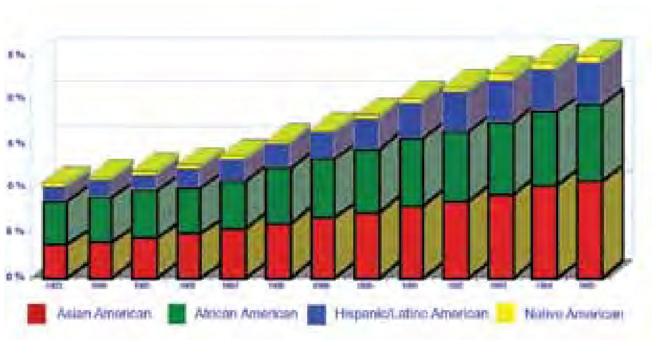
Results
- Top managers: +100% (to 10%)
- P&A: +80 (from 449 to 816)

More Generally
- Building University-wide commitments
- Office of Minority Affairs, Vice-Provost for Minority Affairs
- Demanding accountability
- Included in compensation review
- Included in budget review
- Included in appointment review

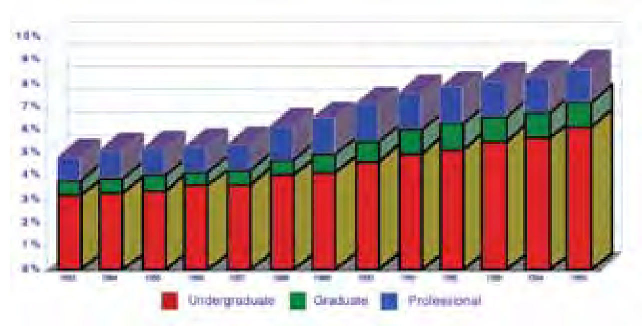
Leadership
- Half of Executiver Officers were African American
- Executive VP Medical Center (Rita Dumas)
- Secretary of University (Harold Johnson)
- VP Research (Homer Neal0
- UM Flint Chancellor Charlie Nelms
- UM Dearborn Chancellor James Renick

JJD's Successor was African American (Homer Neal)

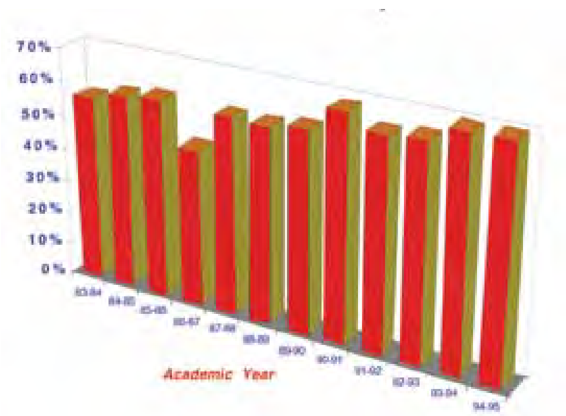
Some Actions and Results of the Michigan Mandate by 1996



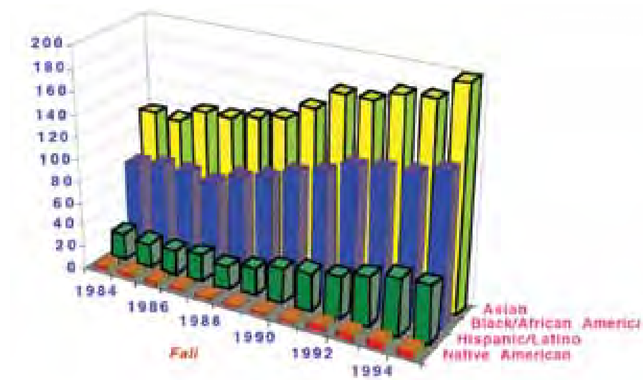

Minority student enrollments (percentages)



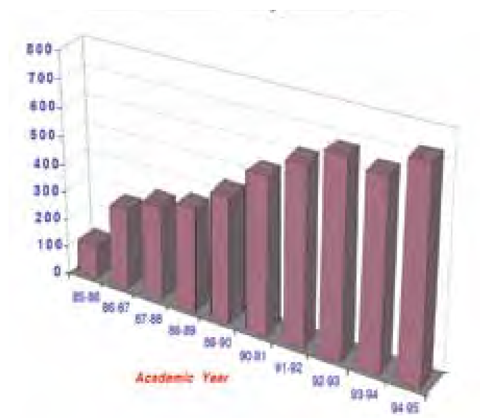

African-American student enrollments (percentages)



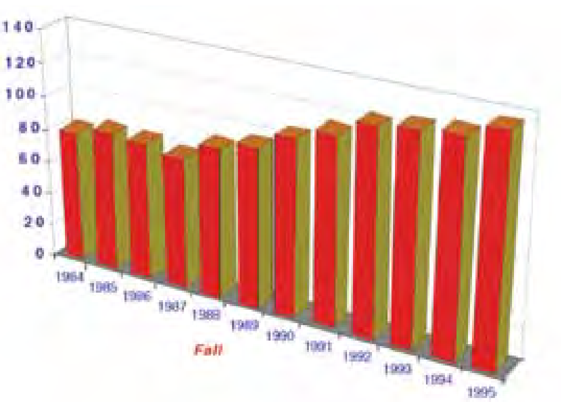

Graduation rates of African-American student cohorts six years afer initial entry




Number of minority tenured and tenure-track faculty




Number of university minority graduate fellowships




Number of African-American faculty


The Michigan Mandate: MLK Day Unity March, addressing student and alumni groups, Professor Bunyon Bryant, Professor Charles Moody (with President Ford), Dean Rhetaugh Dumas, Associate Vice Provost Lester Monts, toasting the heros of the successful Michigan Mandate.

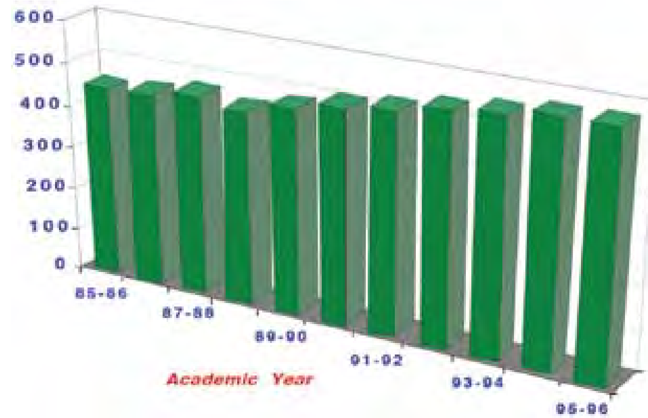
engineering, the shortages were particularly acute. We continued to suffer from the "glass ceiling" phenomenon: that is, because of hidden prejudice women were unable to break through to the ranks of senior faculty and administrators, though no formal constraints prohibited their advancement. The proportion of women decreased steadily as one moved up the academic ladder. Additionally, there appeared to be an increasing tendency to hire women off the tenure track as postdoctoral scholars, lecturers, clinicians, or research scientists. The rigid division among various faculty appointments offered little or no opportunity for these women to move into tenured faculty positions.

Many of our concerns derived from the extreme concentration of women in positions of lower status and power—as students, lower-pay staff, and junior faculty. The most effective lever for change might well be a rapid increase in the number of women holding positions of high status, visibility, and power. This would not only change the balance of power in decision-making, but it would also change the perception of who and what matters in the university. Finally, we needed to bring university policies and practices into better alignment with the needs and concerns of women students in a number of areas including campus safety, student housing, student life, financial aid, and childcare.

To address these challenges, the university developed and executed a second strategic effort known as the Michigan Agenda for Women. While the actions proposed were intended to address the concerns of women students, faculty, and staff, many of them benefited men as well. In developing the Michigan Agenda,

| | Persons of Color | Black | Hispanic/ Latino | Native American | Asian |
|---|---|---|---|---|---|
| Nation | 24.80% | 12.10% | 9.00% | 0.80% | 2.90% |
| State | 17.80% | 13.9% | 2.20% | 0.60% | 1.10% |
| University | | | | | |
| Students | 24.80% | 8.71% | 4.58% | 0.75% | 10.76% |
| Undergraduates | 26.00% | 9.10% | 4.70% | 0.80% | 11.40% |
| Graduates | 21.60% | 7.30% | 8.75% | 0.70% | 4.80% |
| Professional | 24.37% | 9.00% | 10.56% | 0.61% | 4.20% |
| Faculty (Ten. & Track) | 14.42% | 4.98% | 1.90% | 0.26% | 7.28% |
| Academic Administration | 20.20% | 19.40% | 0.80% | 0.00% | 0.00% |
| Professional Non-Faculty | 14.60% | 6.60% | 1.70% | 0.50% | 5.80% |

Under-represented minorities at the UM,
state, and national level, Fall 1995




UM women tenured and tenure-track faculty

we knew that different strategies were necessary for different parts of the university. Academic units varied enormously in the degree to which women participated as faculty, staff, and students. What might work in one area could fail miserably in another. Some fields, such as the physical sciences, had very few women represented among their students and faculty. For them, it was necessary to design and implement a strategy which spanned the entire pipeline, from K-12 outreach to undergraduate and graduate education, to faculty recruiting and development. For others such as the social sciences or law, there already was a strong pool of women students, and the challenge became one of attracting women from this pool into graduate and professional studies and eventually into academe. Still other units such as education and many departments in humanities and sciences had strong participation of women among students and junior faculty, but suffered from low participation in the senior ranks and in leadership roles.

Like the Michigan Mandate, the vision was again both simple yet compelling: that by the year 2000 the university would become the leader among American universities in promoting and achieving the success of women as faculty, students, and staff. Again, as president, I took a highly personal role in this effort, meeting with hundreds of groups on and off campus, to listen to their concerns and invite their participation in the initiative. Rapidly there was again significant progress on many fronts for women students, faculty, and staff, including the appointment of a number of senior women faculty and administrators as deans and executive officers, improvement in campus safety, and improvement of family care policies and child care resources. In 1988 Michigan appointed its first woman Dean of LS&A, Edie Goldenberg, in 1993 our first Vice Provost for Health Affairs, Rhetaugh Dumas, and in 1997 our first woman provost, Nancy Cantor. Finally, in 2002, the University of Michigan named its first woman president, Mary Sue Coleman.

The university also took steps to eliminate those factors that prevented other groups from participating fully in its activities. For example, we extended our anti-discrimination policies to encompass sexual orientation and extended staff benefits and housing opportunities to same-sex couples. This was a particularly controversial action because it was strongly opposed not only by the religious right but also by several of the university's regents. Yet, this was also an issue of equity, deeply frustrating to many faculty, staff, and students, which required attention. Harold Shapiro had tried on several occasions to persuade the regents to extend its anti-discrimination policies to include the gay community, without success. Finally, with a supportive, albeit short-lived, Democratic majority among the regents, I decided to move ahead rapidly to put in the policy while there was still political support, no matter how slim. The anticipated negative reaction was rapid and angry–an attempt by the Legislature to deduct from our appropriation the estimated cost of the same-sex couple benefits (effectively blocked by our constitutional autonomy), a personal phone call to me from our Republican governor (although it was a call he did not want to make and did not insist upon any particular action), and a concerted and successful effort to place two conservative Republican candidates on our Board of Re-

Listening, learning, planning, and selling the Michigan Agenda for Women

gents in the next election (resulting in the horror of a 4-4 divided board during my last two years as president).

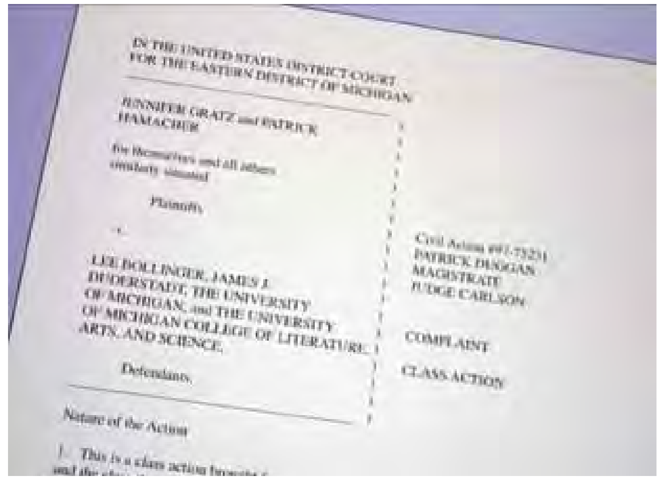
We were determined to defend this action, however, as part of a broader strategy. We had become convinced that the university had both a compelling interest in and responsibility to create a welcoming community, encouraging respect for diversity in all of the characteristics that can be used to describe humankind: age, race, ethnicity, nationality, gender, religious belief, sexual orientation, political beliefs, economic background, geographical background.

But, of course, this story does not end with the successful achievements of the Michigan Mandate in 1996 when I stepped down as president. Beginning first with litigation in Texas (the Hopwood decision) and then successful referendum efforts in California and Washington, conservative groups such as the Center for Individual Rights began to attack policies such as the use of race in college admissions. Perhaps because of Michigan's success with the Michigan Mandate, the University soon became a target for those groups seeking to reverse affirmative action with two cases filed against the University in 1997, one challenging the admissions policies of undergraduates, and the second challenging those in our Law School. Although Lee Bollinger had succeeded me by that time, I was still named personally as a defendant in one of the cases (here I referred to myself as the "et. al" in the Gratz vs. Bollinger, et. al. case), although I had little influence on the strategies to defend both cases to the level of the Supreme Court, aside from giving day after day of depositions and having all of the records of my presidency digitized, archived, and posted publicly by our university history library.

Although the 2003 Supreme Court decisions were split, supporting the use of race in the admissions policies of our Law School and opposing the formula-based approach used for undergraduate admissions, the most important ruling in both cases stated, in the words of the court: "Student body diversity is a compelling state interest that can justify the use of race in university admission. When race-based action is necessary to further a compelling governmental interest, such action does not violate the constitutional guarantee of equal protection so long as the narrow-tailoring requirement is also satisfied." Hence, the Supreme Court decisions on the Michigan cases reaffirmed those policies and practices long used by those selective colleges and universities throughout the United States. But more significantly, it reaffirmed both the importance of diversity in higher education and established the principle that, appropriately designed, race could be used as a factor in programs aimed at achieving diverse campuses. Hence the battle was won, the principle was firmly established by the highest court of the land. We had won. Or so we thought…

While an important battle had been won with the Supreme Court ruling, we soon learned that the war for diversity in higher education was far from over. As university lawyers across the nation began to ponder over the court ruling, they persuaded their institutions to accept a very narrow interpretation of the Supreme Court decisions as the safest course. Actually, this pattern began to appear at the University of Michigan during the early stages of the litigation process. Even as the Bollinger administration launched the expensive legal battle to defend the use of race in college admissions following my presidency, it throttled back many of the effective policies and programs created by the Michigan Mandate, in part out of concern these might complicate the litigation battle. As a consequence, the enrollment of underrepresented minorities began almost immediately to drop at Michigan, eventually declining from 1996 to 2002 by almost 25% overall and by as much as 50% in some of our professional schools. Although there was an effort to rationalize this by suggesting that the publicity given the litigation over admissions policies was discouraging minority applicants, there is little doubt in my mind that it was the dismantling of the Michigan Mandate that really set us back.

Since the Supreme Court decision, many universities have begun to back away from programs aimed at recruitment, financial aid, and academic enrichment


IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF MICHIGAN

JENNIFER GRATZ and PATRICK HAMACHER

for themselves and all others similarly situated

Plaintiffs,

v.

LEE BOLLINGER, JAMES J. DUDERSTADT, THE UNIVERSITY OF MICHIGAN, and THE UNIVERSITY OF MICHIGAN COLLEGE OF LITERATURE, ARTS, AND SCIENCE,

Defendants.

Civil Action #97-75231
PATRICK DUGGAN
MAGISTRATE
JUDGE CARLSON

COMPLAINT

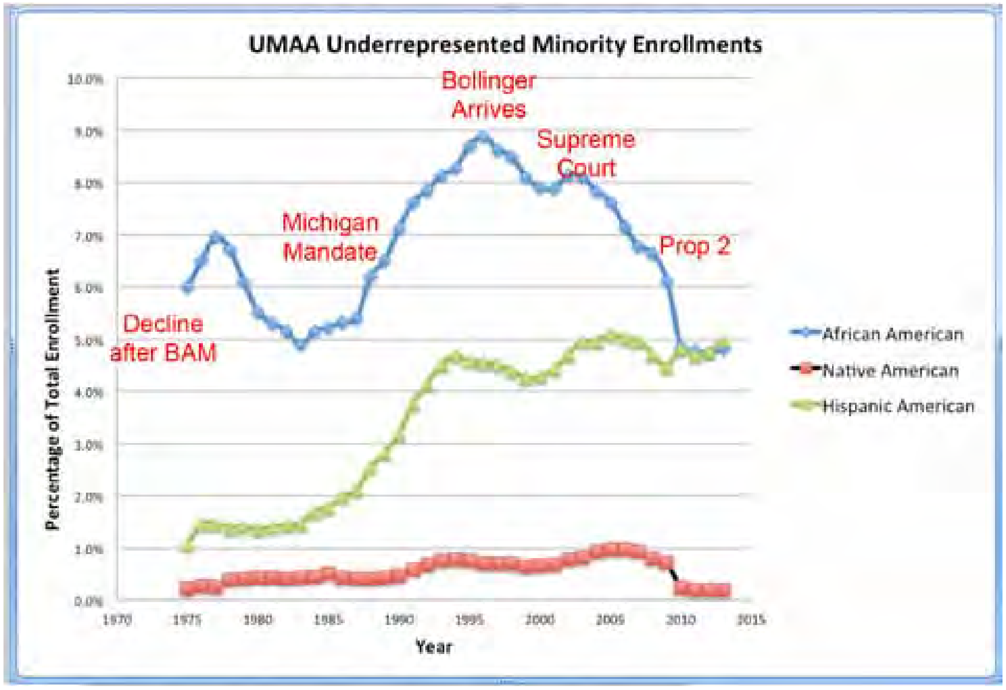
CLASS ACTION

Nature of the Action

The Supreme Court case of 2003

for minority undergraduate students, either eliminating entirely such programs or opening them up to non-minority students from low-income households. Threats of further litigation by conservative groups have intensified this retrenchment. As a consequence, the enrollments of under-represented minorities are dropping again in many universities across the nation (including Michigan). After the years of effort in building successful programs such as the Michigan Mandate and defending the importance of diversity in higher education all the way to the Supreme Court, the tentative nature of the decision ("narrowly tailored race considerations") probably caused more harm than good by unleashing the lawyers on our campuses to block successful efforts to broaden educational opportunity and advance the cause of social justice.

Ironically, the uses of affirmative action (and programs that involved racial preference) actually were not high on the agenda of the Michigan Mandate. Rather our success involved commitment, engagement, and accountability for results. Yet in 2006, Michigan voters approved a constitutional referendum to ban the use of affirmative action in public institutions similar to that of California's Proposition 209. This referendum has prevented Michigan colleges and universities from using even the narrowly tailored prescriptions of the 2003 Supreme Court decision. As predicted, the University has experienced a tragic decline in the enrollments of underrepresented minority students, erasing most of the gains with the Michigan Mandate strategy in the 1990s and returning this measure of diversity to the lev-




Possible causes of the dramatic reversal of progress in UMAA's diversity

els of the 1960s. More specifically (as shown in several charts depicting the enrollments of underrepresented minorities over the past 40 years, African American enrollments have dropped from a peak of 9.1% in 1996 to 4.6% today.

Although certainly the state constitutional ban on affirmative action has had major impact on this effort, it is also disturbing to note that the decline actually began a decade earlier with the arrival of President Bollinger and accelerated following the Supreme Court decision upholding Michigan's use of this policy. A more thorough analysis of this period finds that while supporting diversity as dean, Bollinger moved rapidly halt all of the initiatives of the Michigan Mandate. He argued that it was important for the University to prepare itself for litigation on affirmative action that might lead to the Supreme Court (perhaps resulting in a case with his name on it), and gave instructions to the new general counsel, Marvin Krisloff, to use this argument to shut down diversity efforts. As a result, the trajectory of under-represented minority enrollments immediately began to decline, dropping by roughly 30% during Bollinger's tenure. Another interesting contrast in approaches to diversity came through staffing. Although during my last years as president, 50% of the members of my EO team were African American, by the time Bollinger finished his first round of appointments, only one out of 11 EOs and one out of 18 deans were underrepresented minorities. The University's commitment to diversity remained only in the occasional words of the new president while all action on the agenda ceased. So it is little wonder that diversity began to decline.

While there was an more precipitous drop in enrollments following Michigan's ban on affirmative action, a more thorough analysis suggests that the decline following the Supreme Court action might also be explained by the degree to which the University throttled back pressures on the deans and directors on achieving diversity during the past decade. While diversity was certainly given lip service through a massive public relations effort, it most assuredly was not given priority for specific action or accountability.

## Economic Diversity

Throughout the last decade, there has been an increasing concern that many public universities, particularly flagship research universities such as Michigan, are also losing the economic diversity that characterized their public purpose. Recent studies by Kati Haycock of the Education trust suggested that "Founded to provide "an uncommon education for the common man", many

Change in Minority Enrollments

| Minority | 1996 | 2013 | Change |
|---|---|---|---|
| African Am | 2,824 | 1,816 | -37% |
| Hispanic | 1,473 | 1,876 | +27% |
| Native Am | 227 | 76 | -66% |
| Underrep | 4,567 | 3,638 | -20% |

Change in Minority Percentages

| Minority | 1996 | 2013 | Change |
|---|---|---|---|
| African Am | 9.1% | 4.6% | -50% |
| Hispanic | 4.5% | 5.0% | +11% |
| Native Am | 0.7% | 0.2% | -70% |
| Asian Am | 11.6% | 13.5% | +16% |
| Underrep | 14.1% | 9.6% | -32% |
| Fresh Afric | 9.3% | 4.1% | =56% |

The drop in underrepresented minorities over the past 15 years.

flagship universities have drifted away from their historic mission. Their students not only don't look much like the young people in the states they service, but they also don't look much different from those who attend elite private research universities."

Even more pointedly, the studies demonstrated that when rated on the basis of success and access of low-income and underrepresented minority students over the past decade, the two flagship universities that received the lowest marks for performance and progress were the University of Michigan and the University of Indiana! (Those receiving the highest marks were UC Berkeley, U Florida, U Utah, and SUNY Buffalo.) This has been a rather bitter pill to swallow for an institution that has long prided itself on being not only "the leaders and best" but for "providing an uncommon education for the common man".

More specifically, that the percentage of Pell Grant students enrolled at UMAA (the standard measure used by higher education of measuring enrollment by low income students) at the University of Michigan has dropped to 15% (compared to an average among flagship public universities of 22%), while its fraction of underrepresented minorities is now down to 7% (low again compared to an average of 12%). It is also disturbing that its percentage of first generation college students has now dropped to less than 6% compared to 16% of its public university peers and 14% of the enrollment of highly selective private universities.

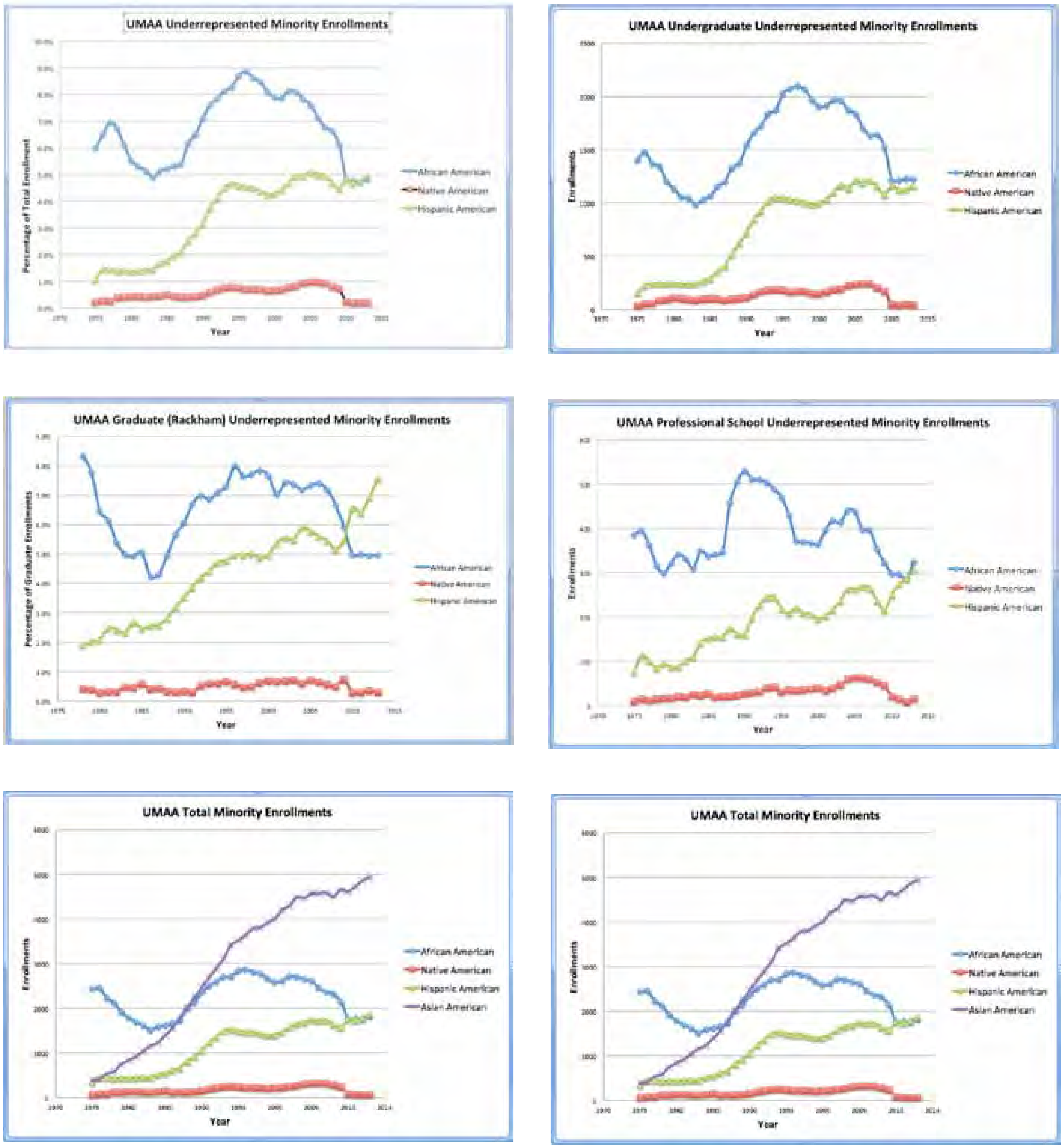
What is happening? To be sure, the State of Michigan ranks at the bottom of the states in the amount of need-based financial aid it provides to college students, requiring the University to make these commitments from its own internal funds. But it is also due to the decision make in the late 1990s to compensate for the loss of state support by dramatically increasing enrollments with a bias toward out-of-state students who generate new revenues with high tuition. Clearly students who can pay annual tuition-R&D at the private rates of $50,000 come from highly affluent families. Indeed, the average family income of Michigan undergraduates is now approaching $200,000 per year, more characteristic of the "1%" than the "common man".

## Restoring Michigan's Public Purpose

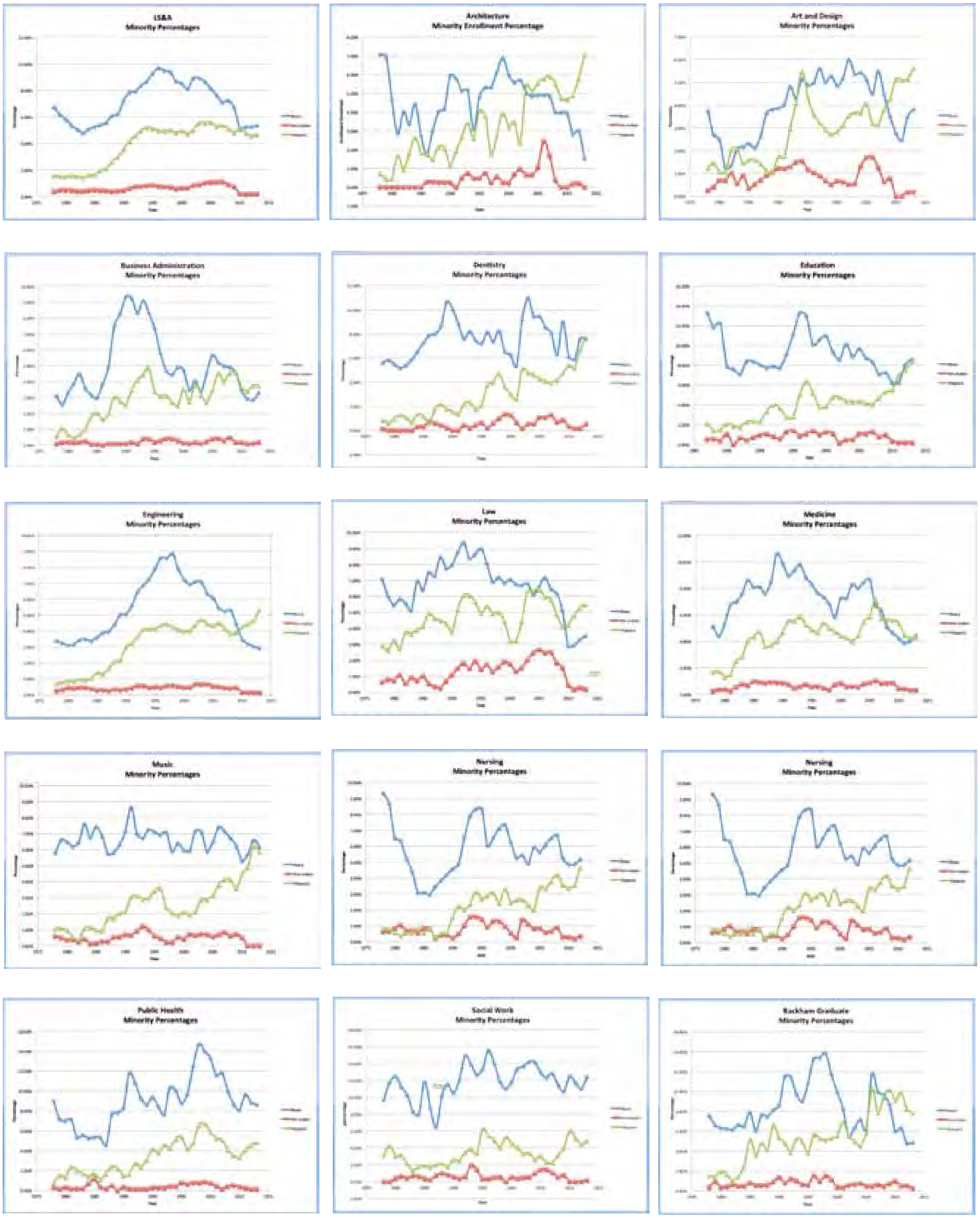
Hence it seems appropriate to end this chapter on the University's public purpose with several conclusions. First, we must always keep in mind that the University of Michigan is a public university, created as the first such institution in a young nation, evolving in size, breadth, and quality but always committed to a truly public purpose of "providing an uncommon education for the common man".

Today there is an even more urgent reason why the University must once again elevate diversity to a higher priority as it looks toward the future: the rapidly changing demographics of America. The populations of most developed nations in North America, Europe, and Asia are aging rapidly. In our nation today there are already more people over the age of 65 than teenagers, and this situation will continue for decades to come. Over the next decade the percentage of the population over 60 will grow to over 30% to 40% in the United States, and this aging population will increasingly shift social priorities to the needs and desires of the elderly (e.g., retirement security, health care, safety from crime and terrorism, and tax relief) rather than investing in the future through education and innovation.

However, the United States stands apart from the aging populations of Europe and Asia for one very important reason: our openness to immigration. In fact,




Changes in minority enrollments over past four decades




Underrepresented Minority Enrollments for Schools and Colleges

| | Percent of undergrads with Pell grants |
|---|---|
| AAU Privates (average) | 15% |
| AAU Publics (average, excluding U-M) | 23% |
| | |
| University of California-San Diego | 40% |
| University of California-Davis | 36% |
| University of California-Los Angeles | 34% |
| Stony Brook University | 33% |
| University of California-Berkeley | 32% |
| University of California-Santa Barbara | 31% |
| University of California-Irvine | 30% |
| University of Florida | 28% |
| University at Buffalo | 28% |
| University of Arizona | 27% |
| Rutgers University | 27% |
| Syracuse University | 25% |
| University of Texas at Austin | 24% |
| Michigan State University | 23% |
| Iowa State University | 22% |
| University of Oregon | 22% |
| Case Western Reserve University | 22% |
| Ohio State University | 21% |
| University of Minnesota | 21% |
| University of Washington | 20% |
| New York University | 20% |
| University of Nebraska | 20% |
| Texas A & M University | 19% |
| Purdue University | 19% |
| University of Missouri | 19% |
| University of Kansas | 19% |
| Emory University | 19% |
| University of Rochester | 19% |
| Massachusetts Institute of Technology | 19% |

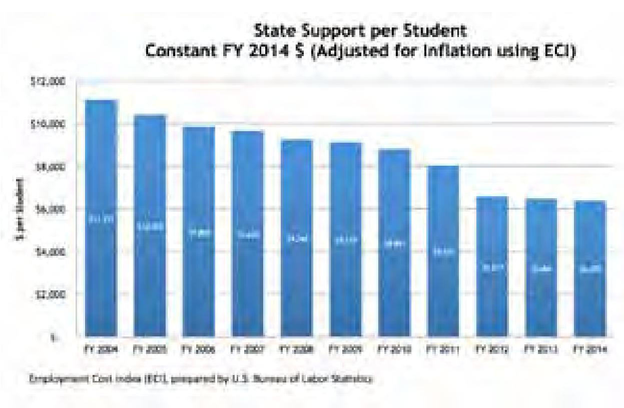
SOURCE: Integrated Postsecondary Education Data System (IPEDS).

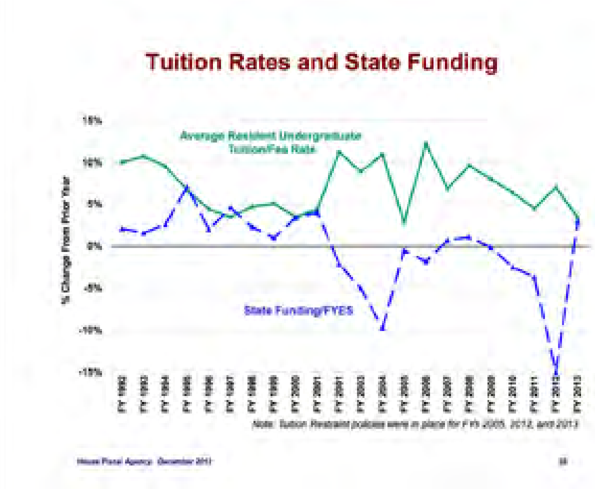
| | Percent of undergrads with Pell grants |
|---|---|
| University of Illinois | 18% |
| University of North Carolina | 18% |
| University of Southern California | 18% |
| Columbia University | 18% |
| Tulane University of Louisiana | 18% |
| Pennsylvania State University | 17% |
| Indiana University | 17% |
| University of Maryland | 17% |
| University of Iowa | 17% |
| University of Pittsburgh | 17% |
| University of Chicago | 17% |
| Brandeis University | 17% |
| University of Colorado | 16% |
| Georgia Institute of Technology | 16% |
| Stanford University | 16% |
| UNIVERSITY OF MICHIGAN | 15% |
| University of Wisconsin | 15% |
| Cornell University | 15% |
| Rice University | 15% |
| Carnegie Mellon University | 14% |
| Vanderbilt University | 13% |
| Brown University | 13% |
| Johns Hopkins University | 13% |
| Yale University | 13% |
| Duke University | 12% |
| University of Virginia | 11% |
| University of Pennsylvania | 11% |
| Northwestern University | 11% |
| Princeton University | 11% |
| California Institute of Technology | 11% |
| Harvard University | 10% |
| Washington University | 6% |

Michigan's ranking in Pell Grant students lags badly behind other public universities.

over the past decade, immigration from Latin America and Asia contributed 53% of the growth in the United States population, exceeding that provided by births (National Information Center, 2006). This is expected to drive continued growth in our population from 300 million today to over 450 million by 2050, augmenting our aging population and stimulating productivity with new and young workers. As it has been so many times in its past, America is once again becoming a nation of immigrants, benefiting greatly from their energy, talents, and hope, even as such mobility changes the ethnic character of our nation. By the year 2030 current projections suggest that approximately 40% of Americans will be members of minority groups; by mid-century we will cease to have any single majority ethnic group. By any measure, we are evolving rapidly into a truly multicultural society with a remarkable cultural, racial, and ethnic diversity. This demographic revolution is taking place within the context of the continuing globalization of the world's economy and society that requires Americans to interact with people from every country of the world.

The increasing diversity of the American population with respect to culture, race, ethnicity, and nationality is both one of our greatest strengths and most serious challenges as a nation. A diverse population gives us great vitality. However, the challenge of increasing diversity is complicated by social and economic factors. Today, far from evolving toward one America, our society continues to be hindered by the segregation and non-assimilation of minority and immigrant cultures. If we do not create a nation that mobilizes the talents of




Two tragic realities: 1) Michigan tuition is determined largely by state support.

all of our citizens, we are destined for a diminished role in the global community and increased social turbulence. Higher education plays an important role both in identifying and developing this talent. And the University of Michigan faces once again a major challenge in reclaiming its leadership in building a diverse campus.

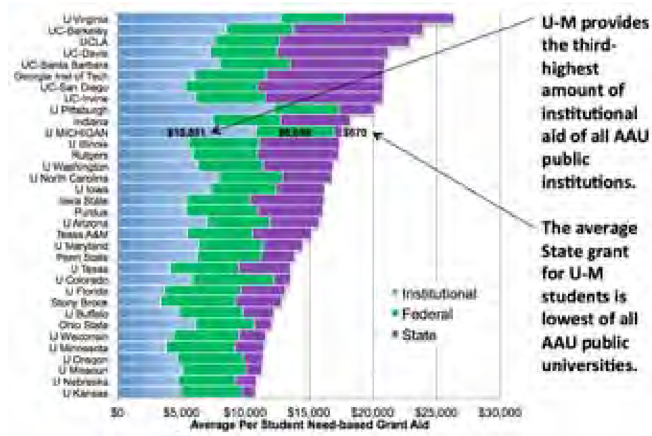
Yet there is ample evidence today from states such as California and Texas that a restriction to race-neutral policies will drastically limit the ability of elite programs and institutions to reflect diversity in any meaningful way. As former UC President Richard Atkinson noted in a recent address in Ann Arbor, "Proposition 209 asked the University of California to attract a student body that reflects the state's diversity while ignoring two of the major constituents of this diversity–race and ethnicity. A decade later, the legacy of this contradictory mandate is clear. Despite enormous efforts, we have failed badly to achieve the goal of a student body that encompasses California's diverse population. The evidence suggests that without attention to race and ethnicity this goal will ultimately recede into impossibility."

In fact, many of the approaches used by the University in the wake of Proposition 209 have been considered by Michigan. They reached out to low-performing high schools, making it possible for students achieving at top levels in these schools would not be penalized in admission decisions for the weaknesses of their schools. The University of California changed its standardized test requirements to put primary emphasis on achievements tests rather than aptitude tests. They sought to look more carefully at applicants to identify those who had overcome serious obstacles in preparing themselves for higher education. They worked with K-12 schools and community colleges to strengthen the preparation for under represented minority students. They launched a major effort to let students, parents, and counselors know about the opportunities UC provided in financial aid, broadened applications, and preparation for attendance. Yet, as Atkinson and his colleagues concluded, "Today if we look at enrollment overall, racial and ethnic diversity at the University of California is in great trouble. A decade later the legacy of Proposition 209 is clear. Despite enormous efforts, we have failed badly to achieve the goal of a student body that encompasses California's diverse population. The evidence suggests that–without attention to race and ethnicity–this goal will ultimately recede into impossibility." Today the University of Michigan provides further evidence from the collapse of its minority enrollments of the difficulty of achieving a diverse campus in the wake of Proposal 2.

But when one turns to economic diversity, the University of California provides a sharp contrast to the University of Michigan. Today 42% of all UC undergraduates receive Pell Grants, compared to 15% at UM. 46% of UC's entering California residents come from families where neither parent graduated from college, compared to 16% for UM. Approximately 25% of undergraduates come from underrepresented minority

| Fiscal Year | Budget | % Change |
|---|---|---|
| FY 2006 | $51,531,977 | 11.6% |
| FY 2007 | $55,506,768 | 7.7% |
| FY 2008 | $61,873,699 | 11.5% |
| FY 2009 | $68,550,532 | 10.8% |
| FY 2010 | $76,560,562 | 11.7% |
| FY 2011 | $84,681,931 | 10.6% |
| FY 2012 | $93,903,679 | 10.9% |
| FY 2013 | $103,414,892 | 10.1% |
| FY 2014 | $117,570,894 | 13.7% |

The majority of this aid is need-based grants.
Other sources of institutional undergraduate financial aid: Endowed Scholarships; School/College aid (both General Fund and non-General Fund).




Two tragic realities: 2) although Michigan makes a substantial commitment to need-based financial aid, it is unable to compensate for the absence of a meaningful state need based financial aid program.

populations (African American, Chicano/Latino, and Native American) compared to 10% at UM (although this later comparison is due in part to the very large growth in the Latino population of California).

So where is the difference? To be sure, since the University of Michigan has managed to contain the actual cost of its educational programs to inflationary levels, the real blame for the increasing costs seen by parents must fall on the State of Michigan, which has dramatically cut its support of higher education. In fact, a chart comparing state appropriations with University tuition and fees demonstrates that almost all of the increase in the costs faced by students and parents have been driven by the erosion of the state subsidy through appropriations. This failure in state support of public higher education has been compounded by the elimination of the state's support of need-based financial aid, now among the lowest levels in the nation. Part of the reason could be do to the more highly integrated higher education system of California, using both the community college system and the California State University as feeder institutions to the University of California

Hence restoring the University's diversity will require not only a serious restructuring of Michigan's financial strategies, but even more important, a renewed commitment to the fundamental public purpose that has guided the University for almost two centuries.

While the University's concerted effort to generate support from other patrons, particularly through private giving and sponsored research, it simply must realize that these will never be sufficient to support a world-class university of this size, breadth, or impact. Without substantial public support, it is unrealistic to expect that public universities can fulfill their public purpose.

Hence the highest priority should be to re-engage with the people of Michigan to convince them of the importance of investing in public higher education and unleashing the constraints that prevent higher education from serving all of the people of this state. This must become a primary responsibility of not only the leadership of the University, but its Regents, faculty, students, staff, alumni, and those Michigan citizens who depend so heavily on the services provided by one of the great universities of the world.

Returning again to President Atkinson's analysis, he suggests that "We need a strategy that recognizes the continuing corrosive force of racial inequality but does not stop there. We need a strategy grounded in the broad American tradition of opportunity because opportunity is a value that Americans understand and support. We need a strategy that makes it clear that our society has a stake in ensuring that every American has an opportunity to succeed—and every American, in turn, has a stake in our society. Race still matters. Yet we need to move toward another kind of affirmative action, one in which the emphasis is on opportunity and the goal is educational equity in the broadest possible



An interesting contrast: Students marching for socialjustice and equity in 1969
vs. preparing for UM vs Ohio State in 2013

sense. The ultimate test of a democracy is its willingness to do whatever it takes to create the aristocracy of talent that Thomas Jefferson saw as indispensable to a free society. It is a test we cannot afford to fail."

## References

Atkinson, Richard, C., "Opportunity in a Democratic Society: A National Agenda", Nancy Cantor Distinguished Lecture, University of Michigan, 2005

Duderstadt, James J., The View from the Helm: Leading the American U*niversity during an Era of Change* (Ann Arbor, MI: University of Michigan Press, 2006) 400 pp.

Duderstadt, James J., *The Michigan Mandate: Looking Back and Looking Forward*, University of Michigan Address, 2007

Haycock, Kati and Danette Gerald. *Engines of Inequality*. Washington, DC: Education Trust, 2008.

Haycock, Kati. *Opportunity Adrift*. Washington, DC: Education Trust, 2010.

# Chapter 17

# Intercollegiate Athletics

Most concerns about college sports today derive from the fact that the culture and values of intercollegiate athletics have drifted far away from the educational principles and values of their host universities. Today's athletic departments embrace commercial values driven by the perception that the primary purpose of athletic competition is mass entertainment. There is ample evidence that the detachment of intercollegiate athletics from the rest of the university—its mission and values, its policies and practices—has led to the exploitation of students and has damaged institutional reputation to an unacceptable degree.

While the defense of truth, justice, and the Michigan way in intercollegiate athletics was a necessary role for the president, it was never a very pleasant or easy one. Over time, it took its toll. But it also provided a vivid education concerning what I gradually came to view as one of the most serious threats to the contemporary American university: the extraordinary commercialization and corruption of big-time college sports.

Over four decades as a faculty member, provost, and president of the University of Michigan and a member and chair of the Council of Presidents of the Big Ten Conference have brought me to several conclusions.

First, while most of intercollegiate athletics are both valuable and appropriate activities for our universities, big-time college football and basketball stand apart, since they have clearly become commercial entertainment businesses. Today they have little if any relevance to the academic mission of the university. Furthermore, they are based on a culture, a set of values that, while perhaps appropriate for show business, are viewed as highly corrupt by the academy and deemed corrosive to our academic mission.

Second, while I believe that one can make a case for relevance of college sports to our educational mission to the extent that they provide a participatory activity for our students, I can find no compelling reason why American universities should conduct intercollegiate athletics programs at the current highly commercialized, professionalized level of big-time college football and basketball simply for the entertainment of the American public, the financial benefit of coaches, athletic directors, conference commissioners, and NCAA executives, and the profit of television networks, sponsors, and sports apparel manufacturers.

If you think about it for a moment, you will realize there are only three reasons why a university would want to conduct big-time college sports: i) because it benefits the student-athletes; ii) because it benefits the university (reputation, community, revenue; and iii)because it benefits the larger community. It is my belief that big-time college football and basketball, as currently conducted, fail to meet any of these criteria.

Third, and most significantly, it is my growing conviction that big-time college sports do far more damage to the university, to its students and faculty, its leadership, its reputation and credibility, that most realize--or at least are willing to admit. The evidence seems overwhelming:

Far too many of our athletics programs exploit young people, recruiting them with the promise of a college education—or a lucrative professional career—only to have the majority of Division 1-A football and basketball players achieve neither.

Scandals in intercollegiate athletics have damaged the reputations of many of our colleges and universities.

Big time college football and basketball have put inappropriate pressure on university governance, as boosters, politicians, and the media attempt to influence governing boards and university leadership.

The impact of intercollegiate athletics on university culture and values has been damaging, with inappropriate behavior of both athletes and coaches, all too frequently tolerated and excused.

So too, the commercial culture of the entertainment industry that characterizes college football and basketball is not only orthogonal to academic values, but it was corrosive and corruptive to the academic enterprise.

## Some Myths and Realities of College Sports

Myth 1: Intercollegiate athletics are self supporting.

Reality: No college programs in America today cover all their expenses (even those who claim to such USC, U Texas, Ohio State, Michigan, and even Notre Dame). Athletic directors use flakey accounting methods that do not include full costs of capital expenditures, hidden subsidies such as instate tuition for out-of-state athletes, indirect costs born by the institution, fund-raising that competes with academic units, etc. The NCAA estimates that in 2009 the total costs for intercollegiate athletics was $10.5 billion, while the total revenue was $5.6 billion (including ticket sales, television broadcasting, licensing, etc.). In reality the only people who make money –and big-time money, at that– from big time athletics are the coaches, athletic directors, NCAA brass, and the networks. But certainly not the "student athletes" and certainly not their host institutions.

In 2012 the media budget deficits for NCAA Division 1 programs averaged $9 million per year. From 2005 to 2009 athletics departments increased spending on student athletes by 50%, to $91,050 per athlete, while the increase for normal students was 20% to $13,470 per student.

Myth 2: Intercollegiate athletics are important for fund raising.

Reality: Donors who give because of winning teams give to wining programs, not to academic activities. But it gets even worse, since the tax-benefited "premium" payments for skyboxes and preferred seating generally come out of gifts that would otherwise have gone to academic purposes. At Michigan, our largest donors could not care less about college sports! They view it largely as a distraction from the primary mission of the University (except for Steve Ross, of course, who gave $100 million to the Athletics Department in 2013 to help build a "Walk of Champions", whatever that is).

Myth 3: All athletic facilities are self-financed.

Reality: Actually many require either institutional or public subsidy. But even those that are debt financed must pledge student tuition revenue for borrowing equity, not anticipated gate receipts or television revenue. They also depend on questionable tax practices such as being counted as 80% "charitable" deductions by the IRS despite the fact that they are quid pro quo required payments for benefits such as premium seating. If these inconsistent disappeared, the big stadium projects would collapse like a house of cards.

Myth : The power of the NCAA will protect the status quo.

Reality: Today the NCAA is in serious trouble and fighting for its survival. Its tax status is dependent upon rulings long ago that its primary purpose is educational. Yet grants-in-aid based on athletic performance could be ruled as "pay for play" and hence require employment rights for athletes (including unionization). The O'Bannon case could require payment to players for the use of their images for commercial purposes. Litigation associated with brain injuries or long-term health impact could cripple both the NCAA and universities. Finally, the compensation of coaches ($5 M and up), athletic directors ($1 M and up), and athletic staff (now several times that of faculty) is now so extreme that it raises the threat of federal action.

Myth 5: Intercollegiate athletics is important for school spirit.

Reality: Sure, student applications do go up after a major championship. But the students attracted to an institution are not necessarily those most concerned about academic achievement. Besides, how important is athletics to the school spirit of institutions like Harvard, Yale…and Caltech? And how important is athletics to Penn State these days?

Myth 6: But we do pay student athletes! We give them valuable scholarships!

Reality 6: A quote from a recent book on college


Marketing and the "wow" factor take over...while winning declines...

sports by Taylor Branch, the great historian about civil rights in America, puts this in an interesting context.

"Scholarship athletes are already paid," declared the Knight Commission members, "in the most meaningful way possible: with a free education." This evasion by prominent educators severed my last reluctant, emotional tie with imposed amateurism. I found it worse than self-serving. It echoes masters who once claimed that heavenly salvation would outweigh earthly injustice to slaves.

Myth 7: But we are preparing athletes for professional careers.

Reality: A recent Michigan survey indicates that most student athletes realize their odds of making the pros are very remote. Instead they view their college experience as an opportunity to enter careers very similar to other students in fields such as business, law, and medicine. But after a few weeks on campus, many of the most vigorously recruited student athletes realize they are woefully academically unprepared and saddled with 50-60 hour/week "jobs" and lives controlled by coaches. Hence they are forced to shift to "majoring in eligibility", enrolling in cupcake majors (sports management, communications, general studies). The attrition rates are tragic, with 6-year graduate rates: less than 50% for football; 40% for basketball. Even those who graduate frequently have meaningless degrees (e.g., recreational sports, golf-course management).

## What to do? The Traditional Approach

It doesn't take a rocket scientist (although that happens to be my background) to see what has to be done to re-establish the primacy of educational over commercial values in college sports:

Freshman Ineligibility: All freshmen in all sports should be ineligible for varsity competition. The first year should be a time for students to adjust intellectually and emotionally to the hectic pace of college life.

Financial Aid: Eliminate the "athletic scholarship" or "grant-in-aid" and replace it with need-based financial aid. Note this would not only substantially reduce the costs of college sports, but it would also eliminate the legal risks of continuing what has become, in effect, a "pay for play" system.

Mainstream Coaches: Throttle back the salaries of coaches, athletic directors, and other athletic department staff to levels comparable to faculty and other university staff. Subject coaches to the same conflict of interest policies that govern other faculty and staff (e.g., eliminating shoe contracts, prohibiting the use of the university's name and reputation for personal gain, etc.)

Mainstream the Administration of Intercollegiate Athletics: Intercollegiate athletics is a student extracurricular activity and, as such, should report to the vice president for student affairs. Academic matters such as student eligibility, counseling, and academic support should be the responsibility of the university's chief


The disparity between expenditures per student on athletics (upper curve) and academics (lower curves) continues to diverge, particularly in the leading confences and institutions.

academic officer (e.g., the provost). Financial matters should be under the control of the university's chief financial officer. Medical issues should be under the control of staff from the university medical center or student health service.

Financial Support: We should adopt the principle that if intercollegiate athletics are of value to students, they should be subsidized by the General and Education budget of the university. To this end, we might consider putting athletics department salary lines (coaches and staff) on the academic budget and under the control of the provost. We could then use a counter flow of athletic department revenue into the General and Education budget to minimize the net subsidy of college sports.

Faculty control: We need to restructure faculty athletics boards so that that they are no longer under control of athletic directors but instead represent true faculty participation. It is important to keep "jock" faculty off these boards and to give priority to those faculty with significant experience in undergraduate education. It is also important for faculty boards to understand and accept their responsibilities for seeing that academic priorities dominate competitive and commercial goals, while student welfare and institutional integrity are priorities.

Rigorous Independent Audits and Compliance Functions: Here we need a system for independent auditing of not simply compliance with NCAA and conference rules, but as well financial matters, student academic standing, progress toward degrees, and medical matters.

Limits on Schedules and Student Participation: We should confine all competitive schedules to a single academic term (e.g., football in fall, basketball, hockey in winter, etc.). Competitive schedules should be shortened to more reasonable levels (e.g., football back to 10 games, basketball to 20 games, etc.). We need to constrain competitive and travel schedules to be compatible with academic demands (e.g., no weekday competition). Student participation in mandatory, non-competitive athletics activities during off-season should be severely limited (including eliminating spring football practice, summer conditioning requirements, etc.).

Throttle Back Commercialization: It is time to forget about the possibility of Division 1-A football playoffs and drastically reduce the number of post-season bowls. Perhaps we should return the NCAA Basketball Tournament to a two-week, conference champion only event. Furthermore, we need to stop this nonsense of negotiating every broadcasting contract as if dollars were the only objective and chase the sports press out of the locker rooms and lives of our students.

Of course, the first arguments launched against such reform proposals always have to do with money. College football and basketball are portrayed as the geese that lay the golden eggs for higher education. However I believe these arguments, long accepted but rarely

2014 NCAAF COACHES SALARIES

| RK | SCHOOL | CONF | HEAD COACH | SCHOOL PAY | OTHER PAY | TOTAL PAY ▼ | MAX BONUS |
|---|---|---|---|---|---|---|---|
| 1 | Alabama | SEC | Nick Saban | $6,950,203 | $209,984 | $7,160,187 | $700,000 |
| 2 | Michigan State | Big Ten | Mark Dantonio | $5,611,845 | $24,300 | $5,636,145 | $650,000 |
| 3 | Oklahoma | Big 12 | Bob Stoops | $5,058,333 | $0 | $5,058,333 | $819,500 |
| 4 | Texas A&M | SEC | Kevin Sumlin | $5,000,000 | $6,000 | $5,006,000 | $750,000 |
| 5 | Texas | Big 12 | Charlie Strong | $5,000,000 | $270 | $5,000,270 | $1,000,000 |
| 6 | Ohio State | Big Ten | Urban Meyer | $4,486,640 | $50,000 | $4,536,640 | $550,000 |
| 7 | LSU | SEC | Les Miles | $4,300,000 | $69,582 | $4,369,582 | $700,000 |
| 8 | Penn State | Big Ten | James Franklin | $4,300,000 | – | $4,300,000 | $1,000,000 |
| 9 | Iowa | Big Ten | Kirk Ferentz | $4,075,000 | $0 | $4,075,000 | $1,750,000 |
| 10 | South Carolina | SEC | Steve Spurrier | $4,000,000 | $16,900 | $4,016,900 | $1,700,000 |
| 11 | Texas Christian | Big 12 | Gary Patterson | $4,008,150 | – | $4,008,150 | – |
| 12 | Auburn | SEC | Gus Malzahn | $3,850,000 | $4,500 | $3,854,500 | $1,400,000 |
| 13 | Washington | PAC-12 | Chris Petersen | $3,681,720 | $0 | $3,681,720 | $1,175,000 |
| 14 | Florida State | ACC | Jimbo Fisher | $3,591,667 | $0 | $3,591,667 | $1,275,000 |
| 15 | Oklahoma State | Big 12 | Mike Gundy | $3,500,000 | – | $3,500,000 | $550,000 |
| 16 | Missouri | SEC | Gary Pinkel | $3,400,000 | $0 | $3,400,000 | $1,825,000 |
| 17 | Georgia | SEC | Mark Richt | $3,200,000 | $114,000 | $3,314,000 | $1,000,000 |
| 18 | Arizona | PAC-12 | Rich Rodriguez | $2,898,500 | $400,000 | $3,298,500 | $2,125,000 |
| 19 | UCLA | PAC-12 | Jim Mora | $3,250,000 | $0 | $3,250,000 | $930,000 |
| 20 | Arkansas | SEC | Bret Bielema | $3,200,000 | $14,000 | $3,214,000 | $700,000 |

2014 compensation of leading football coaches

2013 NCAA ATHLETIC DIRECTORS SALARIES

| RK | SCHOOL | CONF | ATHLETICS DIRECTORS | SCHOOL PAY | OTHER PAY | TOTAL PAY ▼ | MAX BONUS |
|---|---|---|---|---|---|---|---|
| 1 | Vanderbilt | SEC | David Williams | $3,239,678 | $0 | $3,239,678 | $0 |
| 2 | Louisville | Big East | Tom Jurich | $1,401,915 | $10,000 | $1,411,915 | $344,000 |
| 3 | Florida | SEC | Jeremy Foley | $1,233,250 | $0 | $1,233,250 | $50,000 |
| 4 | Wisconsin | Big Ten | Barry Alvarez | $1,143,500 | $86,500 | $1,230,000 | $0 |
| 5 | Nebraska | Big Ten | Shawn Eichorst | $1,123,000 | $0 | $1,123,000 | $0 |
| 6 | Texas | Big 12 | DeLoss Dodds | $1,107,391 | $1,650 | $1,109,041 | $125,000 |
| 7 | Ohio State | Big Ten | Gene Smith | $1,099,030 | $0 | $1,099,030 | $250,000 |
| 8 | Notre Dame | Big East | Jack Swarbrick | $1,026,942 | $0 | $1,026,942 | $0 |
| 9 | Oklahoma | Big 12 | Joe Castiglione | $1,000,000 | $0 | $1,000,000 | $760,000 |
| 10 | Duke | ACC | Kevin White | $906,536 | $0 | $906,536 | $0 |
| 11 | Arkansas | SEC | Jeff Long | $900,000 | $3,900 | $903,900 | $650,000 |
| 12 | Michigan | Big Ten | Dave Brandon | $900,000 | $0 | $900,000 | $200,000 |
| 13 | Iowa State | Big 12 | Jamie Pollard | $900,000 | $0 | $900,000 | $0 |
| 14 | Tennessee | SEC | Dave Hart Jr. | $817,250 | $0 | $817,250 | $0 |
| 15 | Texas A&M | SEC | Eric Hyman | $800,000 | $0 | $800,000 | $200,000 |
| 16 | LSU | SEC | Joe Alleva | $725,000 | $0 | $725,000 | $100,000 |
| 17 | Clemson | ACC | Dan Radakovich | $725,000 | $0 | $725,000 | $50,000 |
| 18 | UCLA | PAC-12 | Dan Guerrero | $715,211 | $0 | $715,211 | $75,000 |
| 19 | Michigan State | Big Ten | Mark Hollis | $700,000 | $0 | $700,000 | $50,000 |
| 20 | Texas Christian | Mt. West | Chris Del Conte | $695,769 | $0 | $695,769 | $0 |

2014 compensation of leading athletic directors challenged, are flawed. Essentially all intercollegiate athletic programs are subsidized, to some degree, by the academic programs of the university (when all costs are included, such as amortization of facilities and administrative overhead.) Furthermore, in the scheme of things, the budgets of these programs are quite modest relative to other institutional activities (e.g., at Michigan, the $150 M/y budget of our athletic department is only about 2% of our total budget, and, more to the point, less than the amount of state support we have lost over the past three years!).

The current culture of college sports is driven by the belief that the team that spends the most wins the most. Not surprisingly, therefore, the more revenue athletic programs generate, the more they spend. Since most of the expenditures are in areas such as grants-in-aid, coaches and staff salaries, promotional activities, and facilities, many of the proposals in the previous section would dramatically reduce these costs. For example, replacing the current system of grants-in-aid by need-based financial aid would reduce these costs by at least a factor of two. Throttling back the extravagant level of celebrity coaches salaries (and applying conflict of interest to eliminate excessive external income and perks) would do likewise. Demanding university control of all auxiliary activities such as broadcasting and licensing so that revenue flows to the institution and not to the coaches would also help. And reducing the expenditures required to mount big-time commercial entertainment events would also reduce costs, thereby compensating for lost broadcasting revenue.

## Treating Athletics Like the Rest of the University

More generally, the first step in reconnecting college sports to the academic enterprise is to stop treating our athletic departments, coaches, and student-athletes as special members of the university community, subject to different rules and procedures, policies and practices than the rest of university. The key to reform is to mainstream our athletics programs and their participants back into the university in three key areas: financial management, personnel policies, and educational practices.

Financial management: Athletics departments should be subject to the same financial controls, poli-


What? Me worry?...About big-time college sports?

cies, and procedures as other university units. Their financial operations should report directly to the chief financial officer of the university and be subject to rigorous internal and external audit requirements and full public disclosure as an independent (rather than consolidated) financial unit. All external financial arrangements, including those with athletic organizations (e.g., conferences and the NCAA), commercial concerns (e.g., licensing, broadcasting, endorsements), and foundation/booster organizations should be under the strict control of the university's chief financial official and subject to rigorous external audits and public disclosure. (And clearly programs that push the bounds both of propriety and perhaps even legality such as the "seat tax" should be prohibited.) In that regard, I would even suggest that we take the Sarbanes-Oxley approach, designed to eliminate abuses in the financial operations of publicly-held corporations, by requiring the Athletic Director, President, and chair of the Governing Board to sign annual financial statements and hold them legally accountable should these later be found to be fraudulent.

Possible Cost Reductions: There are many opportunities for signifcant cost reductions. For example, replacing the current system of grants-in-aid by need-based financial aid would reduce these costs by at least a factor of two. Throttling back the extravagant level of celebrity coaches salaries (and applying conflict of interest to eliminate excessive external income and perks) would do likewise. Demanding university control of all auxiliary activities such as broadcasting and licensing so that revenue flows to the institution and not to the coaches would also help. And reducing the expenditures required to mount big-time commercial entertainment events would also reduce costs, thereby compensating for lost broadcasting revenue.

Key philosophy: Treat college sports like academic programs! The first step in reconnecting college sports to the academic enterprise is to stop treating our athletic departments, coaches, and student-athletes as special members of the university community, subject to different rules and procedures, policies and practices than the rest of university.

The key to reform is to mainstream our athletics programs and their participants back into the university in three key areas: financial management, personnel policies, and educational practices. Athletics programs should not allowed to interfere with or undermine academic policies and principles. For example, the admission of student athletes, their academic standing, and their eligibility for athletic competition must be controlled by the faculty. There should be a ban on special academic support activities for student athletes that further isolate them from the rest of the student body and the university, such as academic support centers or special counseling services under the control of the athletics department. Universities must insist that competitive schedules are compatible with the academic calendar, even if this has significant revenue implications.

Personnel: All athletics department staff (including coaches) should be subject to the same conflict-of-interest policies that apply to other university staff and faculty. For example, coaches should no longer be allowed to exploit the reputation of the university for personal gain through endorsements or special arrangements with commercial vendors (e.g., sports apparel companies, broadcasting, automobile dealers). Employment agreements for coaches should conform to those characterizing other staff and should be subject to review by university financial and personnel units. All personnel searches, including those for coaches, should comply fully with the policies and practices characterizing other staff (e.g., equal opportunity)

Academics: Athletics programs should not allowed to interfere with or undermine academic policies and principles. For example, the admission of student athletes, their academic standing, and their eligibility for athletic competition must be controlled by the faculty. There should be a ban special academic support activities for student athletes that further isolate them from the rest of the student body and the university, such as academic support centers or special counseling services under the control of the athletics department. Universities must insist that competitive schedules are compatible with the academic calendar, even if this has significant revenue implications.

## Who Should Take the Lead in Reform

Several years ago, I received an invitation from William Friday, former president of the University of North Carolina, to testify before the Knight Commission on Intercollegiate Athletics. My book on college sports had just appeared, and they were interested in my views on this complex subject. After stating my concerns, much as I have earlier in this chapter, I went on to suggest a possible approach to reform that began with the premier academic organization, the Association of American Universities (AAU). If these institutions were to adopt a series of reforms–a disarmament treaty, if you will– for their members, much of the rest of the higher education enterprise would soon follow. It is my belief that such an effort by the AAU would propagate rather rapidly throughout other organizations such as the National Association of State Universities and Land Grant Colleges and even the American Council on Education.

I concluded my testimony by stressing the point that as higher education entered an era of great challenge and change, it was essential that we re-examine each and every one of our activities for their relevance and compatibility with our fundamental academic missions of teaching, learning, and serving society. From this perspective, it was my belief there was little justification for the American university to mount and sustain big-time football and basketball programs at their current commercial and professional level simply to satisfy the public desire for entertainment and pursue the commercial goals of the marketplace. The damage to our academic values and integrity was simply too great. If we were to retain intercollegiate athletics as an appropriate university activity, it was essential to decouple our programs from the entertainment industry and reconnect them with the educational mission of our institutions.

After I had finished my remarks, the co-chair of the commission, Father Theodore Hesburg, former president of Notre Dame, was first to respond. He thanked me (after offering a prayer: "May God have mercy on your soul!") for not only reinforcing many of the Commission concerns, but, in effect, providing a first draft of the Commission's report! Of course, others on the Commission challenged some of my more outspoken conclusions and recommendations. But in the end, my conclusions seemed to stand, as evidenced by the strong statement in the final report of the Commission:

> "After digesting the extensive testimony offered over some six months, the Commission is forced to reiterate its earlier conclusion that at their worst, big-time college athletics appear to have lost their bearings. Athletics continue to threaten to overwhelm the universities in whose name they were established. Indeed, we must report that the threat has grown rather than diminished. Higher education must draw together all of its strengths and assets to reassert the primary of the educational mission of the academy. The message that all parts of the higher education community must proclaim is emphatic: Together, we created today's disgraceful environment. Only by acting together can we clean it up."
>
> A Call to Action: Reconnecting College Sports and Higher Education
>
> The Knight Commission on Intercollegiate Athletics June, 2001

Yet, in retrospect, I now believe that while both my testimony and the Knight Commission report urgently portrayed the threat to American higher education posed by the ever-increasing commercialization and corruption of big-time college sports, neither proposed an effective method to deal with the problem. Put simply, in both cases we bet on the wrong horse. We proposed that the university presidents take the lead in the reform of college sports, whether through academic organizations such as the AAU and ACE (my proposal) or the NCAA (the Knight Commission). And nothing has happened.

Clearly working through athletic organizations such as the NCAA, the conferences, or the athletic departments is futile since these are led or influenced by those who have the most to gain from the further commercialization of college sports. It is my belief that we will never achieve true reform or control through these organizations, since the foxes are in firm control of the hen house. After all, the primary purpose of the NCAA is to maintain and promote the commercial value of college sports, not to protect the welfare of student-athletes or higher education.

In fact, a major reason why the various efforts to reform college sports over the past several decades have failed is that we continue to bet on the wrong horse. We continue propose that the university presidents take the lead in the reform of college sports, whether through academic organizations such as the AAU and ACE (my proposal) or the NCAA (the Knight Commission). And very little happens, and the mad rush toward more and more commercialism and corruption continues.

Perhaps this is not so surprising. After all, university presidents are usually trapped between a rock and a hard place: between a public demanding high quality entertainment from the commercial college sports industry they are paying for, and governing boards who have the capacity (and all too frequently the inclination) to fire presidents who rock the university boat too strenuously. It should be clear that few contemporary university presidents have the capacity, the will, or the appetite to lead a true reform movement in college sports.

Well, what about the faculty? Of course, in the end, it is the governing faculty that is responsible for its academic integrity of a university. Faculty members have been given the ultimate protection, tenure, to enable them to confront the forces of darkness that would savage academic values. The serious nature of the threats posed to the university and its educational values by the commercialization and corruption of big-time college sports has been firmly established in recent years. It is now time to challenge the faculties of our universities, through their elected bodies such as faculty senates, to step up to their responsibility to defend the academic integrity of their institutions, by demanding substantive reform of intercollegiate athletics.

To their credit, several faculty groups have responded well to this challenge and stepped forward to propose a set of principles for the athletic programs conducted by their institutions. Beginning first in the Pac Ten Conference universities, then propagating to the Big Ten and Atlantic Coast Conferences, and most recently considered and adopted by the American Association of University Professors, such principles provide a firm foundation for true reform in college sports.

Yet as the influence of the faculty have been pushed out of intercollegiate athletics by eliminating oversight boards, as athletic departments have taken over control of academic counseling (and at some institutions, even admission and academic standing), and as even faculty participation as spectators has eroded due to premium pricing of tickets, little wonder that most faculty members treat the Athletics Department with benign neglect (at least until its missteps severely damage the integrity of their institution.

What about trustees? The next obvious step in this process is for the faculties to challenge the trustees of our universities, who in the end must be held accountable for the integrity of their institutions. To be sure, there will always be some trustees who are more beholding to the football coach than to academic values. But most university trustees are dedicated volunteers with deep commitments to their institutions and to the educational mission of the university. Furthermore, while some governing boards may inhibit the efforts of university presidents willing to challenge the sports establishment, few governing boards can withstand a concerted effort by their faculty to hold them accountable for the integrity of their institution. In this spirit, several faculty groups have already begun this phase of the process by launching a dialogue with university trustees through the Association of Governing Boards.

Ironically, it could well be that the long American tradition of shared university governance, involving public oversight and trusteeship by governing boards of lay citizens, elected faculty governance, and experienced but generally short-term and usually amateur administrative leadership, will pose the ultimate challenge to big time college sports.

After all, even if university presidents are reluctant to challenge the status quo, the faculty has been provided with the both the responsibility and the status (e.g., tenure) to protect the academic values of the university and the integrity of its education programs. Furthermore, as trustees understand and accept their stewardship for welfare of their institutions, they will recognize that their clear financial, legal, and public accountability compels them to listen and respond to the challenge of academic integrity from their faculties.

What about a rising tide of public frustration? To be sure, many of those in charge of college athletics are unable (or unwilling) to understand the minefields that lie in the path of their plans. For example, the Big Ten leadership (conference commissioner and presidents) has largely destroyed the conference, adding new institutions using selection criteria such as television market rather than historical comparisons such as Midwest location or the similarity of academic and athletic programs. As fans begin to realize that long-standing rivalries (e.g., Michigan vs. Wisconsin) will largely disappear to satisfy the Big Ten Network, they could well abandon any loyalty to either teams or institutions. Of course, they could be replaced by new fans with interests more akin to professional sports such as automobile racing or boxing. After all, sports remain the "opiate of the masses".

## Possible "Planet Killers" for College Sports

In summary, who will protect the interests of the student athletes?

Not the coaches or ADs or NCAA. They clearly have conflicts of interests.

What about faculty? They have been pushed to the side.

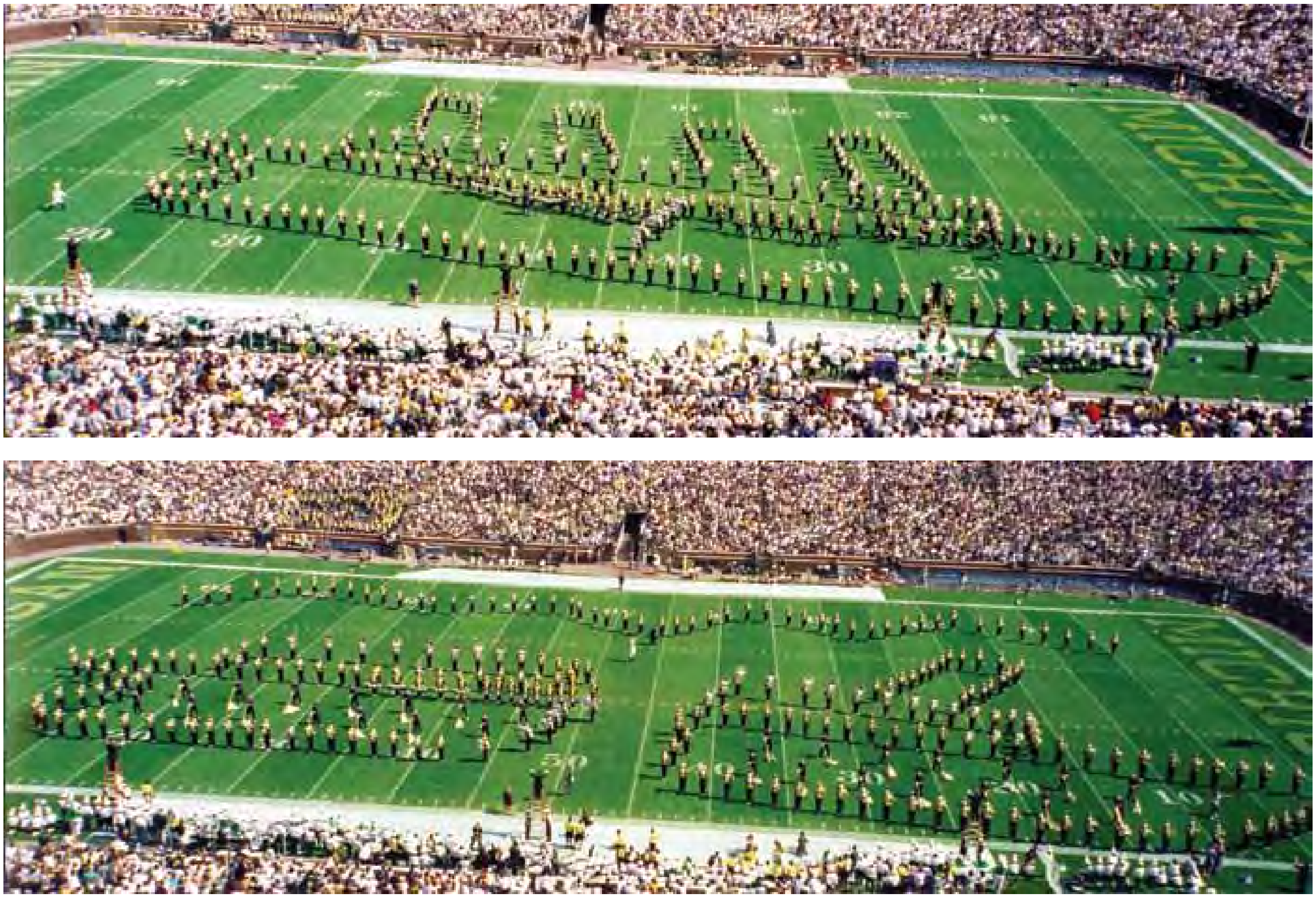
What about university leaders like presidents or trustees? They clearly have abdicated all responsibility!!!

What about the government? They got us into this trouble!!!

What about…lawyers? Perhaps that is the only protection left!!!

However there are still several possibilities on the horizon that could become "planet killers" for college sports as we know them today:

The federal government could finally step up to its responsibility to treat big-time athletics like other business enterprises, subjecting it to more reasonable treatment with respect to tax policy, employee treatment (meaning student-athletes), monopoly and cartel re-



The Michigan Marching Band has a good sense of where big-time college sports are headed!!!

strictions, and possibly even salary constraints.

The O'Bannon case has demonstrated that litigation may become a formidable force for changing college sports as we know it today. There are early signs that student-athletes may be given rights that protect them against exploitation by coaches and athletic departments, and others for personal gain.

But the most serious threat on the horizon is the increasing evidence of the damage that intensifying violent sports such as football, basketball, and hockey to professional levels do the health of young athletes. In recent years, there is growing medical evidence about the long-term impact of concussions and other trauma on longer-term illness such as dementia and Alzheimer's. These concerns are broadening out to explore the epidemiology of longer health impact including life expectancy (now found to be as low as 57 for NFL players). Although most attention has been focused on the health implications of competition at the high school and professional level, it is only a matter of time before college sports falls under the microscope. Beyond the concerns about the impact of violent sports on the health of student athletes, these studies are likely to open up a Pandora's Box of litigation on issues such as institutional liability and requirements for the support of long-term health care that could financially cripple many institutions that insist on continuing to compete at the current level of intensity. In fact, the threat of litigation as class action suits could even eliminate violent sports such as football and hockey as we know them today at all but the professional levels.

## A Final Observation

Today I stand among a growing number of university leaders who believe that today higher education has entered an era of great challenge and change. Powerful social, economic, and technological forces are likely to change the university in very profound ways in the decades ahead. As our institutions enter this period of transformation, it is essential that we re-examine each and every one of our activities for their relevance and compatibility with our fundamental academic missions of teaching, learning, and serving society.

If we were to retain intercollegiate athletics as appropriate university activities, it was essential we insist upon the primacy of academic over commercial values by decoupling our athletic programs from the entertainment industry and reconnecting them with the educational mission of our institutions.

From this perspective, it is my belief there is little justification for the American university to mount and sustain big-time football and basketball programs at their current commercial and professional level simply to satisfy the public desire for entertainment and pursue the commercial goals of the marketplace. The damage to our academic values and integrity was simply too great.

The American university is simply too important to the future of this nation to be threatened by the ever increasing commercialization, professionalization, and corruption of college sports.

I recall a quote from Thomas Paine's Common Sense (February 14, 1776) that applies to this issue:

"Perhaps the sentiments contained in these pages are not yet sufficiently fashionable to procure them general favour; a long habit of not thinking a thing wrong, gives it a superficial appearance of being right, and raises at first a formidable outcry in defense of custom. But the tumult soon subsides. Time makes more converts than reason."

## References

Duderstadt, James J., I*ntercollegiate Athletics and the American University:A University President's Perspective* (Ann Arbor, MI: University of Michigan Press, 2000) 280 pp

Duderstadt, James J., T*he View from the Helm: Leading the American University during an Era of Change* (Ann Arbor, MI: University of Michigan Press, 2006) 400 pp.

# Chapter 18

# Economic Development Roadmaps

Our world has entered a period of rapid and profound economic, social, and political transformation driven by knowledge and innovation. Educated people, the knowledge they produce, and the innovation and entrepreneurial skills they possess have become the keys to economic prosperity, public health, national security, and social well-being. It has become increasingly apparent that economic strength, prosperity, and social welfare in a global knowledge economy will demand a highly educated citizenry. It will also require institutions with the ability to discover new knowledge, develop innovative applications of these discoveries, and transfer them into the marketplace through entrepreneurial activities.

This world of an economy driven by education, knowledge, and innovation may be relatively new. But many areas of the United States are already behind. The purpose of this studies was to seek ways to close that gap and restore regions, states, and metropolitan areas to economic success in the brave new world of a hyper competitive knowledge-drive global economic. To provide our citizens with the knowledge and skills to compete on the global level, we must broaden access to world-class educational opportunities at all levels: K-12, higher education, workplace training, and lifelong learning. We must also build and sustain world-class universities capable of conducting cutting-edge research and innovation and producing outstanding scientists, engineers, physicians, teachers, and other knowledge professionals essential to creating the new jobs of the twenty-first century. We must build the advanced learning and innovation infrastructure necessary to sustain economic leadership in the century ahead.

Yet the traditional institutions responsible for education and innovation—schools, colleges, universities, research institutes, business, and industry—are being challenged by the powerful forces characterizing the global economy: hypercompetitive global markets, demographic change, increasing ethnic and cultural diversity, and disruptive technologies, such as information technology. Hence new strategies and investments are necessary to build the learning and innovation enterprises necessary for prosperity in a global economy. From California to North Carolina, Helsinki to Bangalore, other states, regions, and nations are shifting their public policies and investments to support the new imperatives of a knowledge economy: knowledge creation (e.g., R&D, innovation, and entrepreneurial activities), human capital (e.g., lifelong learning and advanced education, particularly in science and engineering), and infrastructure (e.g., colleges and universities, research laboratories, and broadband networks).

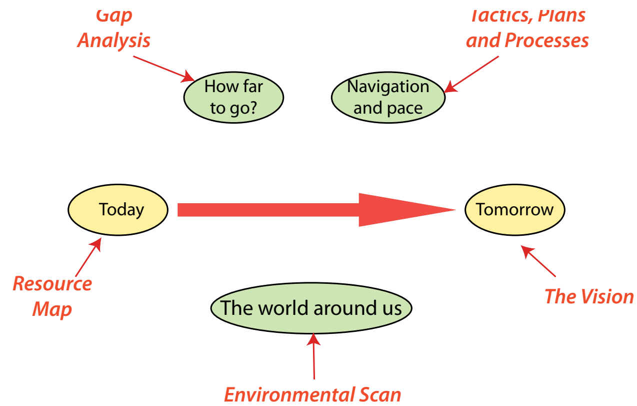
There is a second important theme that characterizes the emerging knowledge economy: the increasing connectivity enabled by modern communications and transportation technologies is rapidly shifting the locus of economic and political power away from conventional geopolitical areas. As Thomas Friedman puts it, "The world is flat! Globalization has collapsed time and distance and raised the notion that someone anywhere on earth can do your job, more cheaply. Can we rise to the challenge on this leveled playing field?" (Friedman, 2005)

## Strategic Roadmapping

So, what to do? That is the goal of this series of studies: to develop a plan for building a learning and knowledge infrastructure for a region–a state, a region such as the Great Lakes states, or a metropolitan area. The plan needs to address the life-long educational needs of its citizens and the workforce skills necessary to compete and flourish in a global, knowledge-intensive economy. In addition, it needs to address how to build the sources of new knowledge, innovation, and entrepreneurial spirit necessary to create world-class companies and a world-class living environment.

Since advanced education and research provide the key human and knowledge resources critical to prosperity in the global economy, colleges and universities will play a central role in this effort. Yet, such studies differs from earlier education planning efforts, such as the "master plan" for higher education developed by California in the early 1960s. Today any such effort must consider the educational needs of the region from a broader perspective embracing pre-college, lifelong learning, and workplace-training activities—that is, education from "cradle to grave." The role of higher education in generating knowledge, enabling innovation, and stimulating entrepreneurial activities must similarly be examined not only from the perspective of both private enterprise and public policy but also within a context that extends beyond the region to encompass national and global concerns.

There are many approaches to such a study. Most common are strategic planning exercises, which progress through the usual sequence of proposing a mission and vision, then assessing available assets and challenges through an environmental assessment, stating goals, proposing strategic actions and a process of tactical implementation, and finally performing assessment and evaluation. In this study we have adopted a common technique used in industry and the federal government: *strategic roadmapping* (Garcia, 1997). In roadmapping exercises, one uses expert panels to assess needs, then constructs a map of existing resources, performs an analysis to determine the gap between what currently exists and what is needed, and finally develops a plan or roadmap of possible routes from here to there, from now to the future. Although sometimes confused with jargon such as environmental scans, resource maps, and gap analysis, in reality the roadmapping process is quite simple. It begins by asking where we are today and where we wish to be tomorrow, then assesses how far we have to go, and concludes by developing a roadmap to get from here to there. The roadmap itself usually consists of a series of recommendations, sometimes



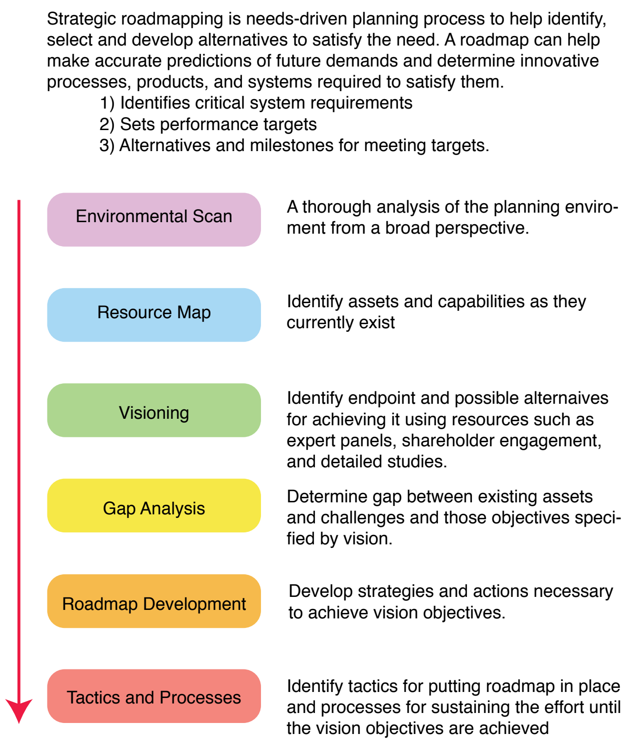

The strategic roadmap

divided into those that can be accomplished in the near term and those that will require a sustained effort.

To provide context, one usually begins with an environmental scan of the imperatives of the global knowledge economy, where robust telecommunications connectivity has empowered billions of new knowledge workers to compete for jobs and prosperity, regardless of location or nationality, provided they have developed the skills and infrastructure. Actually, we have already provided just such an exercise in the second chapter of this book that identifies most of the key issues one must face in achieving economic prosperity.

Next, one uses this scan to identify the knowledge assets and liabilities of a region and assess why it may be having difficulty in making the transition to a knowledge economy. With this analysis in mind, we suggest a vision to better position the region for economy prosperity and leadership in the 21st Century global economy, e.g., a workforce characterized by world-class skills, innovation, and entrepreneurial zeal; and a knowledge infrastructure capable of generating new knowledge and economic opportunities through a strategic utilization of the very technology that is reshaping our world. Put another way, we suggest those skills, educational opportunities, and research and innovation assets needed by the region.

Next, by comparing this vision with the current reality, we can determine how far the region must travel to reach a prosperous future. We can also identify the resource gap that exists between what we have now and what we will need for the future, between the obsolete institutions, policies and programs of today and the globally competitive resources the region must build




The strategic roadmap process

for tomorrow.

We then develop a strategic roadmap, a set of goals and strategies designed to move the region toward this future. Since building a 21st century learning and innovation infrastructure for a region will clearly involve multiple players–institutions, states, and the nation more broadly–this roadmap is developed in a layered fashion, setting out the goals and strategies for each of the key players and patrons.

We then turn to a consideration of the tactics, plans, and processes necessary to achieve the objectives set by the roadmap studies. Here we adopt both the approach of pulling the various roadmaps (national, regional, state, and institutional) into a "master plan" (similar to that taken by the California Master Plan) and suggest a process of continued engagement, action, and refinement to build and sustain momentum (similar to the Bologna Process designed to integrate higher-education strategies for the European Union).

Finally, we take a longer-term perspective by considering bolder visions that exploit truly over-the-horizon opportunities and visions. To this end, we conclude this roadmapping exercise with a series of bolder proposals that would act as game changers to challenge and change the entire learning and innovation infrastructure of the region. Included in this consideration are new types of institutions and practices that depart quite radically from the status quo to create a culture of learning and innovation in the heartland of America.

## A Strategic Roadmap for the State of Michigan

Throughout the 20th century both America and Michigan have been leaders in the world economy. The democratic values and free-market practices of the United States, coupled with institutional structures such as stable capital markets, strong intellectual property protection, flexible labor laws, and open trade policies, positioned our nation well for both economic prosperity and security. With a highly diverse population, continually renewed and re-energized by wave after wave of immigrants, Michigan became the source of the technology and innovation that shaped the 20th-century global economy.

Michigan's history as a frontier state gave it a priceless legacy of pioneering spirit, gritty courage, and self-reliance. Vast natural resources provided the opportunities for prosperous agriculture, lumbering, and mining industries. Our ancestors made our farms and our factories the best in the world. From the beginning Michigan believed in its people and invested heavily in their education and training, embracing the spirit of the Northwest Ordinance, which stated: "Religion, morality, and knowledge being necessary to good government and the happiness of mankind, schools and the means of education shall forever be encouraged."

There was broad recognition that Michigan's most valuable resources were its people. Hence investment in the knowledge, skills, and abilities of its people was seen as key to Michigan's competitive edge in achieving global leadership in innovation, productivity, and trade. Michigan built a great education system of schools, colleges, and universities aimed at serving all of its citizens. It created and supported a social and civil infrastructure that was the envy of the nation. Michigan companies invested heavily in R&D and technological innovation, working closely with the state's universities. The leaders of our state understood well the importance of investing heavily with both public tax dol-

The impact of the global economy on Michigan

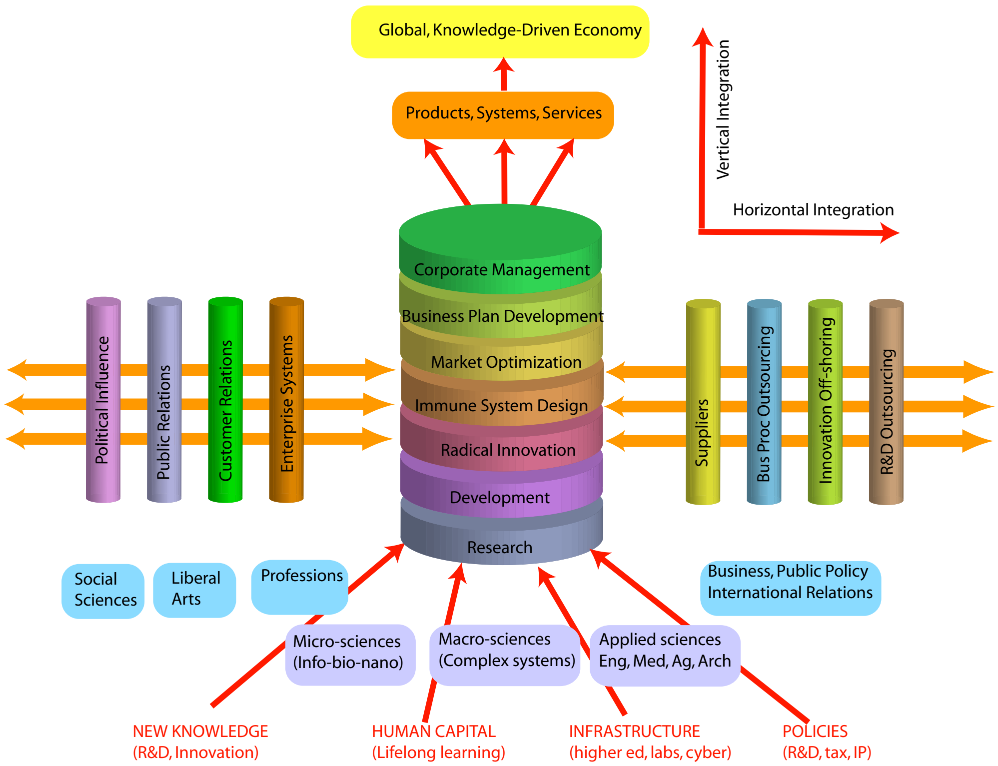
Michigan is still dependent on a factory economy.

lars and private capital in those areas key to prosperity in an industrial economy. State leaders demonstrated a remarkable capacity to look to the future and a willingness to take the actions and make the investments that would yield prosperity and well-being for future generations. And the payoff was enormous, as Michigan led the world in productivity and prosperity. It rapidly became the engine driving the nation's economy. During the last century, it was Michigan that first put the world on wheels and then became the arsenal of democracy to defend freedom during two world wars.

But that was yesterday. What about Michigan today? Ironically, as never before, the prosperity and social well-being of our state today is determined by the skills, knowledge, and talents of our people. In the global, knowledge-driven economy, educated human capital the key. Yet here, the vital signs characterizing Michigan today are disturbing indeed. The spirit of public and private investment for the future appears to have vanished in our state. In recent decades, failed public policies and inadequate investment have threatened the extraordinary educational resources built through the vision and sacrifices of past generations. Michigan business and industry have reduced very significantly their level of basic and applied research and now focus their efforts primarily on product development based on available technologies rather than exploring innovative breakthroughs. Ironically, at a time when the rest of the world has recognized that investing in education and knowledge creation is the key to not only prosperity but, indeed, to survival, too many of Michigan's citizens and leaders, in both the public and private sector, have come to view such investments as a low priority, expendable during hard times. The aging baby boomer population that now dominates public policy in our state demands instead generous retirement benefits, expensive health care, ever more prisons, and reduced tax burdens, rather than demanding that Michigan begin investing once again in education, innovation, and the future.

This neglect of adequate investment in human capital and knowledge infrastructure could not have happened at a worse time. As we enter a new century, Michigan's old industrial economy is dying, slowly but surely, putting at risk the welfare of millions of citizens in our state in the face of withering competition from an emerging global knowledge economy. For many years now we have seen our low-skill, high-pay factory jobs increasingly downsized, outsourced, and offshored, only to be replaced by low-skill, low-pay service jobs– or in too many cases, no jobs at all and instead the unemployment lines. Michigan's inability to adapt to a rapidly changing world is reflected by the fact that today our state ranks 50th in the nation in almost every economic indicator–employment, job creation, growth in personal income, economic momentum, and return of federal tax dollars.

Preoccupied with obsolete and irrelevant political battles, addicted to entitlements, manipulated by lobbyists and special interest groups, and assuming what worked before will work again, Michigan today is sailing blindly into a profoundly different future. Today's

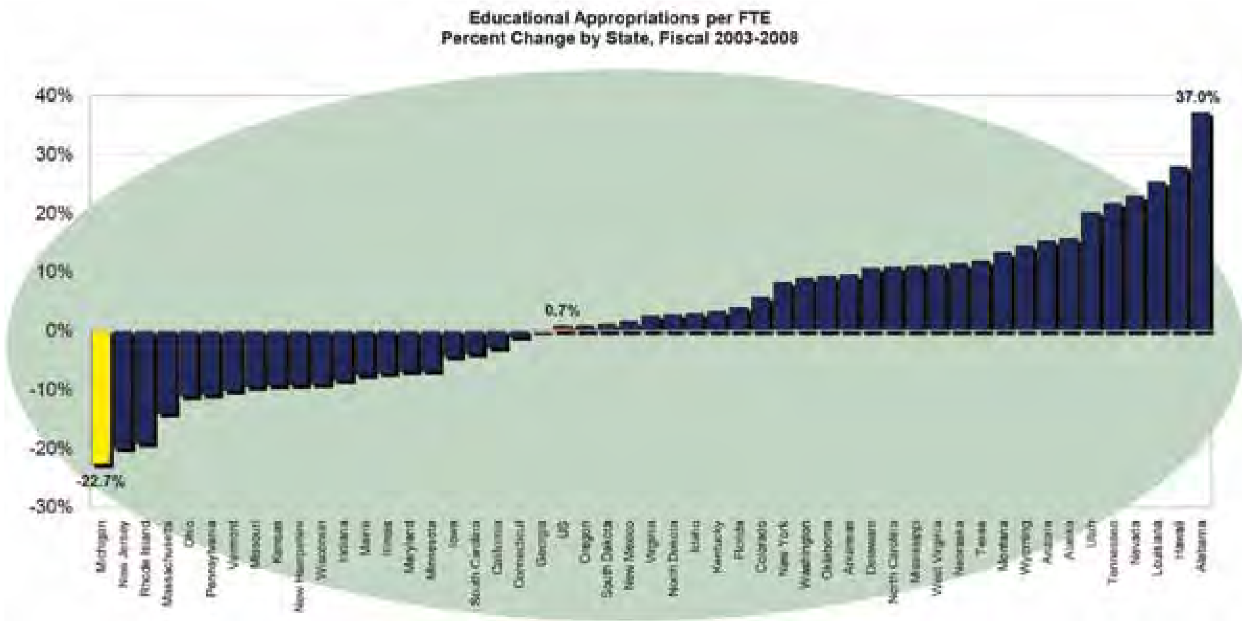



The knowledge economy of the 21st century

policies embraced by state leaders are increasingly incompatible with the realities of the emerging global economy. Our current tax system is not only regressive and inequitable, but it is both structurally and strategically misaligned with the character of Michigan's increasingly knowledge-driven economy, unable to generate the revenues to sustain the necessary investments in our knowledge, social, and civic infrastructure. The legacy costs of obsolete and excessively burdensome retirement and health care benefits threaten to bankrupt both government and industry. Obsolete sentencing policies have burdened us with incarceration rates and prison costs that lead the nation. Our investment in key knowledge resources such as higher education has dropped to last in the nation. We have allowed external groups to persuade voters to cripple Michigan's efforts to secure equal opportunity and social inclusion for an increasingly diverse population. And special interest groups continue to block legislative efforts to bring Michigan in line with other states and nations on critical public health measures such as smoking and environmental protection.

Thus far our state has been in denial, assuming our low-skill workforce would remain competitive and our factory-based manufacturing economy would eventually be prosperous once again. Yet that 20th-century economy will not return. Michigan is at great risk, since by the time we come to realize the permanence of this economic transformation, the out-sourcing/off-shoring train may have left town, taking with it both our low-skill manufacturing jobs and many of our higher-paying service jobs.

Michigan is certainly not alone in facing this new economic reality. Yet as we look about, we see other states, not to mention other nations, investing heavily and restructuring their economies to create high-skill, high-pay jobs in knowledge-intensive areas such as new technologies, financial services, trade, and professional and technical services. From California to North Carolina, Bangalore to Shanghai, there is a growing recognition throughout the world that economic prosperity and social well-being in a global knowledge-driven economy require public and private investment in knowledge resources. That is, regions must create and sustain a highly educated and innovative workforce, supported through policies and investments in cutting-edge technology, a knowledge infrastructure, and human capital development.




Michigan's Achilles heel: failure to invest in education

However, history has also shown that significant investment is necessary to produce the essential ingredients for innovation to flourish: new knowledge (research), human capital (education), infrastructure (facilities, laboratories, communications networks), and policies (tax, intellectual property). Other nations are beginning to reap the benefits of such investments aimed at stimulating and exploiting technological innovation, creating serious competitive challenges to American industry and business both in the conventional marketplace (e.g., Toyota) and through new paradigms such as the off-shoring of knowledge-intensive services (e.g., Bangalore, Shanghai). Yet again, at a time when our competitors are investing heavily in stimulating the technological innovation to secure future economic prosperity, Michigan is missing in action, significantly under-investing its economic and political resources in planting and nurturing the seeds of innovation.

Adequately supporting education and technological innovation is not just something we would like to do; it is something we simply have to do. What is really at stake here is building Michigan's regional advantage, allowing it to compete for prosperity, for quality of life, in an increasingly competitive world. In a knowledge-intensive society, regional advantage is not achieved through gimmicks such as lotteries and casinos. It is achieved through creating a highly educated and skilled workforce. It requires an environment that stimulates creativity, innovation, and entrepreneurial behavior. Specifically, it requires investment in the ingredients of innovation–educated people and new knowledge. Put another way, it requires strategic vision, enlightened policies, and sustained investment to create a knowledge society that will be competitive in a global economy.

To this end, this study has applied the planning technique of strategic roadmapping to provide a framework for the issues that Michigan must face and to suggest the commitments that we must make, both as individuals, as institutions, and as a state, to achieve prosperity and social well-being in a global knowledge economy. The roadmapping process was originally developed in the electronics industry and is applied frequently to major federal agencies such as the Department of Defense and NASA. Although sometimes cloaked in jargon such as environmental scans, resource maps, and gap analysis, in reality the roadmapping process is quite simple. It begins by asking where we are today, then where we wish to be tomorrow, followed by an assessment of how far we have to go, and finally concludes by developing a roadmap to get from here to there. The roadmap itself usually consists of a series of recommendations, sometimes divided into those that can be accomplished in the near term and those that will require longer-term and sustained effort.

By any measure, the assessment of Michigan today is very disturbing. Our state is having great difficulty in making the transition from a manufacturing to a knowledge economy. As we have noted earlier, Michigan has dropped to dead last–50th among the states–in most measures of economic momentum. Our leading city, Detroit, now ranks as among nation's poorest, not to mention becoming the largest U.S. city to declare bankruptcy. Furthermore, Michigan leads the nation in population loss, with the out-migration of young people in search of better jobs the fourth most severe among the states; our educational system is underachieving with one-quarter of Michigan adults without a high school diploma and only one-third of high school graduates college-ready. Fewer than one-quarter of Michigan citizens have college degrees. Although Michigan's system of higher education is generally regarded as one of the nation's finest, the erosion of state support over the past two decades and most seriously over the past seven years–with appropriation cuts to public universities now ranked as the most severe in the nation and ranging from 20% to 40%–has not only driven up tuition but put the quality and capacity of our public universities at great risk.

More generally, for many years Michigan has been shifting public funds and private capital away from investing in the future through education, research, and innovation to fund instead short term priorities such as prisons and excessive employee benefits while enacting tax cuts that have crippled state revenues. And all the while, as the state budget began to sag and eventually collapsed in the face of a weak economy, public leaders were instead preoccupied with fighting the old and increasingly irrelevant cultural and political wars (cities vs. suburbs vs. exurbs, labor vs. management, religious right vs. labor left). In recent years the state's motto has become "Eat dessert first; life is uncertain!" Yet what Michigan has really been consuming is the seed corn for its future.

A vision for Michigan tomorrow can best be addressed by asking and answering three key questions:

1. ***What skills and knowledge are necessary for individuals to thrive in a 21st-century, global, knowledge-intensive society***? Clearly a college education has become mandatory, probably at the bachelor's level, and for many, at the graduate level. Beyond this goal, the state should commit itself to providing high-quality, cost-effective, and diverse educational opportunities to all of its citizens throughout their lives, since during an era of rapid economic change and market restructuring, the key to employment security has become continual, lifelong education.

2. *What competencies are necessary for a population (workforce) to provide regional advantage in such a competitive knowledge economy*? Here it is important to stress that we no longer are competing only with Ohio, Ontario, and California. More serious is the competition from the massive and increasingly well-educated workforces in emerging economies such as India, China, and the Eastern Bloc. Hence the challenge is no longer to simply focus on the best and brightest, the economic and social elite, as in earlier eras, but instead to recognize that it will be the education, knowledge, and skills of Michigan's entire population that determine our economic prosperity and social well-being in the global economy. We must invest in learning opportunities for all of our citizens throughout their lives. And we must recognize that equal opportunity and social inclusion are no longer simply moral obligations but moreover strategic imperatives if we are to compete in the global economy.

3. *What level of new knowledge generation (e.g., R&D, innovation, entrepreneurial zeal) is necessary to sustain a 21st-century knowledge economy, and how is this achieved?* Here it is increasingly clear that the key to global competitiveness in regions aspiring to a high standard of living is innovation. And the keys to innovation are new knowledge, human capital, infrastructure, and forward-looking public policies. Not only must a region match investments made by other states and nations in education, R&D, and infrastructure, but it must recognize the inevitability of new innovative, technology-driven industries replacing old obsolete and dying industries as a natural process of "creative destruction" (a la Schumpeter) that characterizes a hypercompetitive global economy. Yet it must also provide a safety net for those citizens caught in such economic transformations through inclusive social programs.

So how far does Michigan have to travel to achieve

The key question before Michigan: Are today's citizens and their leaders willing to invest in the education and knowledge resources necessary to secure a prosperous and secure future for tomorrow's generations?

a knowledge economy competitive at the global level? What is the gap between Michigan today and Michigan tomorrow?

This part of the roadmapping process does not require a rocket scientist. One need only acknowledge the hopelessness in the faces of the unemployed, or the backward glances of young people as they leave our state for better jobs, or the angst of students and parents facing yet another increase in college costs as state government once again cuts appropriations for higher education. Yet this effort must also challenge the inability of Michigan's leaders to address the imperatives of the global economy, while building an awareness among Michigan parents that nothing will matter more to their children's future than their education. To paraphrase Thomas Friedman, "The world is flat! Globalization has collapsed time and distance and raised the notion that someone anywhere on earth can do your job, more cheaply. Can Michigan rise to the challenge on this leveled playing field?"

So, what do we need to do? What is the roadmap to Michigan's future? In a knowledge-intensive economy, regional advantage in a highly competitive global marketplace is achieved through creating a highly educated and skilled workforce. It requires an environment that stimulates creativity, innovation, and entrepreneurial behavior. Experience elsewhere has shown that strategic vision, enlightened public policies, and significant public and private investments in high-skilled human capital, research and innovation, and infrastructure are necessary to sustain a knowledge economy.

The Roadmap: The Near Term (...now!...)

In the near term our principal recommendations focus on Michigan's most valuable resources, its people, investing in their education, skills, and creativity, and developing the knowledge infrastructure to enable their innovation and entrepreneurial zeal. Our recommendations are also aimed at providing the state's economic sectors and institutions–including government, industry, and education–with capacity, incentives, and encouragement to become more agile and market-smart.

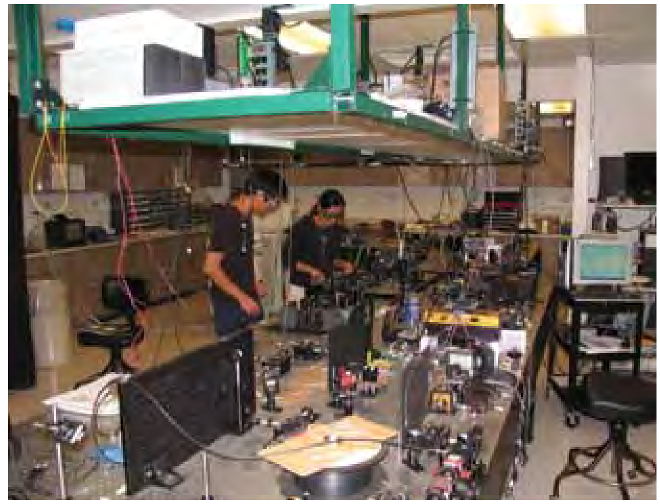
Human Capital

1. The State of Michigan will set as its goal that all students will graduate from its K-12 system with a high school degree that signifies they are college ready. To this end, all students will be required to pursue a high school curriculum capable of preparing them for participation in post-secondary education and facilitating a seamless transition between high school and college. State government and local communities will provide both the mandate and the resources to achieve these goals.

2. Beyond the necessary investments in K-12 education and the standards set for their quality and performance, raising the level of skills, knowledge, and achievement of the Michigan workforce will require a strong social infrastructure of families and local communities, particularly during times of economic stress. To this end, state government and local government must take action both to re-establish the adequacy of Michigan's social services while engaging in a broad effort of civic education to convince the public of the importance of providing world-class educational opportunities to all of its citizens.

3. Michigan must create and articulate clearer pathways among educational levels and institutions while removing barriers to student mobility and promoting new learning paradigms (e.g., distance education, life-

Investing in tomorrow's human capital



Investing in cutting-edge research

long learning, workplace programs) to accommodate a far more diverse student cohort.

4. Higher education must become significantly more engaged with K-12 education, accepting the challenge of improving the quality of our primary and secondary schools as one of its primary responsibilities and highest priorities with the corresponding commitment of faculty, staff, and financial resources. Each Michigan college and university should be challenged to develop a strategic plan for such engagement, along with measurable performance goals.

5. Michigan must increase very substantially the participation of its citizens in higher education at all levels–community college, baccalaureate, and graduate and professional degree programs. This will require a substantial increase in the funding of higher education from both public and private sources as well as significant changes in public policy. This, in turn, will require a major effort to build adequate public awareness of the importance of higher education to the future of the state and its citizens. It will also likely require a dedicated source of tax revenues to achieve and secure the necessary levels of investment during a period of gridlock in state government, perhaps through a citizen-initiated referendum.

6. To achieve and sustain the quality of and access to educational opportunities, Michigan needs to move into the top quartile of states in its higher education appropriations (on a per student basis) to its public universities. To achieve this objective, state government should set a target of increasing by 30% (beyond inflation) its appropriations to its public colleges and universities over the next five years.

7. The increasing dependence of the knowledge economy on science and technology, coupled with Michigan's relatively low ranking in percentage of graduates with science and engineering degrees, motivates a strong recommendation to state government to place a much higher priority on providing targeted funding for program and facilities support in these areas in state universities, similar to that provided in California, Texas, and many other states. In addition, more effort should be directed toward K-12 to encourage and adequately prepare students for science and engineering studies, including incentives such as forgivable college loan programs in these areas (with forgiveness contingent upon completion of degrees and working for Michigan employers). State government should strongly encourage public universities to recruit science and engineering students from other states and nations, particularly at the graduate level, perhaps even providing incentives such as forgivable loans if they accept employment following graduation with Michigan companies.

8. Colleges and universities should place far greater emphasis on building alliances that will allow them to focus on unique core competencies while joining with

other institutions in both the public and private sector to address the broad and diverse needs of society in the face of today's social, economic, and technological challenges. For example, research universities should work closely with regional universities and independent colleges to provide access to cutting-edge knowledge resources and programs.

New Knowledge (R&D, innovation)

9. The quality and capacity of Michigan's learning and knowledge infrastructure will be determined by the leadership of its public research universities in discovering new knowledge, developing innovative applications of those discoveries that can be transferred to society, and educating those capable of working at the frontiers of knowledge and the professions. State government should strongly support the role of these institutions as sources of advanced studies and research by dramatically increasing public support of research infrastructure, analogous to the highly successful Research Excellence Fund of the 1980s. Also key will be enhanced support of the efforts of regional colleges and universities to integrate this new knowledge into academic programs capable of providing lifelong learning opportunities of world-class quality while supporting their surrounding communities in the transition to knowledge economies.

10. In response to such reinvestment in the research capacity of Michigan's universities, they, in turn, must become more strategically engaged in both regional and statewide economic development activities. Intellectual property policies should be simplified and standardized; faculty and staff should be encouraged to participate in the startup and spinoff of high-tech business; and universities should be willing to invest some of their own assets (e.g., endowment funds) in state- and region-based venture capital activities. Furthermore, universities and state government should work more closely together to go after major high tech opportunities in both the private and federal sectors (attracting new knowledge-based companies and federally funded R&D centers–FFRDCs).

11. Michigan must also invest additional public and private resources in private-sector initiatives designed to stimulate R&D, innovation, and entrepreneurial activities. Key elements would include reforming state tax policy to encourage new, high-tech business development, securing sufficient venture capital, state participation in cost-sharing for federal research projects, and a far more aggressive and effective effort by the Michigan Congressional delegation to attract major federal research funding to the state.

Infrastructure

12. Providing the educational opportunities and new knowledge necessary to compete in a global, knowledge-driven economy requires an advanced infrastructure: educational and research institutions, physical infrastructure such as laboratories and cyberinfrastructure such as broadband networks, and supportive policies in areas such as tax and intellectual property. Michigan must invest heavily to transform the current infrastructure designed for a 20th-century manufacturing economy into that required for a 21st-century knowledge economy. Of particular importance is a commitment by state government to provide adequate annual appropriations for university capital facilities comparable to those of other leading states. It is also important for both state and local government to play a more active role in stimulating the development of pervasive high speed broadband networks, since experience suggests that reliance upon private sector telcom and cable monopolies could well trap Michigan in a cyberinfrastructure backwater relative to other regions (and nations).

Policies

13. As powerful market forces increasingly dominate public policy, Michigan's higher-education strategy should become market-smart, investing more public resources directly in the marketplace through programs such as vouchers, need-based financial aid, and competitive research grants, while enabling public colleges and universities to compete in this market through encouraging greater flexibility and differentiation in pricing, programs, and quality aspirations.

14. Michigan should target its tax dollars more strategically to leverage both federal and private-sector investment in education and R&D. For example, a shift toward higher tuition/need-based financial aid policies in public universities not only leverages greater federal financial aid but also avoids unnecessary subsidy of high-income students. Furthermore greater state investment in university research capacity would leverage greater federal and industrial support of campus-based R&D.

15. Key to achieving the agility necessary to respond to market forces will be a new social contract negotiated between the state government and Michigan's public colleges and universities, which provides enhanced market agility in return for greater (and more visible) public accountability with respect to quantifiable deliverables such as graduation rates, student socioeconomic diversity, and intellectual property generated through research and transferred into the marketplace.

16. Michigan must recommit itself to the fundamental principles of equal opportunity and social inclusion through the actions of its leaders, the education of its citizens, and the modification of restrictive policies, if it is to enable an increasingly diverse population to compete for prosperity and security in a intensely competitive, diverse, and knowledge-driven global economy.

The Roadmap (longer term...but within a decade)

For the longer term, our vision for the future of higher education is shaped very much by the recognition that we have entered an age of knowledge in a global economy, in which educated people, the knowledge they produce, and the innovation and entrepreneurial skills they possess have become the keys to economic prosperity, social well-being, and national security. Moreover, education, knowledge, innovation, and entrepreneurial skills have also become the primary determinants of one's personal standard of living and quality of life. We believe that democratic societies–including state and federal governments–must accept the responsibility to provide all of their citizens with the educational and training opportunities they need, throughout their lives, whenever, wherever, and however they need it, at high quality and at affordable prices.

To this end, the long-term roadmap proposes a vision of the future in which Michigan strives to build a knowledge infrastructure–a society of learning–capable of adapting and evolving to meet the imperatives of a global, knowledge-driven world. Such a vision is essential to create the new knowledge (research and innovation), a skilled workforce, and the infrastructure necessary for Michigan to compete in the global economy while providing citizens with the lifelong learning opportunities and skills they need to live prosperous and secure lives in our state. As steps toward this vision, we recommend the following actions:

1. Michigan needs to develop a more systemic and strategic perspective of its educational, research, and cultural institutions–both public and private, formal and informal–that views these knowledge resources as comprising a knowledge ecology that must be adequately supported and allowed to adapt and evolve rapidly to serve the needs of the state in a change driven world, free from micromanagement by state government or intrusion by partisan politics.

2. Michigan should strive to encourage and sustain a more diverse system of education, since institutions with diverse missions, core competencies, and funding mechanisms are necessary to serve the diverse needs of its citizens, while creating an knowledge infrastructure more resilient to the challenges presented by unpredictable futures. Using a combination of technology and funding policies, efforts should be made to link elements of Michigan's learning, research, and knowledge resources into a market-responsive seamless web, centered on the needs and welfare of its citizens and the prosperity and quality of life in the state rather than the ambitions of institutional and political leaders.

3. Serious consideration should be given to reconfiguring Michigan's educational enterprise by exploring new paradigms based on the best practices of other regions and nations. For example, the current segmentation of learning by age (e.g., primary, secondary, collegiate, graduate-professional, workplace) is increasingly irrelevant in a competitive world that requires lifelong

learning to keep pace with the exponential growth in new knowledge. More experimentation both in terms of academic programs and institutional types should be encouraged.

4. The quality and capacity of Michigan's learning and knowledge infrastructure will be determined by the leadership of its research universities in discovering new knowledge, developing innovative applications of these discoveries that can be transferred to society, and educating those capable of working at the frontiers of knowledge and the professions. Because of the importance of research and graduate education to the state's future, these universities should be encouraged to give priority to these activities, while undergraduate education remains the primary mission of Michigan's other colleges and universities.

5. Michigan's research universities should explore new models for the transfer of knowledge from the campus into the marketplace, including the utilization of endowment capital (perhaps with state match) to stimulate spinoff and startup activities and exploring entirely new approaches such as "open source – open content paradigms" in which the intellectual property created through research and instruction is placed in the public domain as a "knowledge commons," available without restriction to all, in return for strong public support.

6. While it is natural to confine state policy to state boundaries, in reality such geopolitical boundaries are of no more relevance to public policy than they are to corporate strategies in an ever more integrated and interdependent global society. Hence Michigan's strategies must broaden to include regional, national, and global elements, including the possibility of encouraging the state's two internationally prominent research universities, the University of Michigan and Michigan State University, to join together to create a true world university, capable of assisting the state to access global economic and human capital markets.

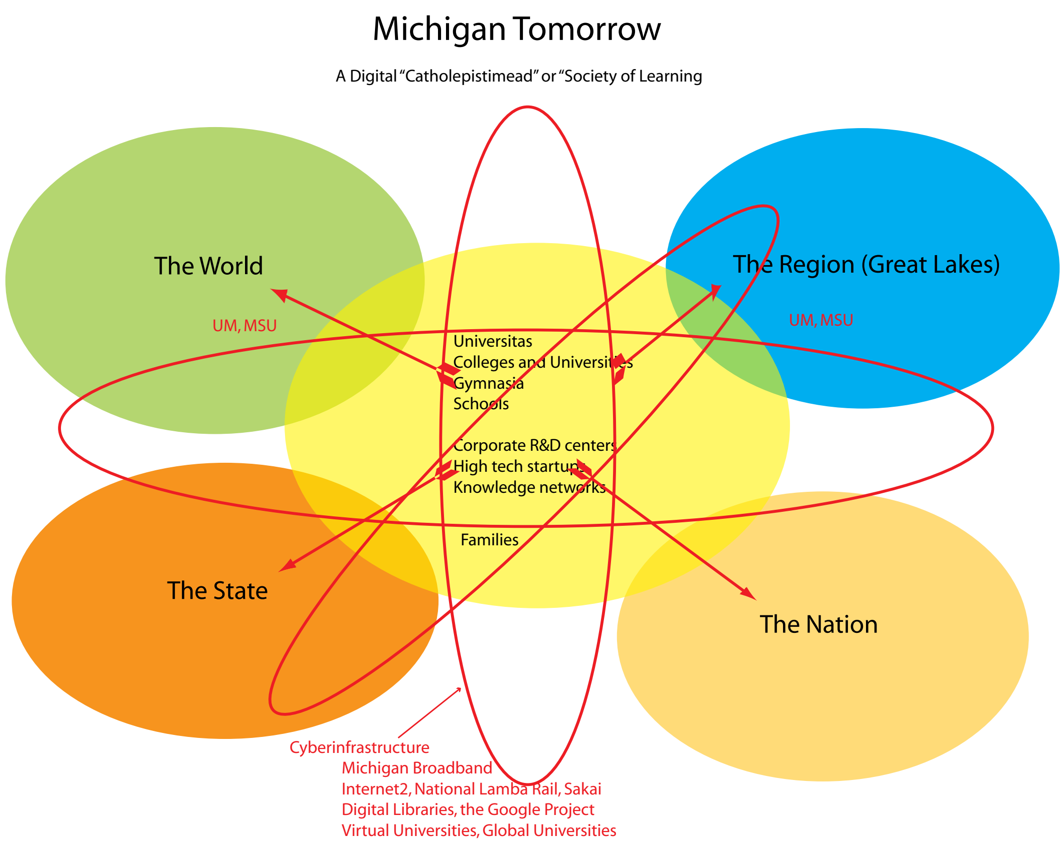
7. Michigan should explore bold new models aimed at producing the human capital necessary to compete economically with other regions (states, nations) and provide its citizens with prosperity and security. Lifelong learning will not only become a compelling need of citizens (who are only one paycheck away from the unemployment line in a knowledge-driven economy), but also a major responsibility of the state and its educational resources. One such model might be to develop a 21st-century analog to the G.I. Bill of the post WWII era that would provide–indeed, guarantee–all Michigan citizens with access to abundant, high-quality, diverse learning opportunities throughout their lives, and adapts to their ever-changing needs.

8. Michigan should work closely with other Great Lakes states facing similar challenges and opportunities to develop a regional agenda, both to facilitate cooperation and to influence national priorities.

9. Michigan should develop a leadership coalition–involving leaders from state government, industry, labor, education, and concerned citizens–with vision and courage sufficient to challenge and break the stranglehold of the past on Michigan's future!

Michigan is far more at risk than many other states because its manufacturing-dominated culture is addicted to an entitlement mentality that has long since disappeared in other regions and industrial sectors. Moreover, politicians and the media are both irresponsible and myopic as they continue to fan the flames of the voter hostility to an adequate tax base capable of meeting both today's urgent social needs and longer-term investment imperatives such as education and innovation. As Bill Gates warned, cutting-edge companies no longer make decisions to locate and expand based on tax policies and incentives. Instead they base these decisions on a state's talent pool and culture for innovation–priorities apparently no longer valued by many of Michigan's leaders, at least when facing actions that challenge partisan politics.

To be sure, it is difficult to address issues such as developing a tax system for a 21st-century economy, building world-class schools and colleges, or making the necessary investments for future generations in the face of the determination of the body politic still clinging tenaciously to past beliefs and practices. Yet the realities of a flat world will no longer tolerate procrastina-




Michigan tomorrow

tion or benign neglect.

It is time for leaders of state government, business, labor, education, and foundations to acknowledge and explain to the public that without the sacrifices we must make today to enable investments for tomorrow, Michigan is well on its way to becoming Mississippi, a backwater filled with the rusting hulls of a obsolete manufacturing economy while other states and nations make the investments to move into the knowledge economy. A civil society does require some degree of sacrifice on the part of all citizens, relative to their capacity and means. To be sure, this might infuriate some–particularly among the affluent who benefit most from this "cut my taxes now; I'll worry about my kids later" mentality, and who will eventually pack off and retire in Florida, taking their tax-cut windfalls with them. It might also lose some votes. But what is the purpose of leadership if all one does is leave behind a legacy of poverty and hopelessness?

Unlike most states, Michigan has no alliance of business, labor, higher education, and public leaders to push for the future of the state. Instead, narrowly focused special-interest groups have captured control of the political parties and public policy process (e.g., labor-left, religious-right, neo-cons). They are running the train off the track, blocking any effective efforts of strategic action. Only the narrowest of political initiatives is able to get any traction (e.g., bans on gay marriages or affirmative action).

It is time that someone sounded the alarm: Michigan is falling apart! It is rapidly losing its ability to compete in the economy of the future. We have only a short time to make the moves that will allow us to stay competitive!

The Michigan Roadmap is intended in part for leaders in the public sector (the Governor, Legislature, and other public officials), the business community (CEOs, labor leaders), higher education leaders, and the nonprofit foundation sector. However, this report is also written for those interested, concerned citizens who have become frustrated with the deafening silence about Michigan's future that characterizes our public, private, and education sectors. The state's leaders, its government, industry, labor, and universities, have

## Recommendations

### The Near Term

Today's Challenge: Enabling Michigan's transition to a knowledge-driven economy capable of providing prosperity, security, and social well-being in a hypercompetitive global economy.

Key Vision:
To invest more adequately, strategically, and intelligently, with investments in people as the highest priority.

Investment Goals:
...human capital (lifelong learning)
...new knowledge (research, innovation, entrepreneurism)
...infrastructure (institutions, labs, cyber)
...policy (tax, investment, intellectual property)

The Elements:

1. All K-12 students will graduate college ready.
2. Priority will be given to the social infrastructure for learning.
3. Create clearer pathways among learning institutions.
4. Higher education will become more engaged with K-12 schools.
5. Increase participation of all citizens in higher education.
6. Move Michigan into top quartile in higher ed investments.
7. Targeted state investment in science and engineering.
8. Stress alliances among Michigan's colleges and universities.
9. Increase state investments in university research infrastructure.
10. Universities should become more engaged in tech transfer.
11. Incentives to stimulate private sector R&D and innovation.
12. Public investment in infrastructure such as broadband is critical.
13. Michigan should invest more in need-based financial aid.
14. State funds should be used to leverage private and federal funds.
15. Universities should be provided with agility to adapt to markets.
16. A recommitment to equity and social inclusion.

### The Longer Term

Tomorrow's Challenge: To provide all of Michigan's citizens with the education and training they need, throughout their lives, whenever, wherever, and however they desire it, at high quality, and affordable cost.

Key Vision: To develop a society of learning capable of responding to the imperatives of a 21st century, global, knowledge-driven society.

Goal: A society of learning, capable of adapting and evolving rapidly to provide learning opportunities, knowledge, and innovation during a period of extraordinary change.

The Elements:

1. Michigan must develop a more systemic and strategic approach to its knowledge resources.
2. The state should encourage more diversity in institutions.
3. New paradigms for K-16 education should be explored.
4. UM and MSU should be encouraged to stress advanced education and research.
5. UM and MSU should be encouraged to develop capacity to access global markets.
6. Michigan's universities should explore bolder models of tech transfer, spinoffs, and startup activities.
7. Michigan should consider bolder models for producing human capital such as a 21st century version of the G.I. Bill that guarantees lifelong educational opportunities for all citizens.

simply not been willing to acknowledge that the rest of the world is changing. They have held fast to an economic model that is not much different from the one that grew up around the heyday of the automobile era–an era that passed long ago.

It should be acknowledged that much of the rhetoric used in this report is intentionally provocative–if not occasionally incendiary. But recall here that old saying that sometimes the only way to get a mule to move is to whack it over the head with a 2x4 first to get its attention. The Michigan Roadmap is intended as just such a 2x4 wake-up call to our state. For this effort to have value, we believe it essential to explore openly and honestly where our state is today, where it must head for tomorrow, and what actions will be necessary to get there. Michigan simply must stop backing into the future and, instead, turn its attention to making the commitments and investments today necessary to allow it to compete for prosperity and social well-being tomorrow in a global, knowledge-driven economy.

Here a second caveat is important. Such roadmaps should be viewed as transient documents, since the Michigan landscape changes over time. As the world continues to change, and as thoughtful and creative people become more engaged in considering our state's challenges and opportunities, new paths to the future will become apparent. Hence it is important for readers to consider this particular effort as both organic and evolutionary. Feedback, criticism, and suggestions are strongly encouraged and these will reshape future versions of the Michigan Roadmap, just as the current Michigan Roadmap Redux was reshaped by the input of many of those who provided feedback on the earlier 2005 document.

What is really at stake today is building Michigan's regional advantage, allowing it to compete for prosperity and quality of life, in an increasingly competitive global economy. In a knowledge-intensive society, regional advantage is not achieved through traditional political devices such as tax cuts for the wealthy, regulatory relief of polluters, entitlements for those without need, or tax-subsidized gimmicks such as lotteries, casinos, or sports stadiums. A knowledge-based, competitive economy is achieved through creating a highly educated and skilled workforce. It requires public investment in the ingredients of innovation–educated people and new knowledge–and the infrastructure to support advanced learning, research, and innovation. It requires an environment that stimulates creativity, innovation, and entrepreneurial behavior. Put another way, it requires strong public purpose, wise public policy, and adequate investment to create a true society of learning. And these, in turn, require dedicated, visionary, and courageous leadership in government, business, education, and other areas of civic life.

To face the opportunities, challenges, and responsibilities of an increasingly uncertain future, Michigan needs to rekindle the spirit of adventure, creativity, innovation, and boundless hope in the future that has characterized its history. During its early years, its frontier spirit was sustained by a sense of optimism and excitement about the future and a relish for change. Today this same spirit needs to be rekindled to secure Michigan's future.

## A Strategic Roadmap for the Midwest

### The Midwest Today

In his recent book, *Caught in the Middle*, Richard Longworth portrays the challenge of regional economic development in a compelling way: "As the Midwest moves toward the future, leaving the past behind, the social disruption is going to be enormous. Hard decisions must be made. State governments, unsupported, cannot make them. Someone else must lead. But lead where. Globalization changes everything in economics and in life. Nothing remains the same. No real future exists except the future that the Midwest creates for itself. New England and the South have already learned this. So have many regions inside the European Union. This future must be crafted regionally, by the Midwest acting as a single unit, not as a mélange of hostile states but as one region that shares not only a past but a future." (Longworth, 2008)

The Midwest and the Great Lakes states

To be sure, it is difficult to address issues such as building world-class schools and colleges, developing a tax policy for a 21st century economy, or making the necessary investments for future generations when the body politic and its political leaders seem determined to cling tenaciously to past beliefs and practices. Yet the realities of a flat world will no longer tolerate procrastination or benign neglect. For this effort to have value, we believe it essential to explore openly and honestly where the Midwest is today, where it must head for tomorrow, and what actions will be necessary to get there.

This report is aimed at several audiences. Certainly it is intended for leaders in the public sector (governors, legislatures, mayors, and other public officials), the business community (CEOs, labor leaders), higher-education leaders, and the nonprofit foundation sector. However, the report is also written for interested and concerned citizens who have become frustrated with the myopia that characterizes our public, private, and education sectors.

The Midwest region faces a crossroads, as a global knowledge economy demands a new level of knowledge, skills, and abilities on the part of our citizens. The goal is to transform what was once the farming and manufacturing center of the world economy into what could become its knowledge center. Put another way, while the Midwest region once provided the muscle for the manufacturing economy that powered the 20th century, now it must make the commitment and the investments necessary to become the brains of the 21st century knowledge economy.

While there are many components to transforming the American Midwest into a learning- and innovation-driven economy–tax policy, providing adequate social services, government restructuring, and, of course, political transformation–this report focuses particular attention on the role played by colleges and universities. In earlier critical moments in our nation's history, public initiatives gave high priority to expanding educational opportunities as a route to prosperity, security, and social well being. The states took action to ensure universal access to secondary education. The Land Grant Acts in the 19th century extended college education to the working class. The G. I. Bill provided the returning veterans of World War II with college educations while the Truman Commission proposed extending college opportunities to all Americans. The partnership developed between the federal government and faculty researchers on the campuses created the American research university as a source of much of the basic research and innovation that powered the global economy in the post WWII years.

A half-century ago, during a period of similar demographic and economic challenge and opportunity, the state of California responded with a master plan that not only broadened the opportunity for a college education to all Californians but also created the finest university in the world, the University of California. As one of the architects of that plan, UC President Clark Kerr, emphasized: "The future of California no longer depends upon the gold in the hills, or the fertility of the valleys, or the climate in Southern California producing Hollywood as a place that can operate all year round and provide a favorable place for artists, for actors and actresses to live. We can no longer count on the physical resources of the state. From here on out, our future depends upon how well we develop our human resources, how well we develop our research and development efforts, how well we develop the skills of our labor force as currently in electronics and biotechnology. So let me conclude with these final words. As goes education, so goes California." (Kerr, 2001)

Today the challenges and opportunities confronting the American Midwest demand a similarly profound vision and commitment. To paraphrase President Kerr: The future of the Midwest region no longer depends on our factories and farms or a labor force possessing physical strength and determination, but limited skills and education. Nor will our region's remarkable natural resources, our forests and fertile fields, our rivers and inland seas, determine our future. From here on out, our future depends on how well we develop our human resources and how we create and apply new knowledge through innovation and entrepreneurial zeal. So let us conclude with final words: As goes higher education, so goes the Midwest!

Overburdened with legacy economic and political burdens, state governments are less and less influential in determining prosperity in the new economy. In today's economy, any region in the world can be a locus for knowledge work. In a wired, interdependent global economy that allows people to choose where to live and work and where to make goods and services, regions are now challenged to identify and nurture their unique economic advantages. Today's economic activities are no longer constrained by traditional geopolitical boundaries, such as states and nations. Instead, they span larger multistate or multinational regions with common economic, demographic, and cultural characteristics. Furthermore, the centers of economic and political activities within such regions have become large metropolitan concentrations, capable of building and sustaining the learning and innovation infrastructure necessary to power the knowledge economy.

The states and cities of the American Midwest, with their common history, demographics, economy, and culture, comprise just such a region. The farms and factories built by pioneers and immigrants transformed the Midwest. The region's innovative and entrepreneurial spirit in key industries, such as agriculture, manufacturing, and transformation made the Midwest the geopolitical, cultural, and economic heartland of twentieth century America.

But, more precisely, just what is the Midwest? It might be defined as those states in the midsection of the nation: Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, and Missouri. More broadly, one could add portions of other states that also rim the Great Lakes and line the Ohio watershed, notably western Pennsylvania and New York, West Virginia, and northern Kentucky, comprising the "Great Lakes-Midwest" region. Or we could add the Great Plains states of North and South Dakota, Nebraska, and Kansas. In fact, one might even cross national boundaries to add the Canadian Great Lakes provinces of Ontario and Quebec, creating an international region with remarkably common histories, geographies, economies, and cultures.

Although we will focus most of our attention on the more narrowly defined eight-state Midwest region, our analysis and discussion will at times adopt a broader definition of the "Greater Midwest" that broadens to include additional states from the Great Lakes and Great Plains regions.

Today the American Midwest, the region that once powered the global economy, created the middle class, fed the world, and defended democracy, is floundering in a twenty-first century global economy driven by knowledge and innovation. The region is having great difficulty in making the transition from an industrial agricultural and manufacturing economy to a knowledge economy. A recent Brookings Institution study summarizes the state of the region as follows:

Still heavily reliant on mature industries and products, its aging workforce lacks the education and skills needed to fill and create jobs in the new economy. Its entrepreneurial spirit is lagging, hampering its ability to spur new firms and jobs in high-wage industries. Its metropolitan areas are economically stagnant, old and beat up, and plagued with severe racial divisions. Its landscape is dotted with emptying manufacturing towns, isolated farm, mining, and timber communities. It continues to bleed young, mobile, educated workers seeking opportunities elsewhere. Its legacy of employee benefits, job, and income security programs–many of which the region helped pioneer–has become an unsustainable burden, putting its firms at a severe competitive disadvantage in the global economy. And most important, the culture of innovation that made it an economic leader in the 20th century has long since vanished. (Austin, 2008)

The Midwest has many assets—the immense fresh water resources of the Great Lakes watershed, the region's limited vulnerability to natural disasters, such as earthquakes and hurricanes, its forests and fertile fields. Other characteristics have more questionable value. Its highways and factories, communications and urban infrastructure, and even its public priorities, evolved to serve a factory-based economy, not a knowledge economy, and today represent more of a liability than an asset.

Yet it is with the most important assets driving the global economy where the Midwest region has the greatest challenge. Our world today has entered an era in which educated people, the knowledge they produce, and the innovation and entrepreneurial skills they possess have become the keys to economic prosperity, public health, national security, and social well -being. Unfortunately, many of the workforce skills of the Midwest region are no longer at world-class levels, both because of aging and declining populations and because of the relatively low priority given to education by an agricultural and factory-based economy. Furthermore, the region has lost much of the zeal for risk-taking and innovation that led to its remarkable economic leadership in agriculture and industry in earlier times.

For years now the Midwest has seen its low-skill, high-pay factory jobs outsourced and replaced by low-skill, low-pay service jobs—or in too many cases, no jobs at all (Glazer, 2010). Other states, regions and nations, from Europe to Asia, invest heavily in high-skill, high-wage jobs in areas, such as information services, financial services, trade, and professional and technical services. Yet in much of the Midwest—among its political leaders, its media and opinion makers, and its people—there is a deafening silence about the implications of a global, knowledge-driven global economy for the region's future. There is little evidence of effective policies, new investments, or visionary leadership capable of reversing the downward spiral of our industrial economies (Power, 2009).

Leaders in both the public and private sectors continue to cling tenaciously to past beliefs and practices, preoccupied with obsolete and largely irrelevant issues (e.g., the culture wars, entitlements, tax cuts or abatements for dying industries, and gimmicks, such as casinos and cool cities) rather than developing strategies, taking actions, and making the necessary investments to achieve economic prosperity and social well-being in the new global economic order. Assuming that what worked before will work again, the Midwest today is sailing blindly into a profoundly different future.

Perhaps nowhere is this inability to read the writing on the wall more apparent than in the Midwest region's approach to education. Our strategies and policies aimed at providing our citizens with the education and skills, the innovative and entrepreneurial spirit, so necessary today for personal well-being and economic prosperity, have been woefully inadequate, all too often political in character, and largely reflecting a state of denial about the imperatives of the emerging global economy.

It may seem surprising that a region, which a century and a half ago led the nation in its commitment to building great public education systems aimed at serving all of its citizens, would be failing today in its human resource development. Indeed the guiding principle of the Northwest Ordinance of 1787 that shaped the new Midwest states preparing to enter the Union stated firmly that: "Religion, morality, and knowledge being necessary to good government and the happiness of mankind, schools and the means of education shall forever be encouraged" (Thorpe, 1909). During the early half of the nineteenth century, the religious revival movement known as the Great Awakening stimulated the efforts of religious denominations to establish hundreds of small religious colleges across the Midwestern United States that today have become some of the nation's finest independent colleges. The Morrill Act of 1863 put federal lands at the disposal of states to build the land-grant universities that would extend educational opportunity to the working class in the nineteenth and twentieth centuries and today comprise the world's greatest concentration of comprehensive research universities. In the late nineteenth century, the public secondary schools first appeared in the Midwest both to provide the further education needed by an increasingly industrial society and to prepare students for further study at the university level, thereby defining and implementing the principle of universal educational opportunity for the nation.

The strength of the Midwest—its capacity to build and sustain such extraordinary institutions—arose from its ability to look to the future and its willingness to take the actions and make the investments that would yield prosperity and well-being for future generations. Yet, today this spirit of public investment for the future has disappeared. Decades of failed public policies and inadequate investment now threaten the extraordinary educational resources built through the vision and sacrifices of past generations.

Beyond educational opportunities, there is another key to economic prosperity in today's global economy: technological innovation. As the source of new products and services, innovation is directly responsible for the most dynamic areas of the U.S. economy and is estimated to have provided roughly 50 percent of America's economic growth since World War II (Augustine, 2005). It has become even more critical to our prosperity and security in today's hypercompetitive, global, knowledge-driven economy. But history shows that significant public investment is necessary to produce the essential ingredients for innovation to flourish: new knowledge (e.g., research), human capital (e.g., education), infrastructure (e.g., facilities, laboratories, communications, and networks), and policies (e.g., tax and intellectual property).

Again, the irony of the region's plight today is that the Midwest led the world in technological innovation throughout much of the 20th century (Longworth, 2008). The automobile industry concentrated in Michigan because of the skills of our craftsmen, engineers, technologists, and technicians and the management and financial skills of corporate leadership as the industry grew to global proportions. Modern agriculture and the commodity markets were defined in both the farming communities of the Midwest and great trading and manufacturing centers such as Chicago. While the workforce skills required by factory manufacturing required only minimal formal education, technological excellence and skillful management enabled Midwestern corporations to achieve global impact. Basic research was also key, funded both by industry in world-class laboratories such as the Bell Laboratories, the Ford Scientific Laboratory, and the General Motors Research Laboratory, by national laboratories in areas such as nuclear research and high energy physics (e.g., Argonne National Laboratory and Fermi National Laboratory), and by the emergence of one of the most formidable concentrations of outstanding research universities in the world.

Yet by the late twentieth century, the Midwestern

Getting ready for the Millennials!

Embracing the diversity a new generation

economic picture had changed. Short-term planning cramped innovation. Restructuring led to the loss of hundreds of thousands of manufacturing jobs. The Midwest's Washington influence was used more to promote farm subsidies and to block federal regulation in areas, such as automobile emissions standards and fuel economy than to attract additional federal R&D dollars to the region. And state governments shifted public funding away from the support of higher education and research and instead to the priorities of aging populations, such as safety from crime (e.g., prison construction), social services (e.g., health care), and tax relief. As a consequence, at a time when other states and nations were investing heavily in stimulating the technological innovation to secure future economic prosperity, much of the Midwest was missing in action, significantly under-investing in the seeds of innovation.

The Strategic Roadmap

We begin with three important perspectives: acting regionally while thinking globally; demanding regional collaboration instead of pointless competition; and thinking far more strategically:

<u>Regional to National to Global</u>: While it is natural to confine policy to state boundaries, in reality such geopolitical boundaries are of no more relevance to public policy than they are to corporate strategies in an ever more integrated and interdependent global society. Hence the Midwest's strategies must broaden to include regional, national, and global elements. (Now!)

<u>Competition to Collaboration</u>: Midwestern states, governments, and institutions must shift from Balkanized competition to collaboration to achieve common interests, building relational rather than transactional partnerships most capable of responding to global imperatives. (Now!)

<u>System and Strategic Perspectives</u>: The Midwest needs to develop a more systemic and strategic perspective of its educational, research, and cultural institutions–both public and private, formal and informal–that views these knowledge resources as comprising a knowledge ecology that must be adequately supported and allowed to adapt and evolve rapidly to serve the needs of the state in a change driven world, free from micromanagement by state government or intrusion by partisan politics. (Now!)

The roadmap for higher education in the Midwest consists of a number of recommendations, some obvious, some seemingly radical, but all aimed at reinvigorating Midwestern education and applying it to the recovery of the Midwestern economy. These recommendations are organized into four groups corresponding to key responsibilities at the national, regional, state, and institutional levels. We begin with the foundation for these recommendations:

Restructuring higher education

The emergence of "world" universities

Pre-College

All Students College- or Workplace–Ready: The Midwest region should set high goals that ALL students will graduate with a high school degree that signifies they are not only either college- or workplace-ready but furthermore prepared for a world that will require a lifelong commitment to learning. State governments and local communities should provide both the mandate and the resources to achieve these goals. (Now!)

Restructuring K-12 to Achieve World-class Performance: To achieve a quantum leap in student learning, Midwest school systems will have to restructure themselves to achieve world-class performance, including setting high standards for student and teacher performance, lengthening the school year, investing in modern learning resources, implementing rigorous methods for assessing student learning, preparing and rewarding outstanding teachers, and managing and governing school systems in an accountable fashion. (Soon)

Social Infrastructure: Beyond the necessary investments in K-12 education and the standards set for their quality and performance, raising the level of skills, knowledge, and achievement of the Midwest's workforce will require a strong social infrastructure of families and local communities, particularly during times of economic stress. To this end, state and local governments must take action both to re-establish the adequacy of the Midwest's social services while engaging in a broad effort of civic education to convince the public of the importance of providing world-class educational opportunities to all of its citizens. (Soon)

Higher Education Engagement with K-12: Higher education must become significantly more engaged with K-12 education, accepting the challenge of improving the quality of our primary and secondary schools as one of its highest priorities with the corresponding commitment of faculty, staff, and financial resources. Each Midwest college and university should be challenged to develop a strategic plan for such engagement, along with measurable performance goals and should be encouraged to join in consortia to address the challenges of K-12 education. (Now!)

Linkages and Pathways: The Midwest must create clearer pathways among educational levels and institutions and removing barriers to student mobility and promoting new learning paradigms (e.g., distance education, lifelong learning, workplace programs) to accommodate a far more diverse student cohort. (Soon)

Higher Education

Demanding Zero-Defects Institutional Performance: All Midwest colleges and universities should be challenged to achieve a "zero-defects, total quality" performance goal in which all enrolled students are expected to graduate in the prescribed period. This will require not only adequate financial, instructional, and

Enhanced college participation and degrees

Preparing for Generation Z

counseling support but as well strong incentives and disincentives at the individual and institutional level (e.g., basing public support on graduation rates rather than enrollments, demanding that faculty give highest priority to adequate staffing of required curricula, and setting tuition levels to encourage early graduation). (Soon)

Institutional Diversity: The Midwest should strive to encourage and sustain a more diverse system of higher education, since institutions with diverse missions, core competencies, and funding mechanisms are necessary to serve the diverse needs of its citizens, while creating a knowledge infrastructure more resilient to the challenges presented by unpredictable futures. Using a combination of technology and funding policies, efforts should be made to link elements of the Midwest's learning, research, and knowledge resources into a market-responsive seamless web, centered on the needs and welfare of its citizens and the prosperity and quality of life in the region rather than the ambitions of institutional and political leaders. (Soon)

Community Colleges and Regional Universities: Key will be enhanced support of the efforts of community colleges and regional universities to integrate the new knowledge developed by research universities into academic programs capable of providing lifelong learning opportunities of world-class quality while supporting their surrounding communities in the transition to knowledge economies by developing additional professional programs more suited to the needs and interests of adult students. (Now!)

Independent Colleges: The region should encourage affiliations among independent colleges stressing high quality undergraduate education based on the liberal arts and research universities capable of providing the vast resources for state-of-the-art education in advanced subjects such as science and engineering. (Now!)

For-Profit and Proprietary Providers: To meet the expanding needs of a knowledge-driven economy requiring lifelong learning opportunities, the Midwest should recognize the strategic importance of for-profit and proprietary higher education providers who not only have the capacity to access capital markets, but have developed successful paradigms for educating adult learners. Yet it is also important that the for-profit sector be held accountable for student success and employability. (Now!)

World Universities: As a component of the Midwest's higher education strategies, serious consideration should be given to encouraging the region's internationally prominent research universities to explore the possibility of evolving into truly world universities, capable of accessing global economic and human capital markets. Key in this effort will be a far more strategic approach to immigration, viewing the region's research universities as portals to attract talent from around the world. (Soon)

Immigration: Immigration is vital to transforming the Midwest economy, as a source of both talent and energy and contributing to its innovation and entrepreneurship. The only immigration policy that will help the Midwest is one that opens the door as widely as possible. (Now!)

Expanding Educational Opportunities: The Midwest must recommit itself to the fundamental principles of equal opportunity and social inclusion through the actions of its leaders, the education of its citizens, and the modification of restrictive policies, if it is to enable an increasingly diverse population to compete for prosperity and security in a intensely competitive, diverse, and knowledge-driven global economy. (Now!)

Restructuring the Higher Education Enterprise: Serious consideration should be given to reconfiguring the Midwest's educational enterprise by exploring new paradigms based on the best practices of other regions and nations. For example, the current segmentation of learning by age (e.g., primary, secondary, collegiate, graduate-professional, workplace) is increasingly irrelevant in a competitive world that requires lifelong learning to keep pace with the exponential growth in new knowledge. More experimentation both in terms of academic programs and institutional types should be encouraged. Academic institutions should be provided with greater agility–albeit accompanied by greater accountability–to adapt and evolve to address new challenges and opportunities. (Eventually)

Adopting Best Practices from Abroad: Beyond strengthening and focusing the existing education infrastructure of the region–its schools, colleges, and universities–it is clear that a changing world will demand these be augmented by new institutions addressing emerging needs. Here the experience and practice of other nations should be considered as possibilities for the Midwest, e.g., European models such as the Gymnasia and Sixth-form colleges used for advanced college preparation; the Fachhochschulen and polytechnic institutes stressing rigorous education in the applied sciences; and the open universities used to provide broad educational opportunities for adults.

New Funding Paradigms: Alternative mechanisms for funding higher education should be explored, such as adopting a "reverse social-security" approach in which students pay for their education from future earnings, institutions align the funding of their multiple missions with key patrons, and "learn grants" from public or private sources that provide strong incentives for early learning by providing all students entering K-12 with college investment accounts. (Soon)

Innovation

Increased Investment in Innovation: The Midwest must invest additional public and private resources in initiatives designed to stimulate R&D, innovation, and entrepreneurial activities. Key elements would include reforming state tax policy to encourage new, high-tech business development, securing sufficient venture capital, state participation in cost-sharing for federal research projects, and a far more aggressive and effective effort by the Midwest state's Congressional delegations to attract major federal research funding to the region. (Now!)

Importance of Science and Engineering Education: The increasing dependence of the knowledge economy on science and technology, coupled with the Midwest's relatively low ranking in percentage of graduates with science and engineering degrees, motivates a strong recommendation to place a much higher priority on providing targeted funding for program and facilities support in these areas in state universities. (Now!)

Innovation Infrastructure: Providing the educational opportunities and new knowledge necessary to compete in a global, knowledge-driven economy requires an advanced infrastructure: educational and research institutions, physical infrastructure such as laboratories and cyberinfrastructure such as broadband networks, and supportive policies in areas such as tax and intellectual property. The Midwest must invest heavily to transform the current infrastructure designed for a 20th-century industrial economy into that required for a 21st-century knowledge economy. (Soon)

Research Universities and Innovation: The quality and capacity of the Midwest's learning and innovation infrastructure will be determined by the leadership of its research universities in discovering new knowledge, developing innovative applications of these discoveries that can be transferred to society, and educating those capable of working at the frontiers of knowledge and the professions. Because of the importance of research and graduate education to the region's future, these universities should be encouraged to strike an appropriate balance between these activities, while undergraduate education remains the primary mission of the Midwest's other colleges and universities. (Now!)

Engagement in Economic Development: The research universities of the Midwest must become more strategically engaged in both regional and statewide economic development activities. Intellectual property policies should be simplified and standardized; faculty and staff should be encouraged to participate in the startup and spinoff of high-tech business; and universities should be willing to invest some of their own assets (e.g., endowment funds) in state- and region-based venture capital activities. Furthermore, universities and state governments should work more closely together to go after major high-tech opportunities in both the private and federal sectors (attracting new knowledge-based companies and federally funded R&D centers). (Soon)

A Roadmap for the Midwestern States

Enhanced College Participation: The Midwest states must commit to increasing very substantially the participation of its citizens in higher education at all levels–community college, baccalaureate, and graduate and professional degree programs. This will require a substantial increase in the funding of higher education from both public and private sources as well as significant changes in public policy. This, in turn, will require a major effort to build adequate public awareness of the importance of higher education to the future of the state and its citizens. (Now!)

Higher Education Funding in the Top Quartile: To achieve and sustain the quality of and access to edu-

Preparing for future unknowns

cational opportunities, the Midwest states should each set an objective to move into the top quartile in their higher education appropriations (on a per student basis). (Soon)

Market-Smart Strategies: As powerful market forces increasingly dominate public policy, the Midwest's higher-education strategy should become market-smart, investing more public resources directly in the marketplace through programs such as vouchers, need-based financial aid, and competitive research grants, while enabling public colleges and universities to compete in this market through encouraging greater flexibility and differentiation in pricing, programs, and quality aspirations. (Soon)

Leveraging Federal and Private-Sector Investment: The Midwest should target its tax dollars more strategically to leverage both federal and private-sector investment in education and R&D. For example, a shift toward higher tuition / need-based financial aid policies in public universities not only leverages greater federal financial aid but also avoids unnecessary subsidy of

A challenge to the nation

high-income students. Furthermore greater state investment in university research capacity would leverage greater federal and industrial support of campus-based R&D. (Now!)

Changing State Higher Education Policies: Key to achieving the agility necessary to respond to market forces will be modernizing the policies that define the relationship between state governments and the Midwest's public colleges and universities to provide them with enhanced market agility in return for greater (and more visible) public accountability with respect to quantifiable deliverables such as graduation rates, student socioeconomic diversity, and intellectual property generated through research and transferred into the marketplace. (Now!)

A Roadmap for Colleges and Universities

World-Class Learning: Colleges and universities should aspire to achieve world-class quality, nimbleness, innovation, efficiency, and the capability of providing our citizens with the higher order intellectual skills (critical thinking, moral reasoning, an appreciation of cultural and human values, commitment to lifelong learning, adaptive to change, tolerance of diversity) necessary for achieving national prosperity, security, and social well-being in a global, knowledge-driven society. (Now!)

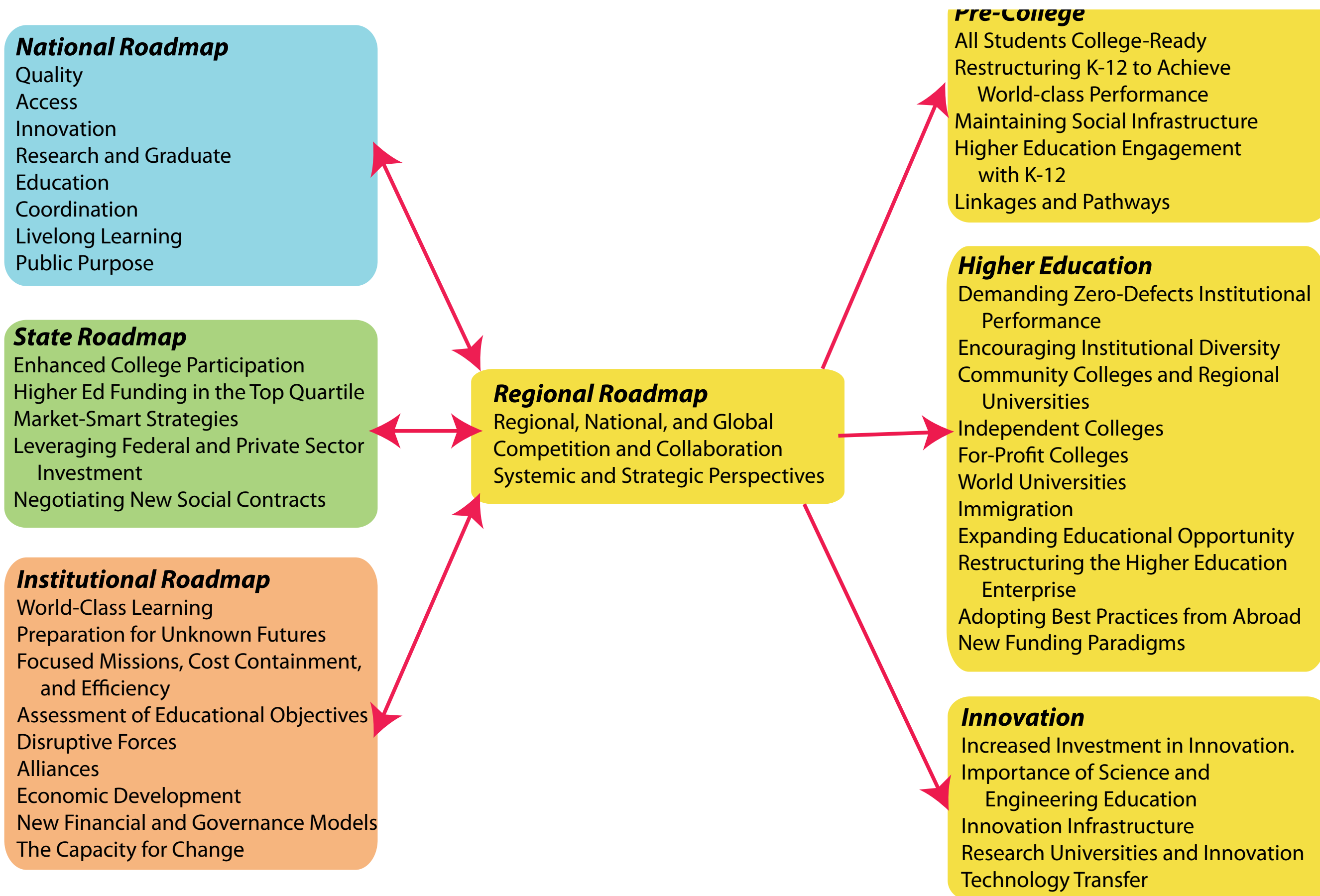
Preparation for Unknown Futures: While colleges and universities should be responsive to the interests of students, their employers, and the nation, it is essential that they should also strive to prepare their graduates for the unknown challenges of careers and citizenship of tomorrow by providing the higher order intellectual skills necessary to cope with a future of continual yet unpredictable change (e.g., critical thinking ability, a commitment to lifelong learning, the ability to adapt to change, and the capacity to thrive in a world of increasing diversity). (Now!)

Focused Missions, Cost Containment, and Efficiency: Colleges and universities should develop the ability (through the necessary changes in governance, leadership, management, and culture) to control costs, focus resources on well-defined missions, and achieve new levels of efficiency while enhancing quality and capacity. (Now!)

Assessment of Educational Objectives: It is time to challenge the academy to redefine the purpose and nature of a college education in today's (and tomorrow's) world and develop methods to assess whether these objectives are being achieved. This will require the development of more sophisticated tools to assess the achievement of the more abstract goals of a college education (e.g., critical thinking, communication skills, inductive/deductive reasoning, quantitative skills, cultural appreciation, systems thinking). (Now!)

Alliances: Colleges and universities should place far greater emphasis on building alliances that will allow them to focus on unique core competencies while joining with other institutions in both the public and private sector to address the broad and diverse needs of society in the face of today's social, economic, and technological challenges while addressing the broad and diverse needs of society. For example, research universities should work closely with regional universities and independent colleges to provide access to cutting-edge knowledge resources and programs. (Soon)

New Financial and Governance Models: Public colleges and universities need to develop new financial and governance strategies better able to adapt to declining state support and 21st century imperatives.




The layers of strategic roadmaps for the Midwest region

(Eventually)

A Higher Education Roadmap for the Nation

Quality: The United States must demand and be prepared to support a world-class higher education system, utilizing market forces shaped by incentives, public-private partnerships, and requirements for evidence-based assessment of educational effectiveness to drive all elements of postsecondary toward higher quality, efficiency, innovation, and nimbleness. (Now!)

Access: Access to higher education should receive the highest priority for public funding, whether through financial aid, state appropriations to colleges and universities, or tax policy (e.g., "tax expenditures"). Public funds should be targeted to those students with greatest need. (Now!)

Innovation: To support American innovation, the nation's colleges and universities must embrace innovation themselves, by developing new learning pedagogies, academic paradigms, and educational forms that are more responsive to national priorities. This will require a very substantial increase in the support of research and development associated with learning and education by the federal government and higher education institutions. (Soon)

Research and Graduate Education: The erosion of state and private sector support of higher education in recent years makes it apparent that it is time for the federal government should assume the lead responsibility for sustaining the capacity of America's research universities to conduct world-class research and graduate education. (Soon)

Coordination: Coordination among the various components of the nation's educational enterprise, including K-12, higher education, workplace training, and lifelong learning–should be strong encouraged and supported at all levels–national, regional, state, and institutional. (Now!)

Public Purpose: Higher education must take decisive action to address current concerns about quality, efficiency, capacity, and accountability if it is to earn the necessary level of public trust and confidence to enable it to pursue its public purpose. (Now!)

Of course, a roadmap is just that, a set of possible directions to the future. Setting a direction is far from arriving at one's destination. Achieving the vision of a learning and innovation-driven economy will require a sustained commitment at all levels, e.g., government, business, labor, education, foundations, citizens, and media.

What is really at stake today is building the Midwest's regional advantage, allowing it to compete for prosperity and quality of life in an increasingly competitive global economy. But today regional advantage is not achieved through politically popular devices, such as tax cuts for the wealthy, public subsidy of dying industries, or attempts to raid business from neighboring states. Instead it is achieved by creating a highly educated and skilled workforce. It requires public investment in the ingredients of innovation—educated people, new knowledge, and the infrastructure to support advanced learning and research. Put another way, it requires firm public purpose, visionary policies, and adequate investment to create a learning and innovation driven society.

## Strategic Roadmapping at the Metropolitan Level: The Kansas City Project

There are times in the lives of great cities when they seem caught, almost suspended, between their past and their future. This is such a time for Kansas City. The city stands with one leg planted in an old economy of manufacturing, rail transportation and low-skill jobs, while the other leg is striding briskly into the knowledge economy of high-tech jobs, complex information systems and the dazzling intellectual revolution of the life sciences. Can Kansas City be a center of excellence in the relentless competition of the global knowledge

The KC Task Force Report

economy? The city has many strengths. It also has some serious problems. Kansas City enjoys great museums, a broadband of exciting music, from classical and opera to jazz and the blues, a lively visual arts community and a thriving theatre scene. It is working hard to bring life back into its depleted urban core with the biggest downtown building boom in the city's history. High tech jobs are growing at twice the rate of old economy jobs, and the city is home to leading enterprises in telecommunications, information systems, engineering and finance. The learned professions — architecture, law, medicine, management, and the clergy — have a strong presence.

Kansas City has a noble tradition of philanthropy. The city's latest example of creative giving has the potential to be its greatest. The Stowers Institute for Medical Research is in its early days, but already has the largest endowment in the world supporting basic life sciences research. The Stowers Institute currently plans to concentrate its expanding presence in Kansas City, which would make the city home to the world's largest private medical research institute. The promise of

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Stowers for Kansas City, for the nation and for humanity is enormous. But for Stowers to reach its potential in Kansas City it must be augmented by world-class higher education research capacity in the life sciences and in cognate areas of knowledge such as computer science and electrical engineering, mathematics and statistics and nanoscience. When the huge promise of Stowers is added to Kansas City's other strengths, one can see that the city has some strong foundations on which to build.

Kansas City also faces some serious problems. The city has a long, dismal history of lack of opportunity for its African-American citizens, most of whom are stuck in the blighted urban core. The same lack of educational opportunity and isolation are spreading to Kansas City's Latino population. Together these groups are one-third of the city, and they are growing faster than other groups. Kansas City will not be a great city for anyone if the city continues to fail its African-American and Latino populations. The only way to address this problem is by providing educational opportunity. This is Kansas City's – and America's – greatest challenge.

Kansas City's second great challenge is that it lacks an essential institutional requirement for competitive strength in the knowledge economy. Kansas City is almost alone among important American cities in not having in its midst a world-class research university that is deeply engaged in meeting all the city's opportunities and challenges. Research universities are the foundation of the global knowledge economy. Universities help cities and regions attract and create skilled human capital which is the most valuable resource today. The discoveries of the university help drive the innovation and entrepreneurship that is the key to economic growth. The fastest growing industries in the information sciences, in biotechnology and in nanotechnology tend to locate where strong basic research universities or private research institutions are found. With the turning of the millennium, Kansas City has taken stock of itself in a number of excellent studies. Virtually every one of these has identified the absence of research university capacity as the city's most serious competitive weakness. The task force agrees with this assessment, although we go farther.

Kansas City needs not only world-class quality higher education research capacity; it equally needs a deeply engaged urban university with energy and imagination to focus creatively on the City's opportunities and major problems, especially the expansion of educational opportunity to the city's African-American and Latino communities.

Kansas City cannot defer to Jefferson City or Topeka to plan the city's human capital strategy, although it can enlist the states as collaborators. The cities that prosper in the global knowledge economy will be the cities that are smart and strategic about human capital. This is Kansas City's challenge, and its greatest opportunity. The city is fortunate to have elements of the higher education capacity it needs in the University of Missouri- Kansas City (UMKC) and the University of Kansas Medical Center (KUMC). But these institutions require substantial enhancement if Kansas City is to enjoy the benefits of a world-class research university that is deeply engaged in the city.

The only feasible way Kansas City can create the higher education capacity it needs is by an integrated, two-state strategy building on all available institutional foundations. This will require an unprecedented level of civic leadership. In building higher education, the city must convert the disadvantage of being divided between rival states to an advantage of being able to work with two state universities to build capacity.

### Life Sciences First

We believe it is clear that research capacity in the life sciences is the broad area of knowledge that offers Kansas City the greatest opportunity. This is the area that holds the greatest promise for economic and humanitarian returns. It is the only broad area of knowledge in which Kansas City has the potential, with Stowers, of becoming one of the world's leading centers of discovery in the decade ahead. It is also the research area that is supported by the most generous external funding. The life sciences are the research area in which

The task force believes that the most important responsibilities of an engaged urban university in Kansas City would include the following:

1) Providing the research capacity needed to drive the regional economy
2) Serving as a magnet for talented students and faculty
3) Expanding educational opportunity for underserved and disadvantaged groups, especially minority groups and the poor
4) Providing educational opportunity for adults and students who work and have families
5) Engaging deeply in K-12 public education to improve urban public schools
6) Enriching and providing the educational foundation for the arts
7) Providing educational capacity to all the city's important professional groups
8) Focusing on work force preparation
9) Applying expertise and hands-on solutions to the city's most pressing problems
10) Bringing energy and vitality to the urban core.

Key KC Task Force recommendations

the returns on investment are highest. If Kansas City becomes a leading life sciences center, it can become an important center for the biotechnology industry, one of the most dynamic sectors of the global knowledge economy.

The life sciences strategy we recommend has four main elements.

1. Build basic research capacity at KUMC, with the bone biology group centered at UMKC's excellent School of Dentistry a strategic partner. In essence, the strategy seeks to move KUMC's research funding from $75 million today to $300 million in ten years. This will give Stowers a strong basic science collaborator and move Kansas City in a decade to a position among the country's top twenty cities in basic life sciences research. There is no better investment Kansas City could make in its future.

2. Align the basic research at KUMC and Stowers with the translational and clinical research capacity of Kansas City's excellent hospitals. KUMC includes a strong teaching and clinical care hospital, the University of Kansas Hospital. However, most of the clinical capacity in the city is in the three hospitals on the Missouri side, St. Luke's, Children's Mercy and the Truman Medical Center. KUMC needs to collaborate closely with these hospitals.

3. Create a compelling life sciences strategy for UMKC. UMKC has not had the leadership in recent years to put together a life sciences strategy that makes sense for itself, for the city and for the state of Missouri. It has had in the past neither the funding nor the mandate to become a strong life sciences research university.

4. Create a Center for Translational Research that is a matrix organization to facilitate the translation of basic discoveries into useful drugs, devices and therapeutic interventions. Enlist the expertise of the Kauffman Foundation and the Bloch School at UMKC in creating an entrepreneurial pipeline for biotech innovation.

An Engaged Urban University

UMKC has embraced in words the strategy of being a "model urban university," deeply engaged with the most important opportunities and challenges of the city that is its home. In some important areas, such as the performing arts and various clinical activities of its schools of dentistry, nursing and medicine, UMKC is an effective, engaged institution. The Bloch School and the Law School also reach out to the community in creative ways. But most elements of the community perceive UMKC to be disengaged. This is particularly true of the urban public education systems of the city. Effective engagement with urban public education is especially important for UMKC. The task force believes that one of the two highest strategic priorities for education at all levels in Kansas City is to dramatically expand educational opportunity for Kansas City's underserved African-American and Latino communities. This requires every college and university in the city to become deeply engaged in improving the city's public schools. UMKC should be the leader in this effort. It is far from that today.

The task force believes that there are three critical elements, now largely lacking at UMKC, which must be in place in order for UMKC to achieve its aspiration


A progress report on the KC Project

as a “model urban university.” The first of these is a broadening of UMKC’s governance to give the Kansas City community a fiduciary role in the university. The second element is leadership, both academic and civic. With governance that has roots in the community, and with effective leadership, UMKC can develop the third critical element: a compelling institutional strategy. We believe there are currently two areas of strength at UMKC where a focused philanthropic investment would pay significant dividends for Kansas City. The first area is the performing and visual arts. The second is the entrepreneurship program at the Bloch School. UMKC surely needs further philanthropic investment. But further philanthropic investment should await a demonstration of effective leadership and the creation of a sustainable institutional strategy.

### A New Consortial University

We believe that Kansas City should consider the creation of a new institution, organized around specific programs, which would be a consortium of a number of universities, private research institutes such as Stowers and Midwest Research Institute (MRI) and charitable foundations. We believe such consortial institutions will increasingly be the model for translational and interdisciplinary research and teaching at the highest levels. The costs of instrumentation and the demands of wide-ranging interdisciplinary teams are becoming too great for even the richest universities to tackle alone. A consortial institution in Kansas City might focus on areas in which KUMC and UMKC need reinforcement or do not offer strong foundations on which to build. Examples of such areas would be bioinformatics, computer science, telecommunications, urban education and nanoscience. Such a consortium would itself require a further careful planning exercise.

### Conclusion

We are enthusiastic about Kansas City’s potential to build a world-class urban research university enterprise that drives innovation and offers educational opportunity to the entire community. Because we believe this is the highest strategic priority for the metropolitan area, we are cautiously optimistic that the concerted philanthropic investment and the determined, long-term civic leadership that are required to achieve it will be forthcoming.

## Five Years Later:
## Is Kansas City Getting It Right?

To address the many opportunities and challenges faced by the Greater Kansas City area, in 2005 a blue ribbon task force, created by several of the city’s foundations and led by the Greater Kansas City Community Foundation, was charged with developing a strategy for capturing the city’s great promise through a major investment in higher education. The resulting report, *Time to Get It Right: A Strategy for Higher Education in Kansas City,* proposed a bold vision for Kansas City’s future based upon focused investments and actions in three critical areas: the life sciences, an engaged urban university, and a consortial approach to attracting the presence of world-class research universities to Kansas City. It was recognized at the outset that this decades-long agenda would require significant collaboration among people and organizations, substantial investment from public and private sources, and considerable restructuring of existing institutions and policies.

Now, four years into this ambitious decades-long agenda, it has become important to assess progress toward the original objectives of the *Time To Get It Right* report, to identify remaining challenges, and to consider possible mid-course corrections. This update provides such an assessment, based upon in-depth interviews of over sixty community leaders of Kansas City foundations, business, educational institutions, health systems, government, and civic organizations, and augmented by independent progress assessments provided by many of the organizations involved in the *Time To Get It Right* project.

At the outset it is important to observe that the challenging national and global environment that stimulated this effort has continued to intensify. The recent recession has provided even more evidence that regional advantage in a hypercompetitive global, knowledge-driven economy requires both a highly education and skilled workforce and an environment that stimulates creativity, innovation, and entrepreneurial behavior. It also requires an unusual degree of cooperation, collaboration, strategic focus, and commitment by a region's people and its institutions, including governments, business, labor, and foundations.

This report concludes that Kansas City has made very significant early progress towards these goals as articulated by the TIME TO GET IT RIGHT report. In the life sciences the Stowers Institute has made remarkable progress in recruiting outstanding scientists, achieving impressive research results, and achieving a world-class reputation. The University of Kansas Medical Center has made similar progress, increasing the level of its sponsored research support by 29%, expanding its faculty and graduate student ranks, and developing important research and training affiliation agreements with other major medical centers in the Kansas City area. It remains well on track to apply for and achieve NCI Designated Cancer Center status in the next several years. The area's life sciences initiative has broadened considerably with the growth of activity in animal health and plant sciences, with the leadership of Kansas State University and the participation of the University of Missouri Columbia and Kansas City industry. The public sector has stepped forward with strong support through the Kansas Biosciences Authority and the Johnson County Education and Research Triangle sales tax, while foundations, corporations, and individual donors have made important commitments to key areas such as cancer research, drug discovery, and pediatric medicine. Supportive organizations such as the Kansas City Area Life Sciences Institute, Kansas Bioscience, the Kansas City Area Development Council, and the Greater Kansas City Chamber of Commerce are playing key roles. The new affiliations among area hospital systems (KUMC, Saint Lukes, Children's Mercy, Truman) in clinical research and training and research programs at the Stowers Institute, UMKC, and KU-Lawrence hold great promise for the next stage of expanding translational research and stimulating economic development in the life sciences. Kansas City's foundations and civic leadership groups continue to play essential roles in supporting and coordinating these rapidly evolving efforts in the life sciences.

There has also been important progress in the area of urban education. The new leadership team at UMKC is providing strong, effective, and accountable leadership, earning the support of faculty and community leaders. The establishment of the private UMKC Foundation for both fund-raising and endowment management has been an important step toward the concept of rooted governance, enabling deeper engagement and influence by the Kansas City community. Key priorities such as the Institute for Urban Education, the Bloch School's Institute for Entrepreneurship, and new leadership in the performing arts, business, engineering, education, and pharmacy are important steps toward transforming the institution into a high quality urban university. Moreover the University of Kansas Edwards Campus in Overland Park continues to exhibit strong vitality and growth, benefiting from solid leadership and strong civic support. The quality, impact, and collaboration of the areas community colleges are essential, commendable, and deserving of greater public and private support. While K-12 education in the urban school districts remains a considerable challenge, there are signs of progress resulting from the numerous efforts targeted to this essential community priority.

While this progress is impressive, it is also clear that much work remains to be done. While the primary objectives of the original the TIME TO GET IT RIGHT remain both valid and compelling, the experience of the past several years suggest several mid-course corrections should be considered. While these suggestions are provided in detail in the report, there are several that require immediate attention by the community if progress is to be sustained:

Today (now!):

1. The joint effort by KUMC, area medical centers, and the Stowers Institute to achieve NCI Designated Cancer Center status must remain the highest near-term priority. Key in this effort is assembling the necessary private support, with a target now set at $92 million. Yet the clock is ticking. While it is understandable that the Kansas City philanthropic community has numerous goals, including many of historic character, the potential impact of the cancer center campaign on the future of the city demands that it be the highest priority for immediate attention and commitment of the necessary support. This effort clearly also requires a more sophisticated and dedicated fund-raising structure with adequate staffing and strong accountability to the life sciences community.

2. While there are many elements of the *Time To Get It Right* effort in the three major areas of the life sciences, urban education, and needs for a comprehensive research university, it is important that the city's major leadership organizations–civic, business, foundation, research and educational–be at the table as participants in each of the major priorities where they are needed and capable of impact. At this critical juncture, the effort will not succeed if key leadership organizations take a "bye" from collaboration and participation, regardless of their particular longer-term agendas.

3. Finally, while the degree of collaboration and cooperation is commendable, it is still falls short of what will be needed to achieve the goals of the *Time To Get It Right*. There remain pockets of resistance toward true partnerships. It is now time to set aside historical divisions and competition to embrace a new spirit of trust and engagement. Those who are unable to achieve this commitment should step aside.

Tomorrow (within the year):

4. It is essential that faculty members and research investigators in Kansas City's key life sciences organizations, e.g., universities, the Stowers Institute, area medical centers, and life sciences businesses, be strongly encouraged to work together. Every effort should be made by organizations to remove those factors that hinder such intellectual collaboration.

5. As public funding declines in the wake of the current recession, it is important that private philanthropy step in to provide support for those programs and institutions key to the region's urban education needs. In particular, the activities of UMKC to transform itself into an urban-focused institution, the needs of the area's community colleges, and those activities aimed at improving K-12 education should be given high priority.

6. The chancellors and president of the University of Kansas, Kansas State University, and the University of Missouri system should begin meeting (along with their key officers) to develop a strategic plan to address Kansas City's urgent needs for those resources that can only be provided by world-class comprehensive research universities.

7. A more concerted and effective strategy needs to be developed and implemented to convince the state governments of Missouri and Kansas about the importance of providing adequate support of public higher education as absolutely critical to the future of their states–particularly during the post-recession period.

The Day After Tomorrow:

It is clear that the *Time To Get It Right* agenda has galvanized the Kansas City community–its colleges and universities, leading civic institutions, the philanthropic community, business, and state and municipal governments–into a powerful force determined to secure a future of prosperity and leadership for the city. There has been very considerable progress on most of the report's recommendations. New levels of cooperation and commitment have been achieved across state lines, municipal boundaries, institutional missions, and cultural differences. Kansas City is clearly "getting it right", although just as clearly, it still has some distance to travel.

Hence the most important recommendation is to stay the course, continuing to focus on the key objectives, while strengthening collaboration and commitments. The highest priorities should be given to those efforts and organizations that draw people and communities together rather than dividing forces and distracting attention.

The importance of sustaining the momentum, commitment, and progress toward the goals of the *Time To Get It Right* effort cannot be overstated. This is one of the few times that the Greater Kansas City community has mounted a major campaign that draws together people and institutions across state lines, counties, and municipalities in a challenging long-term strategy.

In 2005 the *Time To Get It Right* report recommended a series of near term (five-year) actions to begin to move Kansas City toward a bold vision of its future. It is now time to transition to a longer-term agenda (ten years and beyond), to sustain the early momentum, commitment, and focus to actually achieve this vision of hope, prosperity, and leadership.

## Impact

## References

Schmidt, Benno (chair), T*ime to Get It Right: A Strategy for Higher Education in Kansas City*, Greater Kansas City Community Foundation, 2005

Duderstadt, James J., T*he Michigan Roadmap, Redux: A Call for Leadership* (Ann Arbor, MI: Millennium Project, University of Michigan, 2008).

Duderstadt, James J.,, *Time To Get It Right: The View from Year Five* (Kansas City: Great Kansas City Community Foundation, 2009)

Duderstadt, James J., A *Master Plan for Higher Education in the Midwest: A Roadmap to the Future of America's Heartland* (Chicago, Chicago Council on Global Affairs, 2011)

# Chapter 19

# Global Studies

We live in a time of great change, an increasingly global society, driven by the exponential growth of new knowledge and knitted together by rapidly evolving information and communication technologies. It is a time of challenge and contradiction, as an ever-increasing human population threatens global sustainability; a global, knowledge-driven economy places a new premium on technological workforce skills through phenomena such as out-sourcing and off-shoring; governments place increasing confidence in market forces to reflect public priorities even as new paradigms such as open-source software and open-content knowledge and learning challenge conventional free-market philosophies; and shifting geopolitical tensions are driven by the great disparity in wealth and power about the globe, manifested in the current threat to homeland security by terrorism. Yet it is also a time of unusual opportunity and optimism as new technologies not only improve the human condition but also enable the creation and flourishing of new communities and social institutions more capable of addressing the needs of our society. Such issues provide the context for higher education in the 21st century.

## Global Imperatives

Our world today is undergoing a very rapid and profound social transformation, driven by powerful information and communications technologies that have stimulated a radically new system for creating wealth that depends upon the creation and application of new knowledge and hence upon educated people and their ideas. As Thomas Friedman stresses in his provocative book, The World is Flat, information and telecommunications technologies have created a platform "where intellectual work and intellectual capital can be delivered from anywhere–disaggregated, delivered, distributed, produced, and put back together again", or in current business terms, this gives an entirely new freedom to the way we do work, especially work of an intellectual nature. (Friedman, 2005)

Our economies and companies have become international, spanning the globe and interdependent with other nations and other peoples. As the recent report of the National Intelligence Council's 2020 Project has concluded, "The very magnitude and speed of change resulting from a globalizing world–apart from its precise character–will be a defining feature of the world out to 2020. Globalization–growing interconnectedness reflected in the expanded flows of information, technology, capital, goods, services, and people throughout the world will become an overarching mega-trend, a force so ubiquitous that it will substantially shape all other major trends in the world of 2020." (National Intelligence Council, 2004) It is this reality of the hyper-competitive, global, knowledge-driven economy of the 21st century that is stimulating the powerful forces that will reshape the nature of our society and our knowledge institutions.

Nations are investing heavily and restructuring their economies to create high-skill, high-paying jobs in knowledge-intensive areas such as new technologies, financial services, trade, and professional and technical services. From Paris to San Diego, Bangalore to Shanghai, there is a growing recognition throughout the world that economic prosperity and social well being in a global knowledge-driven economy requires investment in knowledge resources. That is, regions must create and sustain a highly educated and innovative workforce and the capacity to generate and apply new knowledge, supported through policies and investments in developing human capital, technological



Addressing the challenges facing our world are increasingly dependent upon educated people and ideas.

innovation, and entrepreneurial skill. (Council on Competitiveness, 2004)

Markets characterized by the instantaneous flows of knowledge, capital, and work and unleashed by lowering trade barriers are creating global enterprises based upon business paradigms such as out-sourcing and off-shoring, a shift from public to private equity investment, and declining identification with or loyalty to national or regional interests. Market pressures increasingly trump public policy and hence the influence of national governments. Yet the challenges facing our world such as poverty, health, conflict, and sustainability not only remain unmitigated but in many respects become even more serious through the impact of the human species–global climate change being foremost among them. The global knowledge economy requires thoughtful, interdependent and globally identified citizens. Institutional and pedagogical innovations are needed to confront these challenges and insure that the canonical activities of universities – research, teaching and engagement – remain rich, relevant and accessible.

## Regional Challenges

Regions face numerous challenges in positioning themselves for prosperity in the global economy, among them changing demographics, limited resources, and cultural constraints. The populations of most developed nations in North America, Europe, and Asia are aging rapidly where over the next decade the percentage of the population over 60 will grow to over 30% to 40%. Half of the world's population today lives in countries where fertility rates are not sufficient to replace their current populations, e.g. the average fertility rate in EU has dropped to 1.45, below the 2.1 necessary for a stable population. Aging populations, out-migration, and shrinking workforces are having an important impact, particularly in Europe, Russia, and some Asian nations such as Japan, South Korea, and Singapore. The implications are particularly serious for schools, colleges, and universities that now experience not only aging faculty, but excess capacity that could lead to possible closure.

In sharp contrast, developing nations in Asia, Africa, and Latin America are characterized by young and growing populations in which the average age is less than 20. Here the demand for education is staggering since in a knowledge economy, it is clear to all that this is the key to one's future security. Unless developed nations step forward and help address this crisis, billions of people in coming generations will be denied the education so necessary to compete in, and survive in, the knowledge economy. The resulting despair and hopelessness among the young will feed the terrorism that so threatens our world today.

Today we see a serious imbalance between educational need and educational capacity–in a sense, many of our universities are in the wrong place, where populations are aging and perhaps even declining rather than young and growing. This has already triggered some market response, with the entry of for-profit providers of higher education (e.g., Laureate, Apollo) into



These require both the traditional and emerging roles of the university.

providing higher education services on a global basis through acquisitions of existing institutions or distance learning technologies. It also is driving the interest in new paradigms such as the Open Education Resources movement. (Atkins, 2007) Yet, even if market forces or international development efforts are successful in addressing the urgent educational needs of the developing world, there are also concerns about whether there will be enough jobs to respond to a growing population of college graduates in many of these regions.

Growing disparities in wealth and economic opportunity, frequently intensified by regional conflict, continue to drive population migration. The flow of workers across the global economy seeking prosperity and security presents further challenges to many nations. The burden of refugees and the complexity of absorbing immigrant cultures are particularly apparent in Europe and North America. In the United States, immigration from Latin America and Asia is now the dominant factor driving population growth (53%), with the U.S. population projected to rise from 300 million to over 450 million by 2050. (National Information Center, 2006) While such immigrants bring to America incredible energy, talents, and hope, and continue to diversify the ethnic character of our nation, this increasing diversity is complicated by social, political, and economic factors. The full participation of immigrants and other underrepresented ethnic groups continues to be hindered by the segregation and non-assimilation of minority cultures and backlash against long-accepted programs designed to achieve social equity (e.g., affirmative action in college admissions). Furthermore, since most current immigrants are arriving from developing regions with weak educational capacity, new pressures have been placed on U.S. educational systems for the remedial education of large numbers of non-English speaking students.

On a broader scale, the education investments demanded by the global knowledge economy are straining the economies of both developed and developing regions. (OECD, 2005) Developing nations are overwhelmed by the higher education needs of an expanding young population at a time when even secondary education is only available to a small fraction of their populations. In the developed economies of Europe and Asia, the tax revenues that once supported university education only for a small elite are now being stretched thin to fund higher education for a significant fraction of the population (i.e., massification). Even the United States faces the limits imposed on further investment in education by retiring baby boomers who demand other social priorities such as health care, financial security, low crime, national security, and tax relief. (Zemsky, 2005; Newman, 2004)

These economic, social, and technological factors are stimulating powerful market forces that are likely to drive a massive restructuring of the higher education enterprise. Already we see many governments tending to view higher education as a private benefit (to students) of considerable value rather than a public good benefiting all of society, shifting the value proposition from that of government responsibility to support the educational needs of a society to that of university responsibility to address the economic needs of government–an interesting reversal of responsibilities and roles. Many nations are moving toward revenue-driven, market-responsive higher education systems more highly dependent on the private sector (e.g., student fees and philanthropy) because there is no way that their current tax systems can support the massification required by knowledge-driven economies in the face of other compelling social priorities (particularly the needs of the elderly).

The changing nature of the global economy is also exerting new and powerful pressures on regional educational needs and capacity. The liberalization of trade policies coupled with the ICT revolution has allowed the emergence of global corporations characterized by weakening ties to regional or national priorities. The trend for out-sourcing of business processes and off-shoring of jobs has accelerated as many corporations are now beginning to distribute not only routine production but fundamental aspects of core business activities (e.g., design, innovation, R&D) on a global basis, leaving behind relatively little core competence in their countries of origin. While this can create new regions of high innovation, these too can out-source/off-shore activities to still less expensive, although competent, labor markets, leaving behind enterprises characterized by little value added aside from financial management and brand name–no longer a solid foundation for a prosperous regional economy. From the United States to India to Viet Nam to Kenya…the out-sourcing/off-shoring practices of the global corporation continue to distribute value-adding activities ever further, wherever skilled and motivated labor is available at highest quality and lowest cost.

## National Responsibilities

In summary then, the forces driving change in our world–changing demographics (aging populations, migration, increasing ethnic diversity), globalization (economic, geopolitical, cultural), and disruptive technologies (info-bio-nano technologies)–are likely to drive very major changes in post-secondary education as a global knowledge economy demands a new level of knowledge, skills, and abilities on the part of our citizens. The strength, prosperity, and leadership of a nation in a global knowledge economy will demand highly educated citizenry and hence a strong system of post-secondary education. It will also require research universities, capable of discovering new knowledge, developing innovative applications of these discoveries, transferring them into society through entrepreneurial activities, and educating those capable of working at the frontiers of knowledge and the professions.

Yet there are broader responsibilities beyond national interests–particularly for developed nations–in an ever more interconnected and interdependent world. Global challenges such as crippling poverty, health pandemics, terrorism, and global climate change require both commitment and leaderships. Whether motivated by the economic design to create new markets or the more altruistic motives of human welfare, affluent nations have a responsibility to address global issues.

The ongoing debate concerning the future of higher education in the United States provides an illustration of the tension between the traditional roles of the university and the needs of the knowledge economy.

## A Case Study: The United States

Higher education in the United States is characterized both by its great diversity and an unusual degree of institutional autonomy–understandable in view of the limited role of the federal government in post-secondary education. As The Economist notes, “The strength of the American higher education system is that it has no system.” It benefits from a remarkable balance among funding sources, with roughly 25% from the federal government, 20% from the states, and 55% from private sources (tuition, philanthropy). Again to quote the Economist: “It is all too easy to mock American academia. But it is easy to lose sight of the real story: that America has the best system of higher education in the world!” (Economist, 2005)

Yet, while this remains true in selected areas such as research and graduate education, many other aspects of higher education in the United States raise serious concerns: an increasing socioeconomic stratification of access to (and success in) quality higher education; questionable achievement of acceptable student learning outcomes (including critical thinking ability, civic participation, communication skills, and quantitative literacy); cost containment and productivity; and the ability of institutions to adapt to changes demanded by the emerging knowledge services economy, globalization, rapidly evolving technologies, an increasingly diverse and aging population, and an evolving marketplace characterized by new needs (e.g., lifelong learning), new providers (e.g., for-profit, cyber, and global universities), and new paradigms (e.g., competency-based educational paradigms, distance learning, open educational resources). Furthermore, while American research universities continue to provide the nation with global leadership in research, advanced education, and knowledge-intensive services such as health care, technology transfer, and innovation, this leadership is threatened today by rising competition from abroad, by stagnant support of advanced education and research in key strategic areas such as physical science and engineering, and by the complacency and resistance to change of the American research university. (Augustine, 2005)

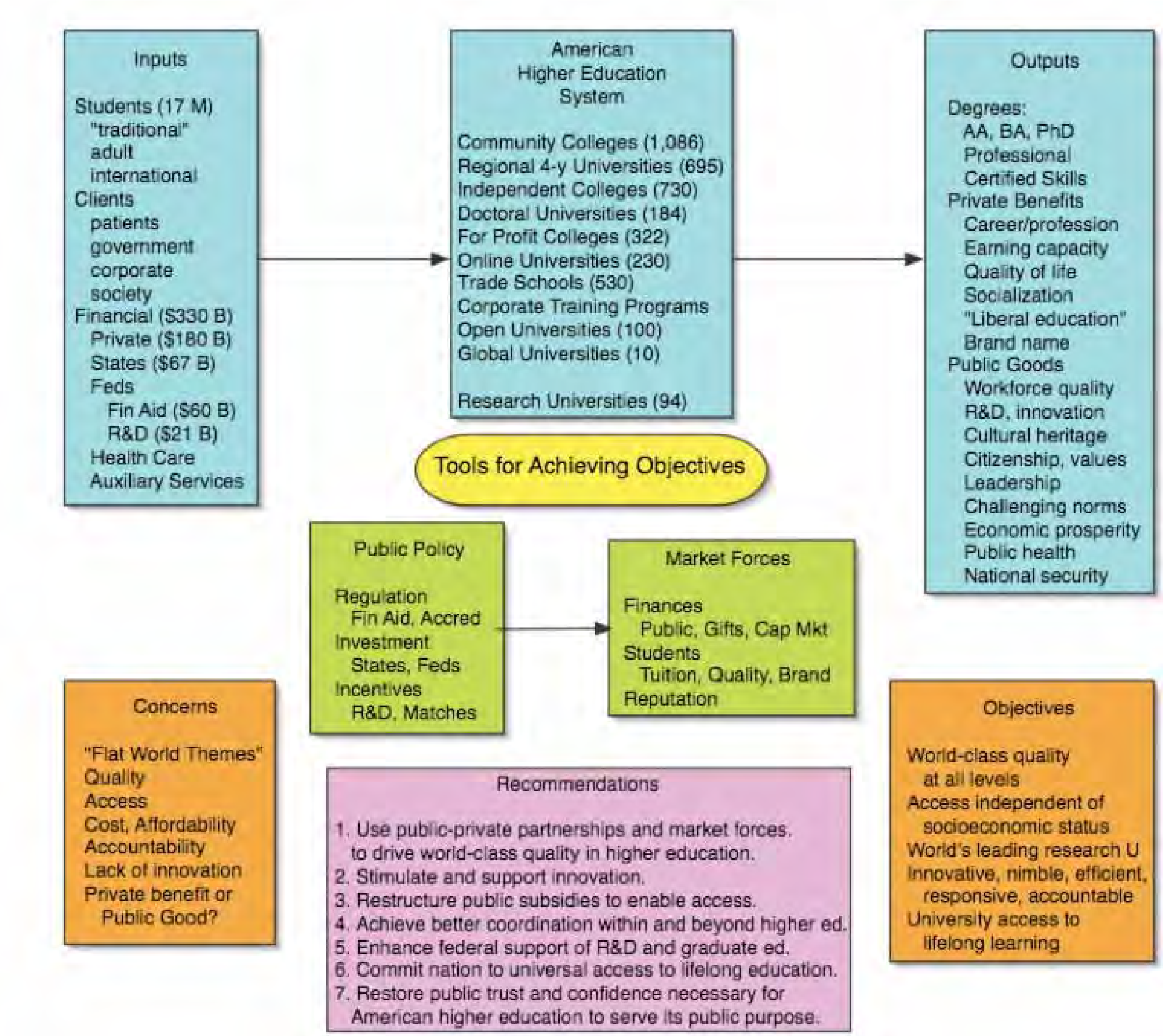
In recent years, numerous studies sponsored by government, business, foundations, the national academies, and the higher education community have suggested that the past attainments of American higher education may have led our nation to unwarranted complacency about its future. Of particular importance here was the National Commission on the Future of Higher Education, launched in 2005 to examine issues such as the access, affordability, accountability, and quality of our colleges and universities. (Miller, 2006) This unusually broad commission–comprised of members from business, government, foundations, and higher education–concluded that "American higher education has become what, in the business world would be called a mature enterprise: increasingly risk-averse, at times self-satisfied, and unduly expensive. It is an enterprise that has yet to address the fundamental issues of how academic programs and institutions must be transformed to serve the changing educational needs of a knowledge economy. It has yet to successfully confront the impact of globalization, rapidly evolving technologies, an increasingly diverse and aging population, and an evolving marketplace characterized by new needs and new paradigms."

More specifically, the Commission raised two areas of particular concern about American higher education: social justice and global competitiveness. Too few Americans prepare for, participate in, and complete higher education. Notwithstanding the nation's egalitarian principles, there is ample evidence that qualified young people from families of modest means are far less likely to go to college than their affluent peers with similar qualifications. America's higher-education financing system is increasingly dysfunctional. Government subsidies are declining; tuition is rising; and cost per student is increasing faster than inflation or family income.

The U.S. Commission on the Future of Higher Education with Secretary Margaret Spellings

Furthermore, at a time when the United States needs to be increasing the quality of learning outcomes and the economic value of a college education, there are disturbing signs that suggest higher education is moving in the opposite direction. Numerous recent studies suggest that today's American college students are not really learning what they need to learn. (Bok, 2006) As a result, the continued ability of American post-secondary institutions to produce informed and skilled citizens who are able to lead and compete in the 21st century global marketplace may soon be in question. Furthermore, the decline of public investment in research and graduate education threatens to erode the capacity of America's research universities to produce new the knowledge necessary for innovation.

The Commission issued a series of sweeping recommendations to better align higher education with the needs of the nation, including 1) reaffirming America's commitment to provide all students with the oppor-




Aligning higher education with national and global needs

tunity to pursue post-secondary education; 2) restructuring financial student aid programs to focus upon the needs of lower income and minority students; 3) demanding transparency, accountability, and commitment to public purpose in the operation of our universities; 4) adopting a culture of continuous innovation and quality improvement in higher education; 5) greatly increasing investment in key strategic areas such as science, engineering, medicine, and other knowledge-intensive professions essential to global competitiveness; and 6) ensuring that all citizens have access to high quality educational, learning, and training opportunities throughout their lives. A series of actions has been launched by government at the federal and state levels along with colleges and universities to implement these recommendations over the next several years.

In a global, knowledge-driven economy, technological innovation–the transformation of new knowledge into products, processes, and services of value to society–is critical to competitiveness, long-term productivity growth, an improved quality of life, and national security. It is certainly true that many of the characteristics of our nation that have made the United States such a leader in innovation and economic renewal remain strong: a dynamic free society that is continually renewed through immigration; the quality of American intellectual property protection and the most flexible labor laws in the world, the best regulated and most efficient capital markets in the world for taking new ideas and turning them into products and services, open trade and open borders (at least relative to most other nations), and universities and research laboratories that are the envy of the world. Yet today, many nations are investing heavily in the foundations of modern innovation systems, while the United States has failed to give such investments the priority they deserve in recent years. Well-documented and disturbing trends include: skewing of the nation's research priorities away from engineering and physical sciences and toward the life sciences; erosion of the engineering research infrastructure; a relative decline in the interest and aptitude of American students for pursuing education and training in engineering and other technical fields; and growing uncertainty about our ability to attract and retain gifted science and engineering students from abroad at a time when foreign nationals constitute a large and productive fraction of the U.S. R&D workforce. (Augustine, 2006: Duderstadt, 2005)

These concerns raised both by industry and the National Academies have finally stimulated the federal government to launch a very major effort, the American Competitiveness Initiative, aimed at sustaining U.S. capacity for innovation and entrepreneurial activities. (OSTP, 2006) The elements of this initiative will span the next decade and involve doubling federal investment in basic research in physical science and engineering (from \$9.75 B/y to \$19.45 B/y); major investments in science and engineering education; tax policies designed to stimulate private sector in R&D; streamlining intellectual property policies; immigration policies that attract the best and brightest scientific minds from around the world; and building a business environment that stimulates and encourages entrepreneurship through free and flexible labor, capital, and product markets that rapidly diffuse new productive technologies.

## Emerging Opportunities

The information and communications technologies enabling the global knowledge economy–so-called cyberinfrastructure (the current term used to describe hardware, software, people, organizations, and policies) evolve exponentially, doubling in power for a given cost every year or so, amounting to a staggering increase in capacity of 100 to 1,000 fold every decade. It is becoming increasingly clear that we are approaching an inflection point in the potential of these technologies to radically transform knowledge work. To quote Arden Bement, Director of the U.S. National Science Foundation, "We are entering a second revolution in information technology, one that may well usher in a new technological age that will dwarf, in sheer transformational scope and power, anything we have yet experienced in the current information age." (Bement, 2007)

Many leaders, both inside and outside the academy, believe that these forces of change will so transform our educational institutions–schools, colleges, universities, learning networks–over the next generation as to be unrecognizable within our current understandings and perspectives. (Duderstadt, 2005; Brown, 2006) Let me illustrate with several possibilities:

The Global University: The emergence of a global knowledge economy is driven not only by pervasive transportation, information, and communications technologies but also by a radically new system for creating wealth that depends upon the creation and application of new knowledge and hence upon advanced education, research, innovation, and entrepreneurial activities. There is a strong sense that higher education is similarly in the early stages of globalization, through the efforts of an increasing number of established universities to compete in the global marketplace for students, faculty, and resources; through the rapid growth in international partnerships among universities; and through for-profit organizations (e.g., Apollo, Laureate) that seek to expand through acquisition into global enterprises. New types of universities may appear that increasingly define their purpose beyond regional or national priorities to address global needs such as health, environmental sustainability, and international development–what one might call "universities in the world and of the world".

Lifelong Learning: Today the shelf life of education provided early in one's life, whether K-12 or higher education, is shrinking rapidly in face of the explosion of knowledge in many fields. Furthermore, longer life expectancies and lengthening working careers create additional needs to refresh one's knowledge and skills through. Hence, an increasing number of nations are setting the ambitious goal of providing their citizens with pervasive, lifelong learning opportunities. Of course, this will require not only a very considerable transformation and expansion of the existing post-secondary education enterprise but also entirely new paradigms for the conduct, organization, financing, leadership, and governance of higher education. Yet, if successful, it could also create true societies of learning, in which the sustained development of knowledge and human capital become the key paths to economic prosperity, national security, and social welfare.

The Meta University: Some of the most interesting activities in higher education today involve an extension of the philosophy of open source software development to open up opportunities for learning and scholarship to the world by putting previously restricted knowledge into the public domain and inviting others to join both in its use and development. MIT led the way with its OpenCourseWare (OCW) initiative, placing the digital assets supporting almost 1,800 courses in the public domain on the Internet for the world to use. Today over 150 universities have adopted the OCW paradigm to distribute their own learning assets to the world. (Vest, 2006) Furthermore, a number of universities and corporations have joined together to develop open-source middleware to support the instructional and scholarly activities of higher education, already used by several hundred universities around the world. (Sakai Project, 2006; Moodle, 2006) Perhaps the most exciting–and controversial–effort is the Google print library project in which a number of leading universities have joined together with Google to digitize a substantial portion of their library holdings, making these available for full-text searches using Google's powerful Internet search engines. (Google, 2006) For example, Michigan expects Google to complete the scanning of its entire 7.8 million volume library by 2010. While there are still many copyright issues that need to be worked through, it is our hope that we will be able to provide full access to a significant fraction of this material to scholars and students throughout the world. When combined with the holdings of the other Google book scan members–now roughly a dozen of the world's leading libraries–the potential of this project amounts to providing full-text search access (and eventually perhaps direct online text access) to over half of the estimated books in the world today–in over 400 languages.

Open source, open content, open learning, and other "open" technologies become the scaffolding on which to build truly global universities–what Vest terms the "meta" university. (Vest, 2006) As he observes, "the incredibly large scale of education world wide; the huge diversity of cultural, political, and economic contexts; and the distribution of public and private financial resources to devote to education are too great." Instead Vest suggests that "through the array of open paradigms, we are seeing the early emergence of a Meta University – a transcendent, accessible, empowering, dynamic, communally-constructed framework of open materials and platforms on which much of higher education world wide can be constructed or enhanced."

Universal Access to Knowledge and Learning: Imagine what might be possible if all of these pieces could be pulled together, i.e., Internet-based access to all recorded (and then digitized) human knowledge augmented by powerful search engines, open source software (SAKAI), learning resources (OCW), open learning philosophies (open universities), new collaboratively developed tools (Wikipedia II, Web 2.0); and ubiquitous information and communications technology (e.g., Negroponte's $100 laptop computer or, more likely, advanced cell phone technology). In the near future it could be possible that anyone with even a modest Internet or cellular phone connection has access to all the recorded knowledge of our civilization along with ubiquitous learning opportunities. Imagine still further the linking together of billions of people with limitless access to knowledge and learning tools enabled by a rapidly evolving scaffolding of cyberinfrastructure increasing in power one-hundred to one thousand-fold every decade. In fact, we may be on the threshold of the emergence of a new form of civilization, as billions of world citizens interact together, unconstrained by today's monopolies on knowledge or learning opportunities. (Atkins, 2007; Kelly, 2006)

Perhaps this, then, is the most exciting vision for the truly global university, no longer constrained by space, time, monopoly, or archaic laws, but rather responsive to the needs of a global, knowledge society and unleashed by technology to empower and serve all of humankind.

## Universities in and of the World

Many of our leading universities have evolved over time from regional or state universities to, in effect, national universities. Because of their service role in areas such as agriculture and economic development, some universities (particularly land-grant institutions) have gone even beyond this to develop a decidedly international character. Furthermore, the American research university dominates much of the world's scholarship and research, currently enrolling over 450,000 international students and attracting faculty from throughout the world. In view of this global character, some suggest that we may soon see the emergence of truly global universities that not only compete in the global market place for students, faculty, and resources but are increasingly willing to define their public purpose in terms of global needs and priorities such as environmental sustainability, public health, wealth disparities, poverty, and conflict. Such "universities in the world and of the world" might form through consortia of existing institutions (e.g., the U.K.'s Open University), new paradigms, or perhaps even existing institutions that evolve beyond the public agenda or influence of their region or nation-state to assume a truly global character. (Weber, 2008)

Lou Anna Simon, president of Michigan State University, one of the nation's earliest land-grant universities, coins the term "world grant university" to describe an extension of the principles inherent in the land-grant tradition adapted to address the global challenges of the twenty-first century and beyond. Such institutions would not be "granted" access to the world in the sense that states were granted tracts of land by the Morrill Act as a resource to support the establishment of land-grant institutions in the United States. Rather, the "world grant" ideal recognizes that fundamental issues unfolding in one's own backyard link directly to challenges occurring throughout the nation and the world. It not only recognizes this seamless connection but also actively grants to the world a deeply ingrained commitment to access and utilization of the cutting-edge knowledge required to address these challenges.

The evolution of a world culture over the next century could lead to the establishment of several world universities (Europe, Asia, Africa, and Latin America) as the focal point for certain sorts of study of international order—political, cultural, economic, and technological. Since the genius of higher education in America is the research university, perhaps these are the institutions destined to play this role for North America.

As *The Economist* notes, "The most significant development in higher education is the emergence of a super-league of global universities. The great universities of the 20th century were shaped by nationalism; the great universities of today are being shaped by globalization. The emerging global university is set to be one of the transformative institutions of the current era. All it needs is to be allowed to flourish."

## Further Studies

The Glion Colloquium has established itself as an influential resource in addressing both the challenges and responsibilities of the world's research universities. Every two years the Glion Colloquium provides a forum for research university leaders to join leaders from business and government to consider together the role that the world's leading universities should play in addressing the great challenges and opportunities of our times. These activities, consisting of papers prepared by participants prior to three days of intense discussions in Glion-above-Montreux, Switzerland, are captured in subsequent books given wide circulation throughout the world.

During the past 16 years, over 200 leaders of higher education, business, and government agencies have participated in the Glion Colloquium to consider topics such as the rapidly changing nature of research universities, university governance, the interaction between universities and society, collaboration between universities and business, the globalization of higher education, and how universities prepare to address the changes characterizing our times. The papers presented and associated discussions at each colloquium have subsequently been published in a series of books available through publishers or downloadable in full-text format on the Glion Colloquium website at http://www.glion.org.

Earlier conferences have considered the many glob-



The Glion Colloquium on the future of the research university al challenges requiring both the human and intellectual contributions of universities, e.g., global sustainability as the activities of humankind threaten the fragile balance of our planet; the widening gaps in prosperity, health, and quality of life characterizing developed, developing, and underdeveloped regions; the accelerating pace and impact of new technologies; and the stability of the global economy in the face of questionable business practices, government policies, and public priorities.

## References

### Glion Colloquia

Duderstadt, James J. and Luc E. Weber, Eds, *Reinventing the Research University* (London: Economica, 2004) 254 pp.

Weber, Luc and James Duderstadt, eds., *Universities and Business: Partnering for the Knowledge Economy*, V Glion Colloquium (Paris: Economica: 2006)

Weber, Luc and James Duderstadt, eds., *The Globalization of Higher Education*, VI Glion Colloquium (Paris: Economica, 2008)

Weber, Luc and James Duderstadt, eds., *University Research for Innovation*, VII Glion Colloquium (Paris: Economica, 2010)

Weber, Luc and James Duderstadt, eds., *Global Sustainability and the Role of Universities*, VIII Glion Colloquium (Paris: Economica, 2012)

Weber, Luc and James J. Duderstadt, *Preparing Universities for an Era of Change*, IX Glion Colloquium (Paris: Economica, 2013)

Weber, Luc and James J. Duderstadt, *Balancing External Responsibilities with University Priorities and Constraints*, X Glion Colloquium (Paris, Economica, 2015)

### Glion Papers

Duderstadt, James J., "The 21st Century University: A Tale of Two Futures," in Challenges Facing Higher Education at the Millennium, Edited by Werner Z. Hirsch and Luc E. Weber (American Council on Education/Oryx Press, Phoenix, 1999) pp. 37-55

Duderstadt, James J., "Fire, Ready, Aim! University Decision Making During an Era of Rapid Change", The Glion II Colloquium, Del Mar, California (2000); also in Governance in Higher Education: The University in a State of Flux, Edited by Werner Z. Hirsch and Luc E. Weber (Economica, London, 2001) pp. 26 – 51.

Duderstadt, James J. "The Future of the University in the Digital Age", in And the Walls Came Tumbling Down: The Glion III Conference, edited by Werner Z. Hirsch and Luc E. Weber (Economica, London, 2002)

Duderstadt, James J. and Robert Zemsky, "Reinventing the University: An American Perspective", in Reinventing the University,

Duderstadt, James J., "University-Industry-Government Partnerships for a 21st Century Global, Knowledge-Driven Economy: An American Perspective", Universities and Business: Partnering for the Knowledge Economy, Glion V Conference (Econometrica: Paris, 2006) pp. 19-29

Duderstadt, James J., "Higher Education in the 21st Century: Global Imperatives, Regional Challenges, National Responsibilities, and Emerging Opportunities", in The Globalization of Higher Education, VI Glion Colloquium (Paris: Economica, 2008)

Duderstadt, James J., "New University Paradigms for Technological Innovation", in Glion VII Colloquium (Paris: Economica, 2009)

Duderstadt, James J., "Global Sustainability: Timescales, Magnitudes, Paradigm Shifts, and Black Swans, VIII Glion Colloquium (Paris: Economica, 2011

Duderstadt, James J., "Research Universities and the Future of America: A Study by the National Academies of the United States", IX Glion Colloquium (Paris: Economica, 2013)

Duderstadt, James J., "The Impact of Technology on Discovery and Learning in Research Universities" , IX Glion Colloquium (Paris: Economica, 2013)

# Chapter 20

# Change Agents

## The Millennium Project

The Millennium Project at the University of Michigan is a research center engaged in both the study and creation of the future through over-the-horizon technologies. Located in the Duderstadt Center, the Millennium Project provides a platform for exploring the impact of advanced technology on social institutions, ranging from nation-states to governments and industry to the university itself. In some ways, the Millennium Project is the analog to a corporate R&D laboratory, an incubation center, where new paradigms can be developed and tested. Rather than being simply a "think-tank", where ideas are generated and studied, the Millennium Project is a "do-tank", where ideas lead to the actual creation of working models or prototypes to explore possible futures.

The Millennium Project

The Millennium Project also serves as a platform for an array of activities associated with my role as President Emeritus and University Professor of Science and Engineering, an appointment that allows me to teach, participate in scholarship, and stimulate activities throughout the University. During its first several years, the Millennium Project provided a platform for the creation of the State of Michigan's first virtual university, the Michigan Virtual Automotive College (which I served as startup president) evolving later into the Michigan Virtual University. It also provided support for an array of instructional and research activities concerning the future of the university, involving several UM schools and colleges (LS&A, Public Policy, Engineering, Education, Information, Residential College) as well as external organizations (National Academies, National Center for Postsecondary Improvement, National Science Foundation, and the One Dupont Circle group of national education organizations), including my chairing several major national studies (e.g., the NAS study of the Impact of Information Technology on the Future of the Research University and various COSEPUP studies on federal research policy). It provided as well a platform for my continued involvement in scientific work (e.g., chairing the Nuclear Energy Research Advisory Committee of the Department of Energy and various NSF projects).

In more recent years, the Millennium Project has been predominantly supported from external funding (aside from $50,000 per year of flexible funding from the Provost and the support of my base appointment as Emeritus President). In particular, we have had a major grant from the Atlantic Philanthropies Foundation ($890,000) and several grants from the National Science Foundation (totaling $510,000) that have enabled us to work on several projects of particular interest (e.g., developing regional "roadmapping" strategies for the implementation of technology in education and devel-

The two of us at the Millennium Project

oping new visions of engineering education, research, and practice). We have also attracted grants from non-profit foundations to support new University activities (e.g., $610,000 from the Dow Foundation to support postdoctoral students in the new Science, Technology, and Public Policy). Furthermore, several of my external activities have been supported by additional grants channeled through the National Academies or other organizations (e.g., the IT Forum, the COSEPUP Committee on Federal Science and Technology Policy, and the Great Lakes Regional Economic Development project).

## Major Projects

### The Impact of Exponentiating Technologies on Society

The Millennium Project has been heavily involved in activities exploring the impact of disruptive technologies such as info-nano-bio technology that evolve exponentially (e.g., Moore's Law). Working through the National Academies, we have led a major effort (the IT Forum) to assess the impact of information and communications technologies on knowledge-intensive organizations such as research universities, corporate R&D laboratories, and national laboratories. Many of these activities will continue through the National Science Foundation and other federal agencies with Dan Atkin's appointment as first director of NSF's new cyberinfrastructure division and my role as chair of the NSF Cyberinfrastructure Advisory Committee.

### The Future of the University

The Millennium Project continues to be actively involved in studies concerning the future of higher education in general and the research university in particular. These have been coordinated with both national efforts (National Academies, ACE, AAU, NASULGC, AGB, Educause), international groups (the Glion Colloquium, OECD), and regional efforts (e.g., Michigan, Ohio, North Carolina, Texas, California, Missouri). Of particular note here are my roles as a member of both the Secretary of Education's Commission on the Future of Higher Education (the Spellings Commission) and the Association of Governing Boards' Task Force on the State of the University Presidency.

### National Science Policy

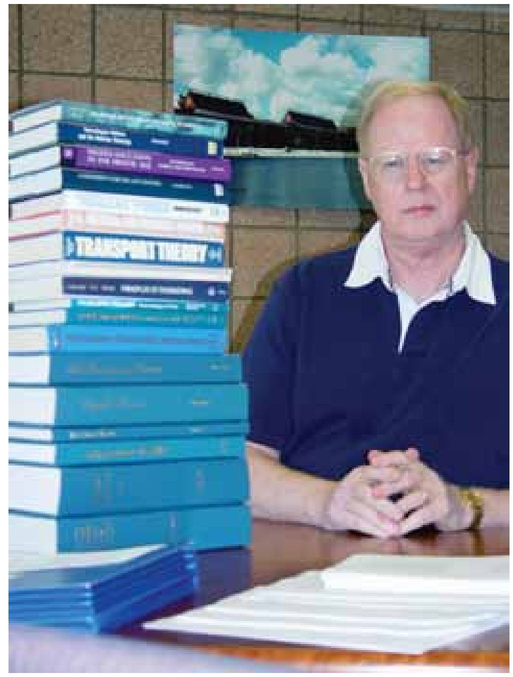
I continue to be heavily involved in national science and technology policy. In particular, during the past year I have chaired a major blue ribbon study by the National Academy of Engineering concerning the federal investment necessary to sustain the nation's technological leadership (a precursor to the "Gathering Storm" report and the American Competitiveness Initiative); a subcommittee of the National Academy's Committee on Science, Engineering, and Public Policy concerned with measuring performance in basic research and working closely with the Office of Management and Budget; and serving on the guidance committees for studies of Interdisciplinary Research and Major Scientific Facilities.

UM Science, Technology, and Public Policy

We have made very considerable progress in building the new Science, Technology, and Public Policy program, centered in the Ford School but involving students and faculty from across the University. This spring the Rackham Executive Board approved the offering of our new STPP graduate certificate program, based on a five-course sequence developed over the past two years. We have received a $610,000 grant from the Dow Foundation to support a STPP postdoctoral program over the next five years, which will add to our capacity to expand both instructional and research activities (including both the introduction of an undergraduate course and Washington-based internships). We are now seeking major endowment through the Michigan Difference Campaign to fund a senior faculty chair in STPP. (I will continue to serve as co-director of this program until another senior faculty member can be recruited.)

University of Michigan Energy Research Initiatives

After serving the past two years as chair of both a committee exploring major energy research activities as well as the executive committee of the Michigan Memorial Phoenix Project, I have merged these committees into a university-wide Michigan Energy Research Council. The first task of this new body has been to develop a plan for creating the Phoenix Memorial Energy Institute as an umbrella organization to coordinate and promote the University's energy research activities (already conducted at a level of $35 million per year). Working closely with VPR Forrest, a multiple-year plan has been developed for building upon the renovated Phoenix Memorial Laboratory and a combination of state, federal, and private support to position the University as a leader in multidisciplinary research in energy sciences, applications, and policy, with particular emphasis on transportation applications.



A growing number of Milproj books and reports

Regional Strategies for a Global, Knowledge-Driven Society

Our regional economic development studies aimed at developing strategies for building the workforce and knowledge infrastructure necessary to complete in a global, knowledge-driven society and culminating in The Michigan Roadmap, has triggered a great deal of interest not only within Michigan but in other states and nations. A broader activity involving the multiple-state Great Lakes region is moving ahead, working with the Brookings Institution. There has been interest expressed in such road-mapping efforts at the international level (Ontario, OECD, and the EU).

The daVinci Project: Creativity, Invention, and Innovation

The North Campus of the University has a formidable concentration of academic programs characterized by the common intellectual activities of creativity, invention, and innovation (e.g., art, architecture, music, engineering, information technology, and design), along with unique commons facilities such as the Duderstadt Center, the Chrysler Center, and the Pierpont Commons. The presence of the Walgreen Center for


Activities in the Millennium Project

Performing Arts will significantly enhance the character of this academic constellation, once referred to by the North Campus deans as the Renaissance Campus.

With the growing priority of the nation given to innovation as the key competency required for economic prosperity and national security in a "flat world", it seems natural to undertake a major effort to better integrate and support joint efforts among these academic units. The Millennium Project continues to support multidisciplinary student innovation projects (Project Inspire).

A Society of Learning

The emerging "perfect storm" of globalization, knowledge economies, demographics, and disruptive technologies has stimulated a growing recognition of the critical importance of lifelong learning in securing economic prosperity, national security, and social well-being. In today's "flat world" (a la Friedman), democratic societies–and state and federal governments–must accept the responsibility to provide their citizens with the educational and training opportunities they need, throughout their lives, whenever, wherever, and however they need it, at high quality and at affordable costs. This led to a series of projects at the state, federal, and international level that have been discussed elsewhere in this compendium.

## The Duderstadt Center

"Open to all those who dare to invent the future…

*For students, faculty, staff, and even our far-flung community of alumni, the Media Union offers a radically new environment for learning, teaching, and performing.*

*Both a physical commons for the North Campus and a virtual commons for the entire campus–open twenty-four hours a day, seven days a week–the Media Union will initially house:*

*An on-line library of the future*
*A laboratory for virtual reality*
*Interactive multi-media classrooms*
*High-tech theater and performance spaces*
*Cutting-edge design and innovation studios*

*But the most important part of this project is its unpredictability. Creative people will continually reshape its mission and determine its impact."*

(1996 Dedication Brochure for the Media Union)

The opening of the Media Union in 1996 was a significant and tangible commitment by the University of Michigan, in partnership with the State of Michigan, to provide all members of the University learning community free access to some of the most sophisticated and transformational tools of the emerging digital revolution. Conceived as a model for the Library of the Future, the building architect for the Media Union project captured the challenge of creating a physical environment to meet needs when we cannot anticipate the changes still to come as "…designing a building full of unknowns."

While the Media Union (aka Duderstadt Center or DC) was sometimes portrayed as a library for the University's North Campus, in reality the design team of deans, faculty, and staff responsible for the design of the new facility envisioned it as more akin to the MIT Media Lab for students and faculty of the North Campus academic programs. It was designed as a high-tech collection of studios, laboratories, workshops, performance venues and gathering and study space for students. Its original program statement in 1993 (see Appendix A) portrayed it as an Internet portal to the world (since the Internet was still rather new at that time). Although it was designed to provide space for the library collections of the College of Engineering and Schools of Art and Architecture, its function as a "traditional" book-based library was never a major part of the vision. Instead it was a place intended for collaboration and innovation in teaching and learning, a place where students, faculty, and staff could access a technology-rich environment, a place open to all "who dared to invent the future".

That building full of unknowns has in the last 15 years become the home for a large and evolving collection of new information and communications technologies far beyond the resources of any one school or college to acquire and maintain. As part of a top research university library, the Media Union's collection of digital assets and resources requires constant renewal with

The Duderstadt Center

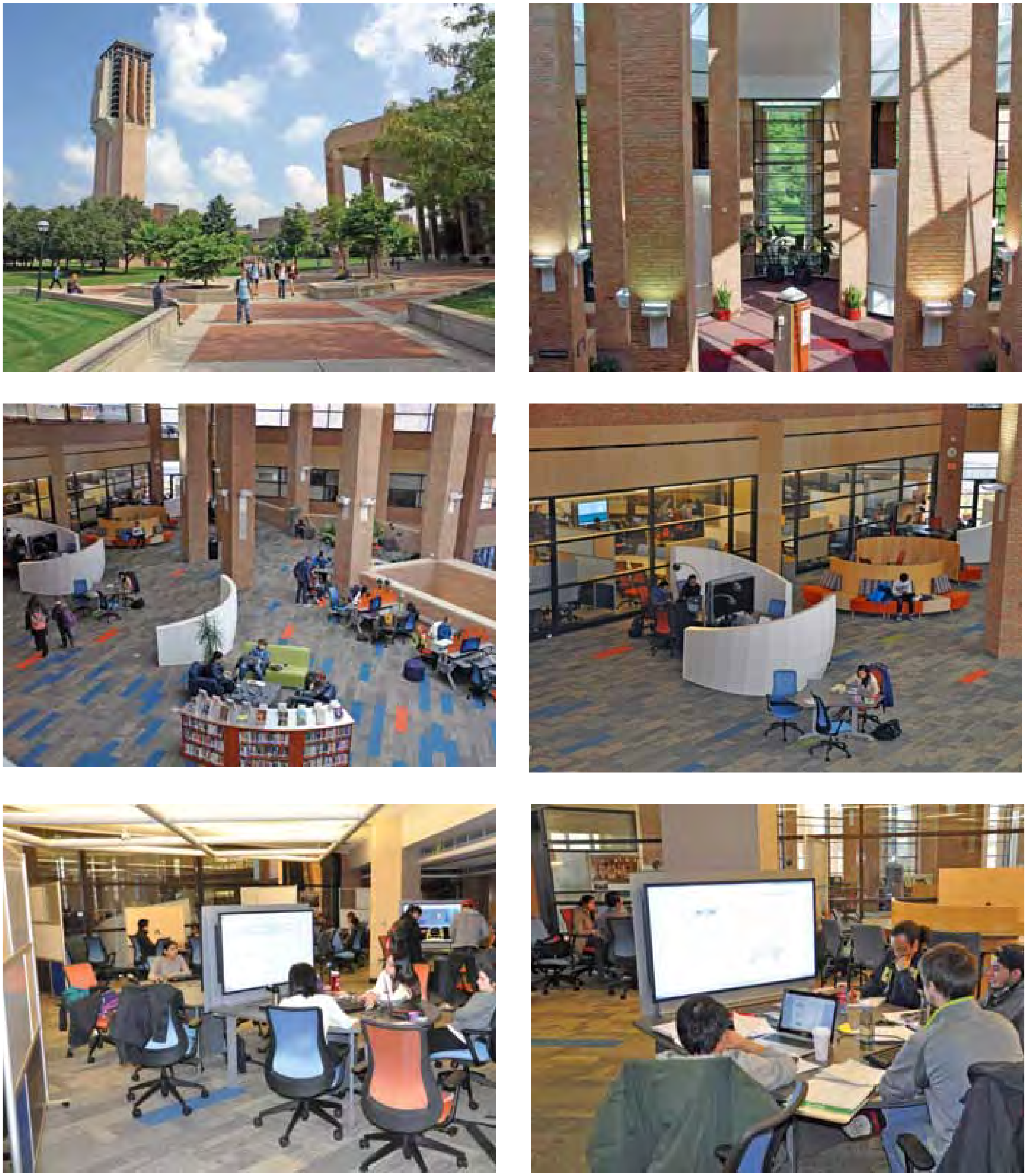
the latest versions of software and hardware, and an expert team of professionals who enable U-M users to get up-to-speed and use them productively for innovative research, teaching and learning. Rationalizing significant investments in cutting-edge resources by enabling free access to a shared, expertly-supported collection of assets has enabled a widespread culture of innovation in digital technologies at the U-M. Students and faculty are free both to envision and to lead, hands-on, change in disciplines being transformed by the digital revolution – from engineering, the design arts and medicine, to economics and government.

Today the Media Union (aka Duderstadt Center or DC) has become one of the most active learning spaces in the University, providing thousands of students with 7x24 hour access to rich resources including libraries, advanced technology, workshops, performance venues, and high quality study and community gathering spaces. Yet, perhaps because of its unusually high level of student use, the DC has increasingly taken on a more operational character providing learning services based on commodity technology rather than its original vision as a source of innovation and creativity. In a sense, production has driven out much of the innovation that characterized the DC during its early years. Furthermore, while the facility has become one of most heavily used student facilities in the University as space for study, computer access, and gathering ("Meet me at the Dude!") it has lost much of the deeper engagement of faculty and graduate students characterizing its early launch with state-of-the-art technology and activities. Although many academic programs continue to view its unique faculties as absolutely critical for their activities–particularly in the performing arts–many other faculty members know it only as a welcoming place to meet colleagues for a cup of coffee and a sandwich (i.e., MUJO). It is time to refresh this successful model of shared investment and open access to the next generation of resources that will enable the U-M learning community to meet the challenge of the "new unknowns".

Hence, there is an ongoing challenge to reconsider the purpose of the DC, reaffirming much of its original vision as an innovation commons capable of providing an environment for developing, demonstrating, and providing the new paradigms of learning, discovery, and creativity enabled by rapidly evolving technologies. Ironically, although not initially intended as a traditional library, it may well be that the new vision for the center can best be framed as a generalization of the concept of the library itself, extending its services beyond the support of inquiry, discovery, and learning to provide additional resources enabling creativity, invention, innovation, and perhaps even enabling newly created ideas and products to be transferred into broader society. After all, throughout history, the library has been the place to obtain access to resources one cannot acquire on their own, objects that support inquiry and learning such as books and artifacts. This "public good" nature of the library can easily be extended to include similar institutions such as museums. Hence, it is natural to suggest that it might be generalized even further to include resources such as high-tech studios,



The dedication of the Duderstadt



Some of the unique facilities of the Duderstadt Center


Activities in the Duderstadt Center

A "word cloud" characterizing Duderstadt Center activities

workshops, performance venues, immersive environments, and gathering spaces where creative activities such as tinkering, invention, design, and innovation can occur. And, in a society increasingly dependent upon the wealth generated by new knowledge, one might even suggest that adding services that enable creative students, faculty, and staff to transfer the fruits of their creative activities into the marketplace would be appropriate.

To be sure, such a generalization of the library might be disturbing to some, since in such environments books would likely disappear "into the cloud" (as they already have for most of the students who utilize the resources of the DC today). Yet, there is already a growing sense across the campus that the time has come to invest in just such a public good.

There have been recent suggestions that just such a generalization of the library might be the best place both to develop and test new paradigms for learning and discover and then propagate these more broadly across the university. All of these goals embrace the philosophy: To know, to create, to demonstrate and to propagate.

Furthermore, the unique character of the academic programs on the University's North Campus, Music, Theater, and Dance; Art and Design; Architecture and Urban Planning; and Engineering, is the degree to which all involve disciplines heavily involved in creativity. Providing a "commons" facility, a place that supports interdisciplinary activities in "making things", responds to a growing need for these programs, as evidenced already by the emergence of new programs such as ArtsEngine, campus-wide entrepreneurial programs, and the Integrated Systems and Design programs. In fact, recapturing the original vision of the Media Union as an innovation commons or creation space where students, faculty, and staff from multiple disciplines gather to create, invent, design, and even make things reinforces the "Renaissance Campus" themes of the 1990s.

Such a generalized library would provide an extraordinary opportunity of the study of the activities of learning, discovery, and creativity themselves. Its unique facilities for inquiry, creativity, innovation, performance, and launching new ideas would provide the University with a laboratory to test, develop, and perhaps implement entirely new paradigms for learning and discovery. To this end, the Duderstadt Center (DC) is evolving:

- The DC has become an innovative center for discovery, learning, invention, innovation, demonstration, and deployment utilizing state-of-the-art technologies and facilities and assisted by expert staff. It would provide the resources to support a community engaged in the creative transition from concept to technical realization.

- It would serves as a new form of public good, an innovation commons, where students and faculty would come to work together with expert staff mentors to develop the skills and tacit learning acquired


The North Campus contains the University's disciplines based on creativity.

through studios, workshops, performance venues, and advanced facilities such as simulation and immersive environments. It would encourage experimentation, tinkering, invention, and even play as critical elements of innovation and creative design.

• It invites and enables the creation of highly interdisciplinary teams of students and faculty from various academic and professional disciplines, providing a Greek agora, where people could come to network, exchange knowledge, and create new ideas with experienced staff.

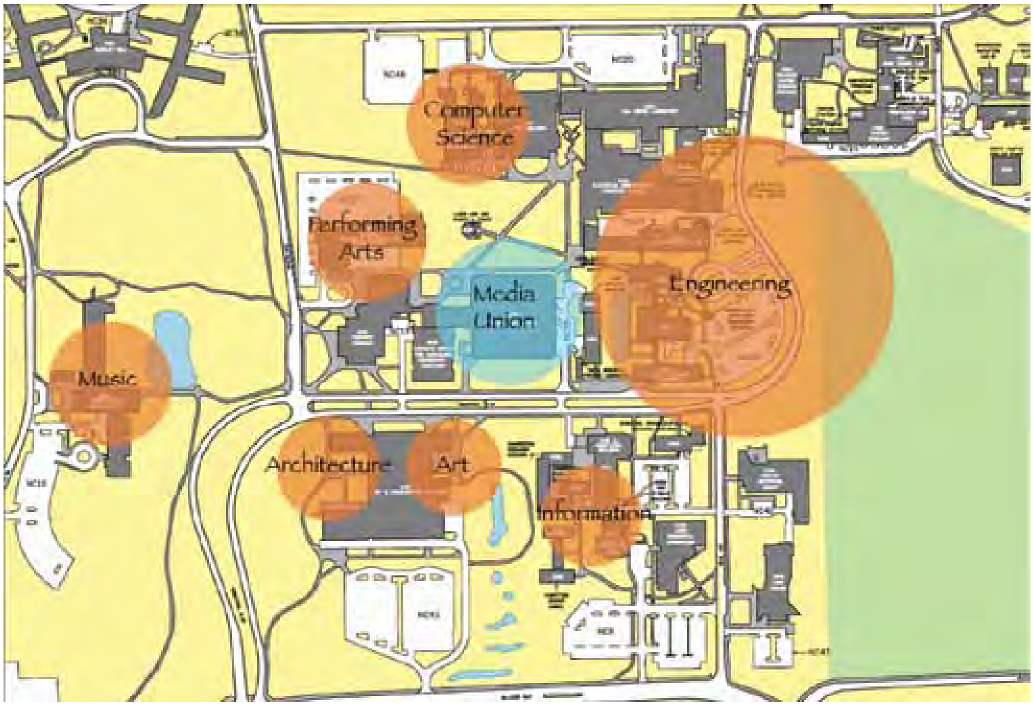
• Beyond providing a platform for learning, discovery, creation, and innovation, it has become a place for studying new paradigms for these activities and propagating them to the rest of the University. In this sense it would serve as a "skunkworks" for the future of learning and discovery, a "do tank" rather than a "think tank", where new paradigms could be created, explored, and launched to serve society.

• As such, the DC is reaffirming its original vision of serving as a change agent exploring new visions for the future of the library as a public good that provides rich resources that enable students and faculty "to know" (inquiry, discovery, learning), "to do" (skills, experience, mentors, tacit knowledge), "to become" (team building, communities of practice), "to create " (workshops, studios, tinkering, intuition, invention, innovation), and "to spinoff" (intellectual property, entrepreneurship, economic impact).

The Renaissance Campus

Largely due to historical accident, the University has located on its North Campus an unusual concentration of academic programs characterized by the common intellectual activities of creativity and innovation (e.g., art, architecture, music, theatrical arts, engineering, information technology, and design), along with very unusual commons facilities to bring together students and faculty from these disparate disciplines. This colocation of the University's creative disciplines provides the University with the opportunity to address the rapid convergence of their intellectual activities, e.g. linking the creativity of the arts with the technological innovation of engineering and architecture. It also positions the University to respond to the increasing importance attached to innovation in our society. Indeed, one might even think of the North Campus, its academic programs, faculties, and students, as the "Renaissance Campus" of the University (a designation once suggested by the North Campus deans).

Beyond the location of the various schools and colleges of the University most deeply engaged in the intellectual activity of creativity, the North Campus also has unique common spaces such as the Duderstadt Center, a true library of the future, and highly interdisciplinary academic programs stressing creative activities such as design and performance.



The Renaissance Campus

## A New Project for the Third Millennium

The Duderstadt Center (and components such as DMC, CAEN, 3D Lab, performance spaces) and its talented staff provide resources that are both unique and extraordinarily valuable for students and faculty desiring to CREATE and INNOVATE. As one student put it, "The Dude is where you go to make your dreams come true!!!"

This "creativity-innovation" commons was designed in the 1990s by a visionary team of faculty and deans of the North Campus schools–Art, Architecture, Music, Engineering, Computer Science–all characterized by the central role played by creativity and innovation in their intellectual disciplines. Indeed, this design group suggested that the North Campus should be renamed (at least informally) as the "Renaissance Campus" of the University. To this end, the facility was named the "Media Union" as both a play on the "Michigan Union" theme that serves as the center of the academic community on the Central Campus and the MIT "Media Lab", which drives much of the high-tech innovation at MIT. (The Media Union was renamed "the Duderstadt Center" in 2004, but its various components retained names suggesting their fundamental purposes.)

Although the Media Union (aka Duderstadt Center) was initially assigned to the Office of the Provost with an advisory committee of the North Campus deans, the concern about the vulnerability of such a unique facility to the vicissitudes of funding priorities motivated a shift of the reporting line of the facility to the University Library, since this provided a "safe harbor" for the evolution of the Duderstadt Center as a public good for the University similar to that provided by the library.

Yet there remain serious challenges. The capacity of the structure and philosophy of the University Libraries is increasingly unable to understand and manage the unique and valuable resources of the Duderstadt Center–its facilities, technology, and staff–thereby limiting both its evolution and access by students, faculty, and staff. In a sense, the management of the University Library regards the center as a "library of the future" restricted to library paradigms, although ironically its books are rarely used (and currently kept in high density storage taking up valuable space in the basement of the facility).

To some degree, the Duderstadt Center is being used as a stalking horse by the University Library in its effort to fund similar resources on the Central Campus. Indeed, Duderstadt Center funds and potential donors are sometimes diverted to Central Campus needs.

Although students and faculty of the North Campus units make heavy use of the Duderstadt Center (probably the most heavily used academic facility on the campus with its 7x24x52 calendar), there remains a need to better inform and align the management of North Campus academic units with the facility.

The Duderstadt Center is first and foremost a technology-intensive "creativity-innovation commons" designed to serve the unique intellectual character of the academic programs on the North Campus–the Renaissance Campus–that tend to be more focused on creating what has never before existed than the Central Campus programs than focus more on analyzing what is and what has been.

In a world increasingly dependent upon new knowledge, creativity, and innovation enabled by the rapid evolution of extraordinarily tools for creation–e.g., of physical objects, life-forms, intelligences, knowledge itself-social institutions such as universities will have to evolve rapidly to adopt to an era similar in character and change to the Renaissance of 15th and 16th century Europe.

In this sense, then, the Duderstadt Center serves more as a model of a "university of the future", enabled by the creativity of the academic programs of the North Campus, i.e., the Renaissance Campus!

To be sure, similar commons resources are needed to enable the evolution of the academic programs on the Central Campus, but these are likely to be quite different in facilities, technologies, and staffing than the Duderstadt Center. Perhaps such resources could be characterized as "a library of the future". But other possibilities should also be explored, such as the possibility of a new civilization characterized by universal access to learning and knowledge analogous to the Enlightenment movement of 18th and 19th century Europe. Here the power of the humanities, natural and social sciences, and professions could be empowered by rapidly emerging technologies (e.g., the Internet, massive digitization, "big data" and analytics) to provide "the light of learning and knowledge" to the world.

So….What to Do?

1. The activities of the Duderstadt Center should be reframed as supporting the creativity and innovation necessary for a Third Millennium world rather than simply a Third Century of the University of Michigan, drawing on the extraordinary facilities, technologies, and staffing to serve the academic programs of the Renaissance Campuses. The DC programs should be provided with adequate priority to access funding from both University and external sources. The deans of the North Campus academic units should have a more influential voice in the future of the Duderstadt Center and similar "public good" assets necessary to serve these programs.

2. While the public good nature of the University Library may continue to provide a suitable "safe harbor" for the Duderstadt Center, it must be recognize that this is clearly not a "library" and requires much a much different style of management and support. Appropriate internal and external advisory groups should be created to assure that the unique nature of the facility and its resources are adequately managed, funded, and allowed to evolve.

3. Since the Duderstadt Center is unlikely to be an appropriate model for the commons resources necessary to serve the academic programs of the Central Campus, a planning group should be formed to begin to develop new visions for such facilities, similar to the group that created the vision for the Media Union in the 1990s. This seems to be a role particularly well-suited for the School of Information, which not only has unusually strong expertise in areas such as information technology and knowledge science, but also in more traditional disciplines such as library science. In particular the School has the experience in how one manages the relationship between traditional disciplines such as library science and advanced concepts such as cyberinfrastructure.

## References

The University of Michigan's Media Union, Dedication Brochure, 1996

Duderstadt, James J. (chair), renewing and Updating the Vision for the Duderstadt Center (aka Media Union), The University of Michigan, 2012

Duderstadt, James J., The Millennium Project, in Positioning the University of Michigan for the New Century: A Case Study in University Transformation, 1999

# Chapter 21

# Science, Technology, and Public Policy

## Science, Technology, and Public Policy Program

In 2003 I was asked to chair a task force to assess whether the University of Michigan should create a science policy program, and if so, then to also provide a plan for its development. Clearly science and technology are of great importance to a broad array of social, economic, and political issues arising in an ever more technology-dependent world. If better public policies with important science and technology content are to be designed and implemented, the basic requirement is an understanding of both the technical/scientific factors and the social, economic, and political factors relevant to the policy. Furthermore, the formulation and execution of effective public policies related to the investment in scientific research and technology development and deployment is similarly important.

Here one should distinguish between the impact of scientific and technological issues on public policy in various areas, e.g., economic development, public health and environment, national security, and the development of public policies specific to science and technology, e.g. federal investment in basic research, regulatory policy, technology transfer. Although policy for science and technology does not rank high on most political agendas, most governments devote significant discretionary resources to building the capability of the national scientific enterprise. Furthermore, scientists, engineers, and physicians have a direct stake in this area of policy, which defines the conditions within which they conduct their professional lives. The STPP Task Force views both areas of "science and technology for policy" and "policy for science and technology" as appropriate for its consideration.

## The Importance of STPP Programs

Clearly science and technology are of great importance to a broad array of social, economic, and political issues arising in an ever more technology-dependent world. If better public policies with important science and technology content are to be designed and implemented, the basic requirement is an understanding of both the technical/scientific factors and the social, economic, and political factors relevant to the policy. Furthermore, the formulation and execution of effective public policies related to the investment in scientific research and technology development and deployment is similarly important.

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There is a third possible area, commonly referred to as "science, technology, and society" (STS), which concerns the study of science and technological issues by historians, sociologists, humanists, as well as interested members of the scientific community. We did not con-

The nation's sources of science and technology policy

sider these topics, both because the University already has a program in these areas, and because our concern was more with those programs more directly focused on the overlay between science / engineering, and social sciences / public policy.

The rationale for such programs generally can be captured by the following considerations:

- the mission of the university to educate an informed citizenry;
- the interest on the part of students in the interface between science and public policy;
- possible careers in areas of policy development where scientific and technological issues become important;
- the interest of faculty members in both teaching and research in STPP areas; and,
- the possibility that such a program might enhance the University's impact on state, national, and international policies.

Principal markets for graduate degrees with either STPP concentrations or certificates would include Congressional staff; federal administration offices such as OSTP, OMB and GAO, federal mission agencies such as NSF, NIH-HHS, NASA, DOE, DOD, EPA, FDA, USDA, and their state government counterparts; and a broad range of nongovernmental policy bodies such as the National Research Council (and the National Academy complex), environmental organizations, nonprofit foundations, and business and industry.

Moreover, there are nearly a million scientists and engineers engaged in national research activities, roughly 75% employed in industry, with the remainder in government agencies and universities . Many of these professionals seek additional training in policy areas relevant to the conduct and management of research and development, the distinguishing economic characteristics and consequences of science and technology, and the broad policy framework within which science and technology activities occur.

As one of the world's leading research universities, Michigan has much to contribute in the STPP area. And, indeed, its faculty members, as individuals, have been quite influential in both "policy for S&T" and "S&T for policy" arenas. The University also has a significant number of opportunities for the focus of such a program that build on existing leadership:

Environmental policy and global climate change (SNRE, LS&A, Bus)
Information technology (SOI, Law, Bus, Eng, Internet2)
Life sciences (LSI, SNRE, Health Sciences)

Energy (Phoenix Laboratory, Eng, SNRE, Bus)

Yet, the STPP Task Force does not believe that the University has had the impact either in shaping public policy or contributing to national priorities it might have with a more coordinated and prominent effort in STPP.

There are many possibilities here. At the outset, the University might consider a more sustained effort to involve those faculty members with extensive experience and involvement in national policy development in advisory roles to the University leadership or as the nucleus of efforts (such as seminars or lecture series) to stimulate broader interest in STPP issues. Building on the foundation provided by key University programs such as the Ford School, the Institute for Social Research, the Life Sciences Institute, and other academic programs related to STPP, the University might develop course sequences that would provide interested students (and perhaps faculty members and practicing professionals) with the necessary knowledge and skills to influence public policy with science and technology, perhaps recognized by a graduate certificate. Going still further, the University might develop formal STPP degree programs at the graduate level, recruiting new faculty with strong research interests in these fields, and seeking (or reallocating) the necessary resources to support such programs.

## Key Characteristics of Leading STPP Programs

Most STPP programs have been built by and enjoy the participation of experienced scientists with substantial experience in shaping federal policy. Furthermore, the core of successful STPP programs rests on faculty with sufficient training and research experience in science, mathematics, engineering, or the health sciences to bring that experience to bear on policy studies and practice. (See Appendix D for summaries of STPP programs.) As the Branscomb Report notes, "No STPP program faculty can expect to represent all the areas of scientific expertise required to take on any policy issue that might arise. The scope of issues explored will have to be matched to the capability at hand. With scientists and engineers of broad experience in both performing and managing research, however, this constraint on scope need not be severe, because scientists with broad capabilities and experience in one area can rapidly gain a sufficiently sophisticated appreciation of the technical issues even in previously unfamiliar areas to make reasonably good assessments."

One of the common themes expressed by the outside visitors (Wiesner Lecturers and others) has been the difficulty of communicating the complexities of science and technology issues to decision-makers with limited background in these areas and even more limited time. If we can assist students and faculty in ways of communicating to decision makers, this would be an important contribution to the nation while perhaps increasing the University's influence in policy circles.

Another theme stressed by several visitors was the importance of involving in such programs both science, engineering, and health sciences faculty with significant stature in the scientific community (e.g., members of the National Academies, service on major federal policy bodies) and social scientists with experience in public policy related to science-based issues.

All of the visitors stressed the importance of approaching STPP activities as highly interdisciplinary in nature, with an appropriate balance between faculty from the scientific disciplines and those from the social sciences and professions. In most cases, this cross-disciplinary nature was reflected in the joint appointments characterizing participating faculty members.

## Markets, Incentives, Constraints, and Challenges

The focus of STPP programs should be on the educational and scholarly opportunities they offer to students and faculty. Since science and technology issues weigh so heavily in many areas of social, economic, and political policy development, one could well make the case for inclusion of STPP material in the curriculum provided for the public policy programs offered by the Ford School. One of our recommendations is that an effort be launched to develop just such courses by a cross-disciplinary team of faculty from scientific and policy disciplines. These courses could serve, not only students of the Ford School, but also those studying for other social science and professional degrees, such as law, business, economics, or political science.

One could also make a case for the importance of providing graduate students in science, engineering, and the health science professions with greater understanding of public policy processes and approaches. Many of these students both have interests in these areas and are likely to find themselves in roles at the interface between scientific and professional work and policy development. Scientists, engineers, and health professionals could benefit significantly in careers in research and professional practice from a greater awareness of economics, political science, law, and other disciplines relevant to public policy. Furthermore, some of our graduate students are interested in policy careers in government or the private sector where science and technology issues become important (e.g., national security, energy, environment, economic development).

Yet here we face a serious challenge, since the academic programs of many graduate students in the social sciences and professions as well as in science and engineering–-or more specifically, their research obligations and the constraints placed upon their graduate research or teaching assistantships by faculty advisors and degree requirements-–may not accommodate such additional coursework, despite the interest of the students themselves. Part of the challenge will be to educate faculty members about the enhanced marketability of their graduate students if their educations are broadened to include policy content. Overcoming this opposition will require identifying faculty advocates in the various departments who could encourage students into the program and could negotiate with advisors who are discouraging students.

The same resistance of faculty members to graduate student participation in STPP programs could also characterize their own involvement in STPP activities. Beyond the fact that there will be a limited set of faculty members with the interest, experience, or inclination to become involved in teaching or research in the STPP area, it is also the case that the reward structure of the University works against faculty involvement in such interdisciplinary instructional programs beyond their own disciplines. Fortunately, the experience of other institutions with leading STPP programs suggests that only a small cadre of interested, experienced (and distinguished) faculty members from the scientific and professional disciplines is required for programs to be successful. On the other hand, the involvement of at least one or two highly distinguished and respected scientists seems imperative for any new program to achieve credibility and visibility on campus.

Perhaps the most serious concern of the STPP Task Force involves the challenge of obtaining the support of senior academic administrators including department chairs, deans, and executive officers. The culture of the contemporary research university suggests that resources must usually be provided to launch such interdisciplinary programs that may be of University-wide interest but perhaps not high priority for particular academic units. During a time of particularly constrained resources, this "What's in it for me?" attitude may be difficult to counter.

Nevertheless, the STPP Task Force believes that building high quality instructional and research programs in science, technology, and public policy is not only very much in the interests of the University, its faculty, and its students, but could be viewed as a responsibility of a world-class research university. Without more formal efforts in these areas, Michigan falls short of providing the human and intellectual resources it is certainly capable of directing toward state, national, and global priorities in the policy arena.

Here, a further word about resources is important. While seed resources will likely be necessary (and might even be generated from external sponsors) to launch new instructional, research, and service activities in the STPP area, of far more importance is the development of sustainable financial models for these efforts. These resource issues suggest that any University effort be staged to explore first those options requiring modest investment (e.g., evolving the Wiesner Lecture series into an ICOS-like University-wide seminar on STPP issues or developing specific courses at the undergraduate or graduate level). At the next level would be the commitment of seed resources necessary to develop and implement targeted short courses or workshops for practicing professionals that would eventually become self-sustaining (e.g., for Congressional staffers or experienced scientists from industry).

The development of a multiple-course concentration for graduate students would require a considerably larger investment, since these would require not only the ongoing support of faculty teaching and program administration, but likely as well new faculty lines.

Here one will face the difficult question as to whether such a graduate certificate program would attract new students and hence generate new tuition revenue, or whether it would compete with existing courses for the same graduate student population and resource base. While a program such as the one described here would provide benefits to students in existing degree-granting programs, it might extend their time to degree and thus limit new student enrollments.

The most resource-intensive initiatives would be those aimed at creating new degree programs at the M.S. or Ph.D. level in STPP similar to those offered at several other universities (e.g., Harvard, UC-Berkeley, CMU). As we will note later, the STPP Task Force recommends against such specific degree programs for pedagogical reasons as much as out of concern for resource requirements.

There are two additional issues of particular importance: The selection of a disciplinary home for STPP instructional programs, and the identification of academic leadership. Although interdisciplinary graduate programs such as STPP can be launched as a University-wide endeavor through an academic unit such as Rackham, over time they will only survive, much less thrive, if they have a home in a disciplinary school or college. At Michigan the logical academic unit for such efforts would appear to be the Ford School. Currently, the Ford School has a disciplinary focus on the social sciences related to public policy (although at least two faculty have interests that overlap with science policy); to initiate and house a STPP program, the Ford School must commit itself to attracting the participation of faculty from other academic and professional disciplines and may need to hire at least one faculty member who is centrally in the science policy area.

Finally, beyond ownership by a particular academic unit and the availability of adequate resources, the identification and commitment of both faculty leadership and participation presents the most significant challenge. Although the University has many faculty with both the scholarly and practical experience to contribute to a STPP program, the difficulty in enlisting the sustained faculty participation necessary for a successful instructional and research program should not be underestimated. The size and diversity of the University's faculty will pose a particular challenge to the identification of those with strong interests in and potential for participation in such a program.

Furthermore, program leadership is an equally critical issue. The experience at other institutions makes it apparent that the most successful programs have been launched and led by distinguished faculty members from the sciences with strong reputations in national policy development, e.g., Harvey Brooks (and later Lewis Branscomb) at Harvard, Granger Morgan at CMU, Wolfgang Panofsky at Stanford, John Holdren at UC Berkeley and now Harvard, Roger Revelle and Bill Nierenberg at Scripps and UCSD, and Donald Stokes at Princeton. The development of a successful STPP program at Michigan will almost certainly require similar leadership. If the University decides to proceed with the implementation of the recommendations of the STPP Task Force, it will need to move early to identify such leadership.

## Recommendations

The Science, Technology, and Public Policy (STPP) Task Force recommends that the University of Michigan begin a phased approach to launching instructional and research activities in two key areas: (1) the application of scientific and technological knowledge to improve decision-making across a broad array of public sector domains ("science for policy") and; (2) the shaping of government policies to ensure continuing progress in science and technology ("policy for science"). More specifically, we propose that the University develop instructional programs to provide disciplinary scientists (including those in traditional scientific and engineering disciplines as well as more cross-cutting fields such as medicine or public health) with a better understanding of the policy context into which science and technology often fit, and to provide social scientists (including those in traditional disciplines as well as those in professional schools such as public policy, law, and business) to better understand the relevance of science and technology to their work.

The STPP Task Force recommends that the goals of any STPP activities conducted by the University should be, in priority order:

1. To provide students and faculty members across

a broad range of academic and professional disciplines educational and research opportunities aimed at developing the knowledge and skills necessary to contribute to the development of public policy that reflects the enormous importance of science and technology in our contemporary world. In addition to providing a systematic introduction to the social sciences relevant to public policy, such instructional programs should aim at developing a deeper understanding of the nature of scientific and technological problems and opportunities, the methods used for analyzing scientific and technological issues and the limitations of those methods, and the dynamics of science and technology as they affect social, economic, and political issues at the national and international level.

2. To establish the University of Michigan as an intellectual center for research, teaching, and service at the interface of the study of science, technology, and public policy.

3. To coordinate and facilitate the ongoing involvement of University of Michigan faculty and staff members in shaping science- and technology-dependent public policy at the state, national, and international levels, both to support their own public service activities and responsibilities, and to enhance the University's contributions in these areas.

Put another way, we see the University activities in the STPP area as spanning the traditional triad of education, research, and service:

Education: Provide instructional opportunities (courses, certificate, degree programs) for graduate students, undergraduates, faculty members, and professionals.

Research: Provide opportunities for faculty and students to conduct research on key STPP areas, drawing on the strengths of existing UM activities (e.g., Ford School, SNRE, S&T activities in schools and colleges, interdisciplinary research units such as ISR and LSI, and unique assets such as Internet2 and the Zell Institute).

Service: Identify, coordinate, and support faculty public service activities in STPP with the aim of providing more such opportunities for University faculty and students and enhancing the University's contributions in the STPP area.

Intellectual Rigor

The STPP Task Force believes that any University activities in these areas should be characterized by rigorous intellectual content and methods. For example, it is clear that instructional programs in science and technology and public policy should be highly interdisciplinary. Efforts to teach students about the scientific issues underlying policy are best provided by those trained in scientific and technological disciplines. Similarly, social scientists and others who can provide the theory behind policy development and implementation (e.g., political agents vs. bureaucrats, different theories of their objectives, the role and evolution of institutions, different notions of the "public good" and how these relate to what decision-makers actually are interested in) are important contributors to STPP programs.

While all instructional efforts should be characterized by rigor, it is also clear that students from different disciplines will require somewhat different approaches. For example, teaching policy-relevant topics to science students is likely to be more straightforward than teaching science to policy students. Policy has some principles that apply to any science topic in the policy realm. In contrast, a social science student who ends up working on issues related to NIH is likely to need a very different science background than one working on NASA issues.

However, the committee believes that these different needs should not be addressed separately. Rather, it is essential to approach the effort of course development and teaching as a joint effort. We must avoid any segregation between the natural and social scientists. They will need to work together and become more familiar with each other's methods, culture, and language. To be sure, involving both science and social science faculty in each course multiplies the effort and the cost. But the real world is a non-segregated arena, and the sooner we recognize and exploit the synergism that comes from mixing the cultures, the better. A UM program that addresses these dual needs effectively could be very special.

The STPP Task Force believes that it is more important that such a program aim not at specific scientific training for social science students, but rather deepen their appreciation for how scientists think (observation, hypothesis, theory, experimentation), the nature of scientific arguments (including the ability to distinguish between good and bad arguments), and the ability to communicate and work with scientists and technologists. Conversely, science students need to understand the thought structure and language of the policy world, including the ways in which policy makers deal with many objectives and constraints in addition to science and technology Of course, such cross-disciplinary training is difficult to achieve through conventional courses alone. Some creativity will be required to develop experiences such as topic-focused workshops involving scientists and technologists with social scientists and policy students, or internships in policy roles as important components of such programs.

Here it is important to avoid envisioning the STPP curriculum at either the undergraduate or graduate level as simply cobbling together a menu of existing courses. New programs generally require new courses that have a direct focus on the program goals. While existing courses have some relevance, they usually have some irrelevance as well, and can be an inefficient, lengthy pathway forward. New courses naturally require time and thought, and that is the justification for investment of funds or release time to faculty.

The uniqueness of the proposed program, especially in comparison to STPP programs at other universities, is based on our belief that a cross-disciplinary curriculum in STPP issues should augment solid, disciplinary degree programs rather than being taught through specific STPP degree programs. Since scientists often seek to influence public policy, and policy makers often need to deal with issues in science and technology, we believe that such cross-disciplinary training will enhance the careers and influence of both groups. The Task Force further believes that all instructional programs and scholarly efforts associated with STPP activities should be infused with rigor (e.g., economic analysis, scientific justification) and an understanding of the complex forces shaping public policy where science and technology issues are important.

A Phased Approach

To this end, we recommend that the University begin in Phase I with the development of courses in science, technology, and public policy, taught through the Ford School of Public Policy by current faculty members from the scientific and public policy disciplines. Although the highest priority should be given to developing courses at the graduate level, both the interest on the part of undergraduates and the opportunities for coordination with existing or proposed interdisciplinary programs suggests that some attention also be given to undergraduate course development. In addition, we recommend that during Phase I the Vice President for Research form an advisory committee on science and technology policy, consisting of faculty members with ongoing roles in shaping national S&T policy, to assist the University in developing R&D strategies; create an ongoing database to inventory, monitor, and coordinate existing University faculty and program activities in the STPP area; and continue and possibly expand the Wiesner Lecture series into a University-wide seminar series on STPP. In Phase I, certain activities should begin in order to build a foundation for Phase II. These "early Phase II" activities include i) the identification of faculty leadership (which is absolutely crucial to the success of this endeavor) and ii) the formation of a faculty planning and implementation committee to guide and implement the development of the STPP program.

For Phase II we recommend that the University expand upon Phase I by developing a graduate course sequence, again taught through the Ford School, designed to augment existing graduate degree programs in the sciences, social sciences, and the professions to better enable those entering research, education, and professional practice to understand the role of policy in their fields, as well as to prepare those students with interests in careers that relate science and technology to policy development in the public and private sector. This will require the investment of adequate resources for program administration, and the selective hiring of new faculty with STPP interests as opportunities arise, both within the Ford School and other academic units associated with the program. We also recommend that the University consider the extension of this STPP course sequence to practicing professionals, possibly taught through an on-campus short course format (similar to the Business School's Executive Management Education program), through courses offsite in Washington, D.C., or perhaps by offering professional fellowships through a model similar to the Knight-Wallace Journalism Fellows program. In addition, we recommend the development of STPP internship opportunities for graduate students. Finally, we recommend the University make a more concerted effort to assist faculty in the identification and pursuit of sponsored research support to establish major research centers in STPP areas.

The STPP Task Force recommends that the University not attempt to launch specific STPP degree programs at the undergraduate, M.S., and Ph.D. level at this time. Although several other institutions do have such programs, the Task Force favors the use of STPP course sequences designed to augment existing degree programs, recognized with a Rackham certificate or undergraduate minor concentration. This approach not only provides students with the flexibility of a more generally recognized degree, but it better leverages the very considerable breadth and quality of the University's existing undergraduate and graduate degree programs, thereby affording a far greater number of students with the opportunities for enriching their studies with STPP training. We also believe it to be a far more timely and cost-effective approach to establishing the University as a national leader in STPP education and scholarship.

## Concluding Remarks

The STPP Task Force recommends that the University of Michigan begin a phased approach to launching educational and programs aimed at training disciplinary scientists (including both those in traditional scientific and engineering disciplines as well as more cross-cutting fields such as medicine or public health) to have a better understanding of the policy context into which science and technology often fits, and training social scientists (including both those in traditional disciplines as well as those professional schools such as public policy, law, and business) to understand the relevance of science and technology to their work. The instructional programs and scholarly efforts associated with STPP activities should be infused with a rigorous analysis and understanding of the forces shaping public policy where science and technology issues are important.

It is our belief that the phased approach recommended in this report provides a cost-effective and timely strategy that not only responds to the very considerable opportunities for the University to build world-class programs in the STPP area, but does so within the very real financial constraints likely to faced by the University for the foreseeable future. The key is to build such a program on the existing and rather considerable strengths of the University, both among the faculty, within existing degree programs in both the academic and professional disciplines, and a long traditional of cross-disciplinary instructional and scholarly activities.

The efforts to coordinate existing faculty interests, efforts, and expertise along with modest STPP course development at both the graduate and undergraduate level can begin immediately. We also believe that the effort to seek external funding could also commence rapidly. The phased approach recommended in this report seems the more realistic strategy for developing high quality STPP course sequences, taught within the Ford School and designed to augment existing graduate degrees in the sciences, social sciences, and the professions. When augmented by faculty efforts to build multidisciplinary sponsored research programs, coordinated and assisted by the central administration, this strategy could rapidly establish the University as major contributor to the production of educated graduates, research, and service contributions in science, technology, and public policy.

## Other Activities in Science Policy

Perhaps because of the experience of chairing a publicly elected university governing board, a presidentially appointed National Science Board, and numerous other boards in higher education, government, and corporations, I continued to get tapped to lead various volunteer efforts. Several of the activities are described below along with several tables and illustrations.

National Academy of Engineering
- Executive Council (member)
- Search Committee for NAE President (chair)
- National Policies for Engineering Research (chair)
- A Flexner Report for Engineering Education, Research, and Practice (chair)


UM Science, Technology, and Public Policy program

As an elected member of the National Academy of Engineering, I continue to play many roles both in the Academy governance as well in many of its studies. The most important of these concerned the future of engineering research in the United States (which led to the concept of translational research organizations now implemented with the "innovation hubs" of the Department of Energy and Department of Commerce) and a more fundamental study of the changing nature of engineering education, research, and practice.

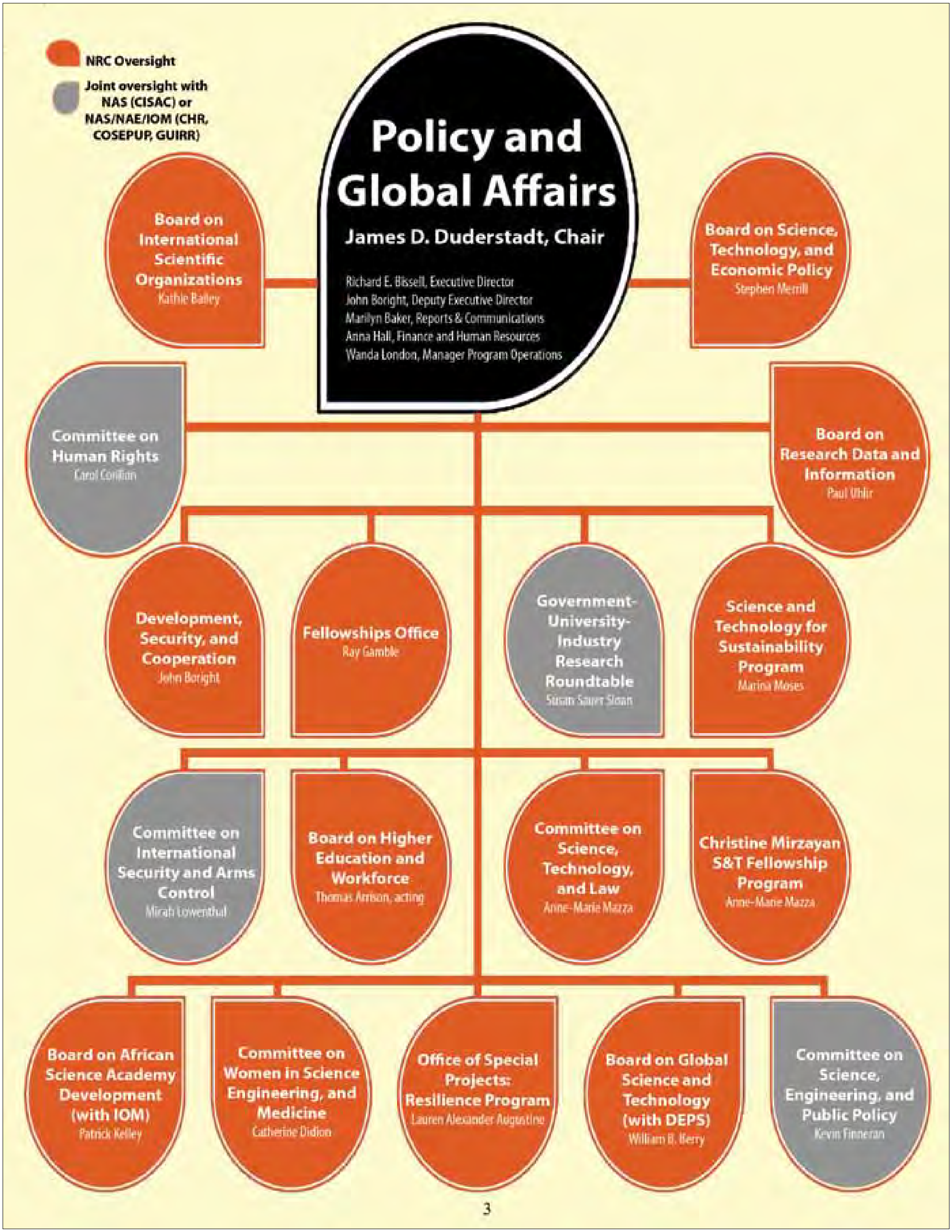
National Research Council
Governing Board
Division of Policy and Global Affairs (chair)

The National Research Council is the principal operating agency of the National Academy of Sciences, the National Academy of Engineering (NAE), and the Institute of Medicine (IOM) providing services to the government, the public, and the scientific and engineering communities. Its mission is to improve government decision making and public policy, increase public understanding, and promote the acquisition and dissemination of knowledge in matters involving science, engineering, technology, and health. Each year, more than 6,000 NAS, NAE, and IOM members and other volunteer experts serve on hundreds of study committees or oversee roundtables, workshops, cooperative research programs, or fellowship programs.

After serving in numerous roles as a member or chair of various National Academy studies, I was asked to chair the largest section of the National Research Council, the Division of Policy and Global Affairs, with an unusually broad mission of helping to improve public policy, understanding, and education in matters of science, technology, and health with regard to national strategies and resources, global affairs, workforce and the economy. The division is particularly charged to identify and build synergy among the disciplines and issue areas, and to promote interaction among science, engineering, medicine and public policy. The division includes a range of standing committees and boards concerned with the vitality of the research enterprise in the US and abroad. In that connection, the units of the division focus particularly on the interaction of key institutions central to science and technology policy, on the standing of US research around the world and cooperation with Science & Engineering bodies in other countries, on the mission and organization of federal research activities, and on the sources of future manpower and funding for research. The division consists of 17 standing committees and boards, with oversight by the Policy and Global Affairs Committee, which manages a diverse portfolio of activities. PGA produces technical and policy reports, convene workshops and conferences, collects and analyzes data, and manages fellowship competitions. It also represents the United States in international scientific organizations, assists researchers subjected to human rights violations, manages international exchanges and collaborative research grants, conducts bilateral dialogues on sensitive topics, and helps to build the capacity of partner academies in developing countries.

National Academies Committee on Science, Technology, and Public Policy
Federal Science and Technology Budget Analysis
Postdoctoral Education
Scientific Research in the States
Postdoctoral Appointments

The Committee on Science, Engineering, and Public Policy (COSEPUP is a joint unit of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine. Most of its members are current or former members of the Executive Councils of the three institutions. COSEPUP mainly conducts studies


NRC Oversight
Joint oversight with NAS (CISAC) or NAS/NAE/IOM (CHR, COSEPUP, GUIRR)
Policy and Global Affairs
James D. Duderstadt, Chair
Richard E. Bissell, Executive Director
John Boright, Deputy Executive Director
Marilyn Baker, Reports & Communications
Anna Hall, Finance and Human Resources
Wanda London, Manager Program Operations
Board on International Scientific Organizations
Kathie Bailey
Board on Science, Technology, and Economic Policy
Stephen Merrill
Committee on Human Rights
Carol Corillon
Board on Research Data and Information
Paul Uhlir
Development, Security, and Cooperation
John Boright
Fellowships Office
Ray Gamble
Government-University-Industry Research Roundtable
Susan Sauer Sloan
Science and Technology for Sustainability Program
Marina Moses
Committee on International Security and Arms Control
Mirah Lowenthal
Board on Higher Education and Workforce
Thomas Arrison, acting
Committee on Science, Technology, and Law
Anne-Marie Mazza
Christine Mirzayan S&T Fellowship Program
Anne-Marie Mazza
Board on African Science Academy Development (with IOM)
Patrick Kelley
Committee on Women in Science Engineering, and Medicine
Catherine Didion
Office of Special Projects: Resilience Program
Lauren Alexander Augustine
Board on Global Science and Technology (with DEPS)
William B. Berry
Committee on Science, Engineering, and Public Policy
Kevin Finneran

on cross-cutting issues in science and technology policy. It was chartered by the National Academies to address the concerns and requests of the President's Science Advisor, the Director of the National Science Foundation, the Chair of the National Science Board, and heads of other federal research and development departments and agencies, and the Chairs of key science and technology-related committees of the Congress. It also monitors key developments in U.S. science and technology policy for the Academies' leadership. COSEPUP studies are usually conducted by special interdisciplinary panels comprising the nation's best scientific and engineering expertise. While many studies are sponsored by government agencies, COSEPUP procedures safeguard its studies from the influence of sponsors or other outside groups.

National Academies
- Studies on Information Technology
- Scholarship in the Digital Age
- Information Technology and the Future of the Research University
- The IT Council

The National Science Foundation
- Education and Human Resources
- Advisory Committee on Cyberinfrastructure (chair)
- Strategic Planning

The Education and Human Resources Committee is one of the standing bodies of the National Science Board. After chairing this body during the 1980s, I was asked to once again become a member in recent years. The Advisory Committee for Cyberinfrastructure (ACCI) provides perspective and advice to the National Science Foundation on the Agency's plans and programmatic strategies to develop and support a state-of-the-art cyberinfrastructure that enables significant advances in all fields of science and engineering. As the former chair of the National Science Board, I am also routinely invited to participate in strategic planning sessions for the National Science Foundation.

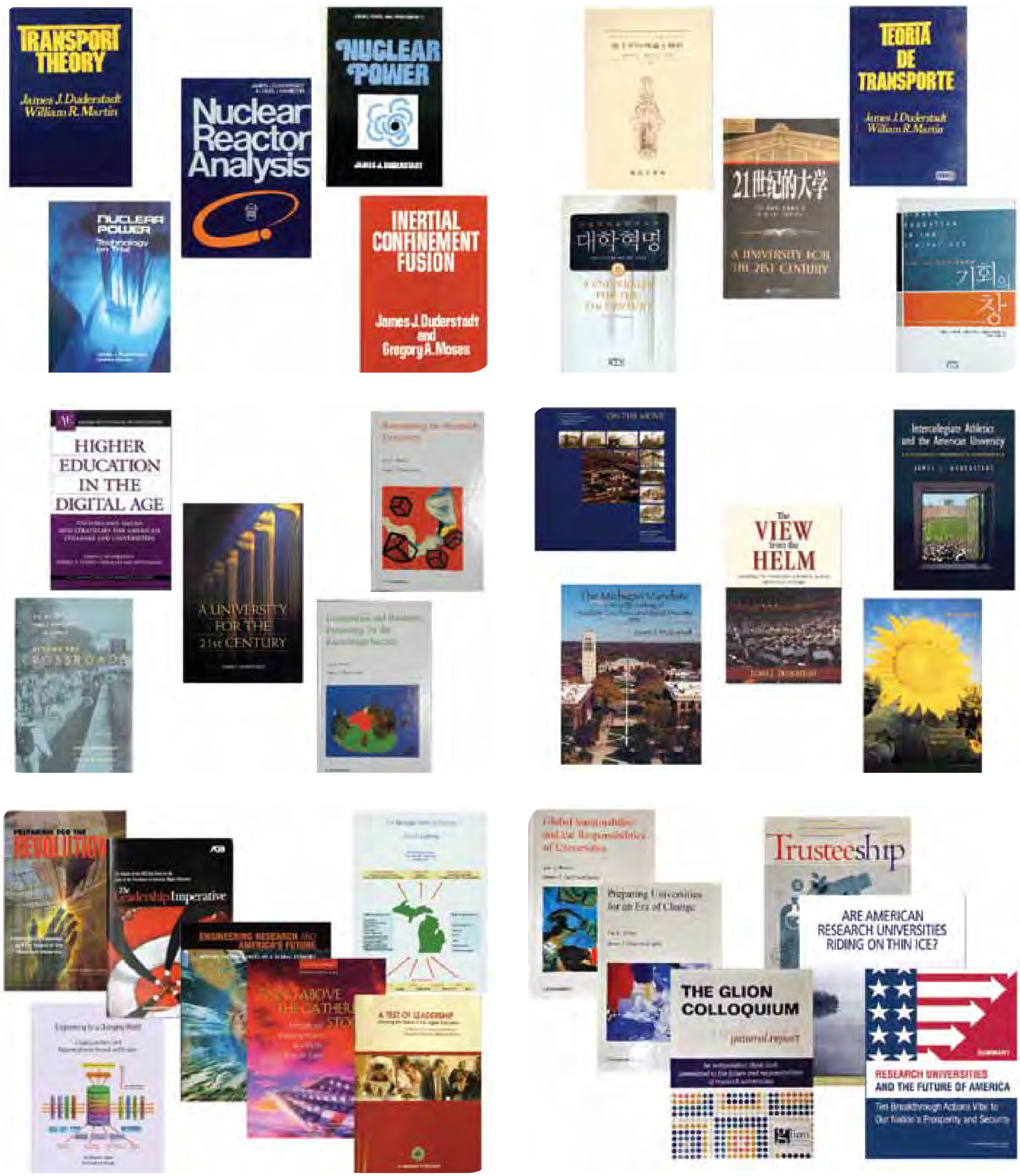
Department of Energy
- Nuclear Energy Research Advisory Committee (chair)
- Secretary of Energy's Commission on Research Futures
- Facility for Rare Isotope Beams Advisory Committee (Michigan State University)
- Consortium for Advanced Simulation of Light Water Reactors (board of directors)

The Nuclear Energy Research Advisory Committee was established in 1998 (with me as its first chair) to provide independent advice to the U.S. Department of Energy (DOE) on complex science and technical issues that arise in the planning, managing, and implementation of DOE's nuclear energy program. NERAC assists DOE by reviewing the research and development (R&D) activities of the Office of Nuclear Energy, Science and Technology (NE) and providing advice and recommendations on long range plans, priorities, and strategies to effectively address the scientific and engineering aspects of these efforts. In addition, the committee provides advice on national policy and scientific aspects on nuclear energy research issues as requested by the Secretary of Energy.

More recently, I have served on the Board of Directors of CASL, the Consortium for Advanced Simulation of Light Water Reactors, the first (and largest) of the DOE Energy Innovation Hubs recommended by our studies for the Brookings Institution.

The Glion Colloquium (co-director)

The Glion Colloquium has established itself as an influential resource in addressing both the challenges and responsibilities of the world's research universities. Every two years, the Glion Colloquium provides a "Davos-like" forum in Switzerland for research university leaders to join with leaders from business and government to consider together the role that the world's leading universities should play in addressing the great challenges and opportunities of our times and to explore together how universities, in partnership with governments, industry, and society, can contribute both to solutions of global challenges and especially as partners and leaders in change. These activities, consisting of papers prepared by participants prior to three days of intense discussions in Glion-above-Montreux, Switzerland, are captured in subsequent books given wide circulation throughout




The evolution of activities from science to education to policy can be seen in the changing nature of the books published.

the world.

Over the past 14 years, over 200 leaders of higher education, business, and government agencies have participated in the Glion activities to consider issues such as the challenges of the new millennium, the governance of universities, the increasingly interdisciplinary nature of teaching and research, the globalization of higher education, the relationship between universities and industry, the role of university research in driving innovation and ways to address the challenges of global sustainability. The publications resulting from the Glion activities are now regarded as an important resource for better aligning higher education with the needs of a rapidly changing world.

The Salzburg Seminar (session leader)

Salzburg Global Seminar is a nonprofit organization that holds seminars on topics as diverse as healthcare, education, economics, geopolitics and philanthropy. Its objective is to "challenge present and future leaders to solve issues of global concern" through seminars held at the Schloss Leopoldskron in Salzburg, Austria and in other locations throughout the world. The mission of the Salzburg Global Seminar is to challenge present and future leaders to solve issues of global concern. The Salzburg Global Seminar convenes imaginative thinkers from different cultures and institutions, organizes problem-focused initiatives, supports leadership development, and engages opinion-makers through active communication networks, all in partnership with leading institutions from around the world and across different sectors of society

Other Major Studies

The Future of Higher Education in America
(Department of Education)

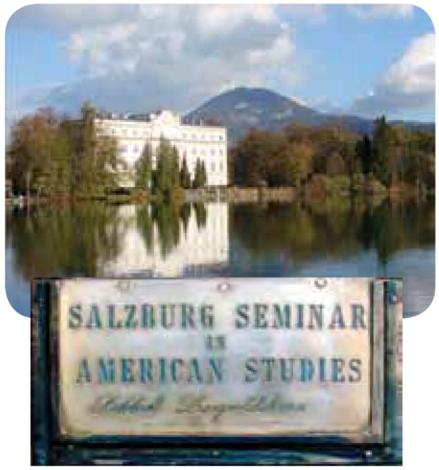
This major study, sometimes referred to as the Spellings Commission after Secretary of Education Margaret Spellings, was launched to address the themes of access, affordability, and accountability in American higher education. The Commission issued a series of sweeping recommendations to better align higher education with the needs of the nation, including 1) reaffirming America's commitment to provide all students with the opportunity to pursue postsecondary education; 2) restructuring student financial aid programs to focus upon the needs of lower income and minority students; 3) demanding transparency, accountability, and commitment to public purpose in the operation of our universities; 4) adopting a culture of continuous innovation and quality improvement in higher education; 5) greatly increasing investment in key strategic areas such as science, engineering, medicine, and other knowledge-intensive professions essential to global competitiveness; and 6) ensuring that all citizens have access to high quality educational, learning, and training opportunities throughout their lives through a national strategy to provide lifelong learning opportunities at the postsecondary level.

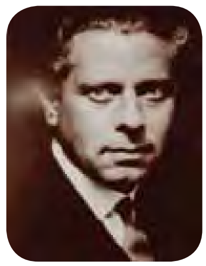
The Future of the American Research University
(National Academies)

Widely considered the best in the world, our nation's research universities today confront significant challenges and opportunities, including financial pressures, advances in technology, developments in teaching and learning, a changing demographic landscape, and increased international competition. In response to a request from Congress to examine these issues, the National Research Council empanelled a committee to undertake a study of the challenges and opportunities our nation's research universities face and the ways our nation can ensure that they continue to play a critical role in meeting national goals, particularly for prosperity and security.

The study committee provided recommendations that Congress, the federal government, state governments, research universities, and others can take to strengthen and focus the work of our nation's research universities, allowing them to continue to produce the knowledge, ideas, and talent the United States needs to be a global leader in the 21st century. It highlighted the need for strengthening and expanding the partnership among universities, government, business, and philanthropy that has been central to American prosperity and security. The study also examined trends in university finance, prospects for improving university operations, opportunities

The Glion Colloquium, Glion-above-Montreaux, Switzerland - Touring the Hadron Collider near Geneva



Max Reinhardt 1873-1943

The Salzburg Seminar for Higher Education for deploying technology, and ways to reduce the regulatory burden on higher education institutions. It also explored ways to improve pathways to graduate education, take advantage of opportunities to increase student diversity, and realign doctoral education for the careers new doctorates will follow.

Brookings Institution, Non-resident Senior Scholar

For the past several years I have served as a nonresident Senior Scholar for the Brookings Institution as part of their Metropolitan Studies program to assess issues of regional economic development. In particular, I chaired a major study of the impact of energy policy on the Great Lakes region, the most energy-intensive region of the United States. This influenced the Energy Innovation Hub program of the Department of Energy. More recently I chaired a major study of the education needs of the region, including K-12, higher education, and lifelong learning to develop a "Master Plan" for education in the Midwest.

Some Other Assignments

Advisory Council, National Center for Atmospheric Research
Keck Futures Initiative Review (National Academies)
Board of Directors, CASL Energy Innovation Hub, (Department of Energy)
Intelligence Science Board (Director of National Intelligence)
The State of the Academic Presidency (Association of Governing Boards)
National Science Policy Commission (American Academy of Arts and Sciences)
Educate to Innovate Study, National Academy of Engineering
Roundtable on Global Sustainability, National Science Foundation
Presidential Search Committee, National Academy of Engineering
Assessment of Triana Satellite, NASA
International Activities
- Dies Academicus, University of Vienna
- European University Association, Spain
- Glion Colloquium, Switzerland
- Universitas 21, Nagoya, Japan
- Diversity Conference, Berlin, Germany

As an example of activities, we have included a brief appendix to this chapter a list of major activities over the past two decades.

## References

Duderstadt, James J. (chair) Proposal for Establishing a Graduate Program in Science, Technology, and Public Policy, 2004); Design of STPP Program in Gerald R. Ford School of Public Policy (2008)

Information on Division of Policy and Global Affairs in the National Academies (2014)

Duderstadt, Anne and James J. Duderstadt, *For the Love of Michigan*, Millennium Project, University of Michigan (2014)

The role of the committee chair...including getting advice.


DOE E. O. Lawrence Award


Chair, National Science Board


NSPE Engineer of the Year


National Medal of Technology


NAE Arthur Beuchle Award


Yale George H.W. Bush Award

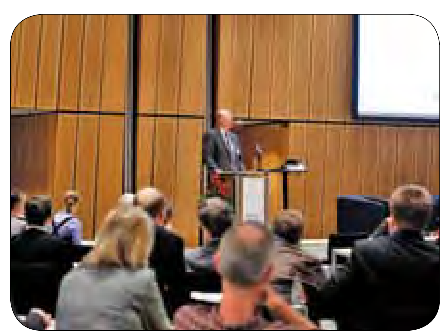

National Academy Election


McGIll Honorary Degree


U Vienna Dies Academicus

Dartmouth Honorary Degree

Arizona State Honorary Degree


Diversity Keynote Berlin

## Appendix to Chapter 21

## Post-Presidency Activities

1996-1997

Sunflower Report
Michigan Strategy
Rebuilding the University
Launch of Media Union
Michigan Virtual Auto College
CMS, Unisys

1997-1998

State Technology Strategy
Committee on Science, Engineering, and Public Policy
Chair, NRC Federal Science and Technology Study
GUIRR-NSB Stresses on the Academy
Stanford National Consortium on Postsecondary Ed
Glion Colloquium
University for 21st Century
Cyber Camp
President Michigan Virtual Auto College
National Academy of Engineering Executive Council
CMS, Unisys

1998-1999

Chair DOE Nuclear Energy Advisory Committee
Chair, Scholarship in the Digital Age
Chair, Future of Science and Engineering
Committee on Science, Engineering, and Public Policy
Director, UM Oberlin Kalamazoo project
Yale Advisory Council on IT
Stanford National Consortium on Postsecondary Ed
Glion Colloquium
National Partnership in Science Computing
Chair, DOE Nuclear Energy Advisory Committee
Ontario Master Plan
UM Admission Litigation
CMS, Unisys

1999-2000

Chair, IT and the Fuure of the University
Chair, NRC Federal Science and Technology Study
Chair, DOE Nuclear Energy Advisory Committee
Committee on Science, Engineering, and Public Policy
NAE Executive Committee
Stanford National Consortium on Postsecondary Ed
Glion Colloquium
Advisor, Naval Postgraduate School
UM Admission Litigation
CMS, Unisys, Diamond Cluster

2000-2001

Chair, DOE Nuclear Energy Advisory Committee
Chair, IT and the Future of the University
Chair, NRC Federal Science and Technology Study
Committee on Science, Engineering, and Public Policy
Stanford National Consortium on Postsecondary Ed
Advisory Board, National Center Atmospheric Res
CMS, Unisys

2001-2002

Chair, DOE Nuclear Energy Advisory Committee
Chair, IT and the Future of the University
Chair, NRC Federal Science and Technology Study
Chair, COSEPUP Scientific Research in the States
Committee on Science, Engineering, and Public Policy
Advisory Board, National Center Atmospheric Res
NSF, Advisory Committee on Education
CMS, Unisys

2002-2003

Chair, DOE Nuclear Energy Advisory Committee
Chair, IT and the Future of the University
Chair, NRC Federal Science and Technology Study
Chair, COSEPUP Scientific Research in the States
Committee on Science, Engineering, and Public Policy
Advisory Board, National Center Atmos Research
NSF, Advisory Committee on Education
CMS, Unisys, Diamond Cluster
NSF Grant: $110,000 for Nuclear Fission minor

2003-2004

Chair, NRC IT Forum

Chair, NRC Federal Science and Technology Study
Committee on Science, Engineering, and Public Policy
DOE Secretary Committee on Research
Chair, NAE Study of Engineering Research
Advisory Board, National Center Atmospheric Res
UM Chair, STPP Committee
UM Chair, Hydrogen Initiatives Commission
UM Co-Chair, World University Workshop
CMS, Unisys, Diamond Cluster
Atlantic Philanthropies Grant ($890,000 to UM)

2004-2005

Chair, NRC IT Forum
Chair, COSEPUP FS&T
Chair, NAE Engineering Research
Co-Chair V Glion Conference
Chair, UM Science, Tech, and Pub Policy Committee
Chair, Hydrogen Initiatives Team
Chair, UM Phoenix Project Executive Committee
Chair, NRC Workshop on OMB Performance Metrics
Chair, WASC Accreditation Team
Member, Kansas City Project Team
Member, Great Lakes Brookings Project
Unisys, Diamond Cluster

2005-2006

Chair, NRC IT Forum
Chair, COSEPUP FS&T
Chair, NAE Engineering Research
Chair, Cyberinfrastructure Advisory Committee, NSF
Chair, Presidential Search Committee, NAE
Member, Spellings Commission, D Ed
Member, AGB Task Force on University Presidency
Member, UC Task Force on Compensation, Accountability, and Transparencies
Chair, STPP Program
Chair, Michigan Energy Research Council
Member, Tulane University Post-Katrina Planning
Member, KC Project Team
Member, Great Lakes Brookings Study
Member, AAAS Executive Council
Funding, Atlantic Philanthropies, IT Leadership ($890,000)
Funding NSF, 21st Century Engineering ($250,000)
Funding, STPP Postdoc, Dow Foundation ($610,000)
Funding, MilProj, GKCCF ($42,500)
Unisys, Diamond Cluster

2006-2007

Member, Intelligence Science Board
Chair, NAE Engineering Research Study
Chair, Cyberinfrastructure Advisory Committee, NSF
Chair, Presidential Search Committee, NAE
Member, Spellings Commission, D Ed
Member, AGB Task Force on University Presidency
Co-Chair, Glion Colloquium
Chair, NRC Review Committee for Keck Futures Program
Chair, STPP Program
Co-Chair, VI Glion Colloquium
Chair, Michigan Energy Research Council
Member, Advisory Committee, New Economy Initiative for Michigan
Member, Detroit Renaissance Team
Member, Executive Council, AAAS
Unisys
Funding NSF, 21st Century Engineering ($250,000)
Funding, STPP Postdoc, Dow Foundation ($610,000)

2007-2008

Member, Intelligence Science Board
Chair, NAE Engineering Research Study
Chair, Cyberinfrastructure Advisory Committee, NSF
Chair, NRC Review Committee for Keck Futures Program
Chair, Brookings Next Energy Project
Member, Spellings Commission, D Ed
Member, Evolution of the Research University Project, NRC
Member, Red Team to Assess 20 year Strategy for Nuclear Energy Research
Member, UC Regents Task Force on Accountability and Transparency
Member, Chicago Council study of Regional Economic Development
Member, AGB, Miller Center, Public Purpose
Member, Advisory Board, UM National Depression Center

Unisys
Funding, STPP Postdoc, Dow Foundation ($610,000)

2008-2009

Member, Intelligence Science Board
Co-Chair, VII Glion Colloquium
Chair, Brookings Next Energy Project
Co-Chair, NSF Roundtable of Global Sustainability
Member, Policy and Global Affairs Committee, NRC
Co-Director, STPP Program
Member, Executive Council, AAAS
Member, Chicago Council study of Regional Economic Development
Member, UC Regents Task Force on Accountability and Transparency
Member, NAE Study of Lifelong Engineering Learning
Chair, Study to Assess Economic Progress of Greater Kansas City
Member, UM Bicentennial Planning
UM Faculty History Project
Unisys
Funding, STPP Postdoc, Dow Foundation ($610,000)
Funding, Grant from GKCCF ($72,000)

2009-2010

Member, Intelligence Science Board
Chair, Brookings Next Energy Project
Co-Chair, NSF Roundtable of Global Sustainability
Member, Policy and Global Affairs Committee, NRC
Member, Chicago Council study of Regional Economic Development
Member, Presidential Search Committee for the University of Khalifa
Member, NAE Lifelong Learning Committee
Unisys
Funding, STPP Postdoc, Dow Foundation ($610,000)

2010-2011

Chair, Policy and Global Affairs Division, National Research Council
Member, National Research Council Governing Board
Member, National Academies Study of Research Universities
Nonresident Senior Scholar, Brookings Institution
Member, President's Project Advisory Committee,
Member, President's Project Advisory Committee, Facility for Research on Ion Beans (FRIB)
Co-Chair, VIII Glion Colloquium
Director, Chicago Council Midwest Master Plan
Member, IT Council
Member, History and Traditions Committee
Co-Director, STPP Program
Member, Executive Council, AAAS
Unisys
Funding, STPP Postdoc, Dow Foundation ($610,000)
Funding, NSF, Glion VIII Colloquium ($99,000)

2011-2012

Chair, Policy and Global Affairs Division, National Research Council
Member, National Research Council Governing Board
Member, National Academies Study of Research Unversities
Nonresident Senior Scholar, Brookings Institution
Member, President's Project Advisory Committee, Facility for Research on Ion Beans (FRIB)
Member, Board of Directors, DOE CASL
Chair, Festshrift for Dan Atkins
Chair, NSF DLI Conference
Chair, Future of the DC
Member, IT Council
Member, History and Traditions Committee
Co-Director, STPP Program
Unisys
Funding, NSF, Glion VIII Colloquium ($99,000)
Funding, NSF Workshop on DLI ($89,000)

2012-2013

Chair, Policy and Global Affairs Division, National Research Council
Member, National Research Council Governing Board
Member, National Academies Study of Research Universities
Nonresident Senior Scholar, Brookings Institution
Member, President's Project Advisory Committee, Facility for Rare Ion Beams, MSU

Member, Board of Directors, DOE CASL
Co-Chair, IX Glion Colloquium
Chair, Festshrift for Dan Atkins
Chair, NSF DLI Conference
Member, Review of UT Fracking Study
Member, NAE, Educate to Innovate Study
Funding, NSF Workshop on DLI ($89,000)

2013-2014

Chair, Policy and Global Affairs Division, National Research Council
Member, National Research Council Governing Board
Member, National Academies Study of Research Universities
Nonresident Senior Scholar, Brookings Institution
Member, President's Project Advisory Committee, Facility for Rare Ion Beams, MSU
Chair, Board of Directors, DOE CASL
Co-Chair, X Glion Colloquium
Member, Advisory Committee, National Center for Nuclear Weapons Verification Technology
Member, American Academy of Arts & Sciences Committee on National Science Policy
Member, UM IT Council

## Major Policy Studies

National Science Board

1982 University Industry Research NSB
1986 Undergraduate S, M, E Education NSB
1987 NSF in Polar Regions NSB
1988 State of U.S. S&E NSB
1989 Foreign Involvement in US Universities NSB
1989 Loss of Biological Diversity NSB
1992 A Foundation for the 21st Century NSB
1993 Desktop to Teraflop NSB
1994 State of US S&E NSB
1995 K-12 STEM Education
1996 US S&E in Changing World NSB
1998 Graduate Postdoc EducatIon NSB
1998 NSB Strategic Plan
2000 NSB History in Highlights
2006 NSF 2020 Strategic Plan NSB

Other NSF Efforts
Nuclear Engineering Minor Study
Strategic Plan Input for NSF
ACCI Reports

National Science Policy

1992 Chair, NSB Study of Future of NSF
1998 FS&T Committee
1998 GUIRR-NSB Stresses on the Academy
1999 Draft Proposal NSF NSB
2000 FS&T Op Ed
2002 Triana NASA Study
2001 Chair, COSEPUP Scientific Research in the States
2003 Chair, NAE Study of Engineering Research
2003 DOE Secretary Committee on Research
2006 Chair, NRC Review Committee for Keck Futures Program
2009 Member, President's Project Advisory Committee, FRIB
2010 Chair, Policy and Global Affairs Division, National Research Council

National Higher Education Policy

1990s Diversity (Michigan Mandate Leadership)
1994 Chair, NASULGC Federal Relations Committee
1994 Direct Student Lending Act
1995 BHEF Study with Red Poling
1998 President, Michigan Virtual University
1998 GUIRR-NSB Stresses on the Academy
1998 University for 21st Century
1999 Restructuring Intercollegiate Athletics
1999 Director, UM Oberlin Kalamazoo project
2000 NASULGC White Paper
2000 ACE Presidency
2000 EDARPA Letter
2001 COSEPUP EARPA
2005 Fixing the Fragmented University
2005 Spellings Commission Framing Paper
2005 Spellings Commission Quality Report
2005 Member, Spellings Commission, D Ed
2005 Chair, Spellings Quality Subcommittee
2005 Member, AGB Task Force on State of Univer-

sity Presidency
2005 Member, UC Task Force on Compensation, Accountability, and Transparencies
2005 Member, Tulane University Post-Katrina Planning
2005 Learn Grant Act
2005 NACME Diversity Talk
2006 Leadership Imperative AGB
2006 Spellings Commission Report
2007 Member, Evolution of the Research University Project, NRC
2007 Member, AGB, Miller Center, Public Purpose
2008 Miller AGB Duderstadt Final
2010 Member, National Academies Study of Research Universities
2010 Director, Chicago Council HE Master Plan
2011 New School Conference
2012 AGB Research Universities Duderstadt
2012 De Lange Rice Address JJD
2012 National Academies Research University Report
2012 National Academies Research University Summary

Economic Development

1999 Ontario Master Plan
2003 Regional Learning Ecologies
2004 Member, KC Project Team, Time to Get It Right
2004 Member, Great Lakes Brookings Project
2005 Chair, Michigan Energy Research Council
2005 Gathering Storm
2005 Michigan Roadmap
2005 Time to Get It Right KC
2005 Member, Great Lakes Brookings Study
2006 Member, Advisory Committee, New Economy Initiative for Michigan
2007 Chair, Brookings Next Energy Project
2007 Member, Chicago Council study of Regional Economic Development
2007 Chicago Midwest Media Project
2007 Michigan Roadmap Redux
2008 Chair, Study to Assess Economic Progress of Greater KC
2009 Kansas City–time-to-get-it-right-Update
2010 Brookings Hubs of Innovation
2010 Director, Chicago Council HE Master Plan
2011 Midwest Master Plan Launch
2011 Midwest Master Plan Heartland Paper

Information Technology and Cyberinfrastructure

1999 Chair, Scholarship in the Digital Age
2000 Chair, ITFRU
2003 Chair, IT Forum
2003 Preparing for the Revolution
2005 Chair, NSF Cyberinfrastructure Committee
2011 Chair, Festshrift for Dan Atkins
2011 Chair, NSF DLI Conference
2011 Chair, Future of the DC
2012 NSF DLI Workshop Description

Engineering

2003 Chair, NAE Study of Engineering Research
2004 21st Century Engineering
2005 Engineering Research and America Future
2005 PI NSF, Flexner - 21st Century Engineering
2007 5XME Workshop
2007 Engineering Flexner Report
2008 ABET Effort
2008 Member, NAE Study of Lifelong Engineering Learning
2009 Brookings Energy Report
2012 Member, NAE, Educate to Innovate Study

## Energy-General

2003 DOE Secretary Committee on Research
2003 DOE-SC SWOT Analysis
2003 DOE_Task_Force
2005 Phoenix Energy Institute
2007 Chair, Brookings Next Energy Project
2009 Brookings Energy Report
2011 Glion VIII Duderstadt Black Swans
2012 Member, Review of UT Fracking Study

## Energy-Nuclear

1999 Chair DOE Nuclear Energy Research Advisory Comm

2000 DOE Nuclear Energy Strategy
2001 Nuclear Engineering Minor Proposal
2002 NSF Grant: $110,000 for Nuclear Fission minor
2004 Nuclear Energy France
2004 DOE Study of Research Priorities
2004 Energy France
2009 Member, President's Project Advisory Committee, Facility for Rare Ion Beams, MSU
2012 Member, Board of Directors, DOE Coalition for Advance Simulation of Light Water Reactors

International Issues

1989 UM International Center
1992 Tree Tops Strategy for State Support
2002 JAPAN Policy Discussions
2002 Nagoya Keynote Lecture
2003 UM Co-Chair, World University Workshop
2005 Canadian Provosts Briefings
2007 Salzburg Seminars
2008 Co-Chair, NSF Roundtable on Global Sustainability

Glion Colloquium Topics

1999 Glion I Challenges Facing HE
2001 Glion II University Governance
2002 Glion III Walls Come Tumbling Down
2003 Glion IV Reinventing the University
2005 Glion V Universities and Business
2007 Glion VI Globalization of HE
2009 Glion VII Universities and Innovation
2012 Glion VIII Global Sustainability
2013 Glion IX Sustainability of Research University Paradigm

## Chapter 21

# University of Michigan Strategic Planning

One of first questions usually posed to candidates for university presidencies concerns their vision for the future of the institution. However, beyond such platitudes as "enhancing the life of the mind" or winning a national championship in a revenue sport, the development of a vision for the future of a university is an extremely difficult task. Universities are notoriously complex institutions whose evolution is strongly influenced by their unique cultures, histories, and traditions. Even those internal candidates possessing intimate familiarity with the institution can find the development of a vision an uphill struggle. Imagine the plight of external candidates, unfamiliar with the institutional saga of the university and given only a brief honeymoon period to propose their vision and plan for the future of the institution.

Yet there have been numerous examples in which visionary university leaders were able to craft both a compelling vision for the future of their institutions and a successful strategy for achieving it. Some notable twentieth-century examples include Clark Kerr, who designed and built the greatest university system in the world in the University of California; Frederick Terman, who transformed Stanford into the scientific and technological powerhouse that created Silicon Valley; Richard Cyert, who led Carnegie Mellon University to a position of leadership in key areas, such as computer science; Charles Young, who transformed the University of California, Los Angeles, from a city college into a great research university; and Richard Atkinson, who led the young University of California campus in San Diego to become one of the leading research universities in the world in less than two decades. Although many Wolverines would hate to admit it, this list would also include John Hannah, who transformed Michigan Agriculture College into a world-class research university, Michigan State University.

The University of Michigan has been fortunate to have been led by visionary presidents during various periods of its long history. Henry Tappan transformed Michigan into one of the nation's first true universities. James Angell and, much later, Harlan Hatcher presided over periods of extraordinary growth in the university. Harold Shapiro understood the need for Michigan to restructure its financial support in the face of declining state support while also strengthening the University's deep commitment to academic excellence.

While there are many examples of visionary leadership in higher education, it is also fair to suggest that it is certainly not the norm. Beyond the challenge of developing a bold vision for a university's future, leading the institution toward such visions can be a hazardous task. It is little wonder that most university presidents tend to polish the status quo rather than proposing new paradigms, content to allow their institution to drift along without rocking the boat, until they disembark


The forces driving change in higher education for their next leadership assignment.

Yet while the status quo may be the safest course for survival of university presidents, it can pose substantial risks to the institution. Universities that drift along, without a vision or strong leadership, can founder on rocky shoals. Although a university may seem to be doing just fine with benign neglect from the administration building, over a longer period of time a series of short-term tactical decisions will dictate a de facto strategy that may not be in the long-range interests of the university. Leading a university during a time of great social change without some formal planning process is a bit like navigating the Titanic through an iceberg floe in the dead of night. Simply reacting to challenges and opportunities as they arise can eventually sink the ship.

At Michigan, we had encountered a particularly large iceberg during the early 1980s with the loss of much of our state support. Harold Shapiro and his administrative team had done an admirable job at addressing the near-term crisis through restructuring both its cost and revenue structure. But Shapiro realized the need to develop a longer-term planning process capable of not only navigating the treacherous waters ahead but seizing the opportunities presented by an increasingly knowledge-intensive society. This was to be my primary assignment when he lured me from my position as dean of the College of Engineering to become the university's provost in 1985. The two of us were to work closely together, as president and provost, to design and launch just such a planning process, although he would remind me, "Man plans while God laughs!"

Here, we accepted several key assumptions. First, we recognized that the University of Michigan was a very complex system, responding to the cumulative effects of its history as well as to its interactions with the changing external world. Despite this complexity, we believed it critical that the university take responsibility for its own future, rather than having its future determined for it by external forces and pressures. In particular, we sought a far more strategic and opportunistic approach to leadership, rather than simply reacting to the changing world about us. Second, we believed that the University of Michigan would face a period of unusual opportunity, responsibility, and challenge in the 1990s. During this pivotal decade, it could—indeed, must—seize control of its own destiny by charting a course to take it into the next century. Finally, we were convinced that the challenges facing higher education in the late twentieth century required a new paradigm for the university in America and that the University of Michigan was in an excellent position to develop this model for the nation, just as it had in earlier times through its trailblazing saga.

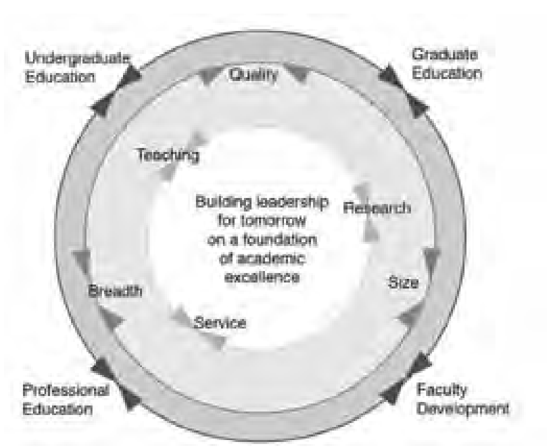
Developing a vision for a hazy future

## The Approach

As dean, as provost, and then as president, I sought progressive, flexible, and adaptive planning processes, capable of responding to a dynamic environment and an uncertain—indeed, unknowable—future. My goal was to develop flexible strategies that avoided rigid paths or deep ruts and positioned the university to take advantage of windows of opportunity to pursue well-defined objectives as they arose. In a sense, I utilized an informed dead-reckoning approach, in which one first selected strategic objectives—where we wanted to go—and then followed whichever path seemed appropriate at the time, possibly shifting paths as strategic plans were updated and as additional information and experience dictated. I never assumed that the planning framework was rigid, since what might appear first as constraints could, with skill and cleverness, frequently be transformed into opportunities. When state appropriations were cut, my team used this as an opportunity to convince donors that since they no longer provided as much funding to the university when they paid their taxes on April 15, they should shift to funding us through private giving, much like a private university. When publishers dramatically increased the cost of serials to our libraries, we were able to convince the Big Ten universities that it was time to set aside competition and share library resources, creating, in effect, a gigantic resource with over 78 million volumes.

Another aspect of our planning was the belief that the real creativity, innovation, and wisdom in a university existed at the grassroots level, among faculty, students, and staff. Hence, every planning effort involved numerous planning groups—some formal, some ad hoc—that played a very essential role in guiding our efforts. Many brainstorming sessions at the President's House went late into the evening, challenging assumptions, proposing alternatives, and wondering "what if." I viewed my role as stimulating, harvesting, shaping, and refining the ideas bubbling up from the university community.

As noted earlier, long-enduring institutions, such as universities, need to begin with an understanding of their history, tradition, and values—their institutional saga. These form the initial conditions for any planning process. Beyond this, it is important to gain an understanding of possible constraints that might restrict planning options, since these might be challenged and relaxed. In our case, a faltering Michigan economy that was no longer able to support a world-class public research university was clearly a serious concern. But so, too, were an array of demographic issues, such as the need to serve underrepresented minority communities and to embrace diversity as key to our capacity to serve an increasingly diverse state, nation, and world. Michigan's long history of international activities had sensitized us to the growing trends of globalization, just as the university's leadership in developing and implementing new technologies, such as the Internet, had given us a good perspective of technological change.




Early diagrams of the "bumper sticker" discussions

Key in the planning effort was the task of developing a vision statement for the university, a task made particularly difficult by the very broad range of activities and roles of the institution. We began by challenging our planning groups to come up with a single word to characterize our future, such as *excellence* or *public* or *diversity*. Next, we asked the groups to combine several of these words into a descriptive phrase, such as "a leading, public, research university." Finally, we asked them to use this exercise to develop, in a phrase (or, rather, a bumper-sticker slogan), a vision for the university's future. Here, there were lots of suggestions (accompanied by lots of discussion): "the nation's leading public university" (but why not simply "the world's leading university"?), "the university of the common man" (or even "the university of the poor"?), "America's university" (but was this not rather impolitic for a "state" university?), and so on.

Soon our planning efforts began to converge on a vision stressing two important themes: leadership and excellence. Looking back over the history of the university, we realized that quality by itself was never quite enough for Michigan. Here, the aspiration of going beyond excellence to achieve true leadership clearly reflected our understanding of the university's history as a trailblazer. This process eventually led to the following planning vision for the 1990s:

*Vision 2000: To position the University of Michigan to become a leading university of the twentieth century, through the quality and leadership of its programs, and through the achievements of its students, faculty, and staff.*

Such a leadership vision required a comprehensive strategy based on improving and optimizing the key characteristics of the university: quality, capacity (size), and breadth (comprehensiveness). Yet even at this early stage of visioning, the campus community became both engaged and energized in exercises to determine the university's future.

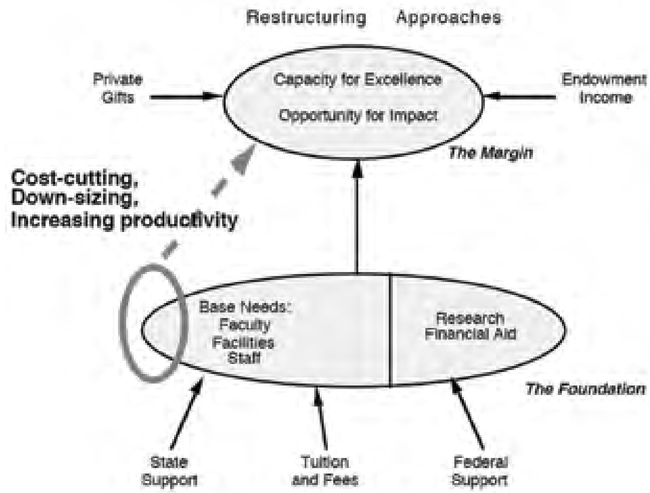

## The Action Plan

Of course, vision statements are empty without follow-through, actions, and results. To shift the institution into action mode, my administrative team set out several general challenges—which I termed "the challenges of excellence"—for the next phase of the planning exercise. First, we asked for a rededication to the achievement of excellence. It was time for Michigan to pick up the pace, by building a level of intensity and expectation that compelled us to settle for nothing less than the best in the performance of faculty, students, and programs. We encouraged the university to strive for even higher quality, since it would be the achievement of excellence that would set us apart and provide us with the visibility to attract the elements so essential to the enterprise—human and financial resources, outstanding students and faculty, and support from the public and private sectors.

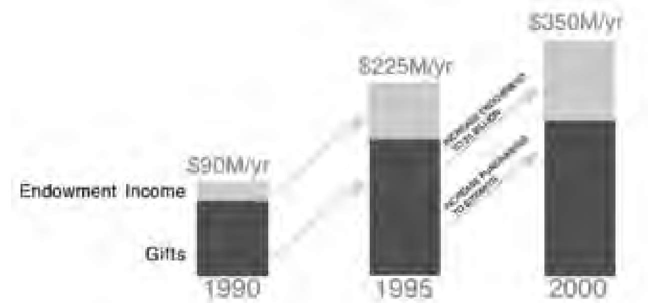
Second, if we were to achieve excellence, we needed to commit ourselves to focusing resources. In decades past, regular increases in public support had allowed the university to attempt to do a great many things with a great many people and to attempt to do them all very well. However, in the future of constrained resources that we faced, we could no longer afford to be all things to all people. Quality had to take priority over the breadth and capacity of our programs and become our primary objective.

Third, as we focused our resources to achieve excellence, we needed to keep in mind that our highest priority was academic excellence—outstanding teaching, research, and scholarship. The University of Michigan's reputation would not be built on the football field. It would be based on the quality of its activities in scholarship and learning.

Fourth, the university needed to be responsive to changing intellectual currents. Academic leadership demanded pursuing the paths of discovery that influence the evolution of intellectual disciplines. We were increasingly finding that the most exciting work was occurring not within traditional disciplines but, rather, at the interfaces between traditional disciplines, where there was a collision of ideas that could lead to new knowledge. At Michigan, we wanted to stimulate a transition to a change-oriented culture in which creativ-




First, get our house in order...




Fund-raising goals for the 21s century

ity, initiative, and innovation were valued. We needed to do more than simply respond grudgingly to change; we needed to relish and stimulate it.

Fifth, the university faced the challenge of diversity and pluralism. Our ability to achieve excellence in teaching, scholarship, and service would be determined over time by the diversity of our campus community. We accepted our responsibility to reach out to and increase the participation of those racial, ethnic, and cultural groups not adequately represented among our students, faculty, and staff. Beyond this, we faced the challenge of building an environment of mutual understanding and respect that not only tolerated diversity but sought out and embraced it as an essential objective of the university. Here, we were clearly sowing the seeds that would later grow into the Michigan Mandate and the Michigan Agenda for Women.

Finally, to achieve the objective of leadership, we proposed to focus wherever possible on exciting, bold initiatives, consistent with the Michigan saga as a trailblazer. We aimed to stimulate, encourage, and support more high-risk activities. As steps in this direction, we began to reallocate each year a portion of the university's academic base budget into a Strategic Initiative Fund designed to support a competitive grants program addressing key university priorities, such as undergraduate education, diversity, and interdisciplinary scholarship. This fund was augmented by private support. Highly creative proposals and initiatives began to bubble up from faculty, students, and staff to address each of our priorities.

Some of our initiatives were obvious, if challenging. We set a goal of building private support for the university to levels comparable to our annual state appropriation, which not only led to the first $1 billion fund-raising campaign for a public university but also stimulated a far more aggressive strategy for investing the university's assets, including its growing endowment. We developed new strategies for rebuilding the university's campuses with internal funding and private support, rather than waiting for the next round of state support for capital facilities. We provided deans and directors with strong authority, along with accountability, in the control of their own revenues and expenditures, essentially completing the decentralization of the university's financial management begun under Harold Shapiro.

We were prepared to make major investments in high-risk intellectual activities, but only in those areas where we had established strength. Some of these investments achieved spectacular success. For example, our investment in the management of NSFnet resulted in the creation of the Internet. Other investments failed, such as the major (but premature) effort to build the nation's first clinical programs in human gene therapy. But even in failure we learned valuable lessons. To create even more of a spirit of innovation, we sprinkled several "skunk works" activities about the campus (analogous to the famous Lockheed Skunk Works), some in existing academic units, such as the transformation of our School of Library Science into a School of Information, and some in new multidisciplinary facilities, such as the Media Union.

Finally, we set a series of stretch goals, including becoming the national leader in such areas as campus diversity, sponsored research activity, faculty salaries, clinical operations, and the global outreach of our academic programs. As we began to make progress on our strategic goals, we fell into a pattern of raising the bar, compressing the timetable, and upping the ante. By the early 1990s, we began to realize something very surprising: we were not only achieving our objectives, but in most cases, we were going far beyond the goals we had originally set. The strategic goals associated with Vision 2000 were essentially achieved by 1993, seven years ahead of schedule. Hence, we soon began to wonder what to do for an encore.

## Lessons Learned and the Growing Concern

There are many lessons, both good and bad, to be learned from Michigan's comprehensive planning effort during the 1980s and early 1990s, particularly when it turned out to be remarkably successful. Beyond the obvious challenges (to build on the institutional saga; to keep our focus on the goals; to be candid, demanding, and evidence-based in our appraisal of progress and generous in praise of achievement), other challenges arose from both the nature and the particular history of the university. I had recognized early in my provost role how important it was to shift the university away from a reactive, crisis mode to a more strategic focus after the trauma of state budget cuts and difficult reallocation decisions during the 1980s.

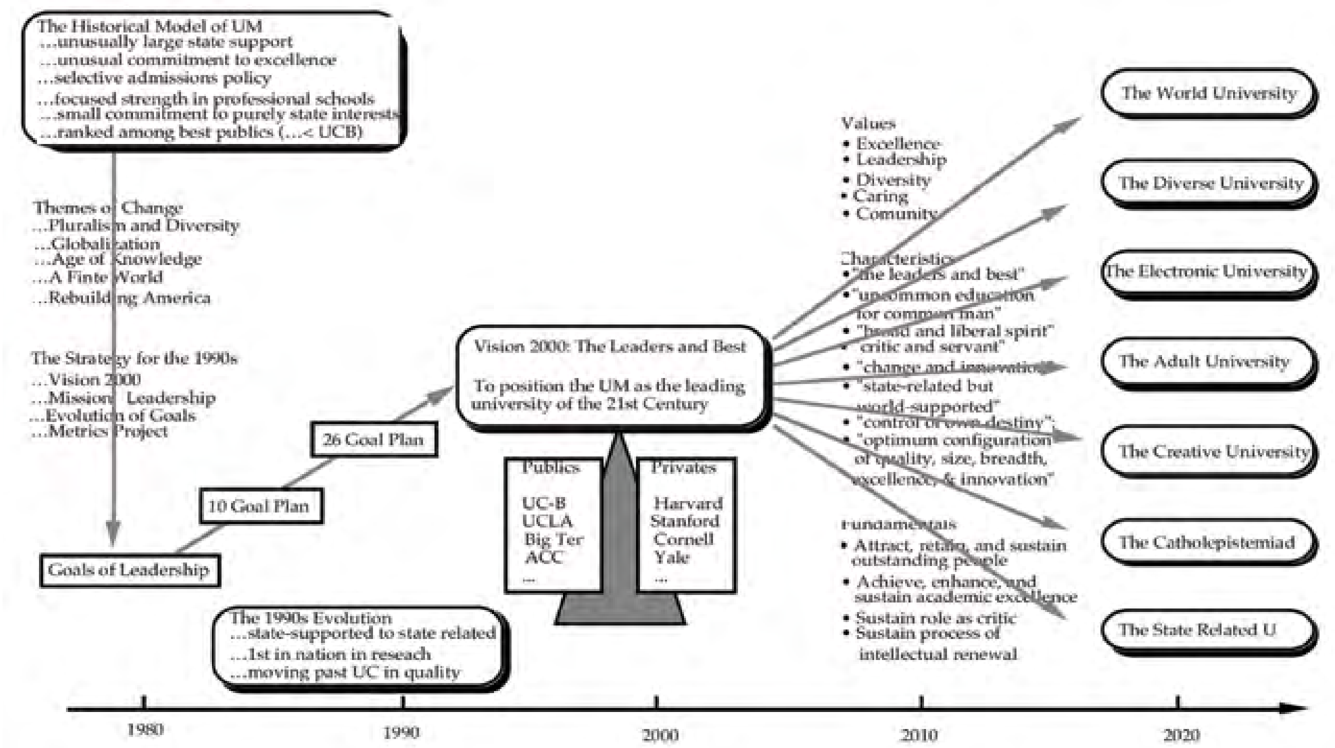
Yet this was very difficult for some of our academic units. Not surprisingly, long-range planning was difficult for such a large and diverse academic unit as our College of Literature, Sciences, and the Arts, with almost 1,000 faculty, 20,000 students, and 45 departments. But, to our surprise, it was equally difficult for some of our professional schools, such as our School of Business, which had difficulty understanding the planning process or accepting any vision other than "We want to be better than Harvard!"

After the hard financial times of the 1980s, it was similarly difficult to re-create the risk-taking culture that had been such an important part of the Michigan institutional saga as a trailblazer. Institutions all too frequently choose a timid course of incremental, reactive change because they view a more strategically driven transformation process as too risky. They are worried about making a mistake, about heading in the wrong direction or failing. While they are aware that this incremental approach can occasionally miss an opportunity, many mature organizations would prefer the risk of missed opportunity to the danger of heading into the unknown.

Yet in the end, through considerable effort by the administration in engaging the university community (and perhaps a certain tolerance for the planning inclinations of an engineer as president—actually, of two engineers for a time, as the provost position was filled first by Chuck Vest and then by Gil Whitaker, a former dean of the School of Business), the planning process was successful in achieving essentially all of our original goals. The Vision 2000 strategy, designed to move the university toward both the leadership vision and the strategic intent of transformation, succeeded beyond our wildest expectations. But this very success turned out to be one of our most formidable challenges.

With each step we took, with every project we launched, with each objective we achieved, I became increasingly uneasy. The closer the university approached its vision for the future, the more distant and uncertain it appeared to me, and the less confident I became that we were headed in the right direction. It became increasingly clear that the forces driving change in our society were far stronger and more profound than we had first thought. Furthermore, many of the social, economic, and technological forces driving change in higher education were disruptive in nature, leading to quite unpredictable futures. The future was becoming less certain as the range of possibilities expanded to include more radical alternatives.

Put another way, I became convinced that the Vision 2000 effort, while bold and challenging, was in reality only a positioning strategy, designed to achieve excellence and leadership, but within the current paradigm of the university in twentieth-century America. To be sure, this effort accomplished many of the tasks neces-



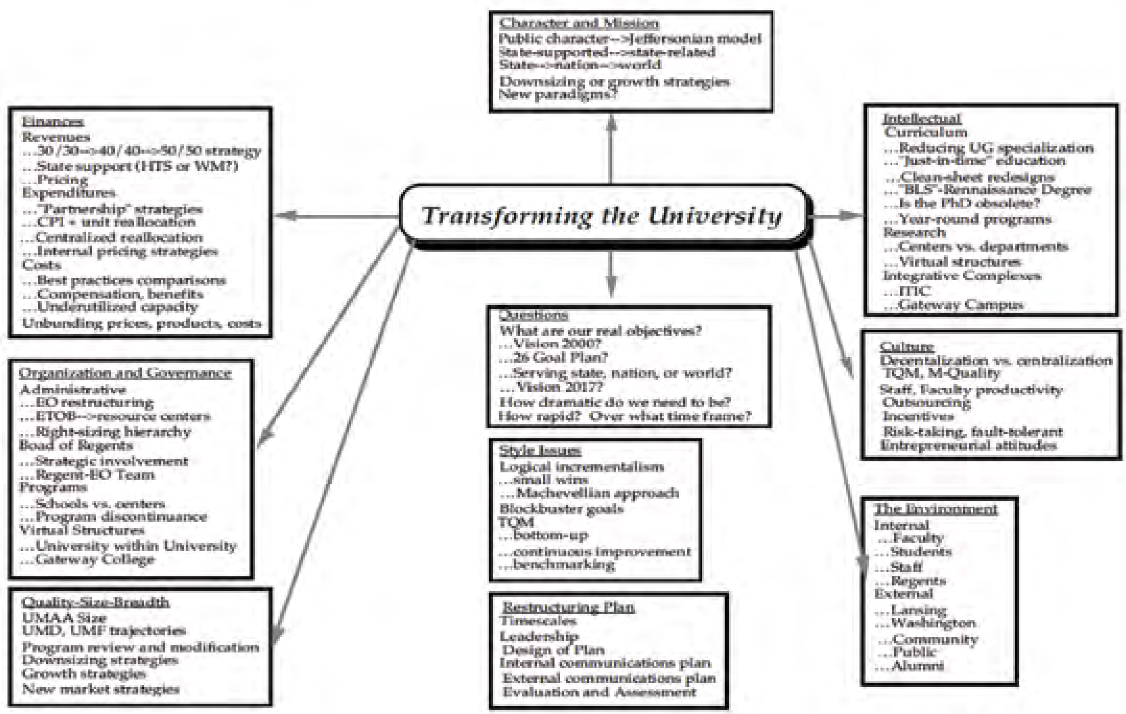

First achieving and then moving beyond Vision 2000.

sary to prepare the university for the new century, such as financial restructuring, diversifying our campuses, and rebuilding our physical environment for teaching and research. But the real challenge lay ahead: to transform the university so that it could better serve a rapidly changing society. We had now positioned the university for leadership. The next task was to determine where it would lead. By the early 1990s, it had become apparent that we needed to shift from our Vision 2000 plan, based on a series of small wins with an occasional opportunistic surge, to a bolder agenda based on blockbuster goals. Put another way, we needed to shift from positioning the university as a leading twentieth-century institution to transforming it into a twenty-first-century university designed to serve a profoundly different world.

## Institutional Transformation

So how does an institution as large, complex, and bound by tradition as the University of Michigan go about the process of transformation? Sometimes, one can stimulate change simply by buying it with additional resources. More frequently, transformational change involves first laboriously building a consensus necessary for grassroots support. But there are also times when change requires a more Machiavellian approach, using finesse—perhaps even by stealth of night—to disguise as small wins actions that were in reality aimed at blockbuster goals. And I must confess that there were times when, weary of the endless meetings with group after group (including, at times, our own governing board) to build consensus, we decided instead to take the Nike approach and "just do it," that is, to move ahead with top-down decisions and rapid execution—although in these cases, the president usually bears the burden of blame and hence the responsibility for the necessary apologies.

Michigan's own history provides many examples of both the payoffs and the risks of institutional transformation. Tappan's effort in the 1850s to transform a small frontier college into a true university was certainly important in the history of American higher education, although it cost him his job in the end. Little's effort in the 1920s to restore the collegiate model was also a transformative effort, but it failed to align with Michigan's history and tradition. During a period of relative prosperity, Hatcher had the capacity to launch




The early transformation strategy

numerous transformative initiatives important for the university—for example, the Residential College, the Pilot Program, and the Center for Research on Learning and Teaching. But during the 1960s, this transformation effort went unstable, as the university was overtaken by political activism that sought not to transform but, rather, to destroy the establishment. This illustrates the danger that arises when a change process becomes entangled with ideology and special interest agendas that divert it from the original goals. In the best scenario, the values and traditions of the institution will provide important limits on the process of change, so that the transformation process does not lead to a destructive outcome.

Of course, I was no stranger to transformation efforts, some highly successful—for example, the rebuilding of the University's College of Engineering, the Michigan Mandate and Michigan Agenda for Women, and the transformation of the university's research environment. But there had also been failures—for instance, the effort to better align auxiliary activities, such as the Athletic Department and the Medical Center, with the core academic values of the university; the attempt to shift the Regents' perception of their roles from that of political governors to loyal trustees of the institution; and the effort to build stronger coalitions of universities, such as the Big Ten Conference, to work together on common goals. Through these efforts (both the successful and the unsuccessful) and from the experience of other organizations in both the private and public sector, it was clear that the more ambitious goal of institution-wide transformation—the reinvention of the university itself—would depend heavily on several key factors.

First, I recognized the importance of properly defining the real challenges of the transformation process. The challenge, as is so often the case, was neither financial nor organizational. Rather, it was the degree of cultural change required. We had to transform a set of rigid habits of thought and arrangements that were currently incapable of responding to change either rapidly or radically enough.[2]

Second, it was important to achieve true faculty participation in the design and implementation of the transformation process. The transformation of faculty culture is generally the biggest challenge of all. I believed that faculty participation should involve its true intellectual leadership rather than the political leader-

2000s Paradigms
- University of the Common Man? No!
- University of the State of Michigan? No!
- Harvard of the West? Similar culture for excellence, but too rich
- Stanford of the East? Similar culture of innovation, but too rich
- University of America? Yes, a strong possibility
- University in and OF the World? Yes, eventually

2010 Paradigms?
- Current Trajectory: UM -> MSU/OSU
- Financial Vision: UM -> GM (Ponderous, Change-Adverse)
- Auxiliaries: Michigan Athletics, Medical Center >>Academic Core
- Michigan Politics: UM -> Alabama (or Wayne State University)
- Donors: UM -> Midwestern U
- Regents: UM -> Free UM for State; USC for everybody else

Third Century Possibilities?
- UM -> National "public" university
- UM -> Hybrid: state/nation/world public; law/bus/med services private
- UM -> University of the Heartland
- UM -> University of America
- UM -> University of the World
- UM -> University FOR the World

Simplistic models of the future of the University of Michigan

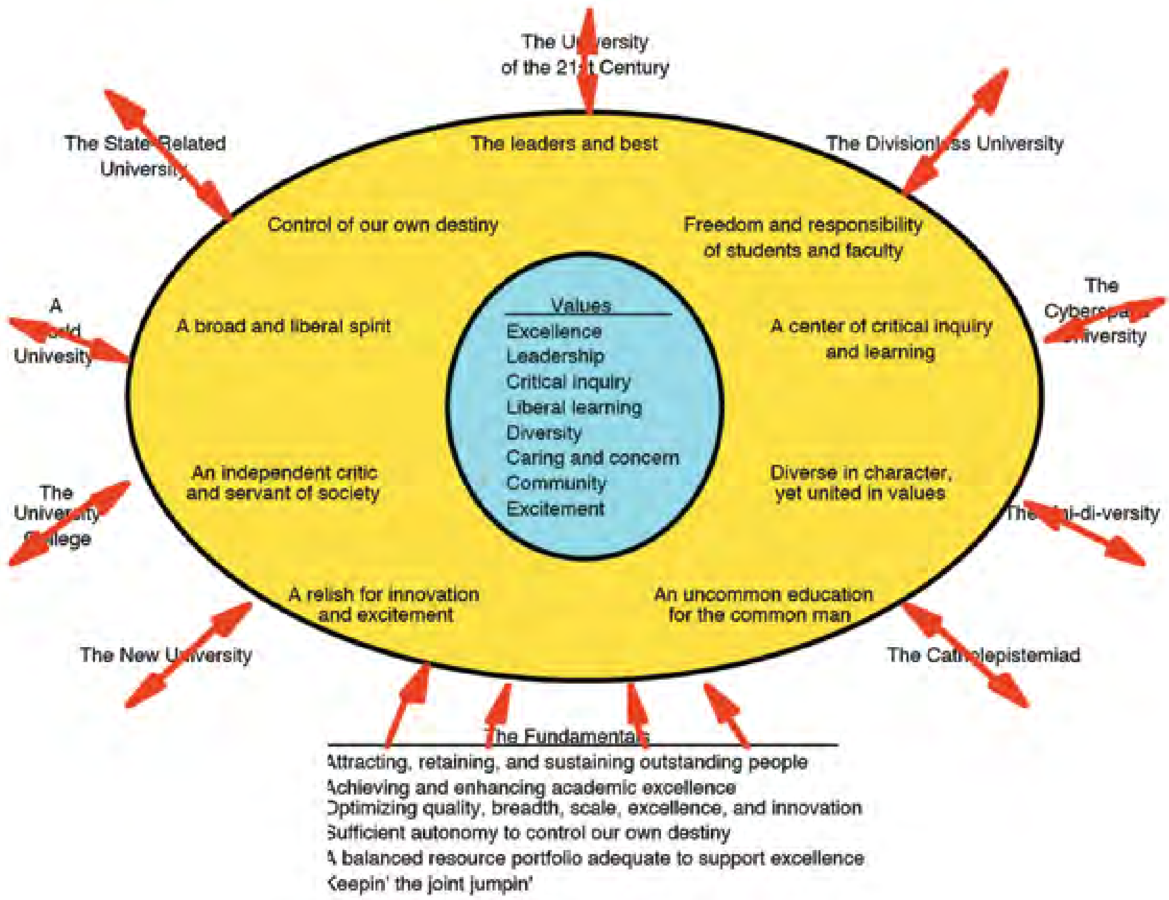
ship more common to elected faculty governance.

Third, experience in other sectors suggested that externalities—both groups and events—were not only very helpful but probably necessary to lend credibility to the process and to assist in putting controversial issues (e.g., tenure reform) on the table. Unfortunately, universities—like most organizations in the corporate sector—rarely have been able to achieve major change through the motivation of opportunity and excitement alone. Rather, it takes a crisis to get people to take the transformation effort seriously, and sometimes even this is not sufficient.

Finally, it was clear that the task of leading transformation could not be delegated. Rather, as president, I would need to play a critical role both as a leader and as an educator in designing, implementing, and selling the transformation process, particularly with the faculty. Furthermore, my presidential leadership had to be visible out in front of the troops rather than far behind the front lines.

Hence, in 1993, the University turned toward a bolder vision aimed at providing leadership through institutional transformation. This objective, termed "Vision 2017" in reference to the date of the two-hundredth anniversary of the university's founding, was designed to provide Michigan with the capacity to reinvent its very nature, to transform itself into an institution better capable of serving a new world in a new century. This transformation strategy contrasted sharply with the earlier, positioning strategy that had guided the university during the 1980s. It sought to build the capacity, the energy, the excitement, and the risk-taking culture necessary for the university to explore entirely new paradigms of teaching, research, and service. It sought to remove the constraints that would prevent the university from responding to the needs of a rapidly changing society—to remove unnecessary processes and administrative structures; to question existing premises and arrangements; and to challenge, excite, and embolden the members of the university community.

Of course, much of the preparation for this transformation had already occurred earlier in my presidency, when several of the major strategic thrusts were launched. A series of planning groups, both formal and ad hoc, had been meeting to consider the future of the university. This effort included the strategic planning teams of the late 1980s, ad hoc meetings of faculty across the university, and numerous joint retreats of executive




The Vision 2017 diagram developed during the 1990s planning activities

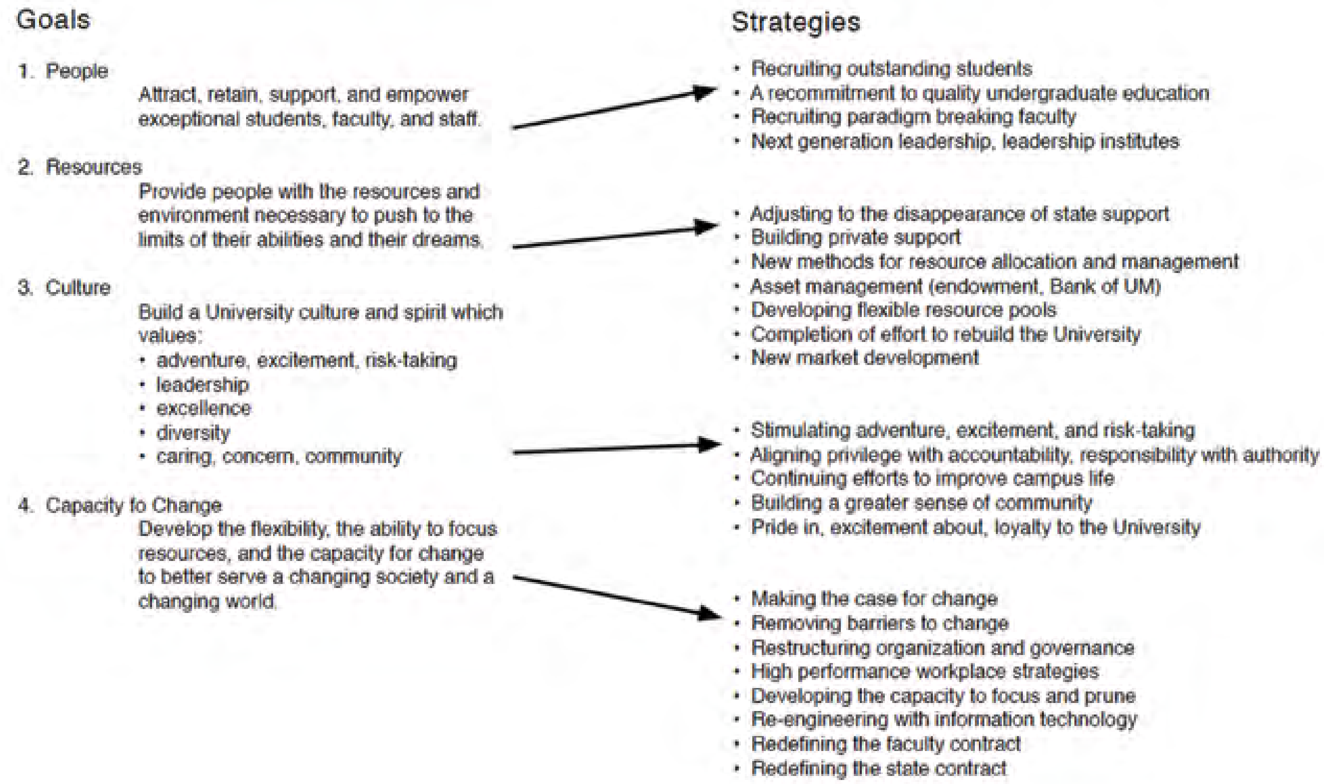
officers, deans, and faculty leaders. A presidential advisory committee of external advisors had been formed and had been meeting regularly on strategic issues for several years. Extended strategic discussions with the board of regents had been initiated and would continue through the transformation effort.

However, we needed something beyond this, to break our thinking out of the box, expanding our sense of the possible to encompass even highly unlikely alternatives. To this end, we first took advantage of the presence on our business school faculty of C. K. Prahalad, one of the world's most influential corporate strategists, asking him to lead a group of senior administration and faculty leaders through the same strategic process that he had conducted for the executive leadership of many of the major corporations in the world. We followed this by inviting Robert Zemsky, both an important thought leader in higher education and an experienced facilitator of strategic discussions, to lead several sessions of a roundtable group, including junior faculty members as well as senior leadership.

The Vision 2000 strategy required a careful optimization of the interrelated characteristics of institutional quality, size, and breadth. Transformation would require more: tapping the trailblazing spirit of the Michigan saga. It would emphasize risk taking and innovation. It would demand the bold agenda of reinventing the university for a new era and a new world.

To capture a bolder vision of the university's future, we turned to C. K. Prahalad for his concept of *strategic intent*.[3] The traditional approach to strategic planning focuses on the fit between existing resources and current opportunities. Strategic intent is a stretch vision that intentionally creates an extreme misfit between current resources and future objectives and thus requires institutional transformation to build new capabilities. Michigan developed the following strategic intent:

*The Strategic Intent (Vision 2017): To provide the university with the capacity to reinvent itself as an institution*




The strategies for Vision 2017

*more capable of serving a changing state, nation, and world.*

Vision 2017 depended for its success on sustaining our most cherished values and our hopes for the future: excellence, leadership, critical and rational inquiry, liberal learning, diversity, caring and concern, community, and excitement. In addition, we paid particular attention to those elements of the university's institutional saga that were important to preserve, as well as those values and characteristics that were our fundamental aspirations. The figure that follows summarizes this aspect of our transformation process. Around the core of values and characteristics are arranged a number of possible paradigms of the university. While none of these alone would appropriately describe the university as it entered its third century, each was a possible component of our institution, as seen by various constituents. Put another way, each of these paradigms was a possible pathway toward the university of the twenty-first century. Each was also a pathway we believed should be explored in our effort to better understand our future.

We proposed four simply stated goals to help move the university beyond the leadership positioning of Vision 2000 and toward the paradigm shifting of Vision 2017:

Goal 1: To attract, retain, support, and empower exceptional students, faculty, and staff

Goal 2: To provide these people with the resources, environment, and encouragement to push to the limits of their abilities and their dreams

Goal 3: To build a university culture and spirit that values adventure, excitement, and risk taking; leadership; excellence; diversity; and social values, such as community, caring, and compassion

Goal 4: To develop the flexibility and ability to focus resources necessary to serve a changing society and a changing world

Although simply stated, these four goals were profound in their implications and challenging in their execution. For example, while Michigan had always sought to attract high-quality students and faculty to

Selling the strategy–to faculty, students, staff, regents, alumni, and to those on campus and those beyond–the public, the state, and the nation.

the university, it tended to recruit those who conformed to more traditional measures of excellence. If we were to go after "paradigm breakers," other criteria—such as creativity, intellectual span, and the ability to lead—would become important. The university needed to acquire the resources necessary to sustain excellence, a challenge at a time when public support was dwindling. Yet this goal suggested something beyond that: we needed to focus resources on our most creative people and programs. We also needed to acquire the flexibility in resource allocation to respond to new opportunities and initiatives.

While most people would agree with the values set out in our third goal of cultural change, many would not assign such a high priority to striving for adventure, excitement, and risk taking. However, if the university was to become a leader in defining the nature of higher education in the century ahead, this type of culture was essential. Developing the capacity for change, while an obvious goal, would be both challenging and controversial. We needed to discard the status quo as a viable option (to challenge existing premises, policies, and mind-sets) and to empower our best people to drive the evolution—or revolution—of the university.

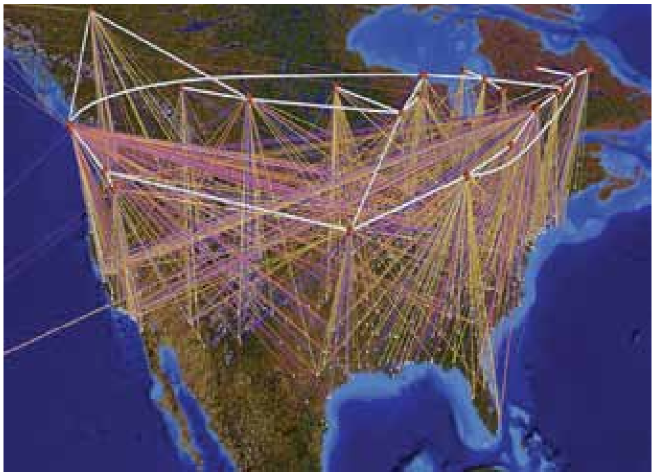
The transformation agenda we proposed, like the university itself, was unusually broad and multifaceted. Part of the challenge lay in directing the attention of members of the university community and its multiple constituencies toward those aspects of the agenda most appropriate for their talents. For example, we believed that faculty should focus primarily on the issues of educational and intellectual transformation and the evolving nature of the academy itself. The Regents, because of their unusual responsibility for policy and fiscal matters, should play key roles in the financial and organizational restructuring of the university. Faculty and staff with strong entrepreneurial interests and skills should be asked to guide the development of new markets of the knowledge-based services of the university.

It is hard to persuade existing programs within an organization to change to meet changing circumstances. This is particularly the case in a university, in which top-down hierarchical management has limited impact in the face of the creative anarchy of academic culture. One approach is to identify and then support islands of entrepreneurialism, those activities within the university that are already adapting to a rapidly changing environment. Another approach is to launch new or greenfield initiatives that are designed to build in the necessary elements for change. If these initiatives are provided with adequate resources and incentives, faculty, staff, and students can be drawn into the new activities. Those initiatives that prove successful will grow rapidly and, if designed properly, will pull resources away from existing activities resistant to change. Greenfield approaches create a Darwinian process in which the successful new initiatives devour older, obsolete efforts, while unsuccessful initiatives are unable to compete with ongoing activities capable of sustaining their relevance during a period of rapid change.

Institutional transformation requires a clear and compelling articulation of the need to change and a strong vision of where the change process will lead. While the debate over specific elements of the transformation process should involve broad elements of the university community and its constituents, the vision itself should come—indeed, must come—from the president. My administration made the case for transformation and both short- and long-range visions (Vision 2000 and Vision 2017) in a series of documents intended to serve as the foundation for the effort. Further, these documents summarized the ongoing planning effort, developed a scheme to measure progress toward goals, and sketched a plan for transforming the university.

Beyond this task, I served, as president, not only as the leader of the transformation effort but also as its principal evangelist. In an academic institution, the role of the president is in many ways like that of a teacher, explaining to various campus and external constituencies the need for transformation and setting out an exciting and compelling vision of where the transformation process will lead. In almost every address I gave during my presidency, in every available forum, stressing two recurring themes: leadership and change. Each of my annual State of the University addresses during my latter years as president focused on different aspects of required change and on the challenges and opportunities these presented to the university—for example, diversity, intellectual change, and renegotiating the social contract between the public university and society. Each of these presentations stressed that the University of Michigan had a long heritage of providing leadership to higher education during periods of change and that it was positioned to do the same in the twenty-first century. As my administrative team's efforts moved into high gear, we televised roundtable discussions among students and faculty on key strategic issues, such as diversity, undergraduate education, and multidisciplinary scholarship. These discussions, which I moderated, were videotaped and shown both on the university's internal closed-circuit broadcasting network and on the community-access channels on Ann Arbor's cable television network.

When we launched the transformation effort in 1993, we held dozens of meetings with various groups on campus (much as we had done with the Michigan Mandate), both to explain the importance of the transformation effort and to seek input and engagement. Over the course of the next two years, I managed to meet not only with the faculties of each of our major schools and colleges and larger departments but also with several dozen staff groups in such areas as business, finance, and facilities. The final element of communication and engagement was to launch a series of presidential commissions composed of leading faculty members, to study particular issues and develop recommendations for university actions. These commissions were chaired by several of our most distinguished and



The university played a leadership role in building NSFnet, the precursor to the Internet.

Not so successful was the effort to develop human gene therapy as a clinical application.

influential faculty and populated with change agents. Among the topics included in their studies were the organization of the university; recruiting and retaining the extraordinary (students, faculty); streamlining processes, procedures, and policies; the faculty contract (i.e., tenure); and developing new paradigms for undergraduate education within the environment of a research university. A more complete description and analysis of the UM experience in strategic planning and institutional transformation during the 1990s is provided in the Internet document *Positioning the University of Michigan for the New Millennium*

http://catalog.hathitrust.org/Record/003448848

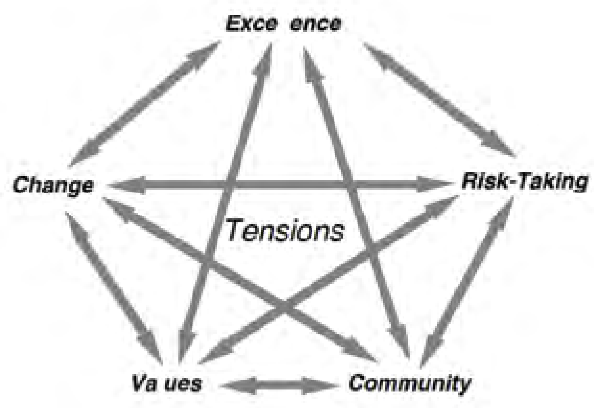
## Experiments and Ventures

As the various elements of Michigan's transformation agenda came into place, our philosophy also began to shift. We came to the conclusion that in a world of such rapid and profound change, as we faced a future of such uncertainty, the most realistic near-term approach was to explore possible futures of the university through experimentation and discovery. Rather than continue to contemplate possibilities for the future through abstract study and debate, it seemed a more productive course to build several prototypes of future learning institutions as working experiments. In this way, the university could actively explore possible paths to the future.

Some experiments had actually been launched during the Vision 2000 positioning phase. One example was our exploration of the possible future of becoming a "privately supported but publicly committed university" by completely restructuring our financing, raising over $1.4 billion in a major campaign, increasing tuition levels, dramatically increasing sponsored research support to the highest in the nation, and increasing our endowment tenfold. Another early experiment was exploring the theme of a "diverse university" through such efforts as the Michigan Mandate and the Michigan Agenda for Women.

There were also new experiments. The university established campuses in Europe, Asia, and Latin America, linking them with robust information technology, to understand better the implications of becoming a "world university." Michigan played leadership roles in the building and management of first the Internet and then its successor, Internet2, to explore the "cyberspace university" theme. We also launched the Michigan Virtual University as such an experiment.

Of course, not all of our experiments were successful. Some crashed in flames—in some cases, spectacularly. My administration explored the possibility of spinning off our academic health center, merging it with another large hospital system in Michigan to form an independent health care system. But our Regents resisted this strongly, concerned that we would be giving away a valuable asset (even though we would have netted well over $1 billion in the transaction and




Planning tensions, sometimes creative,
but also sometimes destructive

Ground zero for managing the process

avoided an anticipated $100 million in annual operating losses as managed care swept across Michigan). Although eventually the Michigan Supreme Court ruled that the intrusive nature of the state's sunshine laws interfered with the Regents' responsibilities for selecting presidents, we ran into a brick wall when attempting to restructure how our governing board was selected and operated. And the university attempted to confront its own version of Tyrannosaurus Rex by challenging the Athletic Department to better align its athletic activities with academic priorities—for example, by recruiting real students, reshaping competitive schedules, throttling back commercialism, and even appointing a real educator (a former dean) as athletic director. Yet the university later spent over $300 million on skyboxes for Michigan Stadium, expanded stadium capacity in the 2000s to over 110,000 and raising ticket prices to over $150 per game (with the seat license fees).

Nevertheless, in most of these cases, at least we learned something—if only about our own ineffectiveness in dealing with such cosmic forces as college sports. More specifically, all of these efforts were driven by the grassroots interests, abilities, and enthusiasm of faculty and students. While such an exploratory approach was disconcerting to some and frustrating to others, there were fortunately many on our campus and beyond who viewed this phase as an exciting adventure. All of these initiatives were important in understanding better the possible futures facing our university. All have influenced the evolution of our university.

## More Lessons Learned:
## The Challenges of Transformation

The experience of the University of Michigan during the 1990s suggests the importance of several factors in achieving successful transformation. First, it is important that any transformation effort always begin with the basics, by launching a careful reconsideration of the key roles and values that should be protected and preserved during a period of change. The history of the university in America is that of a social institution created and shaped by public needs, public policy, and public investment to serve a growing nation. Yet in few places within the academy, at the level of governing boards, or in government higher education policy does there appear to be a serious and sustained discussion (at a time when it is so desperately needed) of the fundamental values so necessary to the nature and role of the university.[6] It is the role of the president to stimulate this dialogue by raising the most fundamental issues involving institutional values.

It is critical that the senior leadership of the university buy into the transformation process and fully support it—or else step off the train before it leaves the station. This is required not only of executive officers and deans but of key faculty leaders as well. It is also essential that the governing board of the university be supportive—or at least not resist—the transformation effort. External advisory bodies are useful to provide alternative perspectives and credibility to the effort. In fact, it is the duty of the governing board to charge a president with the responsibility to develop a plan for the future of the university (setting goals and developing the means to achieve them), if it is to have a framework for assessing presidential performance.

Mechanisms for active debate concerning the transformation objectives and process must be provided to the campus community. At Michigan, we launched a series of presidential commissions on such key issues as the organization of the university, recruiting outstanding faculty and students, and streamlining administrative processes. Each of our schools and colleges was also encouraged to identify key issues of concern and interest. Effective communication throughout the campus community is absolutely critical for the success of the transformation process.

Efforts should be made to identify individuals—at all levels and in various units of the university—who will buy into the transformation process and become active agents on its behalf. In some cases, these will be the institution's most influential faculty and staff. In others, it will be a group of junior faculty or perhaps key administrators. Every opportunity should be used to put in place leaders at all levels of the university—executive officers, deans and directors, chairs and managers—who not only understand the profound nature of the transformations that must occur in higher education in the years ahead but are effective in leading such transformation efforts.

Clearly, significant resources are required to fuel the transformation process, probably at the level of 5 to 10 percent of the academic budget. During a period of limited new funding, it takes considerable creativity (and courage) to generate these resources. As I noted earlier in considering financial issues, the only sources of funding at the levels required for such major transformation are usually tuition, private support, and auxiliary activity revenues, so reallocation must play an important role.

Large organizations will resist change. They will try to wear leaders down or wait them out (under the assumption "This, too, shall pass"). Administrators must give leaders throughout the institution every opportunity to consider carefully the issues compelling change and must encourage them to climb on board the transformation train. For change to occur, administrators need to strike a delicate balance between the forces that make change inevitable (whether threats or opportunities) and a certain sense of stability and confidence that allows people to take risks. For example, how do administrators simultaneously establish sufficient confidence in the long-term support and vitality of the institution and make a compelling case for the importance of the transformation process?

Leading the transformation of a highly decentralized organization is a quite different task than leading strategic efforts that align with long-accepted goals. Unlike traditional strategic activities, where methodical planning and incremental execution can be effective, transformational leadership must risk driving an organization into a state of instability in order to achieve dramatic change. Timing is everything, and the biggest mistake can be agonizing too long over difficult decisions, since the longer an institution remains in an unstable state, the higher the risks of a catastrophic result can be. It is important to minimize the duration of such instability, since the longer it lasts, the more likely it is that the system will move off in an unintended direction or sustain permanent damage. Those who hesitate are lost.

I had learned from my days as dean of the College of Engineering that during the early stages of transformative leadership, you can make a great deal of progress simply because most people do not take you very seriously, while those who do are usually supportive. However, as it becomes more apparent not only that you mean what you say but that you can deliver the goods, resistance begins to build from those moored to the status quo. I sensed that I was becoming increasingly dangerous to those who feared change.

As we broke our thinking out of the box, pushing the envelope further and further, I worried that it was increasingly awkward and perhaps even hazardous for the president to be carrying the message all the time. As my awareness grew about just how profound the changes occurring in our world were becoming, my own speculation about the future of higher education was beginning to approach what some might consider the lunatic fringe. I worried that my own capacity to lead could well be undermined by my own provocative thinking on many of these issues. There were times when I wondered if it was time for the president to stop simply posing public questions (and taking behind-the-scenes actions) and instead begin to provide candid assessments of how we were changing and where we were headed. Or perhaps it was time to set aside the restrictive mantle of university leadership and instead join with others who were actually inventing this future.

Yet university leaders should approach issues and decisions concerning transformation not as threats but, rather, as opportunities. It is true that the status quo may no longer be an option. However, once one accepts that change is inevitable, it can be used as a strategic opportunity to shape the destiny of an institution, while preserving the most important of its values and traditions.

## Impact

During this decade-long effort, begun with Harold Shapiro during my provost years, the university made remarkable progress. Due to the extraordinary talents, commitment, and depth of the leadership team (not to mention a great deal of luck), we had been able to accomplish essentially everything we had originally set out as goals. The institution had been restructured financially and was now as strong as any university in the nation. The Campaign for Michigan, with over a year yet to go, had surpassed its original goal of $1 billion. The endowment had passed $2 billion, almost 10 times the amount we began with. Minority enrollments and faculty representation had doubled as a result of the Michigan Mandate. Michigan had surpassed MIT and Stanford University in research volume, to become the nation's leading research university. The massive $2 billion effort to rebuild the university's campuses was approaching completion, with over a dozen new building dedications already scheduled in the year ahead. Not only was our senior leadership team—executive officers, deans, and administrative directors—highly regarded as one of the strongest in the nation, but talent ran deep throughout the university administration and staff. Furthermore, most of our enemies in state and federal government had either been vanquished or had long since moved on, leaving us with relatively strong support among various external constituencies—including, for a change, even the state's media.

In 1996, our administration handed off a university that not only benefited from the highest academic program rankings in its history but had become regarded nationwide as a leader and an innovator. Michigan led the nation in the magnitude of its research activities. It had the most successful medical center in the nation. It had achieved national leadership in information technology, playing a key role in building the Internet. It had become the strongest public university in the nation in a financial sense, as evidenced by the fact that Wall Street gave it its highest credit rating, AAa, in 1996 (along with the University of Texas, the only two public universities in the nation to receive this rating). A *CBS News* segment on the University of Michigan in 1995 observed, "While America has a number of world-class universities, Michigan truly stands in a class by itself."

More specifically, by the time I stepped down, Michigan's endowment had surpassed $2.5 billion, an increase of almost tenfold. The Campaign for Michigan was nearing completion, raising over $1.4 billion, 40 percent beyond its original goal. The university's portfolio of resources was far more balanced, with tuition revenue increasing to over $500 million per year, and private support (gifts received plus endowment payout) had passed $260 million per year, clearly on track to surpass my administration's goal of exceeding state support by the end of the decade.

The campus environment for teaching and research had been improved significantly. All of the university's campuses—UM Ann Arbor, UM Dearborn, and UM Flint—were essentially rebuilt, with over $2 billion of new construction and renovation, all paid for with little debt left for our successor. The campuses had also been re-landscaped, and new master plans had been not only adopted but achieved. As the quality of the campus was improved, a new sense of pride appeared within the campus communities (particularly among the students), resulting in a dramatic decrease in littering and other activities that defaced the environment.

There was also a significant change in the quality and style of university events and facilities. Both the President's House and Inglis House had been completely renovated. There was a new level of quality achieved in university advancement events. The university had also begun to reconnect itself with its remarkable

One by one, all of the items on the "To Do" charts were being crossed off.

past, developing a new sense of understanding and appreciation for its history and traditions and restoring historically important facilities, such as the Detroit Observatory.

The student body was characterized by a new spirit of leadership and cooperation. Such programs as Leadership 2017 attracted a new generation of leaders, and fraternities and sororities accepted a new sense of responsibility for their activities. Although initially difficult to implement, the student code and campus police had become valuable contributions to the quality of campus life. This was augmented by a major effort to improve campus safety, including the improvement of lighting, transportation, and security.

Michigan athletics had evolved far beyond its football-dominated history, to achieve leadership across a broad range of men's and women's sports. Furthermore, Michigan became the first major university in America to achieve full gender equity in varsity opportunities. The Michigan Mandate and Michigan Agenda for Women had a dramatic impact on the campus, doubling the number of underrepresented minorities among Michigan's students, faculty, staff, and leadership; breaking through the glass ceiling to appoint women to senior leadership positions; and creating a new appreciation for the importance of a diverse campus community.

The external relations of the university were back on track. There were strong teams in place in Lansing, Washington, development, and alumni relations. The university also benefited from what was regarded as one of the strongest leadership teams in the nation at the level of executive officers, deans, and senior administrative staff—although, unfortunately, many of these were to leave early in the tenure of the next president.

Not to say that there were no remaining problems. The Regents still suffered from a political selection process that posed a gauntlet to many qualified candidates. The state's sunshine laws had become increasingly intrusive and were clearly hampering the operations of the university. A scandal was uncovered in the men's basketball program that would plague future presidents. Prospects for the restoration of adequate state support continued to look dim.

Yet in assessing the decade of leadership from 1986 to 1996, it is clear that the university made remarkable progress. It approached the twenty-first century better, stronger, more diverse, and more exciting than ever, clearly positioned as one of the leading universities in the world. During this decade, the University of Michigan completed the ascension in academic quality launched years earlier by Harold Shapiro. Its quality and impact across all academic disciplines and professional programs ranked it among the most distinguished public and private universities in the world.

As the strategic focus of my administration shifted from building a great twentieth-century university to transforming Michigan into a twenty-first-century institution, a series of key initiatives were launched that were intended as seeds for a university of the future. Certainly, highly visible efforts, such as the Michigan Mandate and financial restructuring, were components of this effort. However, beyond these were numerous exciting initiatives led by many of our most distinguished faculty members and designed to explore new paradigms for higher education.

Fortunately, in 1996, as we approached the end of our years in the presidency, the state of Michigan and America were entering what would become the most prosperous time for higher education in many years. State support was relatively generous, and a booming equity market (the "dot-com" boom) stimulated strong private giving and endowment growth. The university coffers were filled. A strong leadership team of executive officers, deans, and administrative staff were in place, and numerous important initiatives were running in high gear. Hence, when I stepped down from the presidency, the future of the university seemed secure—at least for the moment.

## References

Duderstadt, James J., Chapter 16: Preparing for the 21st Century, in Howard H. Peckham, The Making of the University of Michigan (Ann Arbor, MI: University of Michigan Press, 1998) 58 pp

Duderstadt, James J., Positioning the University of Michigan for the New Millennium: A Case Study in University Transformation (Ann Arbor, MI: Millennium Project, University of Michigan, 1999) 630 pp

Duderstadt, James J., On the Move: A Personal History of Michigan's College of Engineering in Modern Times (Ann Arbor: Millennium Project, University of Michigan, 2003) 152 pp.

Duderstadt, James J.,The View from the Helm: Leading the American University during an Era of Change (Ann Arbor, MI: University of Michigan Press, 2006) 400 pp.

Duderstadt, James J., The Third Century: A Roadmap to the University of Michigan's Future (Ann Arbor, MI: Millennium Project, 2014)

# Chapter 23

# Game Changers and Paradigm Shifts

As we look even further into an unknowable future, the possibilities and uncertainties become even more challenging. Attempting to predict the future is always a hazardous activity. We generally overestimate change in the near term and underestimate it for the longer term, in part because we usually tend to extrapolate what we know today into a future that becomes increasingly beyond our imagination. It is very difficult to peer over the horizon. But there are some trends apparent today that will almost certainly influence the longer term that already raise many questions.

How will wealth be created and value added in this global, knowledge-driven economy? Will increasingly robust communications technologies (always on, always in contact, high-fidelity interaction at a distance) stimulate the evolution of new types of communities (e.g., self-organization, spontaneous emergence, collective intelligence, "hives")? Suppose info-bio-nano technologies continue to evolve at the current rate of 1,000 fold per decade. Can we really prepare today's kids for the world of several decades from now when technologies such as neural implants, AI agents ("mind children), and such may actually exist? During the 20th century, the life expectancy in developed nations essentially doubled (from 40 to 80 years). Suppose it doubles again in the 21st century?

More generally, it is clear that as the pace of change continues to accelerate, learning organizations and innovation systems will need to become highly adaptive if they are to survive. Here, we might best think of future learning and innovation environments as ecologies that not only adapt but also mutate and evolve to serve an ever-changing world.

Such future challenges call for bold initiatives. It is not enough to simply build upon the status quo. Instead, it is important that we consider more expansive visions that allow for truly over-the-horizon challenges and opportunities, game changers that dramatically change the environment in which our institutions must function. To this end, it is useful to also speculate about some of the university paradigms shifts that may be required to adapt to an unpredictable future.

## Game-Changers

### Restructuring of the Higher Education Enterprise

Universities serve as the gatekeepers not only for the definition of the academic disciplines and membership in the academy, but, as well, controlling entry to the professions that so dominate contemporary society. While there has been competition among institutions for students, faculty, and resources—at least in the United States—the extent to which institutions control the awarding of degrees has led to a tightly controlled competitive market. Furthermore, most colleges and universities serve primarily local or regional areas, where they have particularly strong market positions. As with most monopoly organizations, today's university is provider-centered, essentially functioning to serve the needs and desires of the faculty rather than the students they teach or the broader society that supports them.

However, today this monopoly character is being strongly challenged. No university can control the growth of knowledge or the educational needs of a society. Information technology is rapidly eliminating the barriers of space and time that have largely shielded campus activities from competition. As the need for advanced education becomes more intense, there are already signs that some institutions are responding to market forces and moving far beyond their traditional geographical areas to compete for students and resources. There are hundreds of colleges and universities that increasingly view themselves as competing in a national or even international marketplace. Even within regions such as local communities, colleges and universities that used to enjoy a geographical monopoly now find that other institutions are establishing beachheads through extension services, distance learning, or even branch campuses. With advances in communication, transportation, and global commerce, several universities in the United States and abroad increasingly view themselves as international institutions, competing in the global marketplace.

Beyond competition among colleges and universities, there are new educational providers entering the marketplace. Sophisticated for-profit entities such as the Apollo Group (i.e., University of Phoenix) and Laureate are moving into markets throughout the United States, Europe, and Asia. Already hundreds of Internet-based institutions are listed in college directories with millions of students enrolled in their programs, including major efforts such as the Western Governors University. It has been estimated that today there are over one thousand corporate training schools in the United States providing both education and training to employees at the college level. Industry currently spends over $200 billion per year on corporate training. And, of course, the MOOC movement and resources such as the Open Courseware Initiative are providing free access to Internet-based courses to millions around the world.

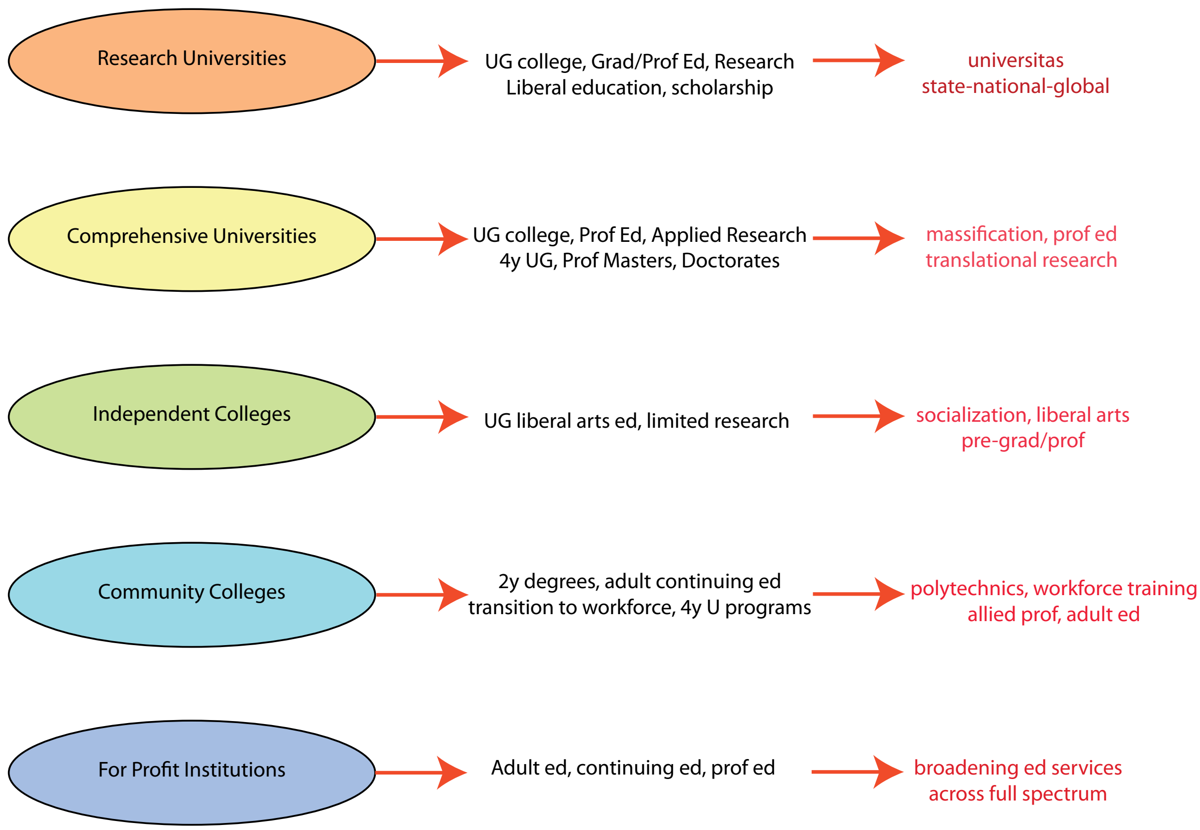
Although traditional colleges and universities enjoy competitive advantages based upon long-standing reputations and control of accreditation and credentialing, these could be eroded quite rapidly by the vast resources from capital markets that the industrial sector is capable of focusing on these efforts. Furthermore, the higher comfort level of industry with technology, intensely competitive marketplaces, strategic alliances, and rapid decision making could prove to be decisive advantages. Finally, with access to the vast resources of capital markets and unhindered by other social commitments or public governance, for-profit providers could cherry pick the best faculty and most attractive products (learning software, courses, or programs) from traditional educational institutions. The competitive threat is very real

The faculty has long been accustomed to dictating what it wishes to teach, how it will teach it, and where and when the learning will occur. Students must travel to the campus to learn. They must work their way through the bureaucracy of university admissions, counseling, scheduling, and residential living. And they must pay for the privilege, with little of the power of traditional consumers. If they navigate through the maze of requirements, they are finally awarded a certificate to recognize their experience—a college degree. This process is sustained by accrediting associations, professional societies, and state and federal governments.

This carefully regulated and controlled enterprise could be eroded by several factors. First, the great demand for advanced education and training cannot be met by such a carefully rationed and controlled enterprise. Second, the expanding marketplace will attract new competitors, exploiting new learning paradigms, and increasingly threatening traditional providers. And perhaps most important of all, newly emerging information technology has not only eliminated the constraints of space and time, but it is also transforming students into learners and consumers. Open education resources are providing learners with choice in the marketplace—access to learning opportunities, knowledge-rich networks and digital libraries, collections of scholars and expert consultants, and other mechanisms for the delivery of learning.

The evolution from faculty-centered and -controlled teaching and credentialing institutions to distributed, open learning environments is already happening. The new learning services are increasingly available among many providers, learning agents, and intermediary organizations. Such an open, network-based learning enterprise certainly seems more capable of responding to the staggering demand for advanced education, learning, and knowledge. It also seems certain not only to provide learners with far more choices but also to create far more competition for the provision of knowledge and learning services.

As a result, higher education is likely to evolve from a loosely federated system of colleges and universities serving traditional students from local communities to, in effect, a global knowledge and learning in-




Evolution of current institutional forms

dustry. With the emergence of new competitive forces and the weakening influence of traditional regulations, education is evolving like other "deregulated" industries, for example, health care, or communications, or energy. Yet, in contrast to these other industries that have been restructured as government regulation has disappeared, the global knowledge industry will be unleashed by emerging information technology as it releases education from the constraints of space, time, and the credentialing monopoly. And, as our society becomes ever more dependent upon new knowledge and educated people, upon knowledge workers, this global knowledge business will represent one of the most active growth industries of our times.

Many in the academy undoubtedly view with derision or alarm the depiction of the higher education enterprise as an "industry" or "business." After all, higher education is a social institution with broader civic purpose and not traditionally driven by concerns about workforce training and economic development. Furthermore, the perspective of higher education as an industry raises concerns that short-term economic and political demands will dominate broader societal responsibilities and investment. Yet, in an age of knowledge, the ability of the university to respond to social, economic, and technological change will likely require new paradigms for how we think about postsecondary education. No one, no government, is in control of the emerging knowledge and learning industry; instead it responds to forces in the marketplace. Universities will have to learn to cope with the competitive pressures of this marketplace while preserving the most important of their traditional values and character.

## Lifelong Learning

The needs for lifelong learning opportunities in a knowledge society are manifold. The shelf life of education early in one's life, whether K-12 or higher education, is shrinking rapidly in face of the explosion of knowledge in many fields. Today's students and tomorrow's graduates are likely to value access to lifelong learning opportunities more highly than job security, which will be elusive in any event. They understand that in the turbulent world of a knowledge economy, characterized by outsourcing and off-shoring to a global workforce, employees are only one paycheck away from the unemployment line unless they commit to continuous learning and re-skilling to adapt to ever changing work requirements. Furthermore, longer life expectancies and lengthening working careers create additional needs to refresh one's knowledge and skills from time to time. And, just as students increasingly understand that in a knowledge economy there is no wiser personal investment than education, many nations now accept that the development of their human capital through education must become a higher priority than other social priorities, since this is the only sure path toward prosperity, security, and social well-being in a global knowledge economy.

Just as in earlier critical moments in our nation's history when federal initiatives expanded the role of education, e.g. the Land Grant Acts in the 19th century to provide higher education to the working class, universal access to secondary education in the early 20th century, and the G. I. Bill enabling the college education of the returning veterans of World War II, today a major expansion of educational opportunity could have extraordinary impact on the future of the nation. It is time for the United States to take bold action, completing in a sense the series of these earlier federal education initiatives, by providing all American citizens with universal access to lifelong learning opportunities, thereby enabling participation in the world's most advanced knowledge society.

Of course, establishing as a national goal the universal access to lifelong learning would require not only a very considerable transformation and expansion of the existing postsecondary education enterprise, but it would also require entirely new paradigms for the conduct, organization, financing, leadership, and governance of higher education in America. For example, most of today's colleges and universities are primarily designed to serve the young–either as recent high school graduates or young adults early in their careers. Yet achieving the objective of universal access to lifelong learning would expand enormously the population of adult learners of all ages. Traditional university characteristics such as residential campuses designed primarily to socialize the young with resources such as residence halls, student unions, recreational facilities, and varsity athletics would have marginal value to adult learners with career and family priorities. Such universal lifelong learning could change dramatically the higher education marketplace, providing for-profit institutions already experienced in adult education with significant advantages. Furthermore it seems likely that the only way that such ubiquitous access can be provided to lifelong learning to adults with career and family responsibilities will be through technology-mediated distance learning.

## Globalization

There is a strong sense that higher education, long international in participation, may now be in the early stages of globalization, through the efforts of an increasing number of established universities to compete in the global marketplace for students, faculty, and resources; through the rapid growth in international partnerships among universities; and through for-profit organizations (e.g., Apollo, Laureate) that seek to expand through acquisition into global enterprises. New types of universities may appear that increasingly define their purpose beyond regional or national priorities to address global needs such as health, environmental sustainability, and international development.As a new world culture forms, a number of universities will evolve into learning institutions serving the world, albeit within the context of a particular geographical area (e.g., North America).

While universities must be responsive to the imperatives of a global economy and attendant to their local responsibilities, they must also become responsible members of the global community. Many of the challenges facing our world such as poverty, health, conflict, and sustainability continue to become more serious through the impact of the human species–global climate change being foremost among them. The global knowledge economy requires thoughtful, interdependent and globally identified citizens. Institutional and pedagogical innovations are needed to confront these challenges and insure that the canonical activities of universities – research, teaching and engagement – re-

Higher education is rapidly globalizing..

main rich, relevant and accessible.

The Changing Nature of Discovery, Learning, and Innovation

The fundamental intellectual activities of discovery and learning enabling these goals are being transformed by the rapid evolution of information and communications technology. Rapidly evolving digital technology, so-called cyberinfrastructure, consisting of hardware, software, people, and policies, has become an indispensable platform for discovery, innovation, and learning. This technology is continuing to evolve very rapidly, linking people, knowledge, and tools in new and profound ways, and driving rapid, unpredictable, and frequently disruptive change in existing social institutions. But since cyberinfrastructure can be used to enhance learning, creativity and innovation, intellectual span, and collaboration, it presents extraordinary opportunities as well as challenges to an increasingly knowledge-driven society. To quote the conclusion of the NSF Blue Ribbon Advisory Panel on Cyberinfrastructure (Atkins, 2003):

"A new age has dawned in scientific and engineering research, pushed by continuing progress in computing, information, and communication technology, and pulled by the expanding complexity, scope, and scale of today's challenges. The capacity of this technology has crossed thresholds that now make possible a comprehensive cyberinfrastructure on which to build new types of scientific and engineering knowledge environments and organizations and to pursue research in new ways and with increased efficacy. Such environments and organizations, enabled by cyberinfrastructure, are increasingly required to address national and global priorities. The emerging vision is to use cyberinfrastructure to build more ubiquitous, comprehensive digital environments that become interactive and functionally complete for research communities in terms of people, data, information, tools, and instruments and that operate at unprecedented levels of computational, storage, and data transfer capacity. Increasingly, new types of scientific organizations and support environments for science are essential, not optional, to the aspirations of research communities and to broadening participation in those communities. They can serve individuals, teams, and organizations in ways that revolutionize what they can do, how they do it, and who participates. This vision has profound broader implications for education, commerce, and social good."

Clearly, today cyberinfrastructure continues not only to reshape but actually create new paradigms for learning and discovery not only in the sciences but increasingly also in the humanities and arts. This is particularly true for emerging technologies such as always-on, ubiquitous connectivity (anywhere, anytime, everyone); social networking, crowd sourcing, collaborative learning and discovery, functionally complete cyberinfrastructures, emerging learning paradigms such as massively open online courses (MOOCs), cognitive tutors, gaming, immersive experiences; big data, data-intensive discovery, learning analytics, intelligent software agents, and possible surprises such as cognitive implants. Of particular concern is the impact of emerging technologies to transform learning institutions (schools, colleges, workplace training, lifelong learning, open learning) and paradigms (from learning about, to learning to do, to learning to become).

The evolution of powerful cyberinfrastructure is driving significant change in the paradigms for discovery and research. Data mining has been added to the

MIT's OpenCourseware Project

Coursera MOOCs

traditional scientific processes of observation, hypothesis, and experiment, becoming more data driven rather than hypothesis driven. Both fundamental research and product development are increasingly dependent on simulation from first principles rather than experimental measurement testing, requiring massive supercomputers. If one subscribes to the view that there is a paradigm shift from hypothesis driven to data driven discovery and simulation, then it is clear that the entire conduct and culture of learning, discovery, and innovation is changing as a result of access to data, technology and social networks. We are going to need new models for sharing data, software, and computational resources.

The impact of rapidly evolving cyberinfrastructure on research and scholarship has been experienced across all of the academic disciplines, e.g., the natural and social sciences, the arts and humanities, and particularly the professional discipline. New paradigms are rapidly emerging for learning and education as well as innovation and professional practice.

Universal Access to Knowledge and Learning

Ironically, while we generally think in terms of this in terms such as terabit/sec networks and exaflop supercomputers, the most profound changes in our institutions may be driven not by the technology itself but rather the philosophy of openness and access it enables–indeed, imposes–on its users. Of particular importance are efforts to adopt the philosophy of open source software development to create new opportunities for learning and scholarship for the world by putting previously restricted knowledge into the public domain and inviting others to join in both its use and development. MIT led the way with its OpenCourseWare (OCW) initiative, placing the digital assets supporting almost 2,000 courses into the public domain on the Internet for the world to use. (Vest, 2006) Today, over 1,000 universities have adopted the OCW paradigm to distribute their own learning assets to the world, with over 15,000 courses now available online. New resources such as Apple's iTunes U and Amazon are providing access to such open educational resources.

Furthermore, a number of universities and corporations have joined together to develop open-source middleware to support the instructional and scholarly activities of higher education, already used by hundreds of universities around the world. (e.g., Moodle, 2007 and Sakai, 2007) Others have explored new paradigms for open learning and engagement, extending the more traditional yet highly successful models provided by open universities, such as Rice University's Connexion Project. There are increasing efforts to open up both data collection and scholarly publication by both individual institutions and university organizations, including the European University Association and the Association of American Universities. More recently major federal research agencies such as NIH, NSF, DOE have implemented new requirements that both the data and publications resulting from their research grants be placed in the public domain on a timely basis.


Google Books


Hathi Trust

To this array of open educational resources should be added efforts to digitize massive quantities of printed material and make it available for search and eventual access. For example, the Google Book project is currently working with a number of leading libraries (26 at last count in 35 languages) around the world to digitize a substantial portion of their holdings (22 million volumes in 2013, with a goal of 30 million by 2020), making these available for full-text searches using Google's powerful internet search engines.

A number of United States universities (60 thus far) have pooled their digital collections to create the Hathi Trust ("Hathi" means "elephant" in Hindi), adding over 400,000 books a month to form the nucleus (already at 14 million books, with 4 million of these already open for full online access) of what could become a 21st century analog to the ancient Library of Alexandria. While many copyright issues still need to be addressed, it is likely that these massive digitization efforts will be able to provide full text access to a significant fraction of the world's written materials to scholars and students throughout the world within a decade.

We should add into this array of ICT-based activities a few more elements: mobile communication, social computing, and immersive environments. We all know well the rapid propagation of mobile communications technology, with over 4 billion people today having cell-phone connectivity and 1.2 billion with broadband access. It is likely that within a decade the majority of the world's population will have some level of cell-phone connectivity, with many using advanced 3G and 4G technologies.

Finally, the availability of new learning resources such as massively open online learning (MOOC) consortia (Udacity, Coursera, and EdX), intelligent AI-based tutor software (Carnegie Mellon's Open Learning Initiative), and immersive learning environments similar to those developed in the massively player gaming world (World of Warcraft) are providing resources that not only open up learning opportunities for the world but furthermore suggest new learning paradigms that could radically challenge and change existing higher education paradigms.

## Preparing for Unknowable Futures

There are other possibilities that might be considered for the longer-term future. Balancing population growth in some parts of the world might be new pandemics, such as a new avian flu virus or air-borne Ebola, which appear out of nowhere to ravage our species. The growing divide between rich and poor, the developed nations and the third world, the North and South hemispheres, could drive even more serious social unrest and terrorism, perhaps armed with even more terrifying weapons.

Then, too, the unrelenting–indeed, accelerating pace of technology could benefit humankind, extending our lifespan and quality of life (although perhaps aggravating population growth in the process), meeting the world's needs for food and shelter and perhaps even energy, and enabling vastly new forms of communication, transportation, and social interaction. Perhaps we will rekindle our species' fundamental quest for exploration and expansion by resuming human spaceflight and eventually colonizing our solar system and beyond.

Sustained progress in the development of new technologies has been the central feature of the past century and is likely to be even more so in the century ahead. But technology will also present new challenges that almost seem taken from the pages of science fiction. Clearly if digital technology continues to evolve at its current pace for the next decade, creating machines a thousand, a million, a billion times more powerful that those which are so dominating our world today, then phenomena such as the emergence of machine consciousness and intelligence become very real possibilities during this century.

John von Neumann once speculated that "the ever accelerating progress of technology and changes in the mode of human life gives the appearance of approaching some essential singularity in the history of the race beyond which human affairs, as we know them, could not continue." The acceleration of technological progress has been the central feature of the past century and is likely to be even more so in the century ahead. Some futurists have even argued that we are on the edge of change comparable to the rise of human life on Earth. The precise cause of this change is the imminent creation by technology of entities with greater than human intelligence. For example, as digital technology continues to increase in power a thousand-fold each decade, at some point computers (or, more likely, large computer networks) might "awaken" with superhuman intelligence. Or biological science may provide the means to improve natural human intellect (Kurzweil, 2005).

When greater-than-human intelligence drives technological evolution, that progress will be much more rapid, including possibly the creation of still more intelligent entities, on a still shorter timescale. To use Von Neumann's terminology, at such a technological "singularity", our old models must be discarded and a new reality appears, perhaps beyond our comprehension. We probably cannot prevent the singularity, since driven as it is by humankind's natural competitiveness and the possibilities inherent in technology, we are likely to be the initiators. But we have the freedom to establish initial conditions, make things happen in ways that are less inimical than others–if we have the wisdom to do so. (Kurzweil, 2005)

Clearly phenomena such as machine consciousness, contact by extraterrestrial intelligence, or cosmic extinction from a wandering asteroid are possibilities for our civilization, but just as clearly they should neither dominate our attention nor our near-term actions. Indeed, the most effective way to prepare for such unanticipated events is to make certain that our descendants are equipped with education and skills of the highest possible quality.

## Paradigm Shifts

### The Common Denominators

As knowledge and educated people become key to prosperity, security, and social well-being, the university, in all its myriad and rapidly changing forms, has become one of the most important social institutions of our times. Yet many questions remain unanswered. Who will be the learners served by these institutions? Who will teach them? Who will administer and govern these institutions? Who will pay for them? What will be the character of our universities? How will they function? When will they appear? The list goes on.

It is difficult to suggest a particular form for the university of the 21st Century. The ever-increasing diversity of American higher education makes it clear that many types of institutions will serve our society. Nonetheless, a number of themes will almost certainly characterize at least some part of the higher education enterprise:

- Universities will shift from faculty-centered to *learner-centered* institutions, joining other social institutions in the public and private sectors in the recognition that we must become more focused on those we serve.
- They will be more *affordable*, within the resources of most citizens, whether through low cost or societal subsidy.
- They will provide *lifelong learning*, requiring both a willingness to continue to learn on the part of our citizens and a commitment to provide opportuni-

ties for this lifelong learning by our institutions.

- All levels of education will be a part of a *seamless web*, as they become both interrelated and blended together.
- Universities will embrace *asynchronous learning*, breaking the constraints of time and space to make learning opportunities more compatible with lifestyles and needs, anyplace, anytime.
- We will continue to develop and practice *interactive and collaborative learning*, appropriate for the digital age, the "plug and play" generation.
- Universities will commit to *diversity* sufficient to serve an increasingly diverse population with diverse needs and goals.
- Universities will need to build learning environments that are both *adaptive and intelligent*, molding to the learning styles and needs of the students they serve.

There is one further modifier that may characterize the university of the future: *ubiquitous*. Today, knowledge has become the coin of the realm. It determines the wealth of nations. It has also become the key to one's personal standard of living, the quality of one's life. We might well make the case that today it has become the responsibility of democratic societies to provide their citizens with the education and training they need throughout their lives, whenever, wherever, and however they desire it, at high quality, and at a cost they can afford.

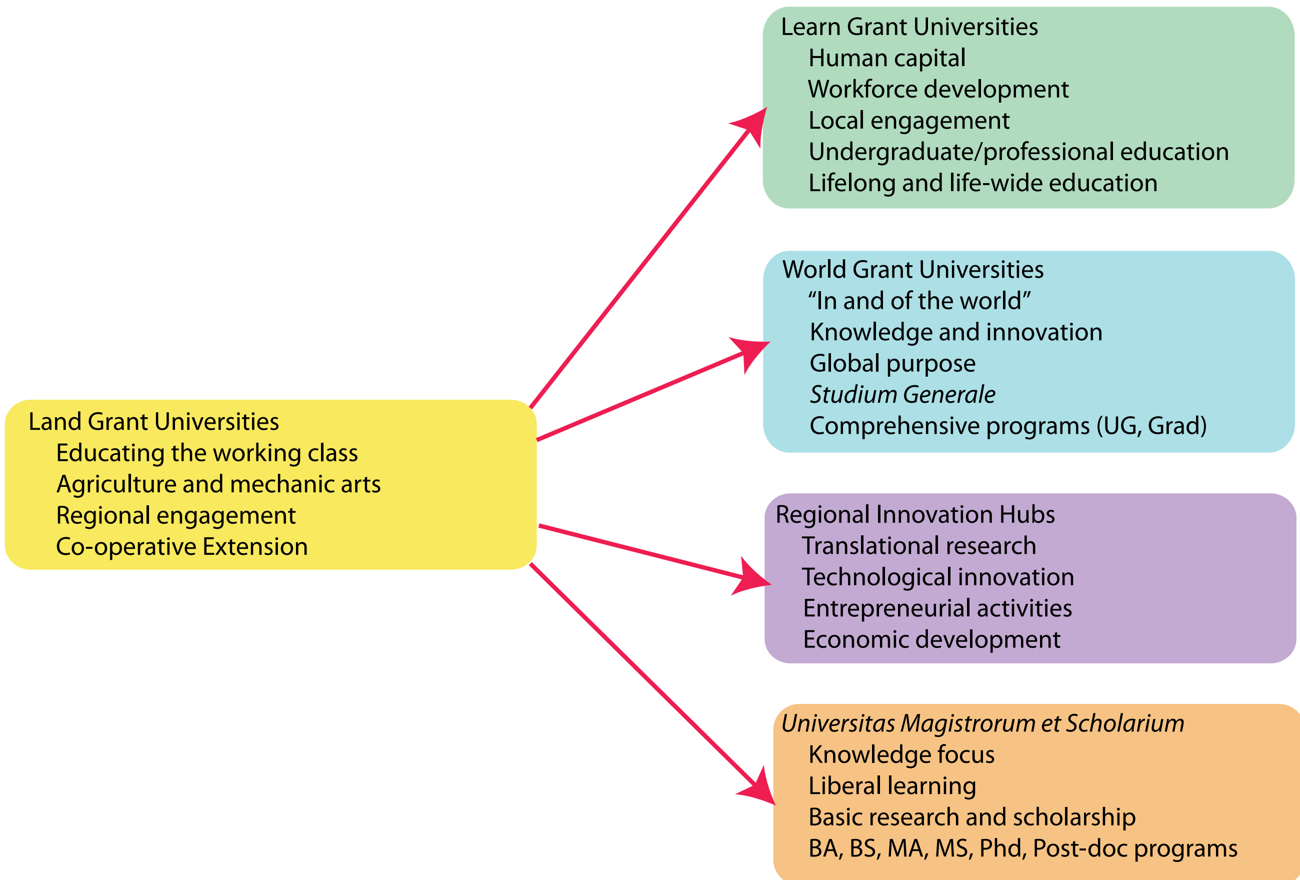
Of course, this has been one of the great themes of higher education in America. Each evolutionary wave of higher education has aimed at educating a broader segment of society—the public universities, the land-grant universities, the normal and technical colleges, and the community colleges. But today we must do even more to serve an even broader segment of our society.

Learn Grant Universities

Perhaps we need new types of institutions that better address the importance of new knowledge and learning opportunities for a 21st century world. Of course our nation has done this before. The land-grant acts of the 19th and 20th centuries created new institutions focused on developing the vast natural resources of our nation to build a modern agricultural and industrial economy. Today, however, we have come to realize that our most important resources for the future will be our people, their knowledge, and their skills and innovation. At the dawn of the age of knowledge, it is clear that learning and innovation are replacing earlier assets such as natural resources, geographical location, or cheap labor as the key to economic prosperity and national security. Perhaps a new social contract based on developing and maintaining the abilities and talents of our people to their fullest extent could well transform our schools, colleges, and universities into new forms that would rival the earlier land-grant university in importance. In a sense, the 21st Century analog to the land-grant university might be a *learn-grant university*.

Such a university would be designed to develop our most important resource, our human resources, as its top priority, along with the infrastructure necessary to sustain a knowledge-driven society. The field stations and cooperative extension programs–perhaps now as much in cyberspace as in a physical location–could be directed to regional learning and innovation needs. While traditional academic disciplines and professional fields would continue to have major educational and service roles and responsibilities, new interdisciplinary fields such as sustainable technologies and innovation systems might be developed to provide the skills, knowledge, and innovation for a region very much in the land-grant tradition.

Other national priorities such as health care systems, environmental sustainability, globalization, and entrepreneurship might be part of an expanded mission for universities. Institutions and academic researchers would then commit to research and professional service associated with such national priorities. To attract the leadership and the long-term public support needed for a valid national public service mission, faculties would be called upon to set new priorities, collaborate across campus boundaries, and build upon their diverse capabilities. This is just one example of many. But the point seems clear. Such a social contract, linking together federal and state investment and interests with higher education and business to serve national and regional needs, could become the elements of a 21st century analog to the land-grant university.




Alternative forms of the land-grant philosophy

World Grant Universities

Many of our leading universities have evolved over time from regional or state universities to, in effect, national universities. Because of their service role in areas such as agriculture and economic development, some universities (particularly land-grant institutions) have gone even beyond this to develop a decidedly international character. Furthermore, the American research university dominates much of the world's scholarship and research, currently enrolling over 765,000 international students and attracting faculty from throughout the world. In view of this global character, some suggest that we may soon see the emergence of truly global universities that not only compete in the global market place for students, faculty, and resources but are increasingly willing to define their public purpose in terms of global needs and priorities such as environmental sustainability, public health, wealth disparities, poverty, and conflict. Such "universities in the world and of the world" might form through consortia of existing institutions (e.g., the U.K.'s Open University), new paradigms, or perhaps even existing institutions that evolve beyond the public agenda or influence of their region or nation-state to assume a truly global character. (Weber, 2008)

Lou Anna Simon, president of Michigan State University, one of the nation's earliest land-grant universities, coins the term "world grant university" to describe an extension of the principles inherent in the land-grant tradition adapted to address the global challenges of the twenty-first century and beyond. Such institutions would not be "granted" access to the world in the sense that states were granted tracts of land by the Morrill Act as a resource to support the establishment of land-grant institutions in the United States. Rather, the "world grant" ideal recognizes that fundamental issues unfolding in one's own backyard link directly to challenges occurring throughout the nation and the world. It not only recognizes this seamless connection


Aligning support (and pehaps governance) with the various patrons of the university

but also actively grants to the world a deeply ingrained commitment to access and utilization of the knowledge required to address these challenges. (Simon, 2010)

The evolution of a world culture over the next century could lead to the establishment of several world universities (Europe, Asia, Africa, and Latin America) as the focal point for certain sorts of study of international order—political, cultural, economic, and technological. Since the genius of higher education in America is the research university, perhaps these are the institutions destined to play this role for North America.

As *The Economist* notes, "The most significant development in higher education is the emergence of a super-league of global universities. The great universities of the 20th century were shaped by nationalism; the great universities of today are being shaped by globalization. The emerging global university is set to be one of the transformative institutions of the current era. All it needs is to be allowed to flourish."

## Hybrid Public/Private/State/National/Global Universities

At a time when the strength, prosperity, and welfare of a nation demand a highly educated citizenry and institutions with the ability to discover new knowledge, develop innovative applications of discoveries, and transfer them into the marketplace through entrepreneurial activities, such vital national needs are no longer top state priorities. The model of state-based support of graduate training and research made sense when university expertise was closely tied to local natural resource bases like agriculture and manufacturing. But today's university expertise has implications far beyond state boundaries. Highly trained and skilled labor has become more mobile and innovation more globally distributed. Many of the benefits from graduate training—like the benefits of research—are public goods that provide only limited returns to the states in which they are located. The bulk of the benefits are realized beyond state boundaries.

Hence, it should be no surprise that many states have concluded that they cannot, will not, and probably should not invest to sustain world-class quality in graduate and professional education—particularly at the expense of other priorities such as broadening access to baccalaureate education. Today, not only is state support woefully inadequate to achieve state goals, but state goals no longer accumulate to meet national needs. The declining priority that states have given to public higher education makes sense for them but is a disaster for the nation. The growing mismatch between state priorities and national needs suggests that it is time once again to realign responsibilities between the state and the nation for higher education and provide adequate resources to sustain American leadership.

We write "once again" because this is not a brand new issue. The success of university research in winning World War II—with innovations such as radar and electronics—and Vannevar Bush's seminal report, "Science, the Endless Frontier: A Report to the President on a Program for Postwar Scientific Research" (1945), convinced national leaders that university research is too important for national security, public health, and economic prosperity to allow it to be entirely dependent upon the vicissitudes of state appropriations and philanthropy. Hence, the federal government assumed the primary responsibility for the support of research, now at a level of $30 billion each year—an effort that has been estimated to have stimulated roughly half of the nation's economic growth during the latter half of the 20th century, while sustaining the nation's security and public health. (Augustine, 2005)

Once more, it is time for the federal government to step in and provide the support necessary to keep our crucial graduate programs among the best in the world. Educating scientists and engineers, physicians and teachers, business leaders and entrepreneurs is vital to developing the human capital that is now key to national prosperity and security in the global, knowledge-driven economy. It cannot be left dependent on shifting state priorities and declining state support.

So how might this work? A new structure would distribute the primary responsibilities for the support of the nation's flagship public research universities among the states, the federal government, and private donors. The states, consistent with their current priorities for enhancing workforce quality, would focus their limited resources on providing access to quality education at the associate and baccalaureate levels, augmented by student tuition and private philanthropy. The federal government would become, in addition to a leader in supporting university research, the primary patron of advanced education at the graduate and professional level. Private patrons, including foundations and individual donors, would continue to play a major role in support of the humanities, the arts, the preservation of knowledge and culture, and the university's role in serving as an informed critic of society—all roles of great importance to the nation. Those functions would also continue to receive state support, because they are essential to high-quality baccalaureate education. (Courant, 2010)

How much additional federal investment will this new approach require? We suggest a magnitude roughly comparable to those of other major federal programs for the support of higher education such as university research ($32 billion per year), the Pell Grant program ($36 billion per year), tax-based aid ($34 billion) , or the foregone federal tax revenues associated with the beneficial tax treatment of charitable giving and endowment earnings ($26 billion per year).

Those additional resources would best be allocated to universities based on a combination of merit and impact. For example, competitive graduate traineeship programs might be used in some disciplines, while grants for other fields might be based on graduation rates or the size of graduate faculties or student enrollments. Other grants could be designed to stimulate and support newly emerging disciplines in areas of national priority, like nanotechnology or global sustainability. In all cases, the key objective would be the direct support of graduate programs through sustained block grants to universities—rather than grants to individual faculty members or students. What matters now is that, more than ever before, America needs to develop a strategy for building and sustaining a system of research universities that is the best in the world.

### The Broadening Mission of Public Universities

An important theme throughout the history of American higher education has been the evolution of the public university. The nation's vision and commitment to create public universities competitive in quality with the best universities in the world were a reflection of the democratic spirit of a young America. With an expanding population, a prosperous economy, and imperatives such as national security and industrial competitiveness, the public was willing to make massive investments in higher education. While elite private universities were important in setting the standards and character of higher education in America, it was the public university that provided the capacity and diversity to meet our nation's vast needs for post-secondary education and research.

Today, however, in the face of limited resources and the pressing social priorities of aging populations, this expansion of public support of higher education has slowed. While the needs of our society for advanced education and research will only intensify as we continue to evolve into a knowledge-driven global society, it is not evident that these needs will be met by further expansion of our existing system of state universities. The terms of the social contract that led to these institutions are changing rapidly. The principle of general tax support for public higher education as a public good and the partnership between the states, the federal government, and the universities for the conduct of basic research and education, established in 1862 by the Morrill Act and reaffirmed a century later by post-WWII research policies, are both at risk.

These forces are already driving major change in the nature of the nation's public research universities. One obvious consequence of declining state support has been the degree to which many leading public universities may increasingly resemble private universities in the way they are financed, managed, and governed, even as they strive to retain their public character. Public universities forced to undergo this privatization transition–or, in more politically acceptable language, "self-sufficiency"–in financing must appeal to a broader array of constituencies at the national—indeed, international—level, while continuing to exhibit a strong mission focused on state needs. In the same way as private universities, they must earn the majority of their support in the competitive marketplace, that is, via tuition, research grants, and private giving, and this will require actions that come into conflict from time to time with state priorities. Hence, the autonomy of the public university will become one of its most critical assets, perhaps even more critical than state support for many institutions.

Indeed, today many states are encouraging their public universities to reduce the burden of higher education on limited state tax revenues by diversifying their funding sources, e.g., by becoming more dependent upon tuition–particularly that paid by out-of-state students–by intensifying efforts to attract gifts and research contracts, and by generating income from intellectual property transferred from campus laboratories into the market-place. Some states are even encouraging experimentation in creating a more differentiated higher education structure that better aligns the balance between autonomy and accountability with the unique missions of research universities. Examples include Virginia's effort to provide more autonomy in return for accountability for achieving negotiated metrics, Colorado's voucher system, performance funding in South Carolina, and cohort tuition in Illinois (Breneman, 2005).

Yet, such efforts to "privatize" the support of public universities through higher tuition or increasing out-of-state enrollments can also encounter strong public and political opposition, even though there is ample evidence that, to date, tuition increases at most public institutions have not been sufficient to compensate for the loss in state appropriations. (Desrochers, 2011) Furthermore, since state support is key to the important public university mission of providing educational opportunities to students regardless of economic means, shifting to high tuition funding, even accompanied by increased financial aid, usually leads to a sharp decline in the socioeconomic diversity of students. (Haycock, 2008, 2010)

The privatizing strategy is flawed for more fundamental reasons. The public character of state research universities runs far deeper than financing and governance and involves characteristics such as their large size, disciplinary breadth, and deep engagement with society through public service. These universities were created as, and today remain, public institutions with a strong public purpose and character. Hence the issue is not whether the pubic research university can evolve from a "public" to a "private" institution, or even a "privately funded but publicly committed" university. Rather, the issue is a dramatic broadening of the "publics" that these institutions serve, are supported by, and become accountable to, as state support declines to minimal levels.

In view of this natural broadening of the institutional mission, coupled with the increasing inability (or unwillingness) of states to support their public research universities at world-class levels, it is even possible to conclude that the world-class "state" research university may have become an obsolete concept. Instead, many of America's leading public research universities may evolve rapidly into "regional," "national," or even "global" universities with a public purpose to serve far broader constituencies than simply the citizens of a particular state who no longer are able or willing to provide sufficient support to sustain their programs at world-class levels. In fact, one might well argue that states today would be better off if they encouraged their flagship public research universities to evolve into institutions with far broader missions (and support), capable of accessing global economic and human capital markets to attract the talent and wealth of the world to their regions.

How might institutions embark on this path to serve far broader public constituencies without alienating the people of their states—or risking their present (albeit low) level of state support? One constructive approach would be to attempt to persuade the public—and particularly the media—that public research universities are vital to states in a far more multidimensional way than simply education alone—through health care, economic development, the production of professionals (doctors, lawyers, engineers, and teachers), talent magnets attracting talent from around the world, and for some a source of pride (particularly in college sports). The challenge is to shift the public perception of public research universities from that of a consumer to that of a producer of state resources. One might argue that for a relatively modest contribution toward their educational costs, the people of their states receive access to the vast resources, and benefit from the profound impact, of some of the world's great universities. It seems clear that we need a new dialogue concerning the future of public higher education in America, one that balances both its democratic purpose with economic and social imperatives.

Today, we face the challenges of a hypercompetitive global, knowledge-driven society in which other nations have recognized the positive impact that building world-class public universities can have. America already has them. They are one of our nation's greatest assets. Preserving their quality and capacity will require not only sustained investments but also significant paradigm shifts in university structure, management, and governance. It also will likely demand that public research universities broaden their public purpose and stakeholders far beyond state boundaries. Preserving the quality and capacity of the extraordinary resource represented by our public research universities must remain a national priority, even if the support required to sustain these institutions at world-class levels is no longer viewed as a priority by our states.

The "No-Frills" University

In recent years there has been growing discussion about the possibility of accelerated three-year baccalaureate programs in U.S. higher education. In part this has been stimulated by the broad adoption by European universities of the three-year degree programs associated with the Bologna Process. But it has also been proposed as a way to reduce the cost of a college education, or as Senator Lamar Alexander puts it, viewed as "the higher ed equivalent of a fuel-efficient car".

In fact, one might go even further and imagine introducing into American higher education streamlined universities more similar to those in Europe. Most European universities enroll adult students directly in three-year disciplinary majors after longer and more intense secondary educations. In contrast, American colleges and universities have inherited from their British antecedents the mission of the socialization of young students. Not only does this require a very substantial investment in supporting infrastructure such as residence halls, community facilities, and entertainment and athletic venues, but it can also distract the university from its more fundamental knowledge-based mission. Nevertheless it has become the expectation of American parents that "college is the place where we send our children to grow up". Furthermore, U.S. colleges and universities are expected to compensate for the significant weaknesses currently characterizing primary and secondary education in the United States, even if that requires providing remedial programs for many under-prepared students.

In sharp contrast, European universities focus their activities on teaching and scholarship for adult students. Entering students enroll in focused three-year discipline-based baccalaureate programs without the preliminary general education experience and socialization programs characterizing American universities. Students are expected to arrange for their own living and social activities, while the university focuses on its "knowledge and learning" mission, thereby avoiding many of the costs associated with socializing young students.

There have been numerous suggestions that the United States explore the "no-frills" approach of European universities by focusing the activities of some of

Most European universities are designed for upper division (adult) students (here at the Sorbonne U. Paris).

their universities entirely upon disciplinary teaching and scholarship for upper-division students, thereby greatly reducing costs and tuition. This would allow the universities to focus their extensive—and expensive—resources where they are most effective: on intellectually mature students who are ready to seek advanced education and training in a specific discipline or profession. It would relieve them of the responsibility of general education and parenting, roles for which many large universities are not very well suited in any event. It might also allow them to shed their activities in remedial education, a rather inappropriate use of the costly resources of the research university. Focusing universities only on advanced education and training for academically mature students could actually enhance the intellectual atmosphere of the campus, thereby improving the quality of both teaching and scholarship considerably. Adult learners would be far more mature and able to benefit from the resources of these institutions.

Ironically, such a focusing of efforts might even reduce public criticism of higher education. Most students—and parents—appear quite happy with the quality of both upper-class academic majors and of professional education. Furthermore, they seem quite willing to pay the necessary tuition levels, both because they accept the higher costs of advanced education and training, and because they see more clearly the benefits of the degree to their careers, "the light at the end at the tunnel." In contrast, most of the concern and frustration expressed by students and parents with respect to quality and cost are focused on the early years of a college education, on the general education phase, since they perceive this style of pedagogy very similar to that of secondary education.

Yet the current quality and character of secondary education in the United States probably will not allow this for most students. Secondary education in Europe and much of the rest of the world is characterized by a more extended and intensive pre-college education, e.g., the German gymnasium, the British Sixth-Form, and the Canadian "college", which provide much of the general education preparation that currently comprises the first two-years of American college education. Hence a major shift to three-year baccalaureate programs or no-frills adult universities would likely require a major restructuring of secondary education in the United States more along the lines of Europe and Canada.

Open and "Open Source" Universities

For many years, the educational needs of many nations have been addressed by open universities, institutions relying on both televised or Internet-based courses and local facilitators to enable students to study and earn degrees at home. Perhaps most notable has been the British Open University, but this is only one of many such institutions that now enroll over three million students worldwide.

These institutions are based upon the principle of open learning, in which technology and distance education models are used to break down barriers and provide opportunities for learning to a very broad segment of society. In these models, students become more active participants in learning activities, taking charge of their own academic program as much as possible. Most of these open universities are now embracing information technology, particularly the Internet, to provide educational opportunities to millions of students unable to attend or afford traditional residential campuses (e.g., the University of the People, which aims to provide tuition-free education to developing economies).

The motivation behind open universities involves cost, access, and flexibility. The open university paradigm is based not on the extension of the classroom but rather the one-to-one learning relationship between the tutor and the student. It relies on very high-quality learning materials, such as learning software and digital materials distributed over the Internet, augmented by facilitators at regional learning centers and by independent examiners. Using this paradigm, for example, the British Open University has been able to provide high-quality learning opportunities (currently ranked among the upper 15 percent of British universities) at only a fraction of a cost of residential education ($7,000 compared to $20,000 per student year in North America).

To date most open universities rely heavily on self-learning in the home environment, although they do make use of interactive study materials and decentralized learning facilities where students can seek academic assistance when they need it. However, with the rapid evolution of virtual distributed environments and learning communities, these institutions will soon be able to offer a mix of educational experiences.

Clearly, the open university will become an increasingly important player in higher education at the global level. The interesting question is whether these institutions might also gain a foothold in the United States. During the 1990s the British Open University attempted to establish a beachhead in the United States, but the financial model did not work. More recently emerging institutions such as the Western Governors' University and the University of Phoenix are now exploiting many of the concepts pioneered by the open university movement around the world, although recently the for-profit higher education sector has been experiencing declining enrollments.

Beyond the open university paradigm of admitting all applicants but setting firm requirements for graduation, some universities are embracing other aspects of the open philosophy in their educational activities. The explosion of online educational materials being made available through the OpenCourseWare and iTunes U paradigms, coupled with access to massive digital libraries such as the HathiTrust, is transforming the knowledge infrastructure of universities–and bringing the marketplace into the classroom, since many of these online courses compete very effectively with the instruction provided by oncampus faculty. A number of universities including the University of Michigan are playing leading roles in providing access to knowledge and learning tools through such open learning resources (e.g. MIT's OpenCourseware, Rice's Connextion Project, and Carnegie Mellon's Open Learning Initiative.) Some institutions are even preparing to explore the possible emergence of "open source" universities, committed to providing extraordinary access to knowledge and learning tools through open learning resources. In fact, some universities might decide to remove entirely the restrictions imposed by intellectual property ownership by asking all of their students and faculty members to sign a Creative Commons license for any intellectual property they develop at the University (at first copyright but eventually possibly even exploring other intellectual properties such as patents). Perhaps this would even redefine the nature of a "public" university, much in the spirit of the "public" library!

### MOOCs, Learning Analytics, and Other "New" Learning Paradigms

The current strong interest (and hype) concerning massively open online courses (MOOCs) provides an example of how the merging of ubiquitous connectivity, social networking, and sophisticated pedagogy can create new forms of learning that access massive markets. Developed originally by computer scientists, the MOOC paradigm has rapidly been extended in numerous disciplines to massive markets by many universities working through integrators such as Udacity, Coursera, and EdX. While there are still many questions both about the rigor of the MOOC pedagogy and its capacity to generate revenues for the host institutions, it nevertheless provides an example of how robust connectivity leveraged through social networks can create massive learning communities at a global level.

Of course, today's MOOCs do have some new elements, aside from the massive markets they are able to build through the Internet and their current practice of free access. (Waldrop, 2013) They augment online broadcast of canned lectures and automated grading of homework with social networks to provide teaching support through message boards and discussion groups of the students themselves. Their semi-synchronous structure, in which courses and exams are given at a specific time while progress is kept on track. Here one might think of MOOCs as a clever combination of UK's

Open University (online education) and Wikipedia (crowd sourcing of knowledge)! Furthermore, MOOCs, like the far-more sophisticated Open Learning Initiative, are able to use data mining (analytics) to gather a large amount of information about student learning experiences. When combined with cognitive science, this provides a strong source of feedback for course improvement.

Some believe that today higher education is on the precipice of an era of extraordinary change as such disruptive technologies challenge the traditional paradigms of learning and discovery. (Friedman, 2011) They suggest that new technologies could swamp the university with a tsunami of cheap online courses from name-brand institutions, or adaptive learning using massive data gathered from thousands of students and subjected to sophisticated analytics, or even cognitive tutors that rapidly customize the learning environment for each student so they learn most deeply and efficiently.

But are these really something new or rather simply old wine in new bottles? After all, millions of students have been using online learning for decades (estimated today to involve over one-third of current students in the United States). There are many highly developed models for online learning, including the UK Open University, the Western Governor's University in the United States, and the Apollo group's global system of for-profit universities. Adaptive learning has been used in Carnegie Mellon's cognitive tutor software for years in secondary schools and more recently in the Open Learning Initiative. Many of the buzzwords used to market these new technologies also have long established antecedents: Experiential learning? Think "laboratories" and "internships" and "practicums"…and even "summer jobs"! Flipped classrooms? Think "tutorials" and "seminars" and "studios". Massive markets of learners? Many American universities were providing free credit instruction to hundreds of thousands of learners as early as the 1950s through live television broadcasts!

Certainly the MOOC paradigm is characterized by a powerful delivery mechanism. But it is just one model. There are also other models to explore and rich collaboration opportunities to share such as the data analytics and adaptive learning used in Carnegie Mellon's Open Learning Initiative or the artificial intelligence-based cognitive tutor technology, developed again by Carnegie Mellon, and used in K-12 and lower division college education for the past decade, open knowledge initiatives such as Google Books, the HathiTrust, and open scholarly data and publication archives; massively player gaming (e.g., Minecraft and the World of Warcraft) and immersive media (e.g., Second Life, and Enders Game). Automated assessment and evaluation could turn the whole education business upside down because we will have access to massive data sets that potentially will give us some insight in not how we deliver content but rather how people learn.

It is likely that MOOCs are a disruptive technology, and that analytics on learning data holds considerable promise. But it is also very important to separate the fundamental character of a college education from the specific resources used to achieve that, e.g., courses and curricula, textbooks and course notes, faculty and laboratory staff, and, of course, the complex learning communities that exist only on university campuses. After all, MOOCs are marketed as courses, not as a college education. We must remember the current university paradigm of students living on a university campus, completely immersed in an exciting intellectual and social physical environment and sophisticated learning communities, provides a very powerful form of learning and discovery. MOOCs are interesting, but they are far from the vibrant, immersive environment of a college education, at least as we understand it today.

Of course, there are highly disruptive scenarios. Suppose Stanford, Harvard, or MIT, the purveyors of for-profit ventures such as Coursera, Udacity, and EdX, were to begin to sell "Harvard-lite" credits or badges to students who successfully completed their MOOCs. Then many colleges would be compelled to accept these credentials for degree-credit, thus undermining their oncampus offerings. It would be ironic indeed if the same rich universiites that are most guilty of driving up college costs by using their vast wealth to compete for the best faculty and students would now thrown in yet another hand grenade consisting of brandname-driven cheap online education that could make them even wealthier while undermining the quality of education offered by traditional campus-based institutions.

What do we know about the effectiveness of these technology-based approaches? Where are the careful measurements of learning necessary to establish the value of such forms of pedagogy? Thus far, promoters have relied mostly on comparisons of performances by both conventional and online students on standard tests. The only serious measurements have been those that Ithaka has conduced on the learning by cognitive tutor software in a highly restricted environment. (Bowen, 2012)

Of course, it eventually comes back to the questions of "What is the most valuable form of learning that occurs in a university…and how does it occur?" Through formal curricula? Through engaging teachers? Through creating learning communities? After all, the graduate paradigm of *Universitas Magistrorum et Scholarium* involving the interaction of masters and scholars will be very hard to reproduce online…and least in a canned video format!!!

As William Bowen, former president of Princeton and the Mellon Foundation and a founder of Ithaka suggests, it is time to "Walk, Don't Run" toward the use of cyberlearning. We need lots of experimentation, including rigorous measurement of education–before we allow the technology tsunami to sweep over us! (Bowen, 2013)

### A Return to *Universitas Magistrorum et Scholarium*–in Cyberspace

It is ironic that the cyberspace paradigm of learning communities may actually return higher learning to the medieval tradition of the master surrounded by scholars in an intense learning relationship. The term "university" actually originated during the Middle Ages with the appearance of "unions" of students or faculty members who joined together to form communities of teachers or students. The Latin origin, *universitas*, meant "the totality" or "the whole" and was used by medieval jurists as a general term to designate communities or corporations such as guilds, trades, and brotherhoods. Eventually the term university was restricted to these unions of masters and scholars and given the more formal Latin title: *Universitas Magistrorum et Scholarium*.

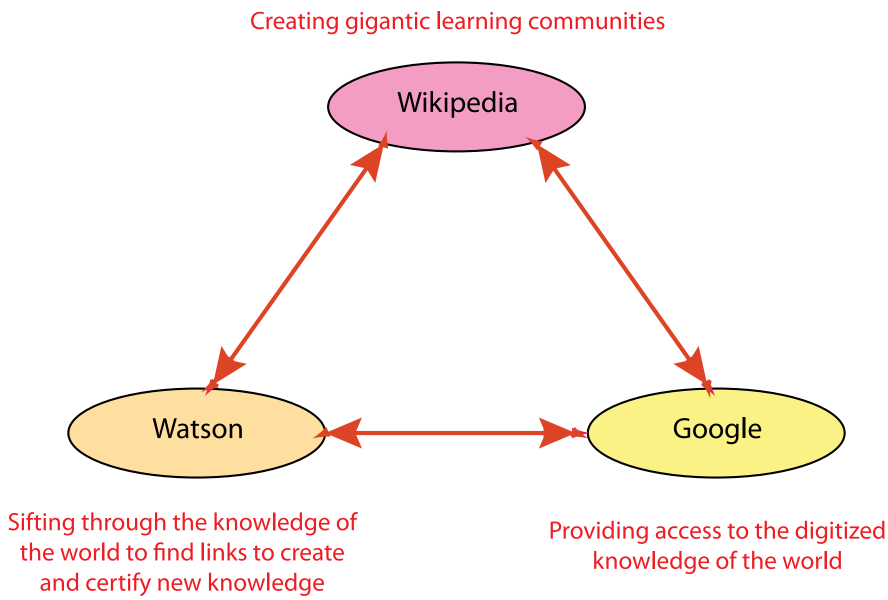
From time to time, educators have attempted to define the university in more intellectual terms. John Henry Newman stressed instead an alternative interpretation of the word: "The university is a place of teaching universal knowledge." In fact, the earliest European universities were designated as *stadium generale* by church or state to indicate their role to provide learning of a broad, universal nature to all of the known world (enabled, of course, by the use of Latin as the universal language of the academy).

We tend to prefer a simpler synthesis of these definitions of the university:

*A university is a community of masters and scholars, a school of universal learning (Newman) embracing every branch of knowledge and all possible means for making new investigations and thus advancing knowledge (Tappan).*

In a sense, this recognizes that the true advantages of universities are in the educational processes, in the array of social interactions, counseling, tutorial, and hands-on mentoring activities that require human interaction. In this sense, information technology will not so much transform the purpose of higher education—at least in the early phases—as enrich the educational opportunities available to learners. In a sense, technology is enabling the most fundamental character of the medieval university to emerge once again, but this time in cyberspace!

There is an important implication here. Information technology may allow—perhaps even require—new paradigms for learning organizations that go beyond traditional structures such as research universities, federal research laboratories, research projects, centers, and institutes. If this is the case, we should place a far higher priority on moving to link together our students and educators both among themselves and with the rest of the world. The necessary cyberinfrastructure would be a modest investment compared with the massive investments we have made in the institutions of the past—university campuses, transportation, and urban infrastructure. It is not too early to consider an overarching agenda to develop deeper understanding of the interplay between advanced information technology and social systems. We may soon have the knowledge to synthesize both in an integrated way as a total system.




A puzzle: Is this a possible future for the university?

Learning Ecologies

John Seely Brown suggests that we might think of the contemporary university as an interconnected set of three core competencies: *learning communities, knowledge resources, and the certification of knowledge skills.* (Brown, 2000) Social computing will empower and extend learning communities beyond the constraints of space and time. Open knowledge and education resources will clearly expand enormously the knowledge resources available to our institutions. And immersive environments will enable the mastery of not simply conventional academic knowledge but tacit knowledge. A fundamental epistemological shift in learning is occurring from individual to collective learning; from a focus on development of skills to instead dispositions, imagination, and creativity; and enabling the acquisition of both explicit and tacit knowledge.

In a rapidly changing world, innovation no longer depends only upon the explicit dimension characterizing conventional content-focused pedagogy focused on "learning to know". Rather, one needs to enable an integration of tacit knowledge with explicit knowledge. Emerging ICT technologies that enable social networking to form learning communities and immersive virtual environments for simulation and play facilitate the "deep tinkering" that provides the tacit knowledge necessary to "learn to do", "learn to create", and "learn to be", tools already embraced by the young if not yet the academy. In a sense, learning has become a "culture", in the sense of the Petri dish that is in a state of constant evolution.

Once we have realized that the core competency of the university is not simply transferring knowledge, but developing it within intricate and robust networks and communities, we realize that the simple distance-learning paradigm of the virtual university is inadequate. The key is to develop computer-mediated communications and communities that are released from the constraints of space and time.

Distance learning based on computer-network-mediated paradigms allows universities to push their campus boundaries outward to serve learners anywhere, anytime. Those institutions willing and capable of building such learning networks will see their learning communities expand by an order of magnitude. In this sense, the traditional paradigm of "time-out-for-education" can be more easily replaced by the "just in time" learning paradigms, more appropriate for a knowledge-driven society in which work and learning fuse together.

To illustrate the implications of such a re-definition of the university, consider a learning ecosystem represented by the diagram of three elements: Wikipedia, Google, and Watson (the IBM computer that used artificial intelligence to beat the champions of the game-

The emergence of new learning ecologies

show Jeopardy). Each of these elements addresses a key core competency of the university:

*Wikipedia* represents the capability to create enormous learning communities with a collective ability to digest and analyze information, self-correcting and evolving very rapidly through crowd sourcing as an emergent phenomenon.

*Google* represents a future in which all knowledge is available in the cloud, digitized, accessible, searchable–everything ever printed, measured, sensed, or created–big data to the extreme.

*Watson* represents the capacity to use artificial intelligence to analyze information, trillions of transactions per second, identifying correlations, curating information, authenticating knowledge, certifying learning, and providing ubiquitous access.

What is this? A postmodernist university? A new epistemology for the 21st Century? The foundation for a 21st analog to the Renaissance or even the Age of Enlightenment? A technological singularity...

Or perhaps...

The University as an Emergent Civilization

So what might we anticipate over the longer term as possible future forms of the university? The monastic character of the ivory tower is certainly lost forever. Although there are many important features of the campus environment that suggest that most universities will continue to exist as a place, at least for the near term, as digital technology makes it increasingly possible to emulate human interaction in all the senses with arbitrarily high fidelity, perhaps we should not bind teaching and scholarship too tightly to buildings and grounds. Certainly, both learning and scholarship will continue to depend heavily upon the existence of communities, since they are, after all, high social enterprises. Yet as these communities are increasingly global in extent, detached from the constraints of space and time, we should not assume that the scholarly communities of our times would necessarily dictate the future of our universities. For the longer term, who can predict the impact of exponentiating technologies on social institutions such as universities, corporations, or governments, as they continue to multiply in power a thousand-, a million-, and a billion-fold?

But there is a possibility even beyond these. Imagine what might be possible if all of these elements are merged, i.e., Internet-based access to all recorded (and then digitized) human knowledge augmented by powerful search engines and AI-based software agents; open source software, open learning resources, and open learning institutions (open universities); new collaboratively developed tools (Wikipedia II, Web 2.0); and ubiquitous information and communications technology (e.g., inexpensive network appliances such as iPhones, iPads, or netbooks). In the near future it could be possible that anyone with even a modest Internet or cellular phone connection will have access to the recorded knowledge of our civilization along with ubiquitous learning opportunities and access to network-based communities throughout the world (perhaps even through immersive environments such as Second

Life).

Imagine still further the linking together of billions of people with limitless access to knowledge and learning tools enabled by a rapidly evolving scaffolding of cyberinfrastructure, which increases in power one-hundred to one thousand-fold every decade. This hive-like culture will not only challenge existing social institutions–corporations, universities, nation states, that have depended upon the constraints of space, time, laws, and monopoly. But it will enable the spontaneous emergence of new social structures as yet unimagined–just think of the early denizens of the Internet such as Google, Facebook, Wikipedia, …and, unfortunately, Al Qaeda. In fact, we may be on the threshold of the emergence of a new form of civilization, as billions of world citizens interact together, unconstrained by today's monopolies on knowledge or learning opportunities.

Perhaps this, then, is the most exciting vision for the future of knowledge and learning organizations such as the university, no longer constrained by space, time, monopoly, or archaic laws, but rather responsive to the needs of a global, knowledge society and unleashed by technology to empower and serve all of humankind. And all of this is likely to happen during the lives of today's students. These possibilities must inform and shape the manner in which we view, support, and lead higher education. Now is not the time to back into the future.

## References

Duderstadt, James J. , "The Future fo the University: A Perspective from the Oort Cloud", De Lange Conference on Higher Education, Rice University, 2012

Duderstadt, James J. , The Third Century: A Roadmap to the University of Michigan's Future (Ann Arbor, MI: Millennium Project, 2014)

Chapter 24

# A Vision for the University of Michigan's Third Century

Today, the University of Michigan approaches a singular moment in its history, its bicentennial year in 2017, which will provide an important occasion to recall, understand, and honor its rich history. But this milestone will also provide a remarkable opportunity to learn from the University's past, to assess the challenges and opportunities it faces at the present, and to chart a course for its future. Indeed, since Michigan's greatest impact has resulted in part from its capacity to capture and sustain the important elements of its history while developing bold visions for the future, the 2017 UM Bicentennial should be viewed as a compelling challenge to develop a new vision for Michigan's third century and a plan to achieve that vision.

## The Challenge, Opportunity, and Responsibility Presented by Change

There are numerous concerns swirling about higher education these days. Many question whether our colleges and universities are achieving acceptable student learning outcomes (including critical thinking ability, moral reasoning, communication, and quantitative literacy). Rising tuitions raise serious concerns about cost-containment and productivity on our campuses, indeed, questioning the very relationship among the cost, price, and value of a college education. Some even raise the question as to whether higher education is really worth the cost, portraying our universities as inadequately aligned with the marketplace and unwilling (or unable) to prepare their graduates to meet the needs of employers. Traditional sources of public support for higher education seem increasingly at risk in the face of a three-decade long decline of state support and current threats to federal research funding. There is clear evidence of an increasing stratification of access to (and success in) quality higher education based upon socio-economic status.

The emergence of disruptive technologies such as computers and networks challenge existing university paradigms by suggesting new approaches to learning such as open educational resources, MOOCs, "flipped" classrooms, and learning analytics, while scholarship and research are changing rapidly due to new resources such as digital libraries, "big data", and data mining. Even more fundamentally, society today is questioning the fundamental public purpose of the university, particularly as its activities have broadened beyond learning and scholarship to include a broad range of market-driven activities such as clinical care in their medical, entrepreneurial efforts to create new businesses, international development, and commercial public entertainment (e.g., college sports).

But there are far more profound changes occurring in our world that will challenge us. We live in a time of great change, an increasingly global society, knitted together by pervasive communications and transportation technologies and driven by the exponential growth of new knowledge. It is a time of challenge and contradiction, as an ever-increasing human population threatens global sustainability; a global, knowledge-driven economy places a new premium on workforce skills through phenomena such as outsourcing and off-shoring; governments place increasing confidence in market forces to reflect public priorities even as new paradigms such as open-source technologies challenge conventional free-market philosophies; and shifting geopolitical tensions driven by the great disparity in wealth and power about the globe, national security, and terrorism.

More specifically, today our world has entered a period of rapid and profound economic, social, and political transformation driven by knowledge and innovation. It has become increasingly apparent that the prosperity, security, and social well-being of region or nation in a global knowledge economy will demand a highly educated citizenry enabled by development of a strong system of education at all levels. It will also require institutions with the ability to discover new knowledge and develop innovative applications of these discoveries to serve society.

The recurrent theme of this study, and, indeed, throughout the history of the University of Michigan, is the need for change in higher education if our colleges and universities are to serve a rapidly changing world. Of course the university as a social institution has always been quite remarkable in its capacity to change and adapt to serve society. Yet the forces of change upon the contemporary university, driven by profound social change, economic imperatives, and rapidly evolving technology, may be far beyond the adaptive capacity of our current educational paradigms. We may be approaching a point of crisis in higher education when it is necessary to reconstruct the paradigm of learning institutions from its most fundamental elements, perhaps even to reinvent the university itself.

This capacity for change, for renewal, is the key objective that the University of Michigan must strive to achieve in the years ahead—a capacity that will allow it to transform itself once again as it has done so many times in the past, to serve a changing society and a changing world.

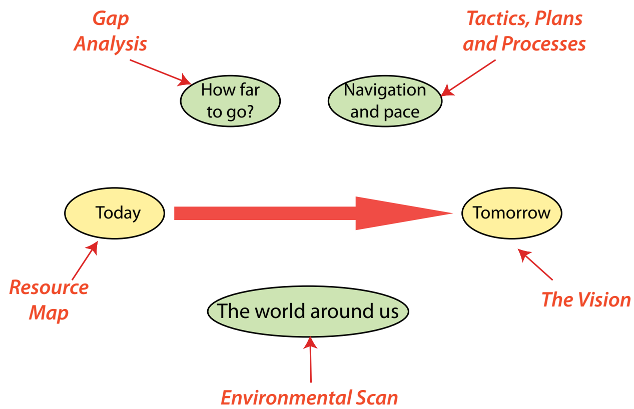
The leadership of the University of Michigan has frequently depended upon its unusual combination of quality, size, breadth, innovation, and pioneering spirit. Michigan has long served as a *pathfinder* by identifying new directions for higher education and society, as a *trailblazer* marking these new pathways for others to explore, and as a *pioneer* building the roads that others might follow (although rarely has Michigan prospered as a *settler* by simply attempting to follow the paths of others.) Through academic innovation, social responsiveness, and its willingness to challenge the status quo, Michigan's history reveals time and time again this pathfinding character. It is this unique heritage that should shape the University's mission, vision, goals, and actions as it approaches its third century.

## Strategic Roadmapping

Key to the University of Michigan's leadership has been its capacity throughout its history to set bold, compelling visions for the future of the institution and then engage the University community in joining together to develop and execute creative plans, policies, and processes to achieve these visions. Of course, planning for such complex, rapidly changing, and unpredictable futures requires a highly disciplined approach. In this report, we have adapted a planning technique commonly used in those sectors of industry and the federal government characterized by extremely rapid and unpredictable change: *strategic roadmapping*. This approach begins by using panels of experts to propose goals or visions for the organization, then to construct a map of existing resources and perform an analysis to determine the gap between what currently exists and what is needed, and finally to develop a plan or roadmap of possible routes from here to there, from now to the future. Although sometimes confused with jargon such as environmental scans, resource maps, and gap analysis, in reality the roadmapping process is quite simple. It begins by asking *where we are today*, then *where we wish to be tomorrow*, followed by an assessment of *how far we have to go*, and finally concludes by *developing a roadmap to get from here to there*. The roadmap itself usually consists of a series of recommendations aimed at navigating toward the vision, augmented by more detailed goals, plans, processes, and tactics designed to enable the necessary institutional change.

## A Vision for the Third Century

To develop a suitable vision for this planning effort we have begun with the most important values of the institution, for example, quality, leadership, academic priorities, liberal learning, diversity, critical and rational inquiry, caring, commitment, and community. We have also kept in mind the key characteristics of the University over its history, as framed by descriptors such as "the leaders and best", "an uncommon education for the common man", "a broad and liberal spirit", "diverse, yet united in a commitment to academic ex-




The strategic roadmapping process

cellence and public service", "a center of critical inquiry and learning", "an independent critic and servant of society", "a relish for innovation and excitement", "control of our own destiny comparable to private universities", and "freedom with responsibility for students and faculty". Furthermore we have extensively surveyed the powerful forces driving change in our world and higher education and evaluated the position of the University of Michigan within this framework for the decades ahead.

From this process, we have arrived at the following themes that comprise a vision for the University within three different timeframes:

The Vision for Today: *Reflection*

For the near term, from now until the Bicentennial Year 2017, we suggest the University of Michigan would benefit from a period of *reflection* upon its remarkable history and accomplishments. The University community should not simply prepare to celebrate two centuries of leadership in higher education. It first should strive to understand and secure those values and characteristics that have played such an important role throughout its history:

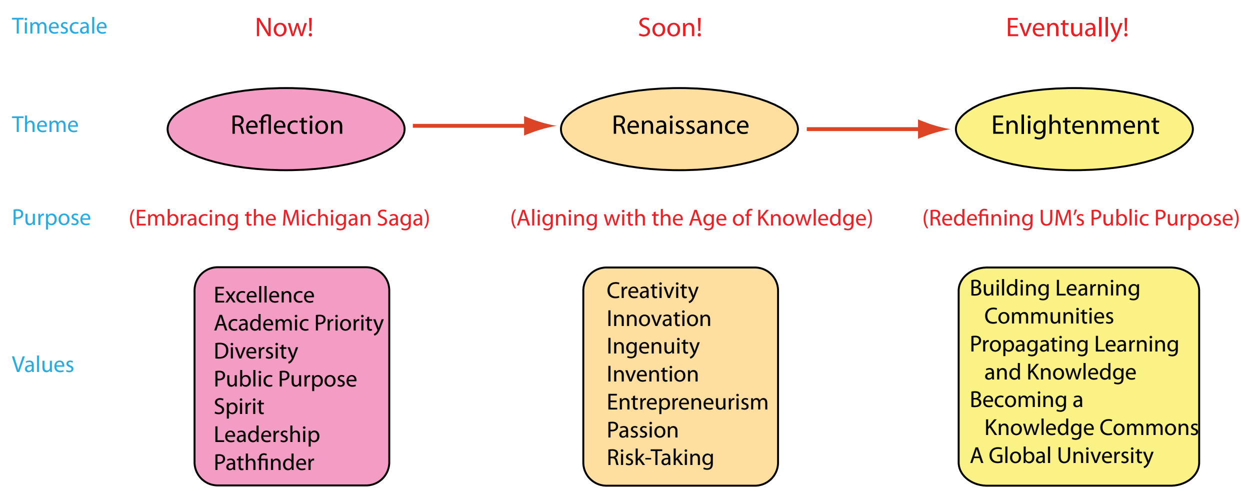
Academic quality: The reputation of Michigan as one of the world's great universities has been based primarily on the quality of its academic programs. While there are many sources of superficial rankings (e.g., US News & World Report, the London Times, Shanghai Jaio Tong, and the QS World Rankings), the most reliable rankings have been the assessments of graduate programs performed every decade by the National Research Council. Of comparable importance is an ongoing assessment of the "ebb and flow" of faculty recruitment and retention, along with faculty awards and reputations.

Establishing and sustaining the academic core of the University as its highest priority: Sometimes in the face of the substantial assets and growth characterizing auxiliary activities of the University (e.g., hospitals, housing, athletics), it is all to easy to forget that Michigan's impact on the state, nation, and world is determined primarily by the quality of its academic programs and the achievements of its faculties. This must always be clearly established and understood as the University's highest priority. The University of Michigan is not primarily a hospital, a hotel, or a football team. It is one of the great learning institutions of the world.

Diversity: The University has long been distinguished by its strong and sustained commitment to providing educational and faculty opportunities to underrepresented racial and ethnic populations. From its earliest efforts to enroll minority students in the 19th century to the BAM activism of the 1960s, to the Michigan Mandate of the 1990s, the University has long been viewed as, and must remain a national leader in the achievement of diversity. Despite the challenges it faces, the University simply must renew its commitment to regain this leadership. Failure is not an option.

Public Purpose: So too, the University's long-standing commitment to providing "an uncommon education for the common man" demands that it provide educational opportunities for students from all economic circumstances. While this has become increasingly difficult in the face of eroding state support, it nevertheless is both a core value of the University and a critical element of its public purpose. It simply must take those actions necessary to restore a more equitable socioeconomic balance in its student body.

Spirit: Michigan's "broad and liberal spirit" has been an important characteristic of our students, faculty, and staff. While this may at times annoy or antagonize the




The trilogy of timefames and visions for the University of Michigan's Third Century

politics that swirl about the institution, such activism is not only an important element of our heritage but at times represents the conscience of the nation on controversial issues. This spirit must always be not only respected and tolerated but furthermore encouraged on the part of the University community.

Leadership: The University of Michigan has long taken pride in its "leaders and best" heritage, seeking both leadership and excellence in its achievements. Key in establishing and sustaining this element of our character is setting bold goals where the University not only aspires to excellence but can have great impact on society, where it can change the world!

The Michigan Saga: Finally, the role of the University in serving as both a pathfinder and trailblazer for all of higher education remains one of its most important roles. To sustain this role requires attracting to the University students, faculty, staff, and leadership of unusual initiative, creativity, and determination.

While renewing the effort (or restoring our commitment if necessary) to achieve these characteristics seems obvious, particularly as we prepare for the University's bicentennial by reviewing its history and honoring its heritage and saga, it is nevertheless in the spirit of the near term vision that we suggest the University should set out to challenge itself.

Renewing our effort (or restoring our commitment, if necessary) to achieve these characteristics may seem obvious, particularly as we prepare for the University's bicentennial by reviewing its history and honoring its heritage and saga. Yet it is nevertheless an important challenge that deserves both greater attention and commitment by the University today.

The Vision for the Near Term: *Renaissance*

The world is changing rapidly, driven by the role played by educated people, new knowledge, innovation, and entrepreneurial skill. The tools of creation are expanding rapidly in both scope and power. Today, we have the capacity to create objects literally atom by atom. We are developing the capacity to create new life-forms through the tools of molecular biology and genetic engineering. We are now creating new intellectual life-forms through artificial intelligence and virtual reality. Already we are seeing the spontaneous emergence of new forms of creative activities, e.g., the "maker" fairs providing opportunities to showcase forms of artistic, recreational, and commercial activity; the use of "additive manufacturing" to build new products and processes atomic layer by atomic layer; and the growing use of the "app" culture to empower an immense marketplace of small software development companies. In fact, some suggest that our civilization may experience a renaissance-like awakening of creative activities in the 21st century similar to that occurring in 16th century Europe.

While these forces challenge us and our social institutions, they also contain the elements of what could become a *renaissance* of creativity and innovation in the 21st century. Since universities will play a critical role as the source of these assets of the age of knowledge, our vision for the early 21st century involves stressing similar characteristics among our people and our programs, e.g., creativity, innovation, ingenuity, invention, and entrepreneurial zeal.

The university of the 21st century may need to shift much of its intellectual focus and priority from the preservation or transmission of knowledge to the process of creativity itself to respond to the opportunities presented by the emerging "maker" society. But here lies a great challenge, since while we are experienced in teaching the skills of analysis, we have far less understanding of the intellectual activities associated with creativity. In fact, the current disciplinary culture of our campuses sometimes discriminates against those who are truly creative, those who do not fit well into our stereotypes of students and faculty. The university may need to reorganize itself quite differently, stressing forms of pedagogy and extracurricular experiences to nurture and teach the art and skill of creativity. This would probably imply a shift away from highly specialized disciplines and degree programs to programs placing more emphasis on the convergence and integration of knowledge.

Here, the University of Michigan is already well positioned to execute such a vision of a renaissance future. On the University's North Campus, we already are fortunate to have several schools which focus on the act of creation, in music, dance, and the performing arts; art and design; architecture; and in engineering—which, of course, is the profession concerned with "creating what has not been." The Media Union (aka Duderstadt Center) on the North Campus provides a "commons" facility, a place that supports interdisciplinary activities in "making things", responds to a growing need for these programs. In fact, recapturing the original vision of the Media Union as an innovation commons or creation space where students, faculty, and staff from multiple disciplines gather to create, invent, design, and even make things reinforces the "Renaissance Campus" themes of the 1990s.

This vision of renaissance aligns well with several other aspects of the University's institutional saga such as its commitment to excellence and leadership and its belief that this rests upon building diverse learning communities. But achieving such a vision will also likely require a culture change that encourages risk taking and tolerates occasional failure as the price one must frequently pay for setting and accomplishing challenging goals.

Particularly key in this effort is the earlier goal of diversity. As Tom Friedman noted in a New York Times column, "The sheer creative energy that comes when you mix all our diverse people and cultures together. We live in an age when the most valuable asset any economy can have is the ability to be creative–to spark and imagine new ideas, be they Broadway tunes, great books, iPads, or new cancer drugs. And where does creativity come from?" As Newsweek described it, 'To be creative requires divergent thinking (generating many unique ideas) and then convergent thinking (combining those ideas into the best result)." And where does divergent thinking come from? It comes from being exposed to divergent ideas and cultures and people and intellectual disciplines. (Friedman, 2011)

### The Vision for the Third Century: *Enlightenment*

We suggest that the longer term vision for the University's third century should be to assume the role of a forerunner of an emerging civilization characterized by extraordinary connectivity, access to knowledge, and ubiquitous learning opportunities, all enabled by rapidly evolving information and communications technologies. No longer constrained by space, time, monopoly, or archaic laws, the University of Michigan should embrace a vision to address the knowledge and learning needs of a global society as its new public purpose.

In a sense, this vision for the third century of the University combines three themes that might characterize the university of the future: a "*Universitas Magistrorum et Scholarium* in cyberspace", a learning ecology, and the university as a vanguard of an emergent global, knowledge-and-learning dependent, and profoundly connected civilization. Much as the Enlightenment of the 18th century swept aside the divine authority of kings by distributing learning and knowledge to empower citizens, today's knowledge-driven global society is increasingly dependent upon the creation of new knowledge and educating those capable of applying it to meet the needs of society. But while the Enlightenment of the 18th century was concerned with "celebrating the luminosity of knowledge shining through the written word", today knowledge comes in many forms–words, images, algorithms, immersive environments, etc. Today's learning communities are no longer constrained by space and time but rather expand rapidly driven by exponentially evolving technologies (e.g., cyberinfrastructure) and practices (e.g., open source, open knowledge). Today, the educational institution most capable of launching a new "age of Enlightenment" is the university, with its dual missions of creating "unions" of scholars and learners and providing "universal" access to knowledge. And just as the leaders of the Enlightment stressed that its goals such as "life, liberty, and the pursuit of happiness" were public in nature, requiring the highest level of inclusivity, it will most likely be *public* universities that will be the most prominent in achieving this vision.

This vision for the University of Michigan's third century builds both upon the institution's past and present. Michigan has played a particularly important role in the history of the American university, not only as one of the nation's first experiments in public higher education but, in fact, as the first attempt to build a true "university" in the European sense in the New World. Michigan's guiding themes, "to provide an uncommon education for the common man" and to "create a community of scholars across the full range of disciplines" has continued throughout its history. During the 1980s UM's leadership in network technology enabled it to play a major role in the building and management of the Internet, the technology that today enables not only access to knowledge but supports communities throughput the world. More recently Michigan's leadership of the open knowledge movement involving the massive digitization and access to formerly printed materials through the Google Books project and the HathiTrust represent important steps toward universal access to the knowledge accumulated and produced by our civilization.

Today the University of Michigan is well positioned to participate in a contemporary version of the Enlightenment, accepting as its expanded public purpose the spreading of knowledge and learning throughout the world through rapidly evolving information and communications technologies.

## The Roadmap to a Vision for the University of Michigan's Third Century

We begin the process of developing a strategy to achieve this vision with four simply-stated goals:

Goal 1: *People*: To attract, retain, support, and empower exceptional students, faculty, and staff.

Goal 2: *Resources*: To provide these people with the resources and environment necessary to push to the limits of their abilities and their dreams.

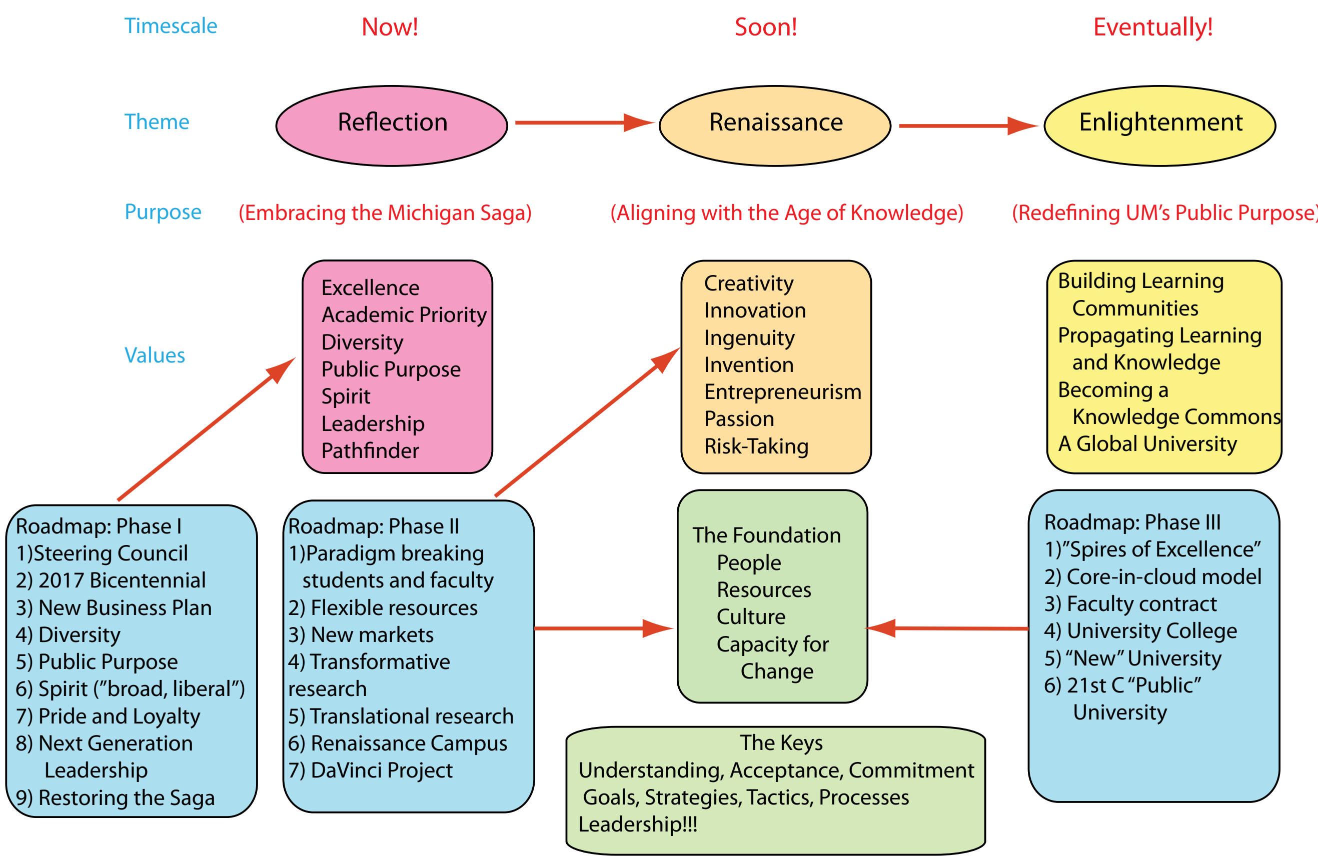
Goal 3: *Culture*: To build a University culture and spirit that values adventure, creativity, excitement, risk-taking, leadership, excellence, diversity, caring, concern, and community.

Goal 4: *The Capacity for Change*: To develop the wisdom, the courage, and the capacity to embrace the changes necessary to serve a changing society and a changing world.

These four concrete goals have profound implications, and each will be deceptively challenging to achieve. For example, while Michigan has always sought to attract high-quality students and faculty to the University, it tends to recruit those who conform to more conventional measures of excellence. If the University is to seek "paradigm breakers," then other criteria such as creativity, intellectual span, aspirations, and the ability to lead become important.

The University needs to acquire as well the resources to sustain excellence, a challenge at a time when public support is dwindling. Yet this goal also suggests the need to focus resources on the University's most creative people and programs. Michigan will need to acquire greater flexibility in resource allocation to respond to new opportunities and initiatives.

While most people and institutions would agree with the values set out in the third goal of cultural change, many would not have assigned such a high




Strategic roadmaps to a vision for the University of Michigan's Third Century.

priority to building an environment that encourages adventure, excitement, and risk-taking. However, if the University is to sustain its saga as a pathfinder and trailblazer in defining the nature of higher education in the century ahead, this type of culture will be essential.

Developing the capacity for change, while an obvious goal, will also be both challenging and controversial. The University will need to discard the status quo as a viable option, challenge existing premises, policies, and mindsets, and empower its best people to drive the evolution—or revolution—of the institution.

These general goals provide the foundation for the specific roadmaps we suggest for each timeframe of the vision for the University of Michigan's third century: *Reflection, Renaissance, and Enlightenment*.

The Roadmap to *Reflection*

To move toward the Reflection vision, the following actions have been recommended:

Preparing for the University's bicentennial in 2017 by using the next few years prior to 2017 to build resources that capture the University of Michigan's remarkable history and more firmly establish the key elements of the University's institutional saga to those on the campus (students, faculty, staff) and beyond.

Restoring the University's commitment to its founding purpose of providing "an uncommon education to the common man".

Strengthening the University's commitment to diversity and its broader public purpose.

Building a greater sense of pride in, respect for, excitement about, and loyalty to the University

Re-igniting the Michigan "broad and liberal" spirit.

Reaffirming the Michigan Saga as a pathfinder and trailblazer.

The Roadmap to *Renaissance*

The second phase of the roadmap process is aimed at the Renaissance vision:

Recruiting outstanding and creative students.

Recruiting paradigm-breaking faculty.

Strengthening human resource development.

Enabling intellectual change.

Lowering disciplinary boundaries.

Educating "T" graduates, characterized both by depth in a particular discipline as well as intellectual breadth.

Restructuring the PhD to address both structural problems such as attrition rate and time to degree as well as intellectual themes such as disciplinary convergence.

Giving high priority in both student and faculty recruiting and resource allocation to areas with the potential for truly transformative learning and scholarship, i.e., breaking the current university paradigms.

Building organizations and programs capable of translational research, i.e., linking fundamental scientific discovery with the use-inspired innovation to serve society.

Building strategic alliances with other universities and knowledge-based institutions in the public and private sector.

Stimulating a greater sense of adventure, excitement, and risk-taking.

Selecting and recruiting next-generation leadership with bold visions, energy, and a sense of adventure.

Developing a more coherent academic program (a "University College") for all undergraduates, reducing the amount of specialization offered in degree programs, and striving to provide instead a more general liberal learning experience.

Launching major new cross-disciplinary efforts such as a "Renaissance Campus" (reconfiguring the pedagogy of the North Campus to stress the intellectual activity of "creating" and "doing") and the Da Vinci Project (the integration of discovery, creativity, innovation, and design).

Establishing "a New University" structure to serve as a laboratory to explore future paradigms for higher education.

The Roadmap to *Enlightenment*

The final vision proposed for the University is the theme of Enlightenment, spreading the light of learning and knowledge to the world, as its public purpose for its third century. Here we suggest major elements of a possible roadmap to this future based upon several paradigms:

- The emergence of a *universitas magistrorum et scholarium* in cyberspace.
- The power of network architectures in distributing knowledge and learning
- The perspective of learning organizations as ecologies that evolve and mutate into new forms
- The university as the prototype of an emergent global civilization

Of course the themes we have suggested for comprising at least a rough roadmap to the Enlightenment vision of the University of Michigan's third century are highly speculative if not utopian in nature. They need to be better defined, refined, and translated into practical steps that the University can begin to take. But such is the case with any bold vision. And, interestingly enough, the University is already taking important steps down the path sketched out by this roadmap.

The elements of this roadmap include:

Continuing to provide leadership in capturing and distributing knowledge to the world.

Providing leadership for the open education resources paradigm.

Providing leadership in both the development and application of advanced cyberinfrastructure in academic environments.

Exploring the use of advanced learning environments such as those based on social networking and immersive environments.

Establishing a global footprint through engagement in international higher education.

Building the necessary foundation of scholarly activity for a global knowledge and learning enterprise.

Moving the University to year-round operation in an effort to broaden educational opportunity and innovation while achieving greater efficiency in the use of campus facilities.

## Plans, Tactics, and Processes

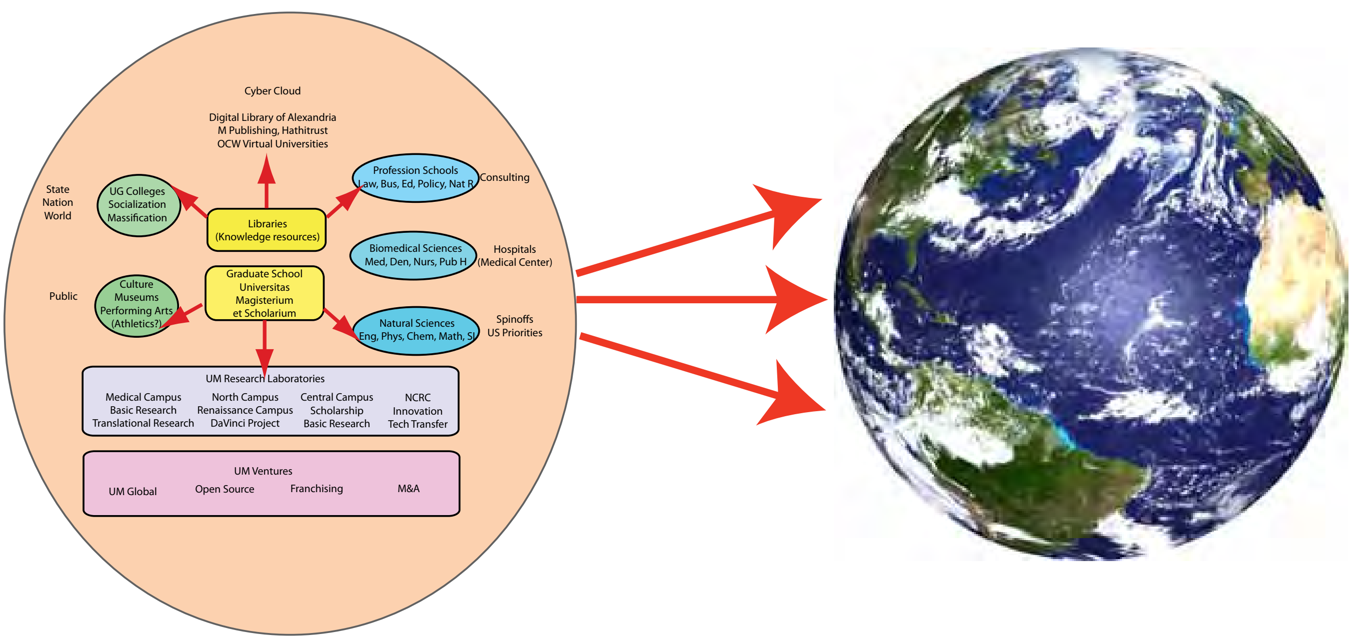
While a vision sets a destination and a roadmap provides direction, institutions and stakeholders require a more definitive and operational strategic plan to embark on these journeys. Simply encouraging and supporting planning at the unit level, perhaps augmented by occasional initiatives, for an institution of Michigan's scale, complexity, and impact is both inadequate and dangerous indeed, both for the institution and those dependent upon it.

It is critical for higher education to give thoughtful attention to the design of institutional processes for planning, management, and governance. The ability of universities to adapt successfully to the profound changes occurring in our society will depend a great deal on the institution's collective ability to develop and execute appropriate strategies. Key is the recognition that in a rapidly changing environment, it is important to develop a planning process that is not only capable of adapting to changing conditions, but to some degree capable of modifying the environment in which the university will find itself in the decades ahead. The University must seek and implement a progressive, flexible, and adaptive process, capable of responding to a dynamic environment and an uncertain—indeed, unknowable—future.

In an institution of Michigan's size, breadth, and complexity, it is usually not appropriate (or possible) to manage centrally many processes or activities. After all, it is the University's current structure as a "loosely coupled adaptive ecosystem: that has enabled it to thrive during periods of rapid environmental challenge and change that have put at risk other institutions. One can, however, establish institutional priorities and goals and institute a process that encourages local management toward these objectives. To achieve institutional goals, processes can be launched throughout the institution aimed at strategic planning consistent with institutional goals, but with management authority residing at the local level. One seeks an approach with accurate central information support and strong strategic direction.

In addition, one requires detailed tactical plans at the operational level in areas such as financial resources, organizational structures, and the launching of appropriate experiments and ventures.

Finally, it is important to recognize that progress to such bold visions will demand substantial institutional transformation. The challenge, as is so often the case, is neither financial nor organizational. Rather it is the degree of cultural change required. The University must transform a set of rigid habits of thought and organization that are incapable of responding to change rapidly or radically enough.




A public purpose for Michigan's Third Century: providing the light of knowledge and learning to the world!

True faculty participation in the design and implementation of the necessary change process is essential, since the transformation of faculty culture is the biggest challenge of all. Both the creativity and the commitment of the faculty are vital to the achievement of such goals. Policies come and go without perturbing the institution; change happens in the trenches where faculty and students are engaged in the primary activities of the university, teaching and research, learning and scholarship.

## The Challenge and Opportunity

Institutions all too frequently choose a timid course of incremental, reactive evolution because they view a more strategically-driven transformation process as too risky. They are worried about making a mistake, about heading in the wrong direction or failing. While they are aware that this incremental approach can occasionally miss an opportunity, many mature organizations, such as universities, would prefer the risk of missed opportunity to the danger of heading into the unknown.

But, today, incremental change based on traditional, well-understood paradigms may be the most dangerous course of all, because those paradigms may simply not be adequate to adapt to a future of change. If the status quo is no longer an option, if the existing paradigms are no longer viable, then transformation becomes the wisest course.

The forces driving change in higher education, both from within and without, are far more powerful than most realize. The pace and nature of change affecting the higher education enterprise both in America and worldwide are likely to be considerably beyond that which could be accommodated by business-as-usual evolution. While there is certainly a good deal of exaggeration and hype about the changes in higher education over the short term—meaning a decade or less—it is difficult to stress too strongly the profound nature of the changes likely to occur in most of our institutions and in our enterprise over the longer term.

We have suggested three elements of a possible vision for future for the University of Michigan as it prepares to enter its third century:

1. A vision for today of *Reflection* upon the past accomplishments, values, and key characteristics of the University's institutional saga;

2. A near-term vision of a *Renaissance* as the University aligns itself to better engage with a world dependent upon learning, knowledge, creativity, and innovation by spanning the broad range of learning from simply "to know", "to do", "to create" and "to become"; and

3. A longer term vision of *Enlightenment* as the University commits itself to expand its public purpose to provide "the light of learning and knowledge" to the world in the new forms enabled by rapidly evolving information and communications technologies.

The University of Michigan has a responsibility to help show the way to change, not to react to and follow it. Its voice must be loud, clear, and unified in the public forum. At the same time, it must encourage vigorous debate and experimentation within academia, setting aside narrow self-interest, and accepting without fear the challenges posed by this extraordinary time in its history.

Although bold, we believe these visions to be consistent both with the University's heritage and the challenges and opportunities it will face as it begins its third century.

We contend that as the University approaches its third century, it should embrace once again its heritage as a pathfinder for higher education, a saga established two centuries ago in the 19th century when the University of Michigan became a primary source for much of the innovation and leadership for higher education. Once again, Michigan has the opportunity to influence the emergence of a new paradigm of what the university must become in our 21st Century world to respond to the changing needs of our society.

This, then, is the particular challenge and opportunity for the University of Michigan. As it has so many times in its past, the University of Michigan must embrace yet again its historic role of leadership for a future characterized by great challenges, immense responsibilities, and exciting opportunities.

References

Duderstadt, James J. , The Third Century: A Roadmap to the University of Michigan's Future (Ann Arbor, MI: Millennium Project, 2014)