Case Studies in

Strategic Roadmapping

for University Planning

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Chapter 1

Preface

Today our world has entered a period of rapid and profound economic, social, and political transformation driven by new knowledge and innovation. It has become increasingly apparent that the strength, prosperity, and welfare 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, to develop innovative applications of these discoveries, and transfer them into the marketplace through entrepreneurial activities.

Throughout most of our history, education in America has been particularly responsive to the changing needs of society during early periods of major transformation, e.g., the transition from a frontier to an agrarian society, then to an industrial society, through the Cold War tensions, and to today's global, knowledge-driven economy. As our society changed, so too did the necessary skills and knowledge of our citizens: from growing to making, from making to serving, from serving to creating, and today from creating to innovating. With each social transformation, an increasingly sophisticated world required a higher level of cognitive ability, from manual skills to knowledge management, analysis to synthesis, reductionism to the integration of knowledge, invention to research, and, today, innovation and entrepreneurship. Our nation's challenge today is to understand that once again it is time to challenge current public policy and make new commitments to education to enable our nation to achieve prosperity, health, and security.

More generally, it is clear that as the pace of change continues to accelerate, our schools, colleges, and universities will need to become more adaptive if they are to survive. 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.

Yet, as many leaders in higher education have come to realize, our changing environment requires a far more strategic approach to the evolution of our institutions. It is critical for higher education to give thoughtful attention to the design of institutional processes for planning, management, leadership, and governance. The ability to adapt successfully to the profound changes occurring in our society will depend a great deal on our 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 higher education will find itself in the decades ahead. We must seek a progressive, flexible, and adaptive process, capable of responding to a dynamic environment and an uncertain—indeed, unknowable—future.

My experience as a scientist, engineer, and university president at the University of Michigan led to the roles of chairing a broader range of higher education policy activities at the institutional, regional, national, and international level. 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.

Of particular interest in this collection of case studies is application of a common technique in technology planning, *strategic roadmapping*, to a broad array of issues in higher education policy. In strategic 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 divided into those that can be accomplished in the near term and those that will require a sustained effort.

This report contains a series of case studies from personal experience, either as a member or, in some cases, chair of major studies of higher education policy. While several of these concern the challenges and future of higher education at the institutional, regional, national, or even global level, others consider the complexities of professional disciplines (engineering) and regional economies.

It is the hope that such case studies will demonstrate both the power of this approach as well as provide insight concerning some of the major national and international challenges of our times.

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Strategic Roadmapping

Strategic planning in higher education has had mixed success, particularly in institutions of the size, breadth, complexity, and culture of the contemporary university. Even the word "strategic" sends shivers up the spine of some faculty members and triggers vitriolic attacks against bureaucratic planners on the part of many others. Yet all too often universities tend to react to—or even resist—external pressures and opportunities rather than taking strong, decisive actions to determine and pursue their own goals. So too, they frequently become preoccupied with process rather than objectives, with "how" rather than "what."

Yet as many leaders in higher education have come to realize, our changing environment requires a far more strategic approach to the evolution of our institutions. It is critical for higher education to give thoughtful attention to the design of institutional processes for planning, management, leadership, and governance. The ability to adapt successfully to the profound changes occurring in our society will depend a great deal on our 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 higher education will find itself in the decades ahead. We must seek a progressive, flexible, and adaptive process, capable of responding to a dynamic environment and an uncertain—indeed, unknowable—future.

The Classical Approach to Planning

Strategic planning first became important to the university in the post–World War II years, as higher education attempted to respond to the growing educational needs of returning veterans and then to a rapidly expanding population of young adults. Although most institutions simply grew as rapidly as resources allowed, there were important planning efforts such as the California Master Plan for higher education. Most institutions had formal planning units, generally lodged in the office of the chief academic officer and staffed by professionals. Typically these efforts were more focused on the gathering of data for supporting the routine decision process than providing a context for longer-term issues. These university planning activities were decidedly tactical in nature and usually did not play a significant role in the key strategic decisions at the executive officer or governing board level.

The marginal role of institutional planning changed in the 1980s as universities first began to grapple with a more constrained resource base and increasingly frequent financial crises. Planning was used to determine institutional priorities for investment or identify candidate activities for possible downsizing or elimination. Planning units became active if sometimes reluctant participants in support of actions adapted from the business world such as reengineering processes and restructuring activities. As the pace of change in the environment of the university began to accelerate during the 1980s, these formal planning activities were largely ignored as university leaders sought more immediate strategies in response to one crisis after another. When formal planning was used at all, it was generally employed to support resource allocation decisions that had frequently already been made by more ad hoc or political mechanisms.

With the financial crises of the 1980s, 1990s, and the "Great Recession" of recent years, there is a growing recognition of the importance of strategic planning at the highest leadership level of the university, par-

ticularly during a period of ever accelerating change. But there are many approaches to planning in higher education. Some university leaders adopt a fatalistic approach. They accept the premise that the university is basically unmanageable, constrained by traditions, with a culture, a complexity, and a momentum that allows only a modest deflection in one direction or another. Hence they focus on several specific issues, usually tactical in nature, and let the institution continue to evolve in a nondirected fashion. They might select several items to fix every few years, for example, capital facilities in one cycle, fund-raising in another, and so on. This small-wins approach essentially assumes that the university will do just fine on most fronts, moving ahead without an overarching strategy. And perhaps for some institutions, during times of stability, this is an appropriate strategy. However, when the planning environment is changing significantly, such an approach can be dangerous. A series of decisions unrelated to a broader vision or goal for the institution can lead to a de facto strategy counter to the university's long-term interests.

Over a longer period of time, however, a series of small tactical decisions will dictate a de facto strategy that may not be in the long-range interests of the university. At Michigan, for example, a sequence of such tactical resource allocation decisions during the 1960s led to investment in a number of programs (e.g., dentistry, education, and natural resources) that were to experience major enrollment losses in the 1970s. Because the University did not have adequate mechanisms in place to adjust resources as enrollments dropped, these losses led to serious problems by the 1980s when resources became more limited. While the decisions leading to selective growth in these units may have responded to the tactical situation at the time, they were not guided by a broader strategic vision of the future of the University.

Institutions all too frequently chose 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 such as universities would prefer the risk of missed opportunity than the danger of heading into the unknown.

Another difficulty with small wins or incremental strategies is that they generally rely on extrapolation rather than interpolation to guide decisions. That is, they develop a vision for the future by simply extrapolating the past. But in a world of such dramatic change, the past may not be a useful guide. It may be more appropriate to first develop a bolder vision of the future of an institution, and then develop strategies that interpolate between the future vision and the present reality. Such approaches are sometimes called *scenario planning*, since there will frequently be a number of possible options considered for the future. Although such scenario planning or interpolative approaches can sometimes miss the mark, in general during a time of change they are superior to incremental strategies that simply cannot cope with dramatic change.

A contrasting approach might be best characterized as *opportunistic planning*. Here the idea is to develop flexible strategies that take advantage of windows of opportunity, which avoid confining the institution to rigid paths, deep ruts. In a sense, this corresponds to an informed dead-reckoning approach, in which one selects strategic objectives—where the institution wants to go—and then follows whichever course seems appropriate at the time, possibly shifting paths as opportunities arise and updating strategic plans with new information and experience, always with the ultimate goal in mind.

Key to any planning effort is an assessment of the planning environment. In universities it is particularly important tap the wisdom of a variety groups to help evaluate both the current and past state of the University as well as the internal and external environment issues that should be considered in planning activities. All of these factors are time-dependent, of course. Hence it is important to consider not only the current environments for planning, but also the historical context that led to these environments and the possible futures that might evolve. Furthermore, it is essential to recognize that the internal and external environments are tightly connected. Hence, external conditions that might first appear to be constraints can be altered through appropriate modifications of the internal environment and related activities.

Rather than view environmental factors as absolute

constraints, they can be recast as challenges or opportunities subject to modification. That is, one can adopt the mindset that the university can influence its planning environment. The key is to begin with the challenging question of asking what can be done to modify the planning environment. There are always opportunities to control constraints—and the future—if one takes a proactive approach. Universities are rarely playing in a zero-sum game. Instead they may have the opportunity to increase (or decrease) resources with appropriate (or inappropriate) strategies. The university is never a closed system.

Put in more engineering terms, any complex system can be designed in such a way as to be less sensitive to initial and/or boundary conditions. In the language of systems engineering, a system can be designed with sufficiently short time constants or decay lengths so that it evolves rapidly into an asymptotic state where the constraints imposed by initial and boundary conditions are no longer controlling.

In an institution characterized by the size and complexity of the contemporary research university, it is usually not appropriate (or possible) to manage centrally many processes or activities. 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 is an approach with accurate central information support and strong strategic direction.

Here there is an important distinction to make. Strategic planning is deciding what should be done, that is, choosing objectives ("What do we want to do"). Tactics are operational procedures for accomplishing objectives ("How do we go about doing it?").

Note as well that long-range planning is not the same thing as strategic planning. Long-range planning establishes quantitative goals, a specific plan. Strategic planning establishes qualitative goals and a philosophy. Because strategic planning should always be linked to operational decisions, some prefer to use the phrase strategic management rather than strategic planning to denote it.

While there are many ways to organize strategic planning, most fit into the following framework of steps:

Mission, vision, and strategic intent
Environmental assessment
Goals
Strategic actions
Tactical implementation
Assessment and evaluation

Clearly an understanding of institution mission is a prerequisite to effective planning. The development of a vision is also important to the strategic process. A successful strategic planning process is highly iterative in nature. While the vision remains fixed, the goals, objectives, actions, and tactics evolve with progress and experience. During a period of rapid, unpredictable change, the specific plan chosen at a given instant is of far less importance than the planning process itself. Put another way, one seeks an "adaptive" planning process appropriate for a rapidly changing environment.

Many organizations go beyond this to develop a strategic intent, a "stretch vision" that cannot be achieved with current capabilities and resources. The adoption of a strategic intent is intended to force an organization to change. The traditional view of strategy focuses on the fit between existing resources and current opportunities; strategic intent creates an extreme misfit between resources and ambitions. Through this, one is able to challenge the institution to close the gap by building new capabilities.

At Michigan during the 1990s we chose a particular refinement of opportunistic strategic planning known as *logical incrementalism*. As with most strategic processes, one begins with a clear vision statement for the institution. Within the context of this vision, one then sets out intentionally broad and rather vague goals—for example, goals such as excellence, diversity, and community. The strategic approach is then to engage broad elements of the institution in efforts to refine and articulate these goals while developing strategic plans and operational objectives aimed at achieving them. Key to the success of logical incrementalism is the skill of separating the wheat from the chaff, that is, separating out only those plans (actions and objectives) that move the institution toward the vision statement and

deflecting those that do not.

Although logical incrementalism is a small-wins strategy, relying on a series of small steps to move toward ambitious goals, it also is a highly opportunistic strategy in the sense that it prepares the organization to take far more aggressive actions when the circumstances arise. The planning process is evolutionary in other respects. It moves from broad goals and simple strategic actions to increasingly complex tactics. So too, the planning process works simultaneously on various institutional levels, ranging from the institution as a whole to various academic and administrative units. The ability to coordinate these multiple planning processes is, of course, one of the great challenges and keys to the success of the approach.

A Postmodernist Approach to Planning

Traditional planning processes are frequently found to be inadequate during times of rapid or even discontinuous change. Tactical efforts such as total quality management, process reengineering, and planning techniques such as preparing mission and vision statements, while important for refining status quo operations, may actually distract an institution from more substantive issues during more volatile periods. Furthermore, 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 more radical transformation becomes the wisest course. Furthermore, during times of very rapid change and uncertainty, it is sometimes necessary to launch the actions associated with a preliminary strategy long before it is carefully thought through and completely developed.

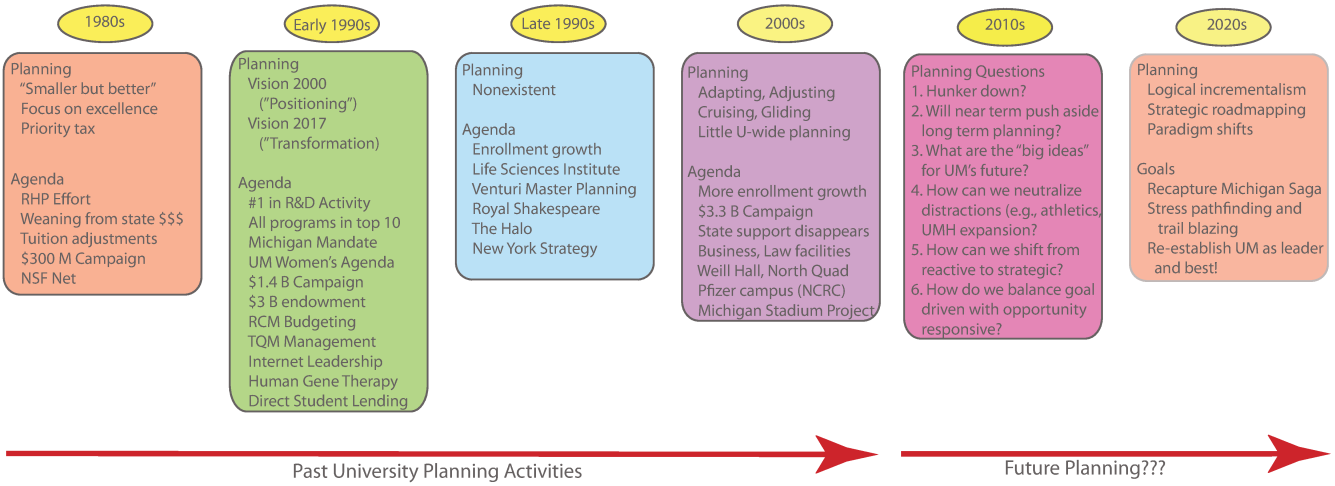
Complex systems, whether natural systems, social institutions, or even academic disciplines, often appear stable but actually fluctuate constantly, held in a precarious state of equilibrium. Chaos theory has taught us that even very small changes can threaten this complex balance of forces. The popular press calls this the "butterfly effect," because it suggests that the minute disturbance of a butterfly's wings could effect major weather patterns halfway around the globe. Thus, dramatic change in knowledge is often triggered by a single new idea or exceptional individual.

This vision of disciplines as complex, chaotic systems echoes philosopher Thomas Kuhn's theory of scientific revolutions. In essence, Kuhn argues that individual disciplines operate under what he calls paradigms. In a sense, a paradigm is what the members of a community of scholars share, their accepted practices or perspectives. Paradigms are not rules, but more like subjects for further study and elaboration, beliefs in certain metaphors or analogies about the world and shared values. For Kuhn, most research consists not of major breakthroughs, but, instead, of mopping up, or sweating out the details of existing paradigms. Major progress is achieved and new paradigms are created, not through gradual evolution, but through revolutionary, unpredictable transformations after the intellectual field reaches saturation.

Translated into more human terms, what these conceptions tell us is that transformations, whether in nature or social organizations, are frequently launched by a few remarkable people with extraordinary ability and/or plain old-fashioned luck. Those who invent new paradigms, who destabilize the structure of a field, are often very young or very new to their field. Uncommitted to current disciplinary rules, they are, as Kuhn says, "particularly likely to see that [these] rules no longer define a playable game and to conceive another set that can replace them." They must also, however, be willing to take serious risks, to participate in the early, flatter, and less productive portion of the learning curve where the broad outlines of new fields are hammered out. These intellectual renegades lend rich new vitality to our scholarship while challenging the status quo.

Note that this view suggests that one of the greatest challenges for universities is to learn to encourage more people to participate in the high-risk, unpredictable, but ultimately very productive confrontations of stagnant paradigms. One must jar as many people as possible out of their comfortable ruts of conventional wisdom, fostering experiments, recruiting restive faculty, turning people loose to "cause trouble," and simply making conventionality more trouble than unconventionality.

There is one final aspect of change in complex, dynamic systems worthy of mention here. Such systems are most adaptable or responsive at just that point be-



An example: the progression of University-wide strategic planning activities at Michigan

fore the onset of chaos. Put another way, while evolutionary, incremental change may suffice during normal times, more dramatic transformations may be necessary when the environment is changing very rapidly. It may be necessary to drive an organization toward instability, toward chaos, in order to shift it from one paradigm to the next. Sometimes this happens naturally as external forces drive an organization into crisis; sometimes it results from the actions of a few revolutionaries; and sometimes it even happens through leadership, although as Machiavelli observed, it is rarely well received by those within the organization.

The Importance of Vision, Planning and Leadership

Developing a bold and compelling vision for the future of an institution can be both a challenging and hazardous activity, particularly for a university with a long history of leadership and distinction. Yet while the status quo may be the safest course for university leadership and governance, it can also pose substantial risks to the institution. Universities that drift along, without a bold vision and leadership, can founder on the rocky shoals of a changing world. 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 dodging icebergs in the dead of night. Simply reacting to challenges and opportunities as they arise can eventually sink the ship.

University planning typically begins with the usual challenges, e.g., economic, demographic, technological, and cultural. But new challenges must also be added into planning activities: rapid globalization; profoundly changing demographics, exponentiating technologies; and even the sustainability of humankind on Planet Earth (e.g., climate change, financial stability, global poverty and health, terrorism and nuclear proliferation). Future possibilities have become not only more diverse but more extreme and possibly even unimaginable.

Because of the unusual challenges and opportunities facing the university today it is imperative to develop progressive, flexible, and adaptive planning processes, capable of responding to a dynamic environment and an uncertain—indeed, unknowable—future. Planning for such a complex, rapidly changing, and unpredictable future requires a somewhat different approach. Beyond boldness and attentiveness to a university's traditions, it requires rigor, discipline, and insight to develop achievable goals, strategies, and tactics.

Strategic Roadmapping

In this study we have adopted and modified a common technique used in industry and the federal government: *strategic roadmapping* (Garcia, 1997). In roadmap-

ping 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:

The Present: Assessment of existing resources and needs ("a resource map").

The Future: Possible goals that would address the needs of the organization ("a vision for the future")

Gap Analysis: An assessment of how far the vision is from the current situation, i.e., the distance between the present and the future.

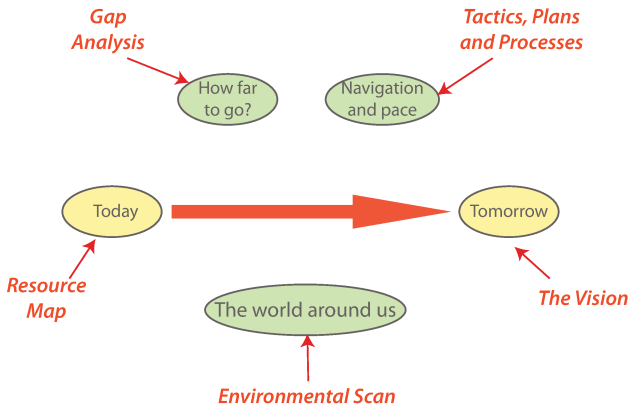
Development of the Roadmap: A set of recommendations and actions that would achieve the proposed future state, overcoming the gaps and shortcomings.

Tactics and Plans: Of course, having a strategy, a roadmap, is usually only a goal that required detailed plans and tactics for their achievement.

Put in even simpler terms, our approach to strategic roadmapping begins by asking where we are today and where we wish to be tomorrow. We then assess how far we have to go and concluded by developing a roadmap to get from here to there. The roadmap usually consists of a series of recommendations, sometimes 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 to provide a context for the roadmap planning activities. Although each of our examples of roadmap planning is characterized by a unique set of conditions, there are general characteristics of our world today that are important in all planning exercises, such as presence of a knowledge-driven economy, changing demographics, globalization, and sustainability.

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.



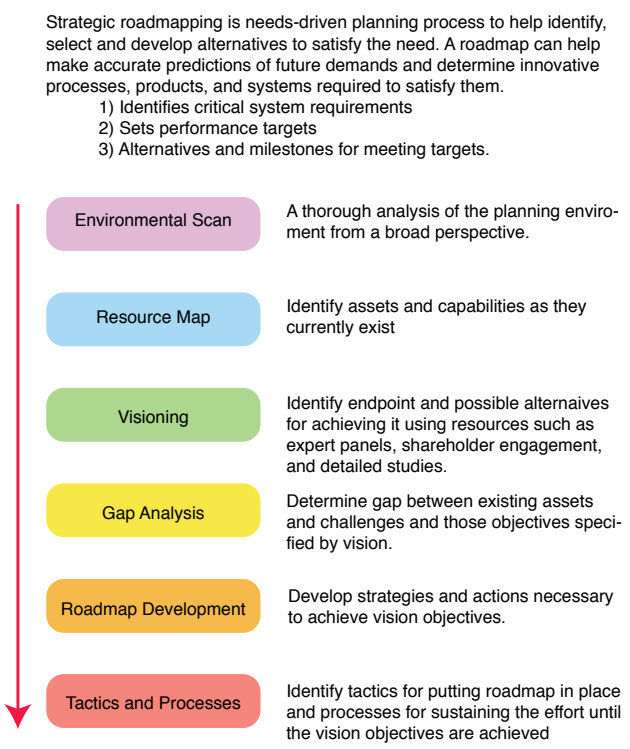
The strategic roadmap

The Road Ahead

As we look to the profound changes ahead of us, it is important to keep in mind that throughout their history, universities have evolved as integral parts of their societies to meet the challenges of their changing environments. They continue to evolve today. This disposition to change is a basic characteristic and strength of university life, the result of our constant generation of new knowledge through scholarship that, in turn, changes the education we provide and influences the societies that surround us.

At the same time, this propensity of universities to change is balanced by vital continuities, especially those arising from our fundamental scholarly commitments and values and from our roots in a democratic society. While the emphasis, structure, or organization of university activity may change over time to respond to new challenges, it is these scholarly principles, values, and traditions that animate the academic enterprise and give it continuity and meaning.

Thus, an integral part of the life of the university has always been to continuously evaluate the world around us, in order to adjust our teaching, research, and service



The roadmapping process

missions to serve the changing needs of our constituents while preserving basic values and commitments. Today, we must once again try to anticipate the future direction of our society in order to prepare students for the world they will inherit.

This capacity for change, for renewal, is the key objective that a university 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 become an institution capable of serving a changing society and a changing world. This challenge must be approached strategically rather than reactively, with a deep understanding of the role and character of the University, its important traditions and values from the past, and a clear and compelling vision for its future.

The road ahead...

Chapter 2

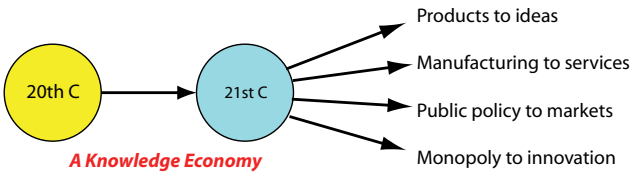
An Environmental Scan

All strategic planning studies are shaped by the context of issues characterizing the period during which they were conducted. Since each of our case studies has several common characteristics, 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.

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 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.

The Age of Knowledge

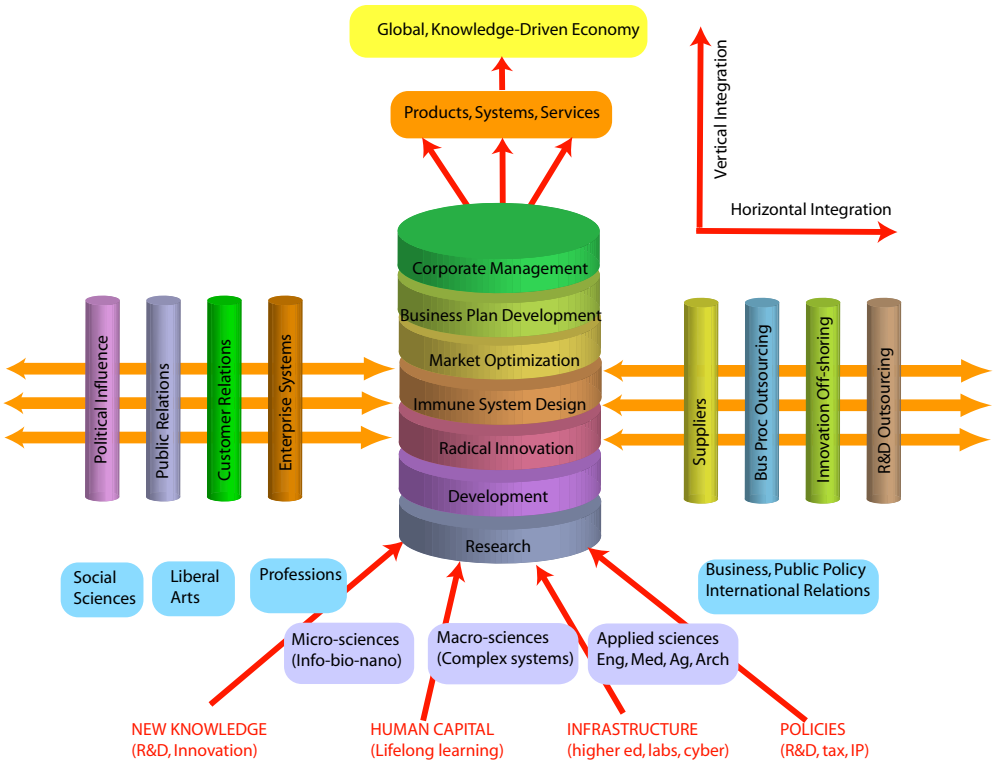
Looking back over history, one can identify certain abrupt changes, discontinuities in the nature, the fabric, of our civilization. Clearly we live in just such a time of



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 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



The way the global knowledge-driven economy works

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 offshoring 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

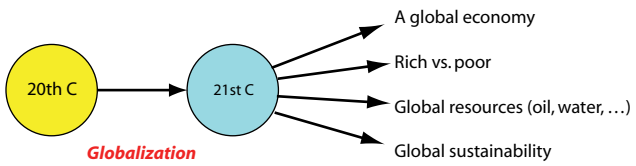
will value instead the skills and knowledge of our entire workforce as a key to economic prosperity, national security, and social well-being. The National Governors Association concludes that, "The driving force behind the 21st Century economy is knowledge, and developing human capital is the best way 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 interconnectedness 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.

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: "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.

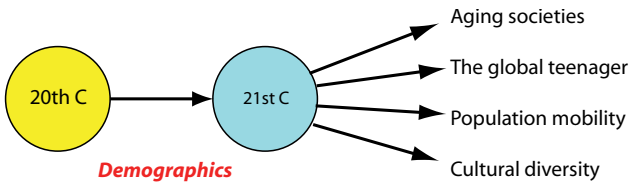
Today's global corporation conducts its strategy, management, and operations on a global scale. The multinational organization has evolved far beyond a collection of country-based subsidiaries to become instead a globally integrated array of specialized components–procurement, management, R&D, manufacturing, 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).

Most policy issues are shaped by their global character.

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 innovation 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.

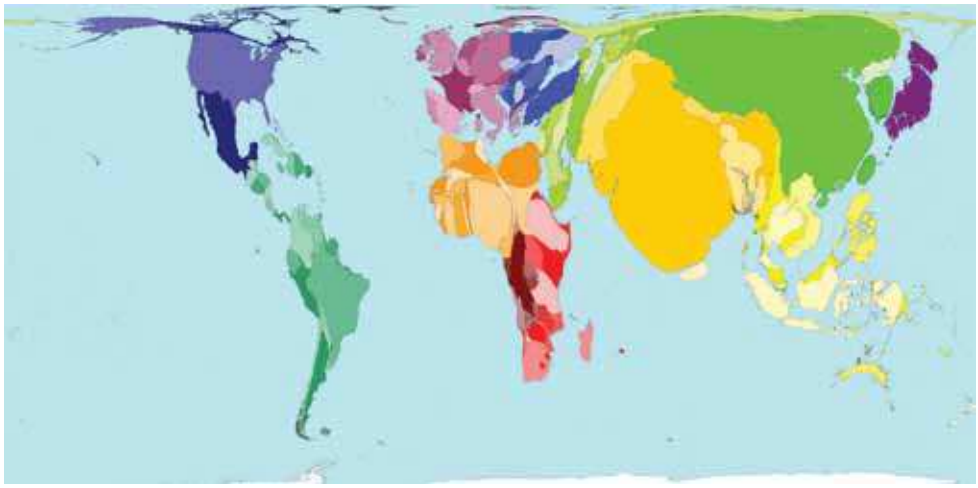
In sharp contrast, developing nations in Asia, Africa, and Latin America are characterized by young and growing populations in which the average age is less than 20. Here the demand for education is staggering since in a knowledge economy, it is clear to all that this is the key to one's future security. 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,



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

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)

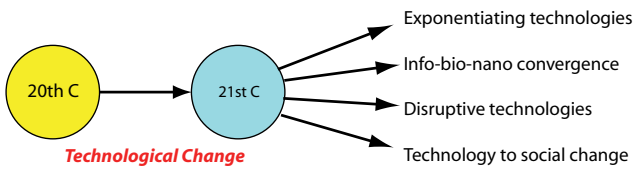
In this future, the full participation of currently underrepresented minorities will be of increasing concern as we strive to realize our commitment to equity and social justice. The achievement of this objective also will be the key to the future strength and prosperity of America, since our nation 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.



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

Titan supercomputer (Oak Ridge National Laboratory)

rapid technological change.

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.

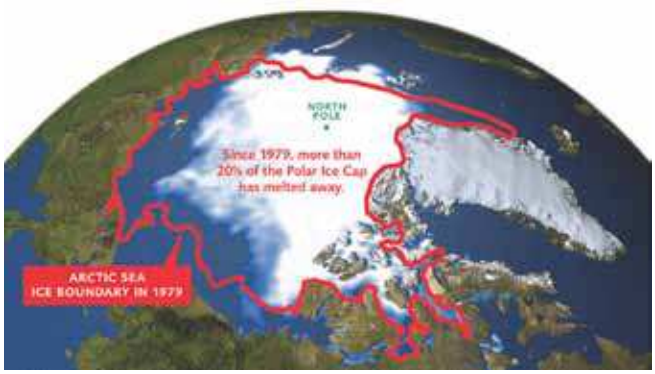
While the fruits of development and modernity are indisputable, the negative consequences of these recent developments appear to be increasingly serious. For example, there is compelling evidence that the growing population and invasive activities of humankind are now altering the fragile balance of 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.

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.

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.

Energy

There are few contemporary challenges facing our nation–indeed, the world–more threatening than the unsustainable nature of our current energy infrastruc-



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

ture. 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)

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 scien-

tific 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).

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" , which have fed much of the world, and the rapid growth of developing economies in Asia and Latin America. 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.

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).

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 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

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

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: "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 since we are likely to be the initiators. But we do 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.

The Challenge to Universities

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)

Chapter 3

A Roadmap to Michigan's Future

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, America became the source of the technology and innovation that shaped the 20th-century global economy.

So, too, 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. Yet 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 dollars 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 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.

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.

Michigan Today

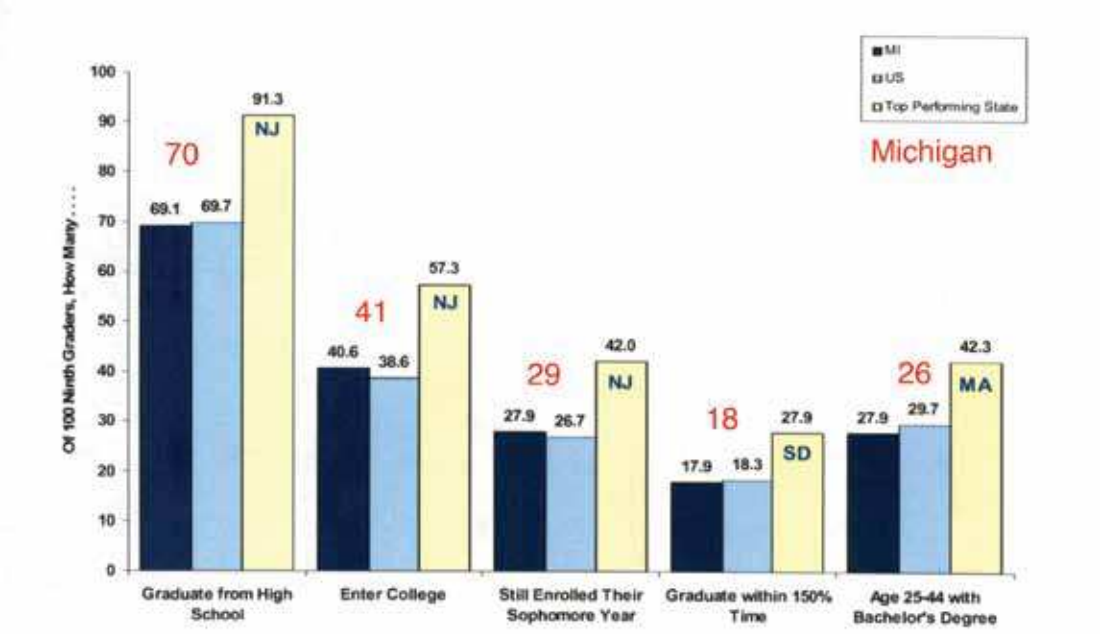
By any measure, the assessment of *Michigan today* is very disturbing. Our state is having great difficulty in making the transition from a manufacturing to a knowledge economy. Michigan currently ranks:

- 50th in the nation in personal income growth
- 50th in unemployment rate
- 50th in employment growth (in fact, as the only state with a decline)
- 50th in the index of economic momentum (e.g., population, personal income, and employment)
- 50th in the change of its support for higher education over the past six years
- 46th in the return of federal tax dollars

Our leading city, Detroit, now ranks as the nation's poorest. 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. Less 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.

Michigan does lead in some areas: incarceration rates and prison costs, health and retirement benefits for both public and industrial employees, mortality rates from smoking (not surprising since the Legislature continues to allow the tobacco lobby to block efforts to ban smoking in public places, putting Michigan far behind other states and nations in this public health epidemic).

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



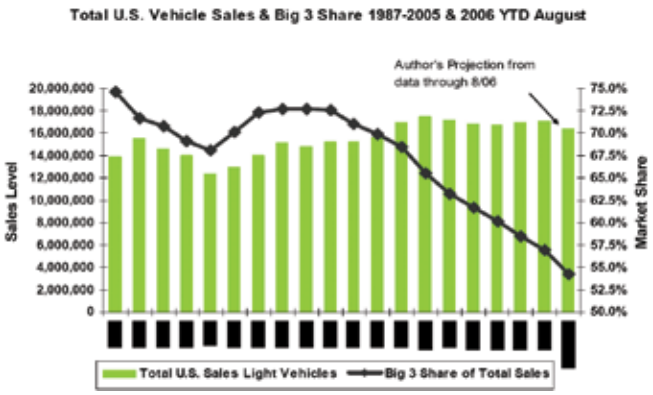
The Michigan education pipeline: Of 100 students entering high school, only 70 will graduate, while 41 will enter college, and only 18 will graduate within six years of admission.

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.

Many of Michigan's problems arise from the fact that the state has slipped far below the national average–and the Great Lakes region–in many measures critical to prosperity and social well-being in a global, knowledge-driven society:

- Michigan's tax burden and revenues have fallen below the national average and considerably below those characterizing states competitive in the new economy (e.g., the West Coast and New England). Michigan's current tax system is obsolete, regressive, inequitable, and totally inadequate to generate the resources necessary to invest in the state's future.
- The costs born by public agencies and private industry are much higher than in most other states, largely because of the legacy costs associated with excessively expensive health care and retirement benefits that have led to an entitlement culture, seriously misaligned with a hypercompetitive global marketplace.
- Public and private investments in assets critical to competitiveness in the global economy–e.g., higher education, civil infrastructure, cyberinfrastructure–have dropped far below the national average and lowest among the Great Lakes states.
- State government continues to be burdened by structural constraints, including overly restrictive term limits for public officials, a state constitution that is far too easy to manipulate by special interest groups and outside forces, and obsolete policies in key areas such as incarceration, redundant regional and municipal governance, maintaining critical infrastructure, and many other areas that drive up the costs and drive down the efficiency and quality of public services.
- Ill-informed voter referenda and questionable judicial decisions have reversed Michigan's long history of tolerance, equal opportunity, and social justice, at a time when both the state and the nation are becoming increasingly diverse.
- The Michigan Congressional delegation continues to be woefully inadequate in attracting federal resources to the state, currently ranked 46th in the nation in return of federal tax dollars.
- Despite the economic trauma experienced by the state, public awareness of the actions that need to

The loss of 25% of Michigan manufacturing jobs since 2000 (CRC, 2007)



The rapid decline of domestic market share by GM, Ford, and Chrysler (CRC, 2007)

be taken (higher, broader, and more progressive taxes; lower labor benefit costs; greater investment in human capital and knowledge resources) is still inadequate, more looking backwards to past entitlements than forward to future challenges and opportunities.

Today Michigan is rapidly becoming not only the poster child but perhaps even the basket case for the global knowledge economy. And what are state leaders doing about it?

- State government remains an absolute disaster, paralyzed into rigor mortis by obsolete agendas and fueled by self-serving actions stimulated more by the personal goals of political power–and perhaps even survival in the face of term limits–as many elected public officials seem more concerned with their political careers than their public responsibilities.
- Leaders of Michigan business, industry, and labor still suffer from a not-on-my-watch syndrome, myopically fixated on short-term agendas, defending obsolete products and cost structures, and inadequately investing in the future as their executives seem more concerned with personal wealth accumulation and retirement than the long term success–indeed survival–of their companies.
- Much of the state's media is still largely tone-deaf, unable (or perhaps unwilling) to set aside narrow political agendas (e.g., tax policy) to sound the alarm as the state continues to sink further into economic collapse, with many publishers and editors more driven by obsolete political philosophies than civic responsibility.
- And as recent surveys suggest, the public remains largely uninformed, still hoping for the return of a world long since vanished and subject to manipulation by political demagogues with all too many Michigan families more committed to spending on personal desires rather than investing in opportunities for their offspring.

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.

Michigan Tomorrow

Over the past several years an increasing number of thoughtful and compelling studies and reports have appeared concerning the future of the State of

Michigan, including an earlier version of this Michigan Roadmap report. While emerging from many different perspectives and sectors of our society, these studies have largely converged in recommending a series of actions that leaders of government, business, labor, and education must take if Michigan is to prosper once again in an intensively competitive, knowledge-driven, global economy. [In this regard, see Austin (2005), Bartik (2006), Clay (2007), Drake (2006), Glazer (2007), Hollins (2006), Ivacko (2007), Michigan Emergency Financial Advisory Panel (2007), Cherry (2004), Power (2006, 2007), Public Sector Consultants (2003), and Slemrod (2006).]

Many of these reports not only identify the challenges facing our state today, but they have offered hope through their compelling visions for the future of our state. They have proposed actions for leaders of Michigan government, industry, and labor that could restore our economic strength and prosperity while sustaining the social and civil infrastructure so necessary to the welfare of our citizens. Their analyses draw on Michigan's remarkable history by demanding adequate investments in its people, their education, and their capacity to complete in an increasingly competitive global economy. If Michigan were to add to its considerable natural assets–the world's largest supply of fresh water, the nation's longest shoreline, and perhaps even eventually (with global warming) a mild climate–a diverse and educated population of world-class quality, it could once again achieve the global economic leadership and quality of life that characterized our state during the past century.

Yet these visions for Michigan's future, supported by such carefully considered and compelling studies and embraced by a growing number of citizens, have failed to stimulate the actions necessary to address the challenges facing our state. Little progress has been made in addressing the challenges facing Michigan. The state's public leaders remain moored to obsolete political philosophies and distracted by largely irrelevant issues, failing miserably in their responsibilities to work together to address the key issues of restructuring Michigan's government and tax system to enable the necessary investments in our future. Similarly too many leaders of Michigan business and industry continue to focus myopically on the near term, resisting the strategic changes necessary to allow their companies to thrive–or perhaps even survive–for the longer term in a hypercompetitive global, knowledge-driven economy.

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 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 envi-

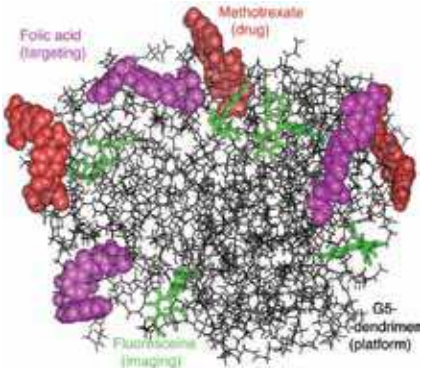
ronmental protection.

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.

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.

Information technology
(IBM supercomputer)



Biotechnology
(UM designed macromolecule)

Nanotechnology
(UM nanotechnology lab)

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.

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.

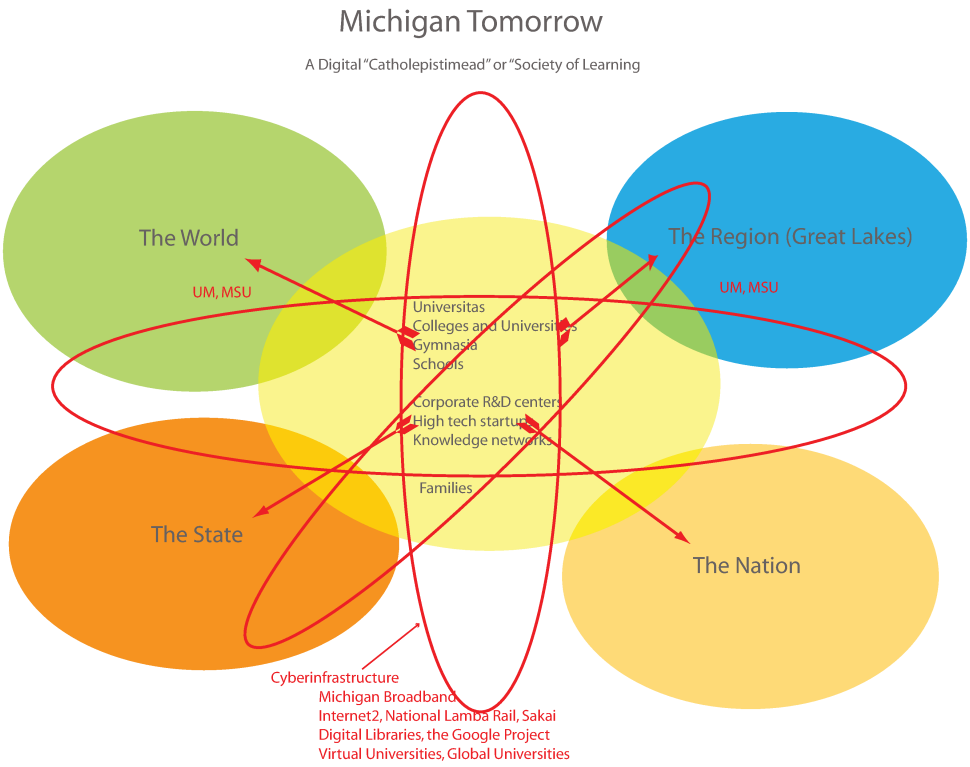
2. *What competencies are necessary for a population (workforce) to provide regional advantage in such a competitive knowledge economy?* Here it is important to stress that we no longer are competing only with Ohio, Ontario, and California. More serious is the competition from the massive and increasingly 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.

The Gap Analysis

Before we can turn our attention to the development of a roadmap to Michigan's future, we first need to determine just how far we must travel in order to build a knowledge society capable of facing the imperatives of the 21st-century global economy. Here we will continue following the roadmapping process by utilizing a *gap analysis* to compare where Michigan is today with what it must become tomorrow. In this effort, we must continue to bear in mind that in the flat world of a global, knowledge-driven economy, the key to prosperity lies not in low taxes, cool cities, and great weather. Rather it requires *educated people, new knowledge, innovation, and an entrepreneurial spirit*. This, in turn, requires visionary public policies and public and private investments that look toward the future rather than clinging to the past. The challenge to Michigan, its leaders, government, business, industry, and labor, its educational and cultural institutions, and its citizens is to invest in the production of the human capital, infrastructure, new knowledge, and innovation necessary to achieve prosperity and social well-being in a 21st-century world.

So *how far does Michigan have to travel* to achieve 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



Michigan needs to develop a more strategic perspective of its knowledge resources.

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.

Michigan's Challenge: Economic Transformation

Today Michigan is experiencing a transition as fundamental as its transformation from a farming society to an industrial society a century ago, driven by the emergence of an economy based on knowledge—educated people and their ideas–powered by breathtakingly rapid development of new technologies; the globalization of the world's economy and culture enabled by technologies of communication and travel; and the demographic changes in the American population bringing hitherto underrepresented groups into a majority of the workforce.

We are learning the hard way that if we want to fully prosper in this new world, we must take the long view, and invest in people and learning institutions, making available life-long education and training while similarly investing in research and the technological innovation it produces. Michigan's major sectors—government, business, labor, and education–must be dramatically restructured to serve us better in the new century. We simply must cease financing our current needs and desires by shifting the cost to future generations.

Today and in the future, it is our people, their character, knowledge, skill, and ability to innovate, that when allied with developing technologies that give us the competitive edge in the world economy. The keys to economic growth are education and innovation, not tax cuts and entitlements. Glazer and Grimes state it well: "These days the keys to economy success are a well-educated workforce, technical know-how, high levels of capital investment, and entrepreneurial zeal–all of which countries can acquire with the help of supportive governments, multinational firms, and international investors. If the United States is to meet the challenge posed by a truly global economy, it will have to insure that its scientists are the most creative, its busi-

Abandoned auto plants...

And an equally abandoned GM Headquarters

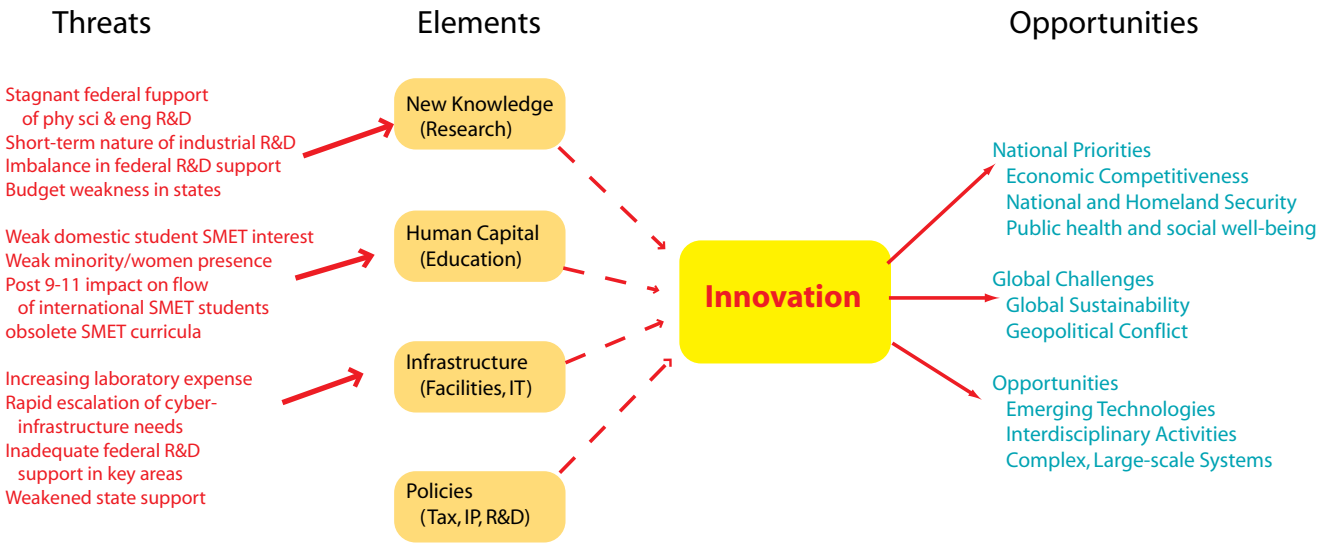
ness leaders are the most innovative, and its workers are the most highly skilled–not easy when other nations are seeking the same goals" (Glazer, 2004). And such is also the important lesson for our state.

As we have noted in Chapter 3, Michigan faces serious challenges in producing the human capital–the educated population, the knowledge workers, the scientists, engineers, and other professionals–that will enable it to compete. Not only is our population aging, but the out-migration of our 25- to 44- year old population creates a brain drain with very serious implications. To be sure, our educational institutions have demonstrated the capacity to compensate to some degree by utilizing their quality and reputation to attract and retain both their graduates and those they attract from throughout the nation and around the world. Yet all too often, state politicians object to Michigan universities enrolling students from other states or nations, apparently oblivious to the fact that over the longer term, the capacity of our academic institutions to attract talented students, knowledge workers, and companies from around the world is of extraordinary importance to our state.

Equally disturbing is the clear failure in achievement at all levels of our educational system. The performance of our K-12 system over the past several decades has been inadequate, as evidenced by the fact that almost half of all Michigan adults are currently hindered by a literacy level too low to function adequately in today's knowledge-driven society. Furthermore, one-quarter of Michigan citizens do not have a high school diploma, while only one-third of high school students graduate with college-ready transcripts (Austin, 2004). Although Michigan's system of higher education is generally regarded as one of the nation's best, here too there are challenges. Although our two flagship universities, UM and MSU, have high graduation rates (90% and 70%, respectively), the rest of Michigan's public universities graduate fewer than 50% of their students (corresponding to roughly 300,000 Michigan students that will enter college only to fail to graduate).

Hence there is growing evidence that a skilled-worker shortage–created by low birthrates, out-migration of young adults, and poor performance of our educational systems–poses a serious threat. Beyond these current challenges, it is also the reality that a global, knowledge-driven economy is continuing to raise the bar for educational achievement. In sharp contrast to a recent state report which suggested that "a vast majority of the emerging high-wage, high-skilled jobs available in Michigan require a level of skill that can be obtained at the community college or technical school level and do not require a bachelor's degree" (MEDC, 2002), the reality is that a bachelor's degree is already almost a mandatory credential for a job in the new economy, and soon advanced degrees–or at least lifelong learning–will become a necessity. We must take great care not to repeat the mistakes of the 20th century when we doomed generations to poverty by restricting their educational opportunities to only the level they needed for the low-skilled jobs of that time. The educational demands of a changing world are moving ever higher.

Michigan also must make investments to create the new jobs to employ better educated graduates. Thus far, too few jobs of this kind—dependent on skill and



knowledge–exist in our state. The old economy is gone, never to return. Furthermore, even if our traditional factory-based industries did manage something of a comeback in the 1990s, they can never dominate our economy again. The productivity gains made through efforts such as total quality management and lean manufacturing unfortunately come at the expense of jobs–and perhaps also at the expense of the R&D necessary to achieve technological innovation and sustain market share.

It seems increasingly clear that new jobs in Michigan are not going to be spawned by existing industry but instead will be created by entirely new activities dependent upon technological innovation, both in high-tech areas such as biotechnology, information technology, and nanotechnology, and in knowledge intensive services. They will require skilled knowledge -workers, technological innovation, and energetic, risk-taking entrepreneurs. And it is from this perspective that the most significant players in building Michigan's new economy could well turn out to be its schools, colleges, and universities, since these institutions are the primary source of all three essential elements of the knowledge economy.

Broader Public Policy Issues at the State Level

A key objective of any policy discussion is to shift the public conversation away from distracting issues such as Balkanized state politics, culture wars, and bitterly partisan battles to focus instead on the imperatives of a knowledge economy: lifelong learning, research and innovation, and knowledge-age infrastructure. Since public commitments and government action are the longer-term key, it is important to lay out a possible agenda for state leaders, the more specific the better. It is important that state policy makers begin to consider new financing and governance issues within the context of future state needs and priorities rather than past political party ideologies.

Most important, state government has to begin by getting its fundamental responsibilities aligned with the needs of a knowledge economy:

1. Empowering families, students, workers with the responsibility and the resources to access lifelong learning opportunities that they determine will be best for themselves, including early childhood, K-12, postsecondary, and continuing education.
2. Providing the infrastructure and the investments necessary to attract federal and private research funding and stimulate innovation and entrepreneurial activities.
3. Developing a tax structure that generates revenues adequate to fund both current obligations and the necessary investments in the future, the broadest possible base and mix of taxable activities, and the most equitable tax burdens, while reducing those

costs of government that are excessive when compared to best practices in other states.

To be sure, many of the challenges of today–globalization, demographic change, a knowledge-driven economy, and ruthlessly competitive markets–driving the tsunami engulfing our state are simply the imperatives of a new age. Yet perhaps the greatest and most threatening gap between the trauma and tragedy of Michigan today and the promise of what it might become (indeed, must become) tomorrow is unique to our state: the absolute vacuum of leadership we are currently experiencing.

Clearly many of the policy issues reflected in our analysis are closely related to important challenges in Lansing itself–a state government unwilling to provide adequate leadership in addressing the issues (e.g., tax increases and expenditure restructuring) necessary to allow adequate investment in the future, overly constraining institutional actions necessary to cope with an increasingly competitive marketplace (e.g., eliminating affirmative action and bans on stem cell research), and apparently characterized by an almost total lack of understanding of the realities and role of education and innovation in a knowledge society–with most of the state's private sector leadership and media sitting on the sidelines, largely silent if not oblivious to the key challenges facing Michigan.

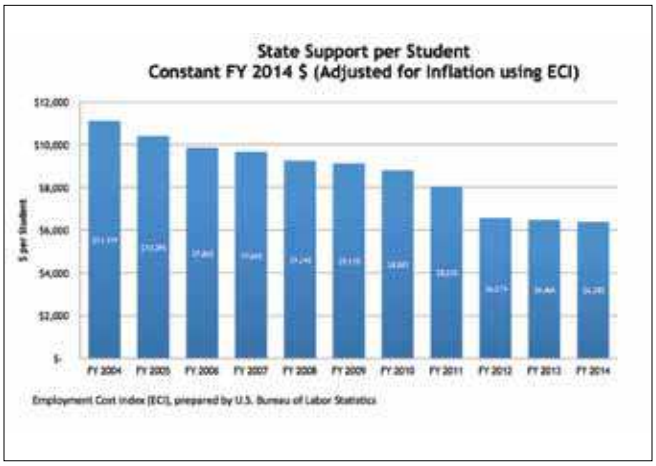
Related to these issues is the increasing irrelevance of Michigan's political parties to the realities of our present and the challenges for the future. Both are largely trapped in the past, driven by the desire to protect old sacred cows (e.g., big business, big labor, big government, and wealthy campaign contributors) or by "value-morality" ideologies (abortion, gay rights, stem cell research, creationism) that are distracting public leaders and public attention from what really matters in a 21st-century global economy. As the Michigan economy crashes to the bottom of the states, our elected public leaders continue to back into the future, clinging to the practices and expectations of an obsolete past, instead of facing up to the actions, commitments, and sacrifices that will be necessary to rebuild Michigan's strength and prosperity in a radically different future.

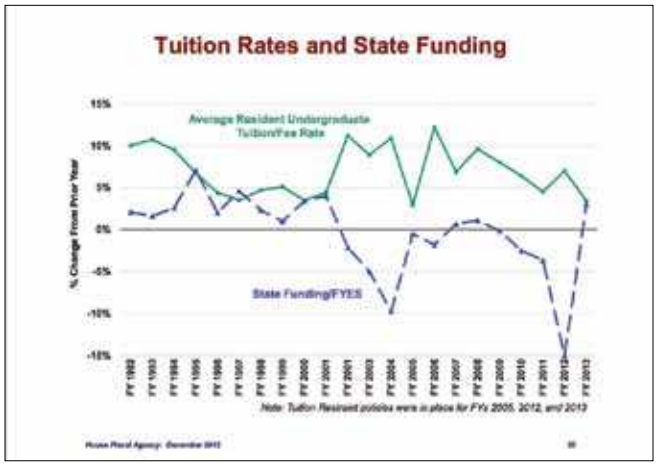
A recent statement from the Michigan League of Women Voters states our current dilemma well: "Government is becoming increasingly irrelevant as it shrinks due to reductions in tax rates and revenues. Essential services are being cut and citizens are losing hope in the prospect that government will protect and support opportunities for people to improve their lives. This trend erodes citizens access to government more than any development we have observed since we began this series of reports" (Milliken, 2005).

Particularly serious is the need to restructure an obsolete tax system, designed for a 1950s factory-based manufacturing economy rather than a 21st-century knowledge economy, and restore both integrity and responsibility to the state budget process. To be sure, a weak economy coupled with the burden of unfunded federal mandates has destabilized the state budget process. 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).

Yet Michigan's budget problems are largely self-inflicted: the combination of tax cuts without corresponding spending cuts, failure to confront overdue government and structural reforms, a pattern of using one-time funds to handle real structural deficits, and the extreme stress placed on the state's manufacturing industry–particularly the automobile industry. Study after study have addressed the misconception that Michigan is a high-tax state, demonstrating instead that our tax burden both for citizens and business has now declined significantly below the national average, although some would prefer that it crash to the bottom along with states such as Mississippi and Alabama (notably those planning to retire in Florida, leaving their children to endure the consequences of the resulting erosion of the state's intellectual, social, and civic infrastructure).

Strategic actions by state government has largely been thwarted by lobbyists and political ideologies moored to the past, resulting in seven years of spending cuts of critical services, over $8 billion of one-time





In Michigan today, the increase in tuition is driven almost entirely by withdrawal of state support.

resources used as bandaids to cover the fundamental imbalance between tax revenues and growing expenditures such as corrections and public employee benefits. During the 1980s, Michigan launched a massive prison construction program, in response both to ill-considered sentencing guidelines and pandering to public concern about crime. In the early 1980s, Michigan had 15 public universities and 8 prisons; today we still have 15 public universities, but now 54 prisons. In fact today the average cost per inmate is roughly five times that of the state appropriation per student in Michigan's public universities. As a result, state spending on prisons surpassed that for higher education in the early 1990s and today has become one of the largest uncontrolled mandates for state tax dollars. Moreover, strong political pressure from unions has dissuaded state leaders from taking strong action to restructure public employee benefits (both state employees and teachers) to levels more comparable to the rest of the nation. Michigan's school finance reform effort of the 1990s created K-12 education as yet another funding mandate, which along with Medicaid and prisons, leaves little left for higher education, which is still treated as a discretionary budget item. As a consequence, over the last several years, no state activity has been cut as much as the funding for public higher education–a glaring sign of the lack of strategic vision on the part of state leaders.

The structural deficiencies in the state budget were compounded during the 1990s. During a period of relative prosperity that should have provided state government with the opportunity to restructure its antiquated tax system and begin to invest in its future by restoring funding for key priorities such as higher education and infrastructure, Michigan instead decided to cut its tax rate–and continued to do so long after the rest of the nation halted this practice in favor of beginning to reinvest in the priorities of the knowledge economy. This has created a permanent budget deficit that becomes worse each year as Michigan's foundering economy continues to weaken, while an aging population and a growing population of uninsured, coupled with the rapid increases in health care costs, drive Medicaid burdens into the stratosphere.

Michigan finds itself simply unable to meet both its obligations for the present (e.g., Medicaid, corrections, K-12 education, public employee benefits) while investing adequately in its future (e.g., higher education, research and innovation, knowledge infrastructure). A term-limited state government, increasingly manipulated by special interests and subject to the narrow agendas of political parties, has been unable to restructure an obsolete tax system, designed for a factory-based industrial economy that is no longer dominant in our state. Even today most of Michigan's economic activity involves knowledge-intensive services–e.g., financial services, health services, and professional services such as law and management, generating revenue that is not included in Michigan's tax base. All too frequently both state and local governments tend to use tax abatements to bail out or attract traditional industries rather than investing in the new knowledge-driven businesses capable of competing in tomorrow's global economy.

Numerous studies have demonstrated that Michigan's tax burden–both for private citizens and business–

has now fallen significantly below the national average, although it remains one of the nation's most regressive and inequitable tax systems. From a more cynical viewpoint, there is absolutely no evidence whatsoever that cutting state taxes has a positive economic impact–although to be sure in the current anti-tax climate, it may generate votes. What is certain, however, is that cutting investments in education, innovation, and knowledge infrastructure is crippling in a knowledge economy. As Bill Gates stresses, "The IT and biotech industries are far more sensitive to quality of talent than incentives. California is No. 1 not because they have the most friendly tax policies there. If you're coming up with a breakthrough in medicine, it doesn't matter if you're paying a little more in taxes" (Gates, 2005).

While any discussion of the "t" word is usually banned in Lansing, it has become increasingly clear that without a major restructuring of state tax policy and public expenditures, Michigan will simply be unable to balance the obligations created by mandates for state funding with the necessary investments in its future. Future generations will bear the burden of our indecision and myopia. The blue-ribbon, bipartisan Michigan Emergency Financial Advisory Panel, led by former governors William Milliken and James Blanchard, rapidly reached an agreement on what state leaders must do to stop Michigan's precipitous decline:

- Move rapidly to enact fundamental reform of both spending and taxes.
- Create a modern tax structure that abandons the focus on the economic system of the 20th century and looks to the developing knowledge economy of the new century.
- End the disinvestment in education and those other assets that define the quality of life that knowledge-based workers seek–cultural offerings, natural resources, and vibrant cities; and
- Develop a fiscal plan that includes a combination of revenue increases, spending cuts, and reform of how public services are delivered.

And how did Lansing respond: By allowing partisan politics and self-interest to paralyze state government as Michigan careened toward the cliff of a budget meltdown in fall of 2007 that would have shut down state services. While the governor and legislature finally came to an agreement that averted disaster only hours from the budget deadline, this was largely a patchwork affair that put off once again the necessary structural reforms in state expenditures and tax policies, suggesting that such train wrecks will happen yet again in the near future–that is, unless Michigan voters wake up to the haplessness of their elected representatives in Lansing.

Diversity and Social Inclusion

A distinguishing characteristic and great strength of our state has been its growing commitment over its history to serve all segments of our pluralistic society. We have never needed such inclusiveness and diversity more than today when differential growth patterns and very different flows of immigration from Asia, Africa, Latin America, the Caribbean, and Mexico are transforming our population. By the year 2030 current projections indicate that approximately 40 percent of all Americans will be members of minority groups, many—even most—of color. By mid-century we may cease to have any one 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. These far reaching changes in the nature of the people we serve and the requirements of global responsibility demand far-reaching changes in the nature and structure of higher education in America.

Our rapidly diversifying population generates a remarkable vitality and energy in American life and in our educational institutions. At the same time, it gives rise to conflict, challenging our nation and our institutions to overcome at last our long history of prejudice and discrimination against those groups who are different, particularly and most devastatingly, those groups identified by the color of their skin. Tragically, race remains a significant factor in our social relations that profoundly affects the opportunities, experiences, and perspectives of those discriminated against as well as those who discriminate. To change this racial and cultural dynamic, we need to understand better how oth-

ers think and feel and to learn to function across racial and cultural divisions. We must replace stereotypes with knowledge and understanding. Slowly, we Americans are learning but there remains a great distance to go.

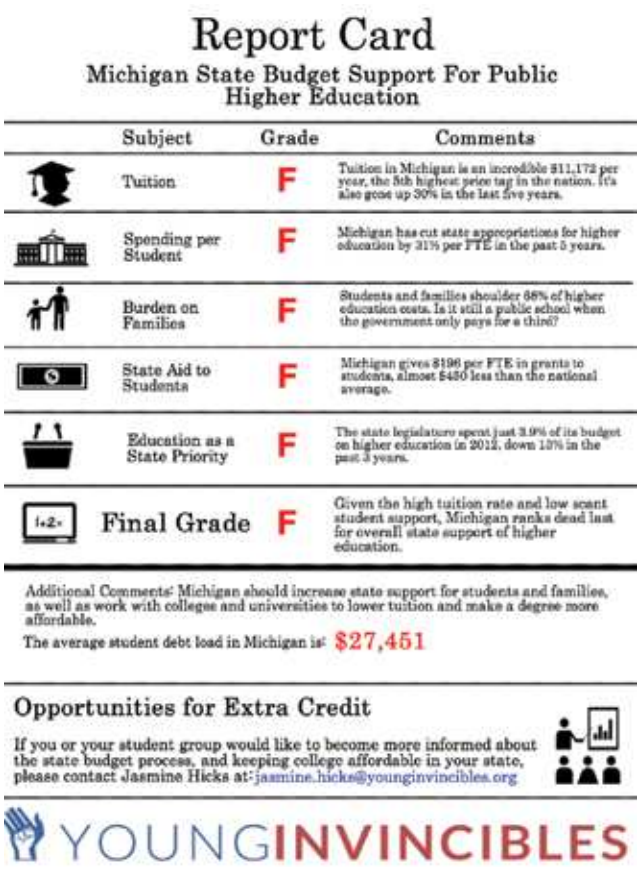
In Michigan we face a particular challenge. Despite the fact that the landmark Supreme Court cases in 2003 involving the University of Michigan's affirmative action program reaffirmed the fundamental principle that "student body diversity is a compelling state interest that can justify the use of race in admissions", in 2006 Michigan voters approved a constitutional referendum to ban the use of affirmative action in public institutions. Already Michigan's public colleges and universities are seeing early declines in social diversity on campus. Unfortunately, this confusing–and many believe ill-considered–referendum, has placed Michigan at a considerable disadvantage both in developing its human capital and competing in an increasingly diverse global economy.

Cultural Challenges

Even if we manage to break the stranglehold of obsolete perspectives and practices upon state government, there are even deeper issues that must be addressed if Michigan is to once again prosper as a national leader. In the effort to close the gap between Michigan today and our vision for tomorrow, there remains one very serious threat standing in the way of our continued progress. As the cartoon character, Pogo, once observed: "I have seen the enemy, and he is us!" Along with our strengths, Michigan continues to have some serious weaknesses—some embedded in our history.

1. *Deteriorating social foundations*: In a period of intense change, all of us, and especially our children, need the security of strong families and communities. Yet these foundations continue to erode and we see the effects in our classrooms and residence halls as well as in all the youth who fall by the wayside, their mindpower gone to waste.

2. *Divisions*: Nothing is more corrosive of our way of life than the growing divisions in our society—by race, ethnicity, class, age, religion, political beliefs, and socio-economic class. These are taking an increasing toll on our ability to study, work and live together and to take part in productive civil discourse. If we do not address continuing inequality, persistent poverty, mutual distrust, nothing else we do can possibly succeed. Furthermore, at a time when we are engaged in an historic debate about America's and Michigan's future, our public discussion too often is distorted by noise of the blame game, paranoia, wishful thinking, stridency, unreasoning rage, and even at times pure hate. If we want to make sound and reasoned decisions, we have to lower our voices and restore mutual trust.



Michigan fails in all phases of a 2014 "report card" for state support of public higher education.

3. *Commitment to excellence*: Americans are addicted to a pernicious vice. Especially in hard times. Too often we are suspicious of, even hostile to, excellence and high achievement, particularly intellectual achievement. Dr. William Hubbard, former CEO of Upjohn, used to point to one of the great character flaws of the Midwest as "our extreme intolerance of extraordinary excellence."

We settle for the lowest common denominator rather than honoring and supporting achievement. You would think that the one lesson we should have learned during the 1980s–in Michigan of all places–is the importance of quality in everything we do, in everything we buy, sell, and produce. It is this culture of competence–a set of attitudes, expectations, and demands–that is often missing in America today. Ultimately, competence requires that people and institutions be held accountable for their performance. Competition helps improve performance. But too often we spend our time trying to protect ourselves from accountability and competition.

4. *Still penny-wise but pound-foolish*: We also see these character flaws when it comes to key investments in our people, such as education and worker training. We seem hell-bent on insisting on bargain-basement prices, even if it means bargain-basement quality in the performance of our institutions or products and services. A few years back–at the time of another administration in Lansing, a prominent state official once proclaimed that quality was a luxury that students had no right to expect from a *public* university. If students and parents wanted quality, they could pay the extra price to go to a private university. Worth noting is the guy who said this had gone to Harvard, suggesting that this was his version of "let them eat cake." This is a long way from the Jeffersonian ideals of our founders, who believed that only the best was good enough for their children, whatever their background or social status, so long as they had the ability and will to achieve. We can no longer afford the luxury of mediocrity in anything we do. Our competitors in the flat world will cut us no slack! Isn't it time, as the Ford ad used to say, we make quality "job number one" in other critical aspects of life such as in educating our children?

5. *An entitlement culture*: For decades Michigan was fabulously wealthy. We developed a culture of expensive practices, entitlements, and expectations: employee benefits, health care, social services, and litigation. Yet today, as Michigan's economy attempts to adjust to the brave, new world of a knowledge-driven society, it still attempts to support a Cadillac appetite on a Prius income. We are still not investing our resources strategically. We are tending to deploy them to pay for past sins (corrections, social services, entitlements), to sustain and perpetuate the past (tax cuts and abatements), or to sustain our personal desires (through the tax cuts that have decimated state budgets and services) rather than investing in the future by creating new skills, new knowledge, and new jobs. This is a burdensome habit for which we can blame no one but ourselves. We are consuming today the resources that will be needed for tomorrow. Too few are willing to make the sacrifices necessary to secure the future in the way that our ancestors made to provide us with opportunity, prosperity, and security.

6. *The "Not on My Watch" syndrome*: It is alarming how few of Michigan's leaders in the public or private sectors are willing to step forward to address the looming challenges or take the actions necessary to secure our state's future. "Defer, delay, procrastinate." Those are the watchwords of today. No need to deal with tax reform now. Let the next Legislature deal with it. Gas prices zooming to $4 and up? Let's introduce a few more big SUV and truck models since surely there are folks out there who don't mind paying a big fraction of their paycheck at the pump. The next team of executive officers at GM (or Ford or Chrysler) can handle the challenge of restructuring our company to build fuel-efficient cars. Besides, by the time that federal fuel efficiency requirements or the marketplace demands 50 mpg cars–or the inability of tax revenue to adequately fund both obligations and investments forces Michigan still further down an economic spiral toward Mississippi)–we'll be long-gone, retired and playing golf in Florida. It will be someone else's problem. (Unless, of course, Florida is under water by then because of global warming…)

Michigan's current challenges are structural, not cyclical, and hence are likely to continue unless bold actions are taken. Glazer stresses that Michigan's decline has been caused, in large part, because the state–its citizens, enterprises, and communities–have been slow to adapt to a rapidly changing global economy. "It is clear to us that the only way to reverse these trends is to let go of the past–no matter how good it was to us–and embrace the future, a future where successful communities will be far more knowledge-driven and entrepre-

neurial" (Glazer, 2006).

Too many of our people and our institutional leaders are floundering, on the defensive, desperately clinging to the past, to the habits and expectations of an earlier era when we were a leading industrial power not just of America but of the entire world. Many among us look for scapegoats—foreign workers and industries, immigrants, business, labor, politicians, ...even universities. Some take a "this too shall pass" attitude, almost as if by closing our eyes we could make change stop. Others demand entitlements, no longer secure in a rapidly changing world.

To be sure, economic and social upheaval of the magnitude we are living through is unprecedented. It challenges our basic assumptions about how we are to live our lives; it changes the rules in mid-game. It displaces and hurts far too many. But the almost certain consequence of this continuing widespread denial of and resistance to change would be to condemn Michigan to a future of decline that would soon be irreversible. Why? Because such denial violates a fundamental law of nature that all living systems must continually adapt to their changing environment or risk extinction. To survive let alone prosper, Michigan has to summon the courage and strength to face up to reality, to see change not as a threat but to seize the opportunities it offers to make a better world for ourselves and our children.

The Michigan Roadmap

We now turn to the Michigan Roadmap. This is designed as an organic and evolving plan to suggest the path our state might take to transform itself from the deteriorating industrial economy of Michigan today to a vibrant, knowledge economy of Michigan tomorrow, capable of competing in a global economy and providing our citizens with prosperity, social well-being, and security.

We begin with a simple premise: *the key to Michigan's future lies with its people*, with their skills, character, creativity, innovation, and entrepreneurial spirit. The quality and diversity of our workforce is our greatest asset. In the past Michigan has exploited its vast natural wealth–its forests, minerals, lakes, and location–to achieve economic strength and global leadership. But this has happened largely because of the pioneering spirit, gritty courage, and self reliance of the people who have been attracted to the state by these assets. It was our people who made our farms and factories the best in the world. Over generations we have learned that if we believe and invest in them and those who come to our state–in their education, health, and social well-being–Michigan's people will keep us at the forefront of innovation, productivity, and trade.

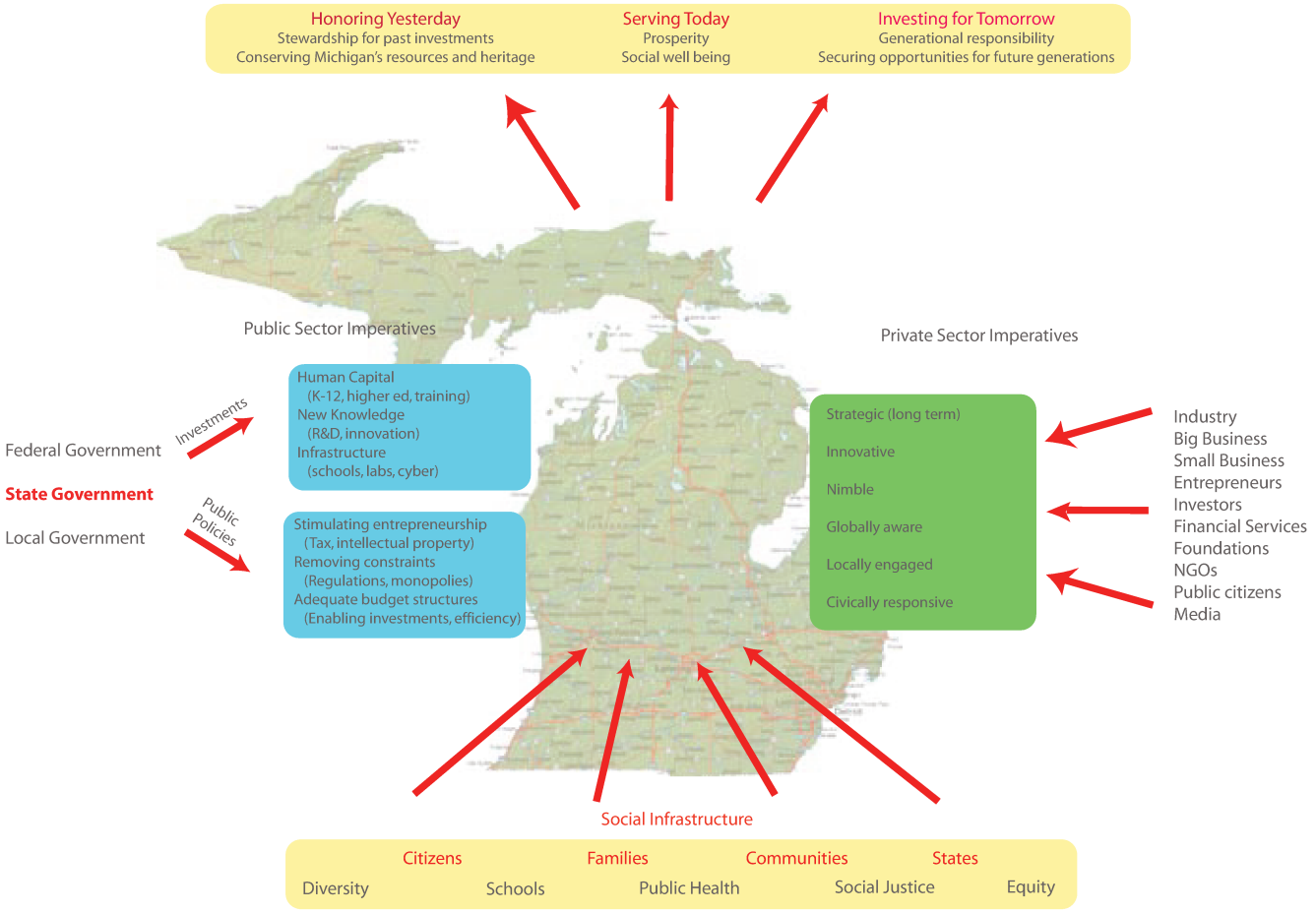
And this is even more true today since, as we have stressed throughout this report, in a knowledge-intensive society, regional advantage is achieved through creating a highly educated and skilled workforce that is competitive on a global level. It requires an environment that stimulates creativity, innovation, and an entrepreneurial spirit. It also requires supporting infrastructure–world-class schools and universities, research laboratories and cyberinfrastructure, tax and intellectual property policies. And it requires vision, commitment, and leadership in both the public and private sectors.

The Roadmap: The Near Term (...now!...)

In the near term our principal recommendations focus on Michigan's most valuable asset, 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

We begin by addressing the primary concerns about both Michigan's and the nation's educational system: the complex interplay of inadequate preparation, lack of information about educational opportunities, and persistent financial barriers that impede the ability of students to pursue their education to the advanced level required by the knowledge economy–particularly for low income and under-represented minority students. Inadequate primary and secondary education not only deprives too many children of the knowledge and skills



The Michigan Roadmap

necessary to compete in the global, knowledge economy but it fails to prepare them adequately for further study at the postsecondary level necessary to provide the knowledge and skills essential both for a globally competitive workforce and personal quality of life.

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.

The Spellings Commission has proposed as a national goal that every student in the nation should have the opportunity to pursue postsecondary education). This imperative for the global knowledge economy will require an unprecedented effort to expand higher education access and success by improving student preparation and persistence at the national, state, and local level, addressing non-academic barriers and providing significant increases in aid to low-income students (Miller, 2005). A high school degree should signify that a student is college and/or work ready. The effort is underway in a number of states including Michigan to better align K–12 graduation standards with college and employers, but we are suggesting that the bar should be set even higher: All students enrolling in our K-12 schools should be prepared for further–indeed, lifelong–learning at the postsecondary level as an absolute requirement for the knowledge economy. No child–or school–should be left behind and forced to settle for anything less than a rigorous college preparatory education!

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.

As we have noted earlier, Michigan's social priorities have become seriously distorted in recent years, placing more emphasis on locking people up or providing tax benefits to the affluent than investing in educational opportunities and welfare of its citizens. A striking example is provided by Michigan's merit scholarship programs, which primarily channel state resources to economically advantaged students attending well-supported schools in affluent areas at the expense of the financial aid necessary to provide educational opportunities to the less fortunate. It is imperative that these merit-based programs be restructured with a strong need requirement if the state is to target public resources where they are likely to have the most impact on Michigan's future workforce.

Furthermore, since the educational standards demanded by the global economy require strong families and communities in addition to schools, Michigan must recommit itself to adequately supporting the necessary social programs and policies to enable all of its citizens–including those disadvantaged by economic dislocation or discrimination–to access educational opportunities.

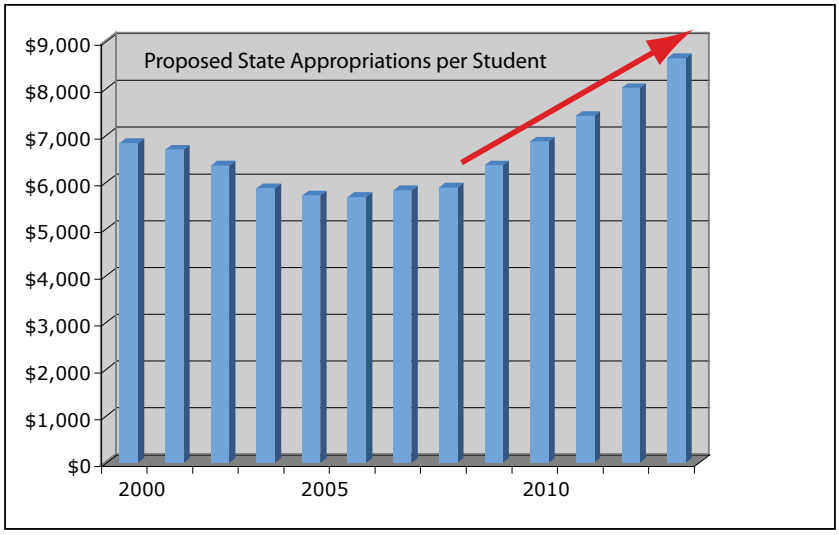
Here part of the challenge is public awareness. Many student and parents don't understand the steps needed to prepare for college, and the system fails to address this information gap. State and local government needs to partner with schools and colleges to provide resources for early and ongoing college awareness activities, academic support, and college planning and financial aid application assistance. Such efforts should include developing students' and parents' knowledge of the economic and social benefits of college through better information, use of role models and extensive career exploration.

Beyond the disturbing fact that the majority of Michigan parents still do not understand the imperatives of postsecondary education for the children's future, it is also clear that an aging population has yet to realize their generational responsibility to invest adequately in Michigan's future. Higher education should partner with business to raise public awareness of the educational and social imperatives of the global economy and the necessary commitments that both parents, citizens, and governments must make to secure their future.

3. Michigan 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.

The key objective here is to greatly expand college participation and success by outlining ways in which postsecondary institutions, K–12 school systems, and state policy makers can work together to create a seamless pathway between high school and college. Both students and the state could be well served by a higher degree of coordination, particularly in facilitating the transition among various sectors (e.g., K-12, community college, undergraduate, graduate, professional, lifelong learning) and elements (public, private, for-profit, corporate training) of education. 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, the state's education enterprise needs to be better coordinated and integrated vertically, while preserving the strong market competition horizontally.

Standards for transfer of credit among higher education institutions should be reviewed and revised, subject to rigorous standards designed to ensure educational quality, to improve access and reduce time-to-completion. Of importance here is the development of a statewide student record system, capable of statistically



Michigan should set and ***achieve*** firm targets to restore support of its public universities to levels comparable to those of leading states

tracking the flow and progress of students throughout postsecondary education, as well as the development of incentives at the state and local level for institutional coordination and cooperation among all elements of the education sector.

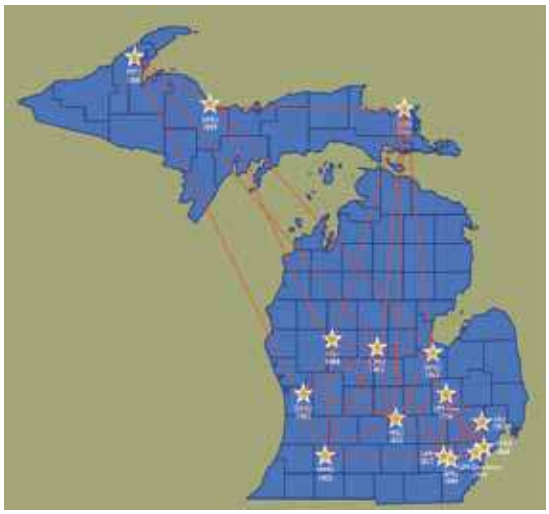
4. Higher education must become significantly more engaged with K-12 education, accepting the challenge of improving the quality of our primary and secondary schools as one of its highest priorities with the corresponding commitment of faculty, staff, and financial resources. Each Michigan college and university should be challenged to develop a strategic plan for such engagement, along with measurable performance goals.

Although the quality of American higher education is heavily dependent upon the quality of K-12 education, most colleges and universities have limited their engagement with K-12 education to teacher training. A few have gone farther, to create and manage charter schools, much in the spirit of the clinical "university schools" characterizing schools of education in the 20th century. But most of higher education has largely viewed the challenges faced by K-12 education in America as somebody else's problem and tended more to criticize the quality of our schools and the preparation they provide to college-bound students than to work with them to correct their deficiencies.

In particular, 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. 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 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.

It is particularly important to develop programs that bring together secondary school and college faculty in peer-to-peer relationships. In the past the federal government used to sponsor summer workshops on the campuses for K-12 teachers that helped in such efforts, particularly in key areas such as STEM education (science, technology, engineering, and mathematics). In the absence of such federal programs, state government should consider assuming this role, perhaps in partner-

The State of Michigan has not invested significantly in its colleges of engineering for over two decades, in sharp contrast to most other states (and nations)!



It is important to encourage collaboration among the state's colleges and universities.

ship with business and the philanthropic community.

The key here is to challenge each of Michigan's colleges and universities to develop a high priority strategic plan for engagement with K-12 education that is both university-wide (perhaps reporting directly to the president or provost of the institution) and characterized by measurable performance objectives. This is simply too important an activity to relegate to schools of education. It must involve the commitment of the entire institution.

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.

As we have stressed throughout this report, the most urgent near-term challenge facing our state's higher education system is the need to develop more enlightened policies and strategies that enable us to invest sufficient public funds in education while providing our academic institutions with the incentives and agility to respond to market pressures. In order to ensure sufficient investment, we need to follow the guiding principles of quality, access, diversity, market agility, and accountability. It is only through an investment in knowledge resources and innovation–education, research, and the infrastructure to support them–that Michigan citizens will be able to compete in this global economy. Simplistic solutions that merely try to increase degree production without addressing quality or funding requirements are clearly both incomplete and inadequate.

However, we also acknowledge that Michigan's current tax base remains inadequate for this purpose. Tax cuts implemented during the economic boom-times of the 1990s have created a dysfunctional state budget, no longer adequate to address current obligations such as K-12 education, corrections, and unfunded federal mandates such as Medicaid, while investing adequately in Michigan's future, particularly during periods of a weak economy–which, without new investments, are likely to become both more frequent and more severe for our state. Yet the current inability of state government to develop and implement tax policies and cost structures appropriate for a 21st century knowledge economy gives us pause.

While flexibility in state budget and tax policy is always desirable, particularly during periods of major social change, we are convinced that investments in education, innovation, and infrastructure are simply too critical to be subject to the year-to-year pressures of a dysfunctional state budget process and an electorate

still embracing an entitlement mentality from Michigan's industrial past. Hence we recommend serious consideration be given to funding public higher education, and perhaps knowledge generating activities such as research, innovation, and supporting infrastructure, from a dedicated tax revenue stream secure from tampering by partisan politics.

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.

There is ample evidence that Michigan's current investments in public higher education are simply inadequate, whether compared with other states, other nations, or in light of the current and future challenges faced by the state. Today, Michigan's annual appropriations to higher education, at a level of $5,700 per FYES, have not only fallen below the national average, but declined to become lowest in the Great Lakes region. Michigan simply cannot compete without a highly skilled workforce, and that workforce is dependent on the availability of advanced educational opportunities.

It is important to set appropriate benchmarks for critical investments such as public higher education. If Michigan aspires to return to a position of national economic leadership, it follows that it must be prepared to invest adequately to create a workforce and stimulate the innovation required for such economic prosperity in a global knowledge economy. In higher education, just as in other economic sectors, quality and access require investment. Insisting on bargain-basement prices, as tax-paying citizens or tuition-paying parents, will inevitably lead to bargain-basement quality, which would likely doom our state's capacity to transform itself into a 21st-century knowledge economy.

More specifically, simply moving to the average of other Great Lakes states would require additional support of Michigan's public universities by a 20% increase in state appropriations per student (after inflation). To move into the top quartile of the states would require a 30% increase, while moving to the level of support provided in states with strong knowledge-based economies such as California, North Carolina, Texas, and Massachusetts, would require an increase of 40%. We recommend an intermediate objective of moving to the top quartile of the states by increasing state appropriations per student by 30% (beyond inflation) over the next five years, with possible further increases after that to allow Michigan to compete with the leading high-tech states.

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.

Michigan ranks relatively low among the states in the fraction of science and engineering degrees among its college-educated workforce. Moreover, because of their intensive capital needs for laboratory facilities and equipment, science and engineering programs tend to suffer comparatively more damage than less technology-dependent programs during periods of inadequate state appropriations such as the past several years. This is aggravated by Michigan's inability to provide tax dollars for badly needed campus academic facilities for over two decades.

Although Michigan is more at risk in this area than many other states, this is a national problem as well. As Intel CEO Craig Barrett warns: "We are not graduating the volume of scientists and engineers, 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 out investments in physical science" (Barrett, 2004). Michigan should heed Friedman's warning: "It takes 15 years to create a scientist or engineer. We should be embarking on an all-hands-on-deck, no-budget-too-large crash program for S&E education immediately. The fact that we are not doing so is our quiet crisis. Scientists and engineers don't grow on trees. They have to be educated through a long process because this really IS rocket science" (Friedman, 2005).

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 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.

One of the ironies of the increasingly competitive global marketplace is the need to cooperate through alliances. This is an important approach that should also be adopted by higher education. Here the key is to encourage far more mission differentiation among institutions, where colleges and universities develop strong capacity in unique areas and then form alliances with other institutions, cooperating and sharing resources, to meet the broader needs of the state. For example, the state's flagship research universities will be under great pressure to expand enrollments to address the expanding populations of both college-age and adult students, possibly at the expense of their research and service missions. It might be far more constructive for these institutions to form close alliances with regional universities and community colleges to meet these growing demands for undergraduate education while protecting their unique capacity to conduct the graduate programs and cutting-edge research critical to an economy increasingly dependent on technological innovation. Another example would be alliances between research universities and independent colleges that take mutual advantage of the learning-intensive environment of the latter and the vast intellectual resources of the former.

The experience of successful higher-education associations suggests that the key coordination point for such interactions should be the chief academic officers, the provosts, since they are, in effect, the chief operating officers for their institutions and somewhat less pressured into a competitive mode. Such an organization already exists through the Presidents Council of State Universities of Michigan, but similar organizations should be developed for Michigan's independent colleges. Furthermore, there should be separate organizations for the state's research universities (UMAA, MSU, and WSU), comprehensive public universities (WMU, MTU, EMU, CMU, NMU, OU, GVSU, SVSU, FSU, LSSU, UMD, and UMF), community colleges, and independent colleges. However there should also be alliances among institutions with differing roles and missions (e.g., partnering research universities with independent colleges and community colleges) as well as between higher education and the private sector (e.g., information technology and entertainment companies). Differentiation among institutions should be encouraged, while relying upon market forces rather than regulations to discourage duplication.

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.

While adequate investment in quality educational opportunities is essential, this by itself will not create the new knowledge-intensive jobs demanded by the global economy. As Bill Gates has noted, cutting edge

companies no longer make decisions to locate and expand in states based on tax policies and incentives. Instead they base their decisions on a state's talent pool and culture for innovation, with particular focus on world-class research universities. Gates notes that California provides a perfect example of a state that saw huge growth in the high tech industries despite a relatively unfavorable tax climate, and it continues to benefit today by sustained public investment in the University of California system and the launch of a series of major state-funded R&D centers in key technologies (biotechnology, communications technology) on university campuses. (Gates, 2005)

Although today Michigan tends to focus its efforts more on public relations (Michigan First) and gimmicks (lotteries, casinos) while cutting support for research universities, during the 1980s the administration of Governor James Blanchard supported a highly successful effort to invest in the research capacity of its universities through the Research Excellence Fund. This effort invested $25 million a year for a seven-year period in the research capacity of its public universities. The impact of this investment was quite extraordinary: the production of cutting edge research, products, and methodologies in manufacturing, biotechnology, advanced materials, and information technology, resulting in the spinoff of dozens of successful companies, numerous technologies adopted by Michigan industry, the involvement in research of hundreds of Michigan companies that became partners in the research centers, and a ramping up of federal research funding leveraged by the state investment by over a factor of ten.

Unfortunately, after seven years of funding, politics and a new governor and state legislature eliminated the Research Excellence Fund. Yet today this state program provides quite strong evidence of precisely the type of investment of state tax dollars necessary to "support high quality research and applied technology development at Michigan's public colleges and universities as a means for making existing Michigan businesses more competitive and creating new jobs and businesses based on newly developed products and successes," in the words of the original Research Excellence Fund legislation. Many other states have learned from and since imitated this program. Unfortunately Michigan did not…

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).

As we noted earlier, there are numerous examples in which universities have not only encouraged faculty, student, and staff participation in high tech startups, but also provided or attracted substantial investment capital for such activities (e.g., CONNECT in San Diego). This creates a virtuous cycle of economic growth and reinvestment in the subsequent waves of high tech development.

Both state government and Michigan research universities need to recommit themselves to such partnerships for the long term, seizing on current opportunities such as alternative energy sources for the transportation industry (e.g., biofuels, hydrogen and hybrid technologies), nanoscale biotechnology, and information systems.

There are very encouraging signs in this direction as Michigan's research universities (MSU, UM, and WSU) have joined together to create the University Research Corridor, aimed both at cooperating in the conduct of basic and applied research, and joining with Michigan industry, entrepreneurs, and the investment community to spin off new discoveries into commercial applications capable of driving economic growth. While in the long run such a consortium will be successful only if Michigan restores adequate public support of these institutions, in the near term each participating institution has committed major resources to launch the effort.

11. Michigan must also invest additional public and private resources in private-sector initiatives designed to stimu-

late 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.

While the development of human capital is the primary responsibility of the state's educational institutions, the generation of new knowledge–R&D, innovation, entrepreneurial activities–and infrastructure will require a partnership among business, higher education, state and federal government. Just as state government must begin to reinvest in the capacity of its public colleges and universities to produce knowledge workers and research, it must also provide strong incentives to re-establish longer-term R&D as a priority for Michigan industry. The state should support private sector investment in joint university-industry collaborative research (e.g., through tax credits) and assist in meeting the cost-sharing requirements for federally sponsored research grants and contracts.

Here the Michigan Congressional delegation should be encouraged to support legislation to provide strong federal tax incentives and policy support to stimulate increased industry investment in R&D. It should also be directed to play a far more active role in attracting federal research dollars to Michigan universities and industry as one of its most important responsibilities. Michigan Congressional representatives should also seek committee leadership positions and influence necessary legislation to direct the establishment of major federal research centers in Michigan. (Here an example of such a research initiative, a Great Lakes Energy Research Network, is provided in Appendix B.)

State government must also play a stronger role in stimulating high tech development. As we have noted, while Michigan has the capacity to attract the technologists and management necessary for startups, it is sadly lacking in adequate private capital, particularly venture capital, necessary for these activities. Here, state incentives should be provided for the investment of both private capital and public assets (e.g., state pension fund, university endowment funds). The state can also play a leadership role in encouraging the partnerships between large, established companies and new startups as well as coordinating university technology development programs and technology transfer activities.

Finally, there is a critical need to revise state tax policy to be more supportive of small business startup activities. As in so many other areas such as education, the state continues to be seriously constrained by an obsolete tax system, designed to favor a 20th-century factory-based manufacturing economy rather than a 21st-century knowledge economy. The state's tax code must be modernized so that it does not penalize and stifle the growth of the companies of the future to subsidize the industry of the past.

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 industrial 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).

The toll taken on higher education in Michigan by the serious erosion in state support of its public colleges and universities. Of particular concern here is the absence of any strategic plan for maintaining the capital facilities infrastructure of state universities, e.g., laboratories, libraries, and classroom facilities. Michigan is unique among the states in providing no sustained appropriations for academic facilities on campuses for almost two decades, in contrast to most other states that provide hundreds of millions of dollars for this purpose

each year. When one considers that a rule of thumb for the renewal or replacement of university capital facilities is based on a 40 year amortization, the benign neglect of public university capital needs by state government puts at great risk the capacity of these institutions to meet the growing needs of the state for advanced education and research. By way of comparison, in 2007 California voters approved $42 billion of bonds for new construction in K-12, higher education, and other needed civil infrastructure. Many other states have made similar commitments. Michigan has been silent…

Today it has become clear that public action is needed to compensate for the inadequate effort of the private sector (telecoms and cable companies) to provide the necessary connectivity for Michigan citizens and businesses. To wait on the private sector to respond while other states and nations rush ahead with publicly funded network infrastructures puts at risk perhaps a million state jobs, as well as the necessary educational infrastructure.

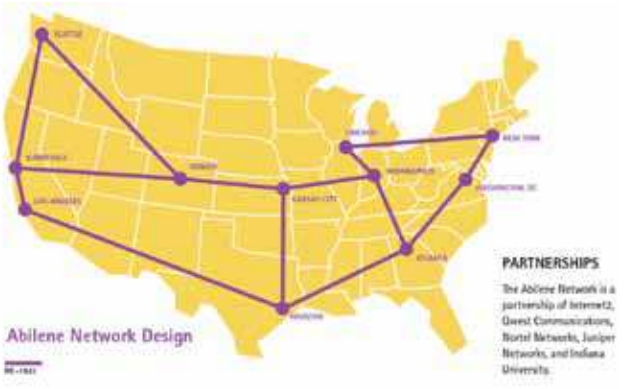
Policies

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.

As we enter a new century, there is an increasing sense that the marketplace is not only a more accurate measure of public priorities than the ballot box or public policy but also a more effective mechanism for allocating both public and private investments. For example, as the economic benefits of advanced education in a knowledge society soar, and higher education is increasingly viewed by society (and its elected governments) as a private benefit rather than a public good, it is important to allow market forces rather than public policy to drive the learning enterprise. Hence at both the state and federal level, government is shifting public investment away from base support of institutions and instead into the marketplace through voucher sys-

Michigan must end its two-decade-long moratorium on investing state dollars in university capital facilities.

During this period, most new academic facilities, such as the UM Ross Business School, have been funded entirely from private sources.



An important asset of Michigan: the presence of the headquarters of Internet2 in Ann Arbor, which operates Abilene, the fastest computer network in the world.

tems, student financial aid programs, and competitive research grants.

Yet this must be done in a sophisticated manner, else the most fundamental responsibilities of government will be abandoned. For example, economists have long known that the most effective way to achieve access to public higher education is through state or federal need-based financial aid programs since this targets limited tax dollars to those who most need assistance to attend college. Merit-based scholarship programs and low tuition at public universities, while politically popular, deploy tax dollars primarily to benefit higher-income students who usually need little incentive or financial assistance in attending college. The same is true for those programs providing tax incentives for college expenditures, since these primarily benefit those with sufficient incomes to incur substantial tax liabilities. Since few state residents will pay sufficient state income taxes to cover the costs of educating their children in public universities (based upon the portion of state tax revenue going to support higher education), it becomes clear that merit-based scholarships, low tuition, and tax incentives represent an extremely regressive social policy–in a blunt sense, welfare for the rich at the expense of educational opportunity for the poor.

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.

Although public universities are state institutions, they are supported largely by resources other than state appropriations: private payments (e.g., tuition), federal support (e.g., student financial aid, research grants), gifts, and market-driven auxiliary activities (e.g., licensing income, executive education, intercollegiate athletics). Indeed, nationwide, almost two-thirds of the support for American higher education comes from private sources with another one-sixth from the federal government. Hence it is imperative that Michigan strategically target its tax dollars to leverage both federal and private sector investment in advanced education and research, compatible of course with fundamental objectives such as broad access to and quality of educational opportunities.

Efforts to constrain tuition levels at the state's public universities have the perverse effect of failing to capture the full benefit of federal financial aid programs, which have actually been designed to support, in part, the far higher tuition levels at private universities. Furthermore, low tuition levels provide unnecessary subsidies for those affluent families who clearly have the capacity to afford the costs of a college education, as evidenced by the fact that they frequently send their children instead to private colleges and universities with costs several times that of public universities.

It is also important here to remind readers that efforts to constrain tuition during a period of eroding state support, while politically popular, can seriously damage institutional quality. When state government cuts appropriations per student at Michigan public universities by 25% to 40%, as it has over the past six years, institutions that have already optimized cost structures over the past two decades to accommodate earlier erosion in state support have only two options: increase tuition or reduce quality. Reducing the level of university activity (e.g., enrollments or research) is not an option for most, both because of their increasing dependence upon tuition and research grants and their sense of public responsibilities to serve the needs of the state.

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.

It is increasingly likely that market forces will dominate public policy and public investment in determining the future of most public universities, particularly as state support continues to become a smaller and smaller component of their revenue base. To micro-

manage or constrain the options of public universities during what might be a several-decade period of weak public support could not only seriously damage their quality but also hinder their capacity to serve the public during this era of a market-driven higher-education enterprise. Hence leaders of state government and higher education should seek an appropriate balance between accountability to public purposes and the autonomy necessary to enable the flexibility to adapt to market forces. For example, there should be agreed-upon and measurable objectives to ensure public accountability, e.g., student enrollments, degree success rate, socio-economic distribution of students, technology-transfer activities, and sponsored research funding in return for state government respecting the constitutional autonomy of the institutions and the authority of their governing boards.

While Michigan's public universities are legally owned by the people of the state, they are enduring social institutions with a duty of stewardship to generations past and a moral obligation and fiduciary responsibility to take whatever actions are necessary to build and protect its capacity to serve future generations. Unlike governments and companies that exist from election to election or quarter to quarter, universities span generations, connecting the past with the future. Even though their actions might conflict from time to time with public opinion or the prevailing political winds of state government, Michigan's constitution clearly provides its public universities with the capacity to set their own course to serve this public purpose. When it comes to objectives such as program quality or access to educational opportunity, university governing boards have always viewed these as long-term institutional decisions rather than succumbing to public or political pressures of the moment.

Yet it is also safe to say that the deep cuts in state appropriations for Michigan public universities, at a time when enrollments are growing along with Michigan's need for advanced education, research, and innovation, have raised serious questions about whether state government is a reliable partner with public higher education in building a knowledge economy. Governing boards, faculty, alumni, students and parents, and the media are beginning to question whether term-limited elected state officials, responsive to the increasingly narrow agendas of Michigan's political parties, can be trusted to act wisely or responsibly in the state's long-term best interests.

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 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 state and 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 as affirmative action and equal opportunity aimed at ensuring social inclusion.

Michigan simply must recommit itself to achieving new levels of understanding, tolerance, and mutual fulfillment for peoples of diverse racial and cultural backgrounds both on our campuses and beyond. We need to shift our attention from simply access to educational opportunity to success in achieving educational objectives. The recent Supreme Court decisions in the Michigan cases have now not only reaffirmed the importance of this fundamental commitment but also clarified the path we may take to achieve diversity. Unfortunately, Michigan citizens stepped back from this commitment through a recent constitutional referendum (Proposition 2) that could cripple the state's ability to achieve social justice and equal opportunity. This issue must be readdressed and rectified if Michigan is to prosper.

The Roadmap: The Longer Term (…But Within a Decade…)

For the longer term, our vision for the future of Michigan 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. 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.

To this end, the long-term roadmap pursues a vision of the future in which Michigan strives to build a knowledge infrastructure 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), skilled workforce, and 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 meaningful 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.

State education policy is far too fragmented, with widely differing perspectives and philosophies depending on its knowledge and learning infrastructure, e.g., K-12 responsible to local communities and the State Board of Education, public higher education largely the responsibility of politically determined governing boards, private higher education quite autonomous, and an array of cultural organizations (museums, libraries), industrial resources (workplace training programs, corporate R&D), and informal learning opportunities largely out of sight, out of mind. In a similar sense, state funding of education tends to run on automatic pilot, determined more by the increasingly inadequate resources provided by Michigan's obsolete tax and burdensome legacy cost structures (e.g., based on a 1950s manufacturing economy rather than a 21st-century knowledge-services economy), driven more by political ideology and patronage than carefully designed as a strategic investment in the state's future. It is essential that leaders of state government, higher education, business, industry, labor, and the public at large (through the media) view higher education in a far more systemic and strategic fashion as a critical resource for Michigan's future.

Here we are certainly not recommending the creation of more state bureaucracy such as the state higher education coordinating boards characterizing many other states. In fact, Michigan's higher education "anarchy," guaranteed by institutional autonomy granted by the state constitution, has proved remarkably effective over the years in providing public colleges and universities with the agility they need to adapt to changing conditions such as the decline of public support and the rise of market forces. Many states look at Michigan with considerable envy concerning the quality, diversity, and cost-effectiveness of its higher-education system, despite its relatively low level of state support over the past two decades.

Rather we believe that more policy attention needs to be given to the strategic evolution of knowledge resources in the state, freed from the tyranny of legislative committees and political election cycles and more responsive to the long-term needs of the state. In other states, citizen groups such as business/higher education roundtables have proven effective, and such groups are increasingly essential to Michigan's future (Power, 2006).

2. Michigan 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 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.

The state needs to give more strategic consideration to the diversity among its public colleges and universities, e.g., how many world-class public research universities it can afford, whether regional universities should become more focused on pre-professional education, and how to build better linkages between independent colleges and public universities that exploit the unique characteristics of each. It is important to encourage a highly diverse educational enterprise, recognizing that a diverse population with diverse needs will require diverse institutions. It would be folly to force all institutions to some lowest common denominator of quality and capacity.

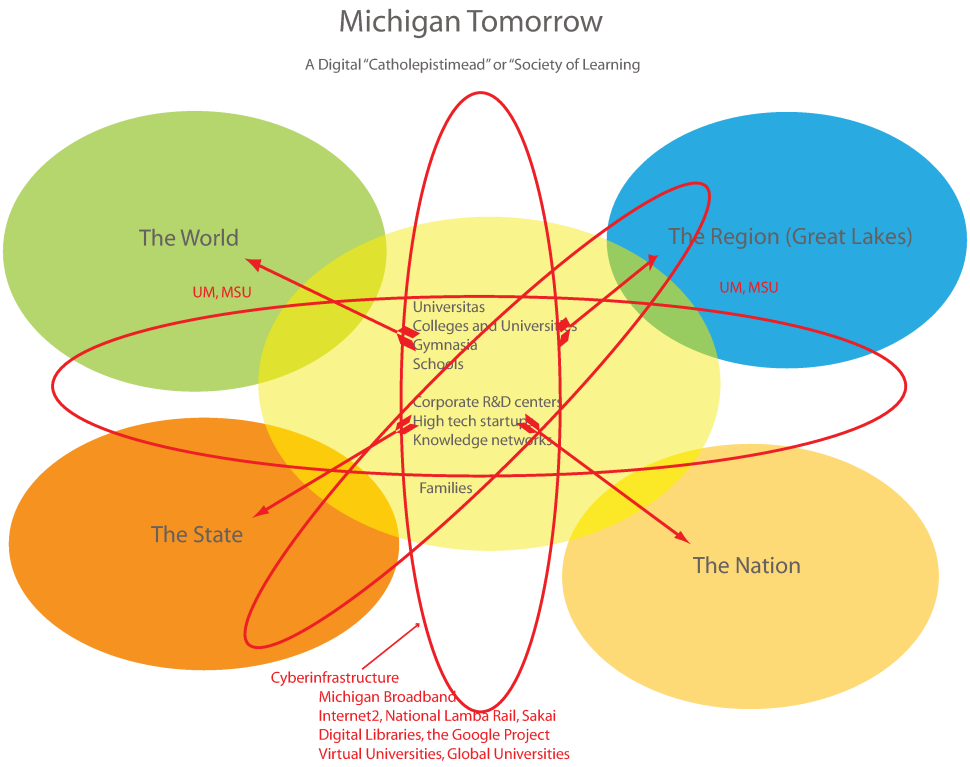
Of particular importance is achieving a better balance between public and private higher education, a balance that is more capable of riding out the inevitable ebb and flow of public and private support. While Michigan has a strong group of independent colleges, the absence of a major private research university leaves it more vulnerable to fluctuations in the state's economy than other states. Perhaps the state should explore a different funding process for institutions such as the University of Michigan-Ann Arbor, which has seen its state appropriation drop below 7% of its operating budget. For example, the state might redefine UMAA as a "state-related" institution (since it is clearly no longer a "state-supported" university) or as a public corporation or public authority (similar to public entities such as hospital systems or transportation authorities), providing state funding for specific purposes on a performance contracting basis, e.g., to support a certain number of Michigan resident students in given fields at a specified tuition level or research projects in areas of key importance to the state, and then allow the institution to determine other characteristics that best optimize its public purpose and market competitiveness (Newman, 2004).

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.

Much of the concern about the quality of higher education arises from the general education/transitional years, grades 11-14, when both the emotional and intellectual maturation of students occurs. Michigan should experiment with new paradigms of post-secondary "general education." An example is a reconfiguration of K-16 education so that secondary school grades 11-12 would be merged with community college and lower-division university programs focused on general education and socialization, much like the gymnasium system in Europe or the Fourth Form in the United Kingdom. This would allow research universities to focus on disciplinary, graduate, professional, and lifelong education, while general education and socialization would be provided by community colleges, regional universities, or independent colleges.

There is some evidence that the highly supportive, learning-intensive residential experiences offered by independent colleges may be the optimum learning environment for most young students. Liberal arts colleges seem to have the best success at this stage, providing both a nurturing and learning-intensive environment. Yet it is also the case that such colleges simply do not have the resources to provide the advanced learning opportunities of a major research university. Hence Michigan should experiment with using technology to link independent colleges with its major research universities.

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 col-



Michigan needs to develop a more strategic perspective of its knowledge resources.

leges and universities.

Michigan is fortunate to have three nationally recognized research universities, UMAA, MSU, and WSU. While these institutions enroll large numbers of students in high quality undergraduate programs, their unique value to the state arises because of their unusual capacity to conduct cutting-edge research and provide advanced education at the graduate and professional level, along with well-established programs of outreach and public service ranging from medical care to economic development. As the state attempts to expand the number of college graduates, particularly during a period of limited resources, it is absolutely essential that the capability of its research universities for advanced training, research, and innovation be protected, since in the end, it will be the new knowledge produced on these campuses, along with the scientists, engineers, and other professionals trained at the advanced level, that will create the new jobs that the graduates from Michigan's other colleges and universities will fill.

5. Michigan's research universities should explore new models for the transfer of knowledge from the campus into the marketplace, including the utilization of investment 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.

Clearly universities have an important responsibility to transfer the knowledge created on their campuses into broader society to address its needs and priorities. Transferring university-developed knowledge to the private sector fulfills a goal of publicly funded research by bringing the fruits of research to the benefit of society. With this important technology transfer come increasingly close relationships between industry and universities.

The traditional models for such technology transfer involve establishing ownership of intellectual property

through copyright or patent and then using licensing or startups, coupled with a strong entrepreneurial spirit and adequate venture capital, to stimulate economic development. This linear approach to technology transfer has several compelling success stories: Silicon Valley, Route 128, and the North Carolina Research Triangle.

While disclosure, patenting, and licensing intellectual property may be appropriate for some areas such as the product-orientation of biomedical research, it may not be an effective mechanism for very rapidly evolving areas such as information technology or instructional content. Today the increasing pace and changing character of knowledge generation (e.g., in digital forms), coupled with the hypercompetitive environment of a global, knowledge-driven economy, suggest that Michigan should not rely entirely on catching up with other regions through conventional mechanisms, but in addition explore entirely new models of technology transfer.

So what other models might universities consider for technology transfer? One of the more interesting is provided by the "open source movement" in software development. In this model, a user community develops and shares publicly available intellectual property (e.g., software source code), cooperating in its development and improvement and benefiting jointly from its use. Perhaps the leading example is the development of the Linux operating system, now evolving as a major competitor to proprietary systems such as Microsoft Windows and Unix. This "gift economy" represents an emergent phenomenon free from a community working together with no immediate form of recompense except for social capital intertwined with intellectual capital.

Suppose public universities could be persuaded that in return for strong public support, they would regard intellectual property developed on the campus through research and intellectual property as in the public domain. They could encourage their faculty to work closely with commercial interests to enable these knowledge resources to serve society, without direct control or financial benefit to the university, perhaps by setting up a "knowledge commons" environment adjacent to the campus (either geographically or virtually) where technology transfer was the primary objective. This might be just as effective a system for transferring technology as the current Bayh-Dole environment for many areas of research and instruction. Furthermore, such an unconstrained distribution of the knowledge produced on campuses into the public domain seems more closely aligned with the century-old spirit of the land-grant university movement. In fact a recent issue of *The Economist* mused that "some zealots even argue that the open-source approach represents a new, post-capitalist model of production" (*Economist*, 2005).

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.

An array of powerful economic, social, and technological forces is reshaping the very nature of the 21st-century university. The emergence of a global, knowledge driven economy has intensified the need for broad access to advanced education and training (massification). The economic value of the knowledge produced by research universities continues to escalate. The rapid emergence of low-cost yet highly sophisticated technical services in large developing markets (e.g., India, China, Russia) has triggered a serious concern about the nature of university education necessary to sustain the high standard of living of wealthy economies. Yet, even in the face of such trends, the aging populations of many developed nations are depending increasingly on market forces and private funding rather than public policy and tax support to determine the future of their higher education systems.

Of particular interest is the way that such forces have stimulated a number of universities–and university organizations–to consider seriously expanding beyond the bounds of their nation-states to become universities both of the world and in the world, accepting a far broader responsibility to understand and serve both the social needs and marketplace of the global com-

munity. Key in such strategies is the rapid evolution in information, communication, and transportation technologies, which are enabling entirely new global learning and knowledge structures.

Again quoting *The Economist*, "the most significant development in higher education is the emergence of a super-league of global universities. This is revolutionary in the sense that these institutions regard the whole world as their stage, but also evolutionary in that they are still wedded to the ideal of a community of scholars who combine teaching with research. The great universities of the 20th century were shaped by nationalism; the great universities of today are being shaped by globalization. These top universities are citizens of an international academic marketplace, with one global academic currency, one global labor force, and increasingly, one global language, English. 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" (*The Economist*, 2005).

The State of Michigan is fortunate in having two such global universities, the University of Michigan and Michigan State University. These could be the backbone of an effort to build a global presence–not simply to explore global markets for Michigan products and services, but also to attract talent to our state from around the world. Both universities have long histories of international programs of considerable distinction and great impact. Michigan State was an important force in the "green revolution" bringing modern agricultural technology to the world. The University of Michigan has had a long international presence, producing much of the academic leadership for Asia (including Japan and China), along with strong ties to Europe and Latin America. These institutions are well positioned to become major players in the global marketplace, accepting responsibility to address many of the great challenges characterizing our world such as global sustainability, international conflict, and human capital development.

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.

Of course, major undertakings in anticipation of opportunities are always difficult, but the United States has a history of rising to such occasions. At least twice before in times of great challenge and opportunity, the federal government responded creatively with novel programs that not only served the needs of society, but also reshaped institutions. In the 19th century the Land-Grant Acts 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. Following World War II, the G.I. Bill and the government-university research partnership were instrumental in establishing the nation's economic and military leadership and creating the American research university, which has sustained U.S. leadership in the production of new knowledge and the creation of human capital.

The current challenges to Michigan's prosperity and social well-being call for a bold initiative of similar magnitude. It is not enough to simply build upon the status quo, for example by doubling the number of post-secondary degree recipients or guaranteeing at a minimum a community college education for all. Instead, we suggest that Michigan consider a bolder vision that would provide all Michigan citizens with pervasive opportunities for education, throughout their lives, which address both their needs and aspirations while reflecting the imperatives of a rapidly changing world. While such a commitment would challenge existing public polices and politics, only an effort to build a true society of learning for the 21st century can recapture the economic and social leadership that Michigan possessed in earlier times.

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 Kalamazoo Promise, a privately funded guarantee to support the four-year tuition costs of a college education for graduates of that city's school system provides strong evidence that such assurances can have powerful impact on student retention and graduation rates (not to mention local economic development). This laudable effort has triggered a number of followers throughout the country. But perhaps something more ambitious might be possible.

Suppose the states would join with the federal government 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.

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 education upon socioeconomic status. America should aspire to the ideal where family income is nearly irrelevant to the ability of a student to access educational opportunities 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.

8. Michigan should work with other Great Lakes states facing similar challenges and opportunities to develop a regional agenda both to facilitate cooperation and to influence national priorities.

Current political boundaries characterizing state or local governance are of little relevance to competitiveness in a global, knowledge-driven economy. The Great Lakes states, once the economic engine of the world, today faces very similar challenges in transforming themselves from industrial to knowledge economies. Only by adopting a regional perspective and developing a collaborative strategy will they be successful.

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!

This is such an obvious need for leadership in our state that no further comment is necessary for this recommendation!

A Call for Leadership

A roadmap is just that: a set of possible directions to future destinations. But leaders in both the public and private sector require a more definitive operational plan that addresses key questions such as: What are the first steps to be taken? What policy actions are necessary? Are there follow-on studies that need to be commissioned? Furthermore, while our effort has focused on developing a roadmap for building a regional knowledge economy in Michigan, it is clear that our vision and our recommendations are highly dependent upon issues in other areas, e.g., federal policy, market forces, and the global economy. Finally, we acknowledge that this roadmapping study has been stated in straightforward–sometimes even blunt–terms. To survive in the political environment of state (and federal) policy, it must be reclothed in more Machiavellian garb.

The initial goal of this roadmapping effort is to shift the public conversation away from distracting issues such as Balkanized state politics, culture wars, and bitterly partisan battles to focus instead on the imperatives of a knowledge economy: lifelong learning, research and innovation, and knowledge-age infrastructure. Our message is deceptively clear:

1. *Knowledge and innovation are the drivers of the global economy today and even more so tomorrow.*
2. *The key inputs to knowledge and innovation are: lifelong learning (human capital), new knowledge creation (R&D, innovation), and the infrastructure that supports these two (schools, colleges, research centers, cyberinfrastructure).*
3. *Strategic public policies and strong public and private investment are critical in developing each of these three capacities. The states and regions that understand this imperative and do it best will be best positioned to succeed in the future. Those that fail to heed these imperatives will become economic backwaters.*

Since public commitments and government action are the longer-term keys, it is important to lay out a possible agenda for state leaders, the more specific the better. It is important that state policy makers begin to consider new financing, investment, and governance issues within the context of future state needs and priorities rather than past political party ideologies.

Most important, state government has to begin by getting its fundamental responsibilities aligned with the needs of a knowledge economy:

1. Empowering families, students, and workers with the responsibility and the resources to choose lifelong learning opportunities that they determine will be best for themselves, including early childhood, K-12, postsecondary, and continuing education.
2. Providing the infrastructure and the investments necessary to attract federal and private research funding and stimulate innovation and entrepreneurial activities.
3. Developing an equitable tax structure and cost accountability sufficient to provide the necessary public services for the present while making the critical investments in the future.

notes that topflight universities present an advantage in drawing intellectual talent to a region. Being an "IQ magnet is a self-enforcing thing" (Gates, 2005). Where top universities are located is where new companies dealing with the biosciences and other high technology projects will locate, Gates stresses.

Yet for decades, Michigan's policies for public education have been directed toward the lowest common

Leaders of our state must never forget the fundamental principle of the Northwest Ordinance upon which Michigan was founded (shown here chiseled above the frieze of the University of Michigan's Angell Hall): "Religion, morality, and knowledge being necessary to good government and the happiness of mankind, schools and the means of education shall forever be encouraged".

denominator of institutional quality, perhaps most recently illustrated by the announced goal to double the number of college graduates in Michigan, but without any plan to provide the necessary improvements in K-12 education or restore adequate support of a higher education system already reeling from several years of deep budget cuts. Instead state government has chosen all too frequently to gain political support by attacking universities for the tuition increases that are inevitably a consequence of state budget cuts and earlier tuition constraints. They have chosen to focus the limited additional funds provided by the tobacco settlement on merit-based scholarship programs, which predominately benefit upper-income families, rather than providing the need-based financial aid that most states (and scholars) have found to be the key to access. Put more bluntly, Michigan state government has not given high priority to funding higher education for almost three decades, preferring instead to build prisons, casinos, or sports stadiums or to subsidize the wealthy through tax cuts, low public university tuition, and merit-driven financial aid programs.

We need to take a hard look at state spending policy more generally, to ask the important question: What is the role of state government and how should resources be allocated? For decades Michigan was fabulously wealthy. We developed a culture of expensive practices and expectations: employee benefits, health care, social services, and litigation. Yet today, we continue to deploy our resources–already limited both by a weak economy and commitments made in more prosperous times–to pay for the past rather than investing in the future by creating new knowledge, new skills, and new jobs.

Not investing in education and research is not only irresponsible but, indeed, is tantamount to economic suicide in a knowledge-intensive society. Although many public leaders ignore this reality of the age of knowledge, they do so at risk not only to Michigan's future, but increasingly to their own political survival as public awareness of the importance of investment in learning and knowledge resources grows. And, of course, without regard to the damage they are doing to their children's future.

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.

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Chapter 4

A Roadmap to the Midwest's Future

Today 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 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, apply these discoveries, and transfer them to the marketplace through entrepreneurial activities.

Today's economy no longer is locked within traditional geopolitical boundaries, such as states and nations. Instead, it spans 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. Yet, today the American Midwest, a 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 Midwest is struggling to make the transition from an industrial agricultural and manufacturing economy to a knowledge economy.

One of the Midwest's most valuable resources critical to this transformation is its extraordinary array of colleges and universities—local community colleges, regional universities, independent liberal arts colleges, research universities, and for-profit providers. To help the Midwest position and use these remarkable assets, this report has applied a common planning technique, strategic roadmapping, to develop a higher education strategy for the Midwest region. Simply stated, the roadmapping process begins by asking where we are today and where we wish to be tomorrow, judges how far we have to go, and ends with a roadmap to get from here to there.

Building a twenty-first century learning and innovation infrastructure for a region clearly involves multiple players—institutions, states, and the nation more broadly. Furthermore while our focus is the role played by higher education, this cannot be detached from other elements of the education continuum including K-12, workplace training, and lifelong learning. Hence our roadmap must span the entire education spectrum and its various patrons.

The roadmap for higher education in the Midwest consists of a number of recommendations, some obvious, some seemingly radical, but all aimed at reinvigo-

The Midwest and Great Lakes states

rating 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. The urgency of each recommendation has been suggested by assigning to each a timescale of *now* (within months), *soon* (a few years), and *eventually* (a decade hence).

The Midwest Today: A Knowledge Resource Map

The Midwest's frontier history has given it a priceless legacy of pioneering spirit, gritty courage, and self-reliance. Our ancestors made our farms and our factories the best in the world. The region's state and local governments believed in their people and invested heavily in their education and training, catapulting the region into a position of global leadership in innovation, productivity, and trade. There was broad recognition that it was our people–their character, knowledge, skill, and ability to innovate–that would give the region the competitive edge.

A century ago, the Midwest led the nation in building institutions to provide such knowledge resources. State governments created great education systems aimed at serving all of their citizens, demonstrating 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. Midwest companies invested heavily in R&D and technological innovation, working closely with the region's research universities. Our leaders understood well the importance of investing with both public tax dollars and private capital in those areas key to prosperity in an industrial economy. The payoff was enormous, as the Midwest led the world in productivity, technology, and prosperity.

Yet today the region is struggling, overtaken by a fiercely competitive global economy and hindered by a culture of denial that seeks to restore the low-skill agricultural and industrial economies of the past at the expense of the investment needed to create a highly educated workforce and entrepreneurial culture for the future. A brief review of the characteristics and assets of the region today will serve as an appropriate starting point for the development of a roadmap to prosperity tomorrow.

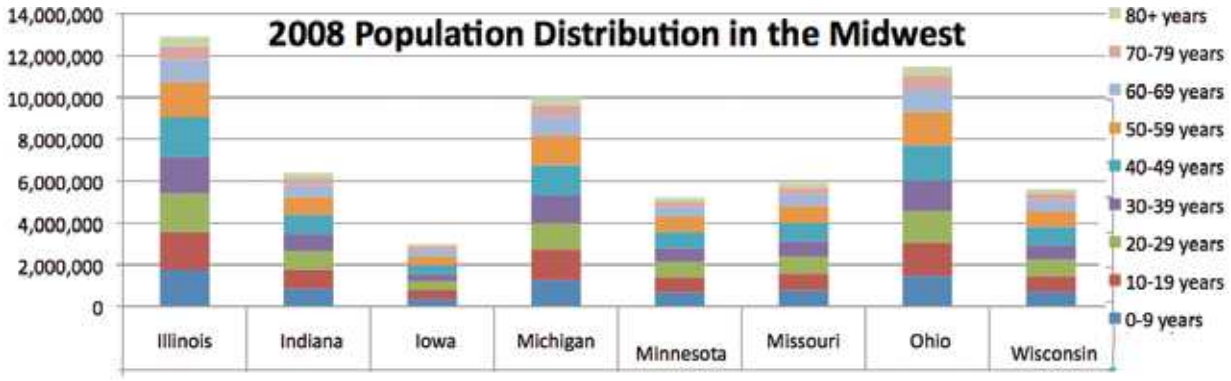
The Midwest's greatest natural asset: the Great Lakes (NASA, 2004)

Natural Features

The Midwest region is blessed with unique natural and environmental attributes and features that both enhance the area's quality of life and have the potential to support vibrant economic development. Of course, the most distinctive natural features are the Great Lakes themselves. They contain one-fifth of the world's volume of freshwater, making the Great Lakes the single greatest freshwater resource on the planet. Their watershed includes 11,000 miles of coastline along with rivers, forests, and scenic and recreation areas that rival any of America's other coasts. With fast-growing coastal areas of the U.S. prone to natural disaster (the "North Coast" of the Great Lakes is decidedly not)— and many fast-growing sunbelt regions facing serious water scarcity issues—the Great Lakes are a tremendous asset for the region, and a vital resource for the entire country (Austin, 2006).

The region also includes large forests in the north and tall grass prairies in the south. Thousands of inland lakes complement the five Great Lakes. The region is home to the world's richest arable lands, making the Midwest the world's breadbasket. Although many of the forests have been leveled, the vast copper and iron ore deposits mined out, and the family farms replaced by industrial agriculture, the natural resources of the Midwest region are still immense. (Austin, 2006)

Given its abundant water, fertile land, and the fact that it is largely immune to hurricane and other natural



The age distribution of Midwestern states
(U.S. Census Bureau, 2008)

disasters, this "hazard free" third, or "freshwater" coast of the continent can support economic and population growth other parts of the continent and world cannot. As significantly, people choose and prefer locations to live and work with scenic, environmental, and recreational amenities. The magical quality of water and other nature features are important factors in location desirability, and are a factor in the real choices people make for where to live, work, and locate a business.

Demographics

The Midwest region has a significant population of 60 million people. Furthermore the population of the major metropolitan areas clustered in the Great Lakes region alone approaches 40 million, making it second only to the U.S. Eastern seaboard as a highly integrated, urbanized economic "mega-region." This has enabled it to become one of the largest industrial production centers and consumer marketplaces in the world. (Austin, 2005)

Yet the region has experienced slower population growth than the rest of the nation over the past two decades. Although in part due to the aging of the baby boomers and the low birthrates characterizing Midwest states, this has been aggravated by an anticipated loss of 12% in its 25- to 44-year old population from 2000 to 2025 as this group seeks new experiences and more dynamic regional economies in other regions of the nation. Much of the Midwest—particularly rural areas and small- to medium sized manufacturing-based communities—face a significant "brain-drain" of young educated workers (the fourth largest percentage decline in the nation), as they flee to the faster-growing, more dynamic urban economies both within and outside of the region. Michigan, Illinois, and Ohio have been particularly hard hit by the out-migration of young, educated adults to other regions. One sees this in the hollowed-out cores of many Midwestern cities as they lose population (Longworth, 2008).

The final demographic characteristic with great implications for the future of higher education in the region is the anticipated decline in the number of college age students over the next decade, anticipated to be as large as 15% or more in some states. Like many northern states, the Midwest is once again sliding down the backside of the post-WWII baby boom and bust cycle, in contrast to the southern and western states where immigration has provided the population growth to compensate for these cycles. Already many areas have had to downsize K-12 education, e.g., Detroit, where the population of school age children has declined from 150,000 to 30,000 and Kansas City, where the decline has been from 76,000 to 18,000. As this decline propagates to college age students, it will present a formidable challenge to many four-year colleges and universities in the Midwest, which are likely to see declining enrollments and perhaps even be pushed to financial collapse. (The numbers of high school graduates are projected to drop by 2016 by 16% in Wisconsin, 6.6% in Minnesota, 6.3% in Ohio, 3% in Michigan, and 1.6% in Missouri and Iowa.)

The aging population in the Midwest has other implications. Health care costs are increasing rapidly. Productivity is declining as retirements increase. Furthermore, an aging voter cohort is shifting the priorities for

public funds to health care, retirement security, safety from crime, and tax relief rather that giving high priority to investment in the future through education.

The Midwest Economy

The sheer size of the Midwest's region's economy is a huge asset. With over 32 percent of U.S. GDP, the region is one of the largest wealth generators and marketplaces in the world. And if it stood alone as a country it would be the 2nd biggest economic unit on earth, second only to the U.S. economy as a whole and larger than Japan, the rising powers of China and India, and the traditional heavyweights of Germany, France, and the United Kingdom. The Midwest is a national leader in fast-growing global trade, generating 30 percent of all U.S. merchandise exports. The region's exports dwarf that of the West and the Northeast, and are exceeded only by exports from the South. (Austin, 2008)

The Midwest had traditionally relied on two enterprises for a living–farming and heavy industry. It is both the breadbasket and foundry of America–a cultural bellwether and engine of the American economy. Although the number of manufacturing firms and jobs in the Great Lakes region has declined considerably over the past several decades, the sector is still a major driver of the economy. Twenty percent of jobs in the region are in manufacturing, compared to less than 11 percent nationally. In fact, the region boasts 44 percent of the nation's manufacturing jobs, while its overall share of employment is just 37 percent (Austin, 2006).

Given its rich history of new industry creation and its number of globally connected firms, the region remains a decision and research and development center in key sectors of the economy. Over 30 percent of North American corporate headquarters, including 300 of the nation's Fortune 1000 firms, are located in the region, serving as the brains for new business, product, and technology development.

The major cities that factory-based agriculture and manufacturing have created have certain advantages in the new, knowledge-intensive and innovation-based economy if those advantages are properly exploited. Large and dense metropolitan areas are attractive to high-wage employers because firms tend to locate in places that are big enough to offer easy access to an educated workforce, to take advantage of the specialized suppliers that develop in response to the presence of similar firms; and to promote innovation, which in turn enables industry in that region to grow and prosper.

Today all of Midwestern states have been pulled into the maelstrom of globalization. The region faces many challenges transitioning from the industrial era, which it once dominated, to the knowledge age. It is still heavily reliant on mature industries and products, with a workforce ill prepared to obtain or create jobs in the new economy. Its landscape is dotted with hollowing city centers, emptying manufacturing towns, and isolated farm, mining, and timber communities, which continue to bleed mobile, educated knowledge workers.

Workforce

Research by Glazer and Grimes shows that the most thriving regions and metropolitan areas are those with a high proportion of adults with four-year degrees that are creating and working in high-pay, knowledge-based industries such as information, finance and insurance, professional and technical services, management of companies, education, health care, and government (Glazer, 2010). Yet today the Midwest region is hampered by serious human capital deficits, reflected in a population that generally lacks the postsecondary degrees and credentials essential to succeed in the global economy. This is largely due to the region's significant brain drain, its aging workforce, and the legacy of an industrial economy that once provided good jobs and wages without a college degree.

The overall lack of an educated workforce represents a significant challenge for the Midwest economy. While a high school education was sufficient for the 20th century industrial economy, today 80 percent of new jobs requiring some form of postsecondary education or training. Yet, only two Midwestern states—Minnesota and Illinois—rank high in the fraction of their populations holding a bachelor's degrees or higher. Low-skill (e.g., without college degrees) middle-aged and older workers make up the fastest growing share of the states' total population and available workforce, and constitute a larger share of Midwest state population than in the U.S. as a whole. The skills of many of

these workers have already become obsolete. Many others are high school dropouts, uneducated, some virtually illiterate. They are totally unqualified for any job other than the ones they just lost. Similarly while the workforces of small Midwestern towns are comprised of hardworking high school graduates, they simply do not have the skills or education that the new economy demands and may be increasingly unemployable.

Yet another challenge arises from the generous employee benefits, job security, and income practices negotiated that powerful labor unions have negotiated with profitable companies over the years. While this was instrumental in creating a prosperous middle class, it now has saddled the Midwest with costs that can no longer be supported by the current economy (*The Economist*, 2006). The impact of legacy costs such as pensions, health care benefits, and unemployment compensation have bankrupted many companies–including, of course, General Motors and Chrysler–and in turn swelled the welfare burdens of state governments. Ironically, it was just these generous benefits that also persuaded low skill factory employees that there was little reason to invest the time or effort in a college education, both for them and, unfortunately, for their children as well. If a high school diploma was all one needed to get an assembly line job making $70,000 a year with generous health, pension, and employment contracts, then why bother with more education. As a result, a culture developed over generations that no longer valued the importance of education either as a family responsibility or a public investment–a blue-collar mentality that today haunts much of the Midwest.

Communities

Although many imagine the Midwestern life to consist of small towns and cornfields, in reality over 80% of the region's population live in large metropolitan areas. Cities such as Chicago, Cleveland, Pittsburgh, Detroit, and St. Louis evolved first as trading and transportation centers and later as industrial concentrations (Longworth, 2008). Of course there is also a small town life in the Midwest; towns that once were market towns for farmers sprinkled across the townships established by the Northwest Ordinance. But today Midwest states such as Ohio, Illinois, Michigan, and Indiana are quite urban, with economies based on heavy manufacturing, with rural communities based primarily on farming largely only a memory. It is likely that with the continuing industrialization of agriculture, most small farming towns will continue to shrink and eventually disappear unless they are the location of a major food-processing plant or close enough to a metropolitan area to draw suburbanites.

Midwestern cities face a different challenge: to globalize their economies and cultures (through immigration) or slowly fade away. Chicago provides a good example of a city that has managed to turn the corner and enter the new economy based on global trade and business services, enabled by a growing knowledge workforce and a large immigrant population (30%).

Yet here Chicago is unique in the Midwest, currently listed 6th on the Global Cities Index 2010 (along with 8 other U.S. cities) among the top 65 global cities in the world (Foreign Policy, 2010). Unfortunately none of the other cities in the Midwest region have managed to move to the global scale. In fact, several are sliding rapidly backwards. Detroit provides the case study for the other extreme, a city that has seen its population shrink from over 2 million to 800,000, with acre after acre of abandoned neighborhoods and empty factories, burdened by the legacy costs of entitlement practices that can no longer be afforded, a deteriorating infrastructure, dysfunctional public schools, and unable to attract either young knowledge workers or immigrants (only 7%).

Culture

Perhaps because of the farming cultures characterizing their pioneer and immigrant ancestors, Midwesterners have long taken pride in their self-sufficiency, seeking to sustain their communities with hard work and traditional values. In decades past there was a sense of generational responsibility, best illustrated by the strong investment in schools and colleges to provide their children with outstanding education opportunities. The Midwest was able to embrace the innovation and risk-taking of men like Ford, Durant, and Kettering as they built great the industries that provided the region with prosperity (Longworth, 2008).

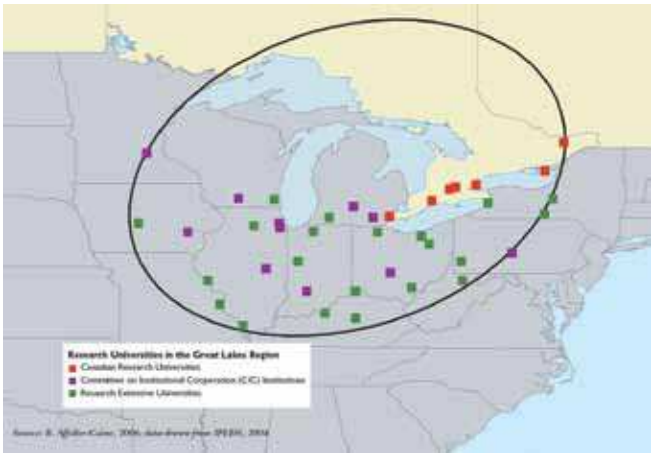
Ironically, however, because of this wealth and pros-

perity, a culture of expectation and entitlement evolved during the past century that turned the Midwest culture away from innovation and entrepreneurism. People and firms began to believe that prosperity would long endure, high wage jobs with great benefits would continue, without effort or education. Openness, engagement, and comfort with new ideas and people were not valued traits, nor was cooperation among cities, states, companies, and universities. Safety and the status quo were more prized than risk-taking and change. And as this new culture took root in the post WWII economic boom, the Midwest began its slow economic descent. The family farms vanished, the steel mills closed, and the automobile companies began to experienced strong competition from Asia. The decline of the Midwest economy dropped off precipitously with the Internet and the emergence of a truly global, knowledge driven economy, culminating in the bankruptcy of icons such as General Motors in 2009. Today this decline of the Midwest economy continues–yet, unfortunately, so does its denial of the changes required by the global imperatives.

In their panic to save their deteriorating cities, dying industries, and low skill yet well-compensated jobs, Midwest states have declared economic war on one another, launching a barrage of tax cuts and abatements to raid companies and jobs, even though these desperate efforts unbalanced their budgets and destroyed their capacity to invest in the future, e.g., in schools and colleges. The Balkanization of the Midwest intensified with every state–and city–for itself. As Longworth summarizes the current situation "[today]… the industrial Midwest amounts to a wasteland of empty factories, corroding cities, and crumbling neighborhoods. Most of the Midwest remains in denial. Other regions of the world, from New England to India, know they are in global competition and off and running. The truth is just beginning to dawn on much of the Midwest. Heavy manufacturing, the family farm, small towns…all going, going, gone…" (Longworth, 2008)

Educational Resources

Numerous studies have established that in the knowledge economy, education has become the key to not only to economic prosperity but as well to one's personal standard of living and quality of life. The breakpoint between those who graduate from secondary and continue on to succeed in college and those who fail is perhaps the most critical decision point in one's life (McPherson and Schapiro, 2005).



The Midwest's concentration of research universities (Austin, 2008)

With their commitment to "an uncommon education for the common man," the settlers of the Midwest region built what was once arguably the strongest educational infrastructure in the nation characterized by outstanding schools, colleges, and universities. The region established nation's first secondary school systems, founded many of the nation's leading independent colleges, and created the land-grant public universities to educate the working class and further industry and commerce.

Of particular relevance to the region's future is the presence of perhaps the strongest concentration of research universities in the world. At its core are the Big Ten universities, or more correctly, the C. I. C. (Committee on Institutional Cooperation) group, which consists of the eleven Big Ten universities plus the University of Chicago (CIC, 2008). These twelve universities conduct more research, produce more scientists and engineers, doctors and lawyers, business executives and teachers, than any collection of universities in the world, including the University of California, the Ivy League, Oxford and Cambridge, and the other concentrations of leading universities in Europe and Asia. According to Institute of Higher Education at Shanghai Jiao Tong University, 19 of the top-ranked 100 universities in the world are Midwest institutions–compared with only 15 in the

University of Michigan

University of Wisconsin

University of Illinois

University of Minnesota

Michigan State University

University of Iowa

Purdue University

Penn State University

Northwestern University

University of Indiana

Ohio State University

University of Chicago

The CIC (Committee on Institutional Cooperation) Universities

Cornell University

University of Missouri

Case Western Reserve University

Iowa State University

Notre Dame University

University of Pittsburgh

University of Rochester

SUNY Buffalo

Syracuse University

University of Illinois Chicago

Washington University

University of Toronto

The Midwest-Great Lakes region has many other world class universities.

Oberlin College

Allegheny College

Dennison College

Depauw University

Earlham College

Hope College

Kalamazoo College

Kenyon College

Ohio Wesleyan

Wabash College

Wooster College

Antioch

The Great Lakes College Association

Eastern Michigan University

Indiana State University

Miami University

Michigan Tech

Missouri State University

Ohio University

Southern Illinois University

Wayne State University

Western Michigan University

Kalamazoo Community College

Lansing Community College

Oakland Community College

Comprehensive Universities and Community Colleges

Northeast/Mid- Atlantic, and 13 on the West Coast.

Midwest universities are among the nation's leading creators and exporters of talent. With 33 percent of the U.S. population, the Great Lakes states produces 38 percent of the country's bachelor degree holders, 36 percent of all science and engineering degrees, and 37 percent of all advanced science and engineering degrees in 2003—far outstripping any other region of the country. The region's research universities conduct over $6 billion/year of R&D, enroll over 300,000 undergraduates and 76,000 graduate students, award roughly one-fifth of the nation's doctorates in fields such as engineering, chemistry, mathematics, and computer science. When one adds to these institutions other leading research universities of the Great Lakes regions such as the University of Missouri, Washington University, Cornell, Carnegie Mellon, Pittsburgh, Case-Western Reserve, and Iowa State, one has a significant fraction of the world's top research universities.

As the flagship universities of their states, these institutions already set the pace for broader educational activities, both at the post-secondary and K-12 levels. Each of these universities has built world-class excellence in unique areas (e.g., Illinois in computer technology, Minnesota in chemistry and chemical technology, Ohio State in materials science and technology, Michigan State and Penn State in agricultural technology, Wisconsin and Michigan in engineering, the natural and social sciences, and biomedical science, Northwestern in medicine and business administration, and Chicago in the humanities and sciences). (Hollis, 2007)

Midwestern universities are strong competitors for federal funds and use these federal dollars to educate students, perform cutting-edge research, and catalyze local economic development. In federal support for university R&D, Midwestern universities capture 16 percent of total federal support for university R&D. Both the University of Michigan and the University of Wisconsin-Madison rank among the top five recipients of federal R&D funds, and the breadth of the region's excellence can be seen by the presence of 11 institutions, at least one from each of the Midwest states, among the top 50 recipients.

The rapid evolution of digital technologies provide powerful new paradigms to integrate together the programs and activities of these institutions. Midwest universities have led the development of this technology for the nation, e.g., University of Minnesota developing the supercomputer, University of Illinois introducing the web browser (Netscape), University of Michigan building the backbone of the Internet, and the University of Indiana today managing the development of Internet2.

Because of their land-grant traditions, Midwestern universities also have a long history of public service and extension, not only within their states but throughout the world. These institutions are characterized by a long tradition of global outreach and international development that might enable them to coalesce into a true "world university", reaching into all parts of the globe to open up new markets and access world-class human capital. Perhaps most important, there is a long-standing tradition of cooperation among these institutions (in addition to their highly visible competition through the Big Ten Athletic Conference). They work together on both regional and national agendas, merging library and research resources, and sharing curricula and instructional resources with faculty and students. Aggregating these "spires of excellence" by linking these institutions would give the region the world's leading programs in a broad range of key knowledge areas.

While the flagship public research universities in the Great Lakes region face similar challenges today as their state's budgets struggle to cope with staggering costs for health care, corrections, security, and infrastructure in the face of political forces demanding tax relief, this has made them lean and mean.

The Midwest is also characterized by a concentration of many of the nation's leading independent colleges, coordinated through organizations such as the Great Lakes College Association, and committed to providing undergraduate education of exceptional quality within the liberal arts tradition. These colleges have a remarkable record of sending their graduates on to further study at the graduate and professional level to become some of the nation's leading scientists, physicians, lawyers, teachers, and public leaders.

The strong commitment of the Midwest states to broaden opportunities for higher education have led to an extensive network of regional universities and community colleges. Many of these evolved from special-

ized institutions such as the normal colleges focused on teacher education to become comprehensive universities with substantial offerings at the graduate level. The region's community college have also evolved over time beyond their original role to provide young high school graduates with local access to professions requiring associate degrees or transitional curriculum to enable admission to baccalaureate programs offered by universities. Today these community colleges play a critical role in providing college level instruction to adults seeking to expand their skills and track the ever-changing requirements of the workplace. Since independent colleges, regional universities, and community colleges play a critical role in extending college opportunities–what the Europeans call "massification"–they must be an essential element of any educational strategy for the Midwest. We will return in Chapter 6 to consider both their role and the likelihood that they will continue to evolve, broadening and deepening their educational mission, to serve the emerging knowledge economy.

Research, Development, and Innovation

Although much of the culture of innovation that helped make the Midwest an economic leader has been lost, the region continues to possess strong and powerful assets needed to compete in today's economy, assets that, if built upon, could accelerate its transformation. The region remains the advanced manufacturing cockpit of the world, with the sector becoming more competitive, productive, and of better quality even as it employs far fewer people. At the same time, it is a globally significant center of new knowledge creation, talent, and innovation, with an unrivaled network of private and public research and higher education institutions; globally engaged businesses, cities, and civic institutions; a huge, strategically located marketplace; and unique water and natural resource attributes. Finally, as the pioneer in the creation of today's social welfare system, the Great Lakes states are an ideal laboratory for remaking public policy to more effectively and efficiently support economic success and security, helping workers adapt to a more unpredictable economic environment than that of the past.

Research and development is an integral part of the Midwest's regional economy (Koizumi, 2008). In 2004, the latest year for which comprehensive figures on industrial as well as federal R&D expenditures are available, $53 billion was spent on R&D in these seven states, accounting for 18 percent of the national effort. This is roughly proportional to the Midwest's one-fifth share of the U.S. population. Private industrial firms dominate R&D in the Midwest. Of the $53 billion in R&D performed in the Midwest in 2004, $43 billion was funded by industry. Taken together, the Great Lakes states perform 29 percent of the nation's total public and private research and development (Koizumi, 2008).

This region received $8.1 billion in federal R&D funds in fiscal year (FY) 2005, 7.3 percent of the national total. Over time, the Midwest's share of total federal support for R&D has been mostly steady at around 7 percent, except for fluctuations in Ohio's defense R&D. The result is that the flow of R&D funds to the region has mirrored national trends in R&D funding. The Midwest's steady share of total R&D is a result of the diversity of the region's R&D institutions and federal funding sources, detailed earlier in this report, and this consistency suggests that the future of R&D in the Midwest will continue to closely track national trends. But in recent years, the share has trended downward and broke through 8 percent in 2004 down to a new low of 7.3 percent in 2005, just when the overall federal R&D investment grew slower than the rate of inflation in 2005 for the first time in a decade. As in the nation as a whole, federal support of R&D in the Midwest has helped to build a strong R&D enterprise. Federal support for R&D has been especially important for the region's universities, which are world-class centers of excellence that not only perform research at the frontiers of knowledge but attract faculty and students from all over the world. Federal funds have also helped to sustain the region's privately funded R&D, through the support of graduate education of scientists and engineers at the region's universities who go on to staff industrial R&D labs and also through linkages between federal and private R&D, especially evident in the Midwest in the links between commercial agriculture and federally funded agricultural research.

The Midwest is home to a number of companies with strong R&D investments, such as GM, Ford, 3M, and Motorola, all of which have large R&D laborato-

ries in the region. 24 percent of the nation's industry-funded R&D, now approaching $180 billion a year, is performed in the Midwest. The Midwest has traditionally relied on industrial R&D for the strength of its R&D enterprise, but the federal role is also crucial in sustaining the knowledge and science bases that are the foundation of future discoveries and industries. In FY 2005, the latest year for which statistics on federal government obligations are available, the federal government obligated $8.1 billion in funds for R&D to the Midwest. Of this amount, the largest share ($3.9 billion) went to the region's universities, followed by industrial firms ($1.8 billion), government labs ($1.1 billion), and three federally funded research and development centers in Illinois and Iowa ($670 million). Although the flow of federal R&D funds to the region is significant, it is less than what one might expect based on the region's population and economic strength. For the past few decades, federal R&D to the Midwest has remained fairly steady at about 8 percent of total federal R&D, although in recent years this share has dipped toward 7 percent. This is less than the Midwest's 17 percent share of the U.S. population and is far less than the Midwest's 24 percent share of industry-funded R&D.

Federal support for R&D is especially important to the region's network of large research universities, many of which were founded as land-grant institutions nearly 150 years ago. Together, the Midwest's universities received nearly $4 billion in R&D funds from the federal government in FY 2005 (see Table 3), and received even more in federal funds when training grants, student aid, and other funds are counted. Nearly two thirds of the federal funds for university R&D came from the Department of Health and Human Services (HHS), home of the National Institutes of Health (NIH; see Chart 4). NIH funds nearly two thirds of total federal support for university research, and that is true for the Midwest as well. In FY 2005, HHS sponsored $2.6 billion in R&D in Midwestern universities, nearly four times as much as the next-largest sponsor, the National Science Foundation with $666 million. Other important sponsors are the Department of Defense (DOD, $234 million), the National Aeronautics and Space Administration (NASA, $87 million), the Department of Energy (DOE, $152 million), and the U.S. Department of Agriculture (USDA, $133 million).

Midwestern firms receive only 4 percent of total federal support for R&D, chiefly because the largest defense contractors, who receive over half of all federal support for industrial R&D, are located outside the region in the South and the West. Similarly, government labs in the region receive only 5 percent of total federal support for government labs. The three Midwest national labs operated account for 7 percent of total federal spending on such facilities.

Working together, this public and private basic and applied research base contributes a significant share of both nations' new ideas and new intellectual property—cornerstones of productivity gains and new products and firms. For example, the Great Lakes states produce nearly a third of the nation's new intellectual property in the form of patents.

The Midwest is home to three federally funded research and development centers, which performed $679 million in federal R&D in FY 2005, mostly for the Department of Energy (DOE). Argonne National Laboratory and Fermi National Accelerator Laboratory, both in Illinois, performed $333 million and $319 million in R&D, respectively, and Ames Laboratory in Iowa performed $27 million in FY 2005. DOE is the third-largest federal sponsor of R&D in the Midwest with a total of $855 million.

Yet despite its strong network of higher education institutions, the Great Lakes region has not been terribly successful spurring new firms, jobs, and industries. Overall, the region has not created enough jobs in high-wage advanced services industries to offset declines in factory jobs, and has struggled to commercialize and develop locally the fruits of its research products and innovations. But while once the hotbed of innovation, much of the region lacks the entrepreneurial, churning, change-oriented economic culture needed to translate ideas into jobs. Minneapolis-St. Paul is the only large Great Lakes metro that ranks among the top 20 percent of the nation's most entrepreneurial areas.

The region's lagging entrepreneurialism is likely a product of several forces. First, small business creators and owners are better educated and more likely to be longer-term community residents. Low overall education levels in the region and the continued out-migration of young talent could thus be hindering the development of new enterprises. Venture capital firms

want to have their investments nearby and today is concentrated largely on the coasts, leaving a void in the middle part of the country. Another impediment to entrepreneurialism in the Great Lakes region may be the change-averse culture that has been nurtured through several generations of industrial employment.

Ultimately, it may simply be that the Great Lakes culture as it has evolved does not today promote or encourage entrepreneurial behavior. Openness, engagement, and comfort with new ideas and people are central features of innovative communities.

Lessons from the Past, Challenges for the Future

In *Alice Through The Looking Glass*, the Red Queen warns: "Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!" (Brown, 2007) Such is life in today's hypercompetitive global, knowledge-driven economy where only world-class products and services survive. What assets of the Midwest region are sufficiently world-class to compete, to run twice as fast, particularly if today's artificial barriers were removed (e.g., trade restrictions, tax subsidies, perhaps even time and space if Moore's Law continues to rule)? Our companies? The quality of our workforce? The quality of our business environment? The quality of our government? Our universities? Our weather? Or none of the above?

Certainly the natural assets of the Midwest region are immense positives–the Great Lakes, its fertile farmlands, the forests now re-emerging after a century of exploitation, and of course, the relative safety from natural disasters such as hurricanes or earthquakes (leaving aside the New Madrid fault for the moment). Its geographic location, at the center of one great nation and across the border from another, and its role as a transportation and telecommunications nexus for the work are also great assets.

However much of its civic infrastructure such as its transportation systems, urban infrastructure, and industrial facilities evolved long ago to serve a factory-based manufacturing economy that is now dying. The same can be said for its policy environment–state and local governments that originally evolved to serve regions drawn on maps long ago that made little geographic or economic sense and today have demonstrated an extraordinary resistance–indeed, incompetence–in adapting to the imperatives of a global, knowledge economy.

It is imperative that the Midwest increase student degree attainment in higher education.

But perhaps the greatest weakness of the Midwest, its Achilles' heel, is its human capital, an aging workforce, inadequately educated and skilled for the global economy, addicted to entitlements and stability, resisting the key characteristics that will determine the future of the region, innovative skills, entrepreneurial zeal, immigration, risk, and change. Today many have forgotten or ignored the remarkable history of the Midwest, the great creativity and innovation of wave after wave of immigrants who build the farms, factories, and cities that both sustained and defended a 20th century world, and who invested heavily and sacrificed so that their descendants could benefit from world-class educational opportunities and enjoy a life better than theirs.

The Midwest must embrace, not hide from globalization and the emerging world economy. It has become increasingly clear that it can thrive only if it meets its global challenges on a regional basis. It must cast aside 19th century political and social structures and 20th century entitlement cultures and practices and look to the future. It must remember and embrace the philosophy that once made the region an economic and social leader: its strength lies in its people, in their skills and diversity, in their ambition and drive, and in their hopes and their dreams. For it is only by investing in its people, in their learning and skill and creativity, can

the Midwest restore and sustain its prosperity and leadership in an ever more competitive knowledge-drive world.

The Midwest Tomorrow: A Vision for the Future

Clearly the future of the Midwest states will be determined by the region's success in building a world-class learning and innovation infrastructure for its citizens. But just what is the nature of such a challenge? This can be most easily framed in terms of three important 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 increasingly mandatory for most careers in the knowledge economy, probably at the bachelors level, and for many, at the graduate level. Beyond this goal, a region 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 continuous education.

2. What skills and knowledge are necessary for a population (workforce) to provide regional advantage in such a competitive knowledge economy?

Here it is important to stress that the concern is no longer competition among cities and states within the Midwest region for prosperity or with other states such as California or Texas. More serious is the competition from the massive and increasingly well-educated workforces in emerging economies such as China, India, and Central Europe.

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?

It has become increasing clear that innovation is the key to global competitiveness in regions aspiring to a high standard of living. 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 the hypercompetitive global economy.

But such inquiries only scratch the surface. There are also deeper, critical questions: What does it mean to be "an educated person" in the 21st century? What does it mean to be "literate"? What will be our needs for the deeper purposes of academic institutions, such as their capacity to generate new knowledge, to preserve and transfer the cultural achievements of our civilization from one generation to the next, to serve as a constructive social critic, and to produce the human capital and innovation necessary for prosperity and security?

Clearly, the implications of a global, knowledge-driven economy for discovery-based learning and knowledge institutions–schools, colleges, and universities– are particularly profound. The knowledge economy is demanding new types of learners and creators. 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. Institutional and pedagogical innovations are needed to confront these dynamics and insure that the canonical activities of universities – teaching, research, and engagement – remain rich, relevant and accessible.

Implications for Workforce Development

Today and ever more so in the future, the knowledge content of jobs will increasingly determine their value and hence compensation at levels determined by a global marketplace. Highly educated, high-skill knowledge workers will become the backbone of the workforce of the most prosperous economies. The low-

skill but generously compensated factory jobs that once powered the Midwest's economy and sustained its middle class will disappear as these jobs continue to be off-shored to regions characterized by labor costs more competitive in the global economy. To be sure, Midwest industry will continue to manufacture products. But tomorrow's factories will likely employ only a handful of workers, e.g., highly trained engineers to program the robots performing the tasks that once employed millions of the Midwest's workforce. Instead most of the region's manufacturing jobs will be in knowledge-intensive areas such as R&D, design, global supply chain management and logistics, marketing, sales, and service. These are the high-pay jobs that will sustain the middle class, and they will all require not only a college education but furthermore a commitment to lifelong learning. (Glazer, 2010)

Yet what about those in the Midwest's current workforce whose education and skills have been swept aside by a hypercompetitive global economy? Here the region faces a serious dilemma. The reality is that the Midwest is no longer capable of supporting its current population with an economy based upon low-skill yet highly compensated manufacturing jobs that are rapidly being off-shored. It is clear that the legacy costs of the old entitlement culture can no longer be sustained without a dramatically restructured economy capable of generating wealth in the global, knowledge-driven economy.

Hence the most immediate priority of the Midwest region–its governments, cities, and towns–is to make the investments today that will create the knowledge and human resources capable of competing and prospering in a global knowledge-driven economy. But this will take time. We must first elevate our educational, research, and innovation resources to the world-class levels. Then we must utilize these assets to provide future generations with world-class education opportunities, innovative skills, and entrepreneurial spirit. The Midwest must take bold actions to recapture the resources necessary to upgrade the quality of its workforce, to provide its citizens with the educational opportunities and skills demanded by the global economy. Put more bluntly, the regions must shrink the burdens of a workforce no longer competitive in the global economy if it is to free up the resources necessary to invest in its future. It must downsize its public and private commitments and legacy costs (e.g., health care, pensions, corrections, social services) to levels more appropriate for a smaller population, particularly in those cities experiencing major economic decline and population loss. It must restructure its tax, expenditure, entitlement, and legacy cost structures to align with this "smaller but better educated" population.

How can we jump-start this process? It is estimated that the majority of new jobs created in the knowledge economy will require not only a college degree but also education in science and mathematics necessary to master the new technologies driving the global economy, e.g., computers, networks, biotechnology, and engineering. Yet today in the Midwest, less than one quarter of our workforce have such educational credentials or skills. Sadly, it is unrealistic to expect that the skills of much of our current workforce can be upgraded to world-class levels. The reality is those workers with skills and education no longer competitive in the global, knowledge economy will face the choice of either accepting the few remaining jobs compatible with their skills at far lower compensation or migrating elsewhere to economies less burdened by entitlement cultures and legacy costs. Hence even if we are able to free up the resources necessary to invest in educational opportunity for our future workforce, we will still face the challenge of building a globally competitive workforce for today.

Immigration

There is only one way to rapidly upgrade the quality of our workforce: immigration. The Midwest must simply set aside its xenophobic tendencies and embrace once again immigration as absolutely essential for its future prosperity–just as it has been, of course, for its past successes. We should remember that the Midwestern United States was settled and built by generation after generation of immigrants. In fact, nearly all Americans are descended from people who came from other parts of the world in the past couple of centuries. They built our farms and cities, our companies and industries, providing our spirit and drive, shaping our culture and values, and establishing this region as the economic engine of the work.

Today immigrants are needed once again not only

to do the work that must be done to keep the Midwest functioning, but to provide it with the knowledge workers and entrepreneurs so essential to its future. Fortunately, today the immigrants are coming again, to take the jobs offered by global cities. It is estimated that during the past two decades 25% of new U.S. ventures (and 50% of Silicon Valley firms) were created by immigrants. A disproportionate number of U.S. breatkthrough inventions have come from immigrant inventors. And, of course, the massive flow of refugees from war-torn Europe during the 20th century brought many of the scientists and engineers who not only helped the Allies win WWII, but also have been the Nobel Prize winners and inventors sustaining American science and technology. (*The Economist*, 2009)

It is abundantly clear that cities and regions that are booming today all have large and growing foreign-born populations, for example New York and San Francisco at 35% and Chicago at 30%. Cities in trouble do not–such as Detroit at 7.5%, Cleveland at 3%, Indianapolis at 3.5%, and St. Louis at 3%. In fact it might even be suggested that one way to assess whether a metropolitan area will be capable of surviving as a global entrepot in today's hypercompetitive economy is to consider its attractiveness to immigration. Unfortunately, with the exception of Chicago, most Midwestern cities face a serious challenge (Foreign Policy, 2010; Longworth, 2008.)

Yet there is another lesson here that can be learned from our neighbors to the north. One key reason that Canada fares better than the United States in international measures of college attainment is that it attracts a better-educated mix of immigrants. Although a larger share of Canada's population is foreign-born (20% compared to 12% in the U.S.), the regions of origin are much different. About 52% of US immigrants and 11% of Canadian immigrants come from Latin American nations with relatively weak educational infrastructure. In contrast, about 14% of US immigrants and 37% of Canadian immigrants come from Europe. (*Chronicle*, 2009) People from Asia and the Middle East also account for a larger share of the Canadian immigrant stream. About a third of immigrants in the US over the age of 25 do not have a high-school diploma, compared to only 10% of Canadian immigrants.

In summary, immigration is vital to growing the regional economy and can increase innovation and entrepreneurship, grow talent, and transform the culture of the Midwest. The region needs all the immigrants it can get. This is particularly true of more educated Asians, Europeans, and Africans but also true of poorly educated Latinos. The Midwest needs to speak with one voice in demanding that its needs for more workers and citizens are met. The only immigration policy that will help the Midwest is one that opens the door as widely as possible (Longworth, 2008).

Learning in the Digital Age

Today's students are citizens of the digital age. They have spent their early lives surrounded by robust, visual, interactive media—not the passive broadcast media, radio and television of our youth, but rather Wii's, iPhones, Facebook, and virtual reality. They are "digital natives", comfortable learning, working, and living in the digital world, unlike those of us who are "digital immigrants" who are struggling to keep pace with digital technologies (Pensky, 2001). This is not an easy task for educators, who for the most part remain reluctant to embrace the new technologies in their teaching and hence are increasingly detached from today's students (Gura and Percy, 2005).

Today's students are no longer the people our current educational system was designed to teach. Rather they learn by experimentation and participation, not by listening or reading passively. They are indeed the "plug and play" generation. They embrace interactivity and demand the right to shape and participate in their learning. They are comfortable with the uncertainty that characterizes their change-driven world. These students will increasingly demand new learning paradigms more suited to their learning styles and more appropriate to prepare them for a lifetime of learning and change.

New knowledge media are forcing us to rethink the nature of literacy. We have seen the definition of literacy shift before in history, from the oral tradition to the written word to the images of film and then television and now 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 rheto-

Today's college students

The Millennial Generation

ric, then writing, and now in multimedia. 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. Emerging 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 be", tools already embraced by the young if not yet the academy. In the language of the digital generation, learning has become "hanging out" (knowing), "messing around" (playing), and "geeking out" (creating) (Ito, 2009; Brown, 2009).

From a broader perspective, our society increasingly values not just analysis but synthesis, enabled by the extraordinary tools of the digital age. Learning occurs not simply through study and contemplation but through the 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!" (Brown, 2009)

Lifelong Learning

Today, learning has become a lifelong activity since a changing world will demand that students continue to learn, through both formal and informal methods, throughout their lives. Of course, K-12, college, or even graduate and professional education was never intended to provide all of the knowledge needed for a lifetime. But in years past, most of the additional knowledge necessary for a career could be acquired informally, through on-the-job learning or self-study. Today, however, both rapid growth of knowledge and the multiple career transitions facing graduates demand a more strategic approach to lifetime learning. We need to rethink educational goals from this lifetime perspective. We should view K-12 and college as just steps—important step to be sure—down the road of a lifetime of learning. This would allow us to better match learning content and experiences with both the intellectual maturation and the needs of the learner.

The needs for lifelong learning opportunities in a knowledge society are manifold. The shelf life of education acquired 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.

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 preparation for 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.

In fact, we might even make the case that it is time for the nation to step up to its 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 essentially a civil 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.

Of course, establishing universal access to lifelong learning as a national goal would require not only a very considerable transformation and expansion of the existing education enterprise, but it would also require entirely new paradigms for the conduct, organization, financing, leadership, and governance of 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.

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, which 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 one's personal productivity and hence lifelong prosperity through future education. By making such lifelong learning ("LiLa's") savings accounts mandatory, again like Social Security, one would create a sense of ownership on the part of all citizens, 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.

The Globalization of Education

Globalization and the attendant emergence of the global knowledge economy are exerting tremendous pressures on learning institutions around the world

Today's students are far more diverse in age, ethnicity, nationality, and interests.

and reshaping some of their basic assumptions and activities. The international movement of students and scholars in higher education was the earliest expression of these conditions, and it continues to be the most visible expression of the global nature of the higher education enterprise. Today students in the millions are internationally mobile in search of a university degree and a cross-cultural experience. Universities and their faculties build international linkages, attracting students from far and wide for their academic programs, and augmenting these with exchange programs, sabbaticals, and conferences to support the free exchange of knowledge and ideas.

The global knowledge economy has stimulated an explosion in the demand for higher education, with the number of university students estimated to increase from 50 million in 2000 to over 150 million by 2025 (Daniels, 2001). While the leading American universities continue to dominate world rankings, their high-cost instructional programs and multiple missions such as socializing young adults and running academic medical centers are unlikely to be adopted by most of the rest of the world. Rather most nations are developing national strategies that link higher education directly to economic development in such a way as to stimulate strong public and private investments in expanding educational opportunities and developing world-class capabilities in advanced education and research. Although Europe continues to depend primarily upon public universities, in much of the rest of the world and particular in Asia, private higher education, including for-profit institutions, is expanding rapidly (Johnson, 2010).

The higher-education needs of large populations and rapidly expanding economies based on highly skilled workforces has stimulated massive investments in higher education in Asia, particularly in Singapore, Korea, China, and India. Europe is also successfully implementing important regional strategies such as the Bologna Process aimed at stimulating greater commonality and cooperation among national higher education systems while elevating the importance of university research through the European Research Area (Adelman, 2009).

The implications of the globalization of higher education are immense for American colleges and universities, both for opening up new markets for students but perhaps more importantly, for increasing competitive pressures as more world-class universities emerge as a consequence of national and regional strategies addressing the imperatives of the global economy (Weber, 2007). For example, American universities are heavily dependent on immigration, with over 50% of graduate students and 25% of faculty members in science and engineering being foreign born. As research universities around the world rapidly increase in value, there will be increased competition for this academic talent that could stem the flow to U.S. universities. The brain gain provided by the contribution of international students and faculty to American higher education may become a brain drain as the global emergence of high-quality universities attract these ex-patriots back to their home countries. Yet it is also clear that current U.S. policy at the state and federal level has yet to address the challenges and opportunities presented by globalization.

Broadening Educational Opportunity

As *The Economist* notes, the rise of the knowledge economy has driven the democratization of education, as an increasing fraction of the workforce will need to have access to postsecondary education. As knowledge has replaced physical resources as the driver of economic growth, schools, colleges, and universities have become the most important engines of the knowledge economy. This is happening throughout the world, not only in developed nations in North America, Europe,

and Asia, but in all regions–developed, developing, and underdeveloped–aspiring to prosperity and security in an intensely competitive global, knowledge-driven economy. And here, market competition extends far beyond traditional business and trade to include knowledge resources such as human capital, R&D, and innovation, all both key products and assets of learning institutions (*The Economist*, 2005).

But this raises an important challenge to balance the twin demands of mass access, necessary for a competitive workforce, and world-class quality, necessary to provide the new knowledge and innovation essential for a knowledge economy. As *The Economist* notes, "We already possess a successful model of how to organize higher education: America's. That country not only has almost a monopoly on the world's best universities, but also provides access to higher education for the bulk of those who deserve it." State and federal governments play a more limited role in American higher education since almost two-thirds of the support for our colleges and universities comes from the private sector, e.g., tuition and philanthropy, rather than federal or state government. This creates a highly market-driven and diverse array of colleges and universities, evolving and adapting to serve the ever-changing and diverse needs of American society. To conclude, *The Economist* stresses: "There is no shortage of things to marvel at in America's higher education system, from its robustness in the face of external shocks to its overall excellence. However what particularly stands out is the system's flexibility and its sheer diversity."

Key in the achievements of both excellence and access in American higher education has been the public university, which today educates 80% of all college students in this country while conducting 70% of its research. With an expanding population, a prosperous economy, and compelling needs such as national security and industrial competitiveness, the public was willing to make massive investments in higher education during the 20th century. While elite private universities have been important in setting the standards and character of higher education in America, it has been the public university that provided the capacity and diversity to meet our nation's vast needs for postsecondary education.

Today, however, in the face of limited resources and more pressing social priorities, this expansion of public support of higher education has slowed. While the needs of our society for advanced education will only intensify as we evolve into a knowledge-driven world culture, it is not evident that these needs will be met by further expansion of our existing system of public 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 federal government and the universities for the conduct of basic research are both at risk, a consequence of the increasingly limited tax resources and the declining priority given higher education in the face of other social needs. (Zemsky, 2005; Newman, 2004)

Today, even as the need of our society for postsecondary education intensifies, we also find erosion in the perception of education as a public good deserving of strong societal support. States have joined the federal government by shifting priorities away from investment in the higher-education enterprise (appropriations to institutions) to investment in the marketplace for higher-education services (loans or 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 paid for by the individuals benefiting most directly–the students. This shift from the perception of higher education as a public good to an individual benefit has another implication. To the degree that higher education was a public good, benefiting all (through sustaining democratic values, providing public services), one could justify its support through taxation of the entire population. But viewed as an individual benefit, public higher education can become a highly regressive social enterprise since, in essence, the poor subsidize the education of the rich, largely at the expense of their own opportunities.

Even more fundamentally, as we enter the new millennium, there is an increasing sense that the social contract between educators and American society may need to be reconsidered and perhaps even renegotiated once again. *In an age of knowledge, 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 an affordable cost.

Of course, this has been one of the great themes of education in America. Each evolutionary wave innovation in education has aimed at educating a broader segment of society, at creating new educational forms to do that—primary and secondary schools, public universities, land-grant universities, the normal and technical colleges, community colleges, and today's emerging generation of cyberspace universities. Our efforts to meet the educational needs of the 21st century are constrained, in part, by institutions, systems, policies, and politics which were determined by a 20th century industrial society.

But we now will need new types of educational institutions with new characteristics:

1. Like other social institutions, our schools, colleges, and universities must become more focused on those whom they serve. They must transform themselves from faculty-centered to learner-centered institutions, becoming more responsive to what their students need to learn rather than simply what their faculties wish to teach.

2. Society will also demand that educational institutions become far more affordable, providing learning opportunities within the resources of all citizens. Whether this occurs through greater public subsidy or dramatic restructuring of the costs of higher education, it seems increasingly clear that our society—not to mention the world—will no longer tolerate the high-cost, low-productivity paradigm that characterizes much of education in America today.

3. In an age of knowledge, the need for advanced education and skills will require both a personal willingness to continue to learn throughout life and a commitment on the part of educational institutions to provide opportunities for lifelong learning. The concepts of student and alumnus will merge.

4. America's highly partitioned system of education will blend increasingly into a seamless web, in which primary and secondary education; undergraduate, graduate, and professional education; on-the-job training and continuing education; and lifelong enrichment become a continuum.

5. Already new forms of pedagogy are emerging: asynchronous (anytime, anyplace) learning that utilizes emerging information technology to break the constraints of time and space, making learning opportunities more compatible with lifestyles and career needs; and interactive and collaborative learning appropriate for the digital age, the plug-and-play generation. In a society of learning, people would be continually surrounded by, immersed in, and absorbed in learning experiences, i.e. ubiquitous learning, everywhere, every time, for everyone.

6. The great diversity characterizing higher education in America will continue, as it must to serve an increasingly diverse population with diverse needs and goals. But it has also become increasingly clear that our institutions must strive to achieve diversity within a new political context that will require new policies and practices.

It is clear that the access to advanced learning opportunities is not only becoming a more pervasive need, but it could well become a defining domestic policy issue for a knowledge-driven society. Higher education must define its relationship with these emerging possibilities in order to create a compelling vision for its future as it enters the new millennium. (Duderstadt, 2000, 2005)

Innovation

The creativity, ingenuity, and courage of innovators will be critical to our nation and our region in the twenty-first century. As a superpower with the largest and richest market in the world, the United States has consistently set the standard for technological advances, both creating innovations and absorbing innovations created elsewhere. From Neil Armstrong's walk on the Moon to cellular camera phones, engineering and scientific advances have captured people's imaginations and demonstrated the wonders of science. In fact, groundbreaking innovation was the driving force behind American success in the last century. An endless number of innovations—from plastics to carbon fibers,

electricity generation and distribution to wireless communications, clean water and transportation networks to pacemakers and dialysis machines—has transformed the economy, the military, and society, making Americans more prosperous, healthier, and safer in the process (Duderstadt, 2005).

Future breakthroughs dependent on research and innovation will have equally powerful impacts. The innovations that flow from advanced education and research are not simply nice to have, like high-definition television; many are essential to the solutions of previously intractable challenges. Research in materials, electronics, optics, software, mechanics, and many other fields will provide technologies to slow, or even reverse, global warming, to maintain water supplies for growing populations, to ameliorate traffic congestion and other urban maladies, and to generate high-value products and services to maintain our standard of living in a world of intense competition. To meet these and other grand challenges, the Midwest must be an innovation-driven region that can capitalize on fundamental advances in life sciences, physical sciences, and engineering (Branscomb, 2008).

Here it should be kept in mind that Midwest is very much part of a global economy in which research and development are performed worldwide. Our multinational corporations manage their R&D activities to take advantage of the most capable, most creative, and most cost-efficient engineering and scientific talent, wherever they find it. Smaller firms without global resources are facing stiff competition from foreign companies with access to talented scientists and engineers—many of them trained in the United States—who are the equals of any in this country. Relentless competition is driving a faster pace of innovation, shorter product life cycles, lower prices, and higher quality than ever before.

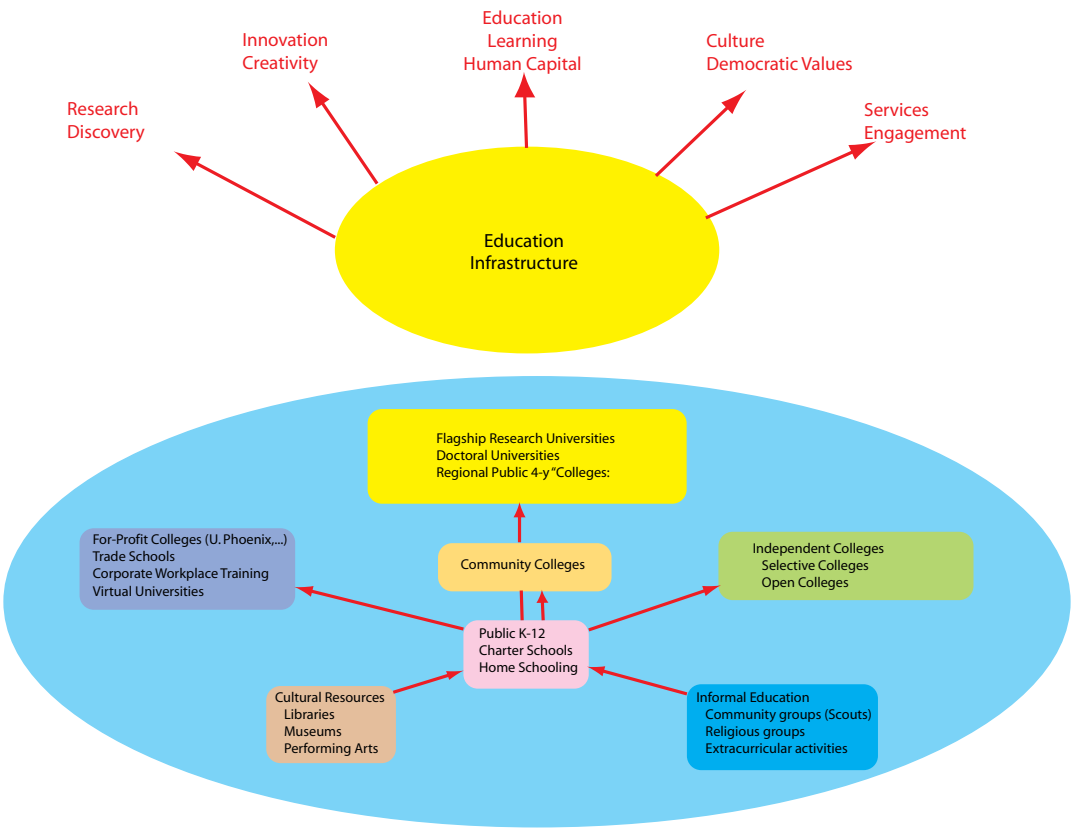
To meet the demands of global competition, other states and nations are investing heavily in the foundations of modern innovation systems, including research facilities and infrastructure and strong technical workforces (Weber, 2009). Some of the innovations that emerge from these investments will be driven by local market demands, but many will be developed for export markets. As other regions develop markets for technology-laden goods and international competition intensifies, it will become increasingly difficult to maintain a globally superior innovation system. Only by investing in research and advanced education can the Midwest retain its competitive advantage in high-value, technology-intensive products and services, thereby encouraging multinational companies to keep their R&D activities in this country.

Colleges and universities have a long history of contributing to U.S. preeminence in technological innovation. Research universities are particularly critical to generating new knowledge, building new infrastructure, and educating innovators and entrepreneurs. The Land-Grant Acts of the nineteenth century and the G.I. Bill and government-university research partnerships of the twentieth century showed how federal action can catalyze fundamental change. In the past, universities dealt primarily with issues and problems that could be solved either by a disciplinary approach or by a multidisciplinary approach among science and engineering disciplines. To meet future challenges, however, universities will need a new approach that includes schools of business, social sciences, law, and humanities, as well as schools of science, engineering, and medicine. Solving the complex systems challenges ahead will require the efforts of all of these disciplines.

But there is yet another challenge. While our colleges and universities 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 curricula sometimes discriminates against those who are truly creative, those who do not fit well into our stereotypes of students and faculty.

Our educational systems may need to reorganize themselves quite differently, stressing forms of pedagogy and extracurricular experiences to nurture and teach the art and skill of creation and innovation. This would probably imply a shift away from highly specialized disciplines to programs placing more emphasis on integrating knowledge. Perhaps it is time to rip education out of the classroom and place it instead in the discovery environment of the laboratory or studio or the experiential environment of practice.

By combining research with education, universities not only tap into the creativity of young people, but also train them in critical thinking, research methodologies, and solid engineering skills. Because of the high quality



A "learning ecology" for the Midwest

of the people and tools provided by American universities, industries have chosen to locate their facilities in the United States, and emerging industries have tended to cluster around major engineering research universities (e.g., Silicon Valley, Route 128, Research Triangle, etc.) where they have access to a continuous supply of technical talent. An academic campus is one of the few places where precompetitive, use-inspired, long-term basic research can be conducted without the constraints of quarterly earnings. 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.

In spite of severe fiscal constraints, many areas of the United States have recognized that research and technology-development capacity are key elements in restoring their economic prosperity in an intensely competitive, global, technology-driven marketplace. 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 Midwest can and must take control of its 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 prosperity in a 21st century knowledge economy. Fortunately it has the unique resources of the world's leading concentration of research universities (e.g., the CIC group) and the headquarters of made of the world's leading technology-based companies to build upon. Yet it is also clear that many of the most promising technologies–sustainable energy generation and transportation, biotechnology, nanotechnology, information services, water resources–make sense only if pursued aggressively on a regional basis.

Of course there are many approaches to building globally competitive economies built upon innovation. Some focus on restoring lagging support for basic research and the need to reform science and engineer-

ing education. Others stress the importance of market forces in bridging the "valley of death" between basic research and commercial innovations. Yet throughout the world it has become clear that BOTH strong public investment and powerful market incentives are necessary ingredients for successful innovation-driven economies.

The Atlantic Century study suggested the following imperatives for innovation-driven economies (Atkinson, 2009):

1. Put in place incentives for firms to innovate within their borders. These should include robust R&D tax incentives; incentives, such as accelerated depreciation, to invest in new equipment, particularly IT; and other policies that spur investment in the building blocks of growth, such as workforce development tax credits.

2. Be open to high-skill immigration. High-skill immigrants are the source of many new ideas and innovations. Countries that are open to high-skill immigration will be able to better succeed.

3. Foster a digital economy. Nations should not only expand public investments in IT in areas such as health care, energy systems, transportation, government, and education, but also put in place the right regulatory frameworks to spur, not limit, digital investment. Nations need to also consider how existing regulatory and public procurement policies can be redesigned to intentionally spur digital transformation.

4. Support the kinds of institutions that are critical to innovation. Nations need to expand funding not just for university research, but for the kinds of mechanisms and institutions that help foster commercialization of research. In addition, they need to boost support for a host of efforts such as local economic development, entrepreneurship development, and workforce training.

5. Ensure that regulations and other related government policies support, not retard, innovation. Too often, powerful interest groups (business, civic, and labor) fight against change and innovation, often under the guise of the public interest, but all too often the result is that progressive and positive innovation is slowed. Nations should ensure that their regulations, procurement, and other related policies tilt toward innovation.

The Midwest region must recognize that a broad range of government policies directly affect the nation's power to innovate: new technology investments, economic policy, trade strategy, government procurement, intellectual property, and standards policy. A major recalibration of private-sector thinking and government policies and priorities is in order. The way we think about networks of talent, the tools we have for building institutional skills and trust, the approach we take to competition in a world of process networks--all must be addressed. The temptation to revert to protectionism must be resisted. The growing importance of technically sophisticated, middle-sized firms that know how to cooperate and compete in a new world of peer-networked enterprises must be recognized and encouraged.

A Society of Learning and Innovation

The themes that will govern the future of the Midwest are simple to state if challenging to address: the imperatives of the global, knowledge-driven economy, universal learning opportunities, the capacity and drive to continually innovate, and risk-taking rather than entitlement–and all sought on a regional basis. In particular, lifelong and life-wide access to advanced educational opportunities will become the defining domestic policy issue for a knowledge-driven society. This will clearly require the development of new paradigms for delivering education to even broader segments of our society, perhaps to all of our society, in convenient, high-quality forms, at a cost all can afford. Fortunately, today's technology is rapidly breaking the constraints of space and time. It has become clear that most people, in most areas, can learn and learn well using asynchronous learning, that is, "anytime, anyplace, anyone" education. Lifetime education is rapidly becoming a reality, making learning available for anyone who wants to learn, at the time and place of their choice, without great personal effort or cost. With advances in modern information technology, the barriers in the educational system are no longer cost or technological capacity but rather perception and habit.

It is becoming increasingly clear that the dominant

priority of a knowledge-driven society has become intellectual capital: the education of our citizens, the support of their ideas, their creativity, and their innovation and entrepreneurial efforts. This will require new concepts, institutions, policies, and investments, articulated by the vision of society of learning and innovation. Hence the challenge is to set aside the usual constraints imposed by existing educational structures (e.g., schools and colleges, policies and politics) and instead begin with a clean slate to determine the lifelong educational needs of citizens in a global knowledge-driven society and how one might meet these needs (Duderstadt, 2005; Brown, 2009).

The Gap Analysis

In this chapter we consider the road ahead, how far the Midwest must travel in order to build a society capable of facing the imperatives of the 21st century global economy. In this effort we will continue following the roadmapping process by utilizing a *gap analysis* to compare where the Midwest is today with what it must become tomorrow. Here we must continue to bear in mind that in the flat world of a global, knowledge-driven economy, the key to prosperity lies not with low taxes, cool cities, and great weather. Rather it requires educated people, new knowledge, innovation, and an entrepreneurial spirit. This, in turn, requires visionary public policies and public and private investments that look toward the future rather than clinging to the past. The challenge to the Midwest, its public leaders, its business, industry, and labor, its educational and cultural institutions, and its citizens is to invest in the production of the human capital, infrastructure, new knowledge, and innovation necessary to achieve prosperity and social well-being in a 21st world.

By any measure, the assessment of the current state of the Midwest is very disturbing. The region is having great difficulty in making the transition from a low-skill agricultural and manufacturing economy to one based on knowledge and innovation. In recent years our auto-industry states have led the nation in unemployment; the out-migration of young people in search of better jobs is among the most severe in the nation; our educational systems are underachieving with one-quarter of our adults without a high school diploma and only one-third of high school graduates college-ready. Although the Midwest's system of higher education was once regarded as one of the nation's best, the erosion of public support over the past three decades has not only driven up tuition, but also put the quality and capacity of our public colleges and universities at great risk.

To be sure, the Midwest was once the economic engine of the world, the arsenal of democracy, largely due to the investments made by our ancestors in public assets such as schools and colleges, social benefits, and civic infrastructure. Ironically, at a time when the rest of the world has recognized that investing in education, research, and innovation is the key to not only prosperity but, indeed, survival, too many of our citizens and leaders, in both the public and private sector, have come to view such investments as a low priority, expendable during hard times.

From this perspective, the vision we have proposed for the Midwest tomorrow as a society of learning and innovation seems very distant indeed. The road ahead looks long, perilous, and uncertain.

The Midwest's Challenge: Economic Transformation

Today the Midwest is experiencing a transition to a postindustrial society as fundamental as the transformation from a farming society to an industrial society a century ago, driven by the emergence of an economy based on knowledge—educated people and their ideas–and powered by breathtakingly rapid development of new technologies; the globalization of the world's economy and culture enabled by technologies of communication and travel; and the demographic changes in the American population bringing hitherto under-represented groups into a majority of the workforce. Yet many of our people and our institutional leaders are reeling from the transformation, on the defensive, desperately clinging to the past, to the habits and expectations of an earlier era when we were a leading agricultural and industrial power not just of America but of the entire world. Many among us look for scapegoats—foreign workers and industries, immigrants, business, labor, politicians, even schools and colleges. Some take a "this too shall pass" attitude, almost as if we closed our eyes we could make change stop. Oth-

As economic activity and jobs are off-shored to low-cost, high skill centers such as Bangalore and Shanghai, it is clear that Midwest states are no longer just competing with one another.

ers demand entitlements, no longer secure in a rapidly changing world.

Perhaps the recent bankruptcies of General Motors and Chrysler should be viewed as harbingers of what is to come if the region continues to back into the future. In fact, the decline of the American automobile industry has been underway for decades, as management continued to resist change and ignore innovation while relying on a workforce with increasingly obsolete skills, protected by powerful unions demanding benefits inconsistent with the emerging global economy and by political leaders determined to isolate the industry from the new imperatives such as emissions control and fuel efficiency (Longworth, 2008). While other nations developed industries for the 21st century that have now moved onto our shores, the leaders of the American automobile industry sought instead short-term profits based on products that were soon to become dinosaurs in the new world order. The Big Three were in many ways the poster children of the Midwest's failure to cope with global challenges–an aging industry with high costs, obsolete, factories, resistance to change, an absence of innovation and imagination, crippled by myopic management and dependent upon a workforce with education and skills no longer competitive in the global marketplace. As a consequence, the auto industry has now lost more than half a million Midwest jobs over the past decade, with Michigan and Ohio losing respectively 75% and 60% of their automobile jobs.

Today we find the Midwest midway through a several-decade-long transition from a region dominated by big companies, big unions, and big government to a new economy dependent upon thousands of small, dynamic companies competing in a broad spectrum of world markets. We are experiencing a transition from low-skill, high-pay jobs to high-skill, high-pay jobs; from a transportation industry to an information services industry; from the Industrial Age to the Age of Knowledge. We're learning the hard way that if we want to fully prosper in this new world, we must take the long view, invest in people and learning institutions—in making available life-long education and training, and similarly invest in research and the technological innovation it produces. The Midwest's major sectors—government, business, and labor–must be dramatically restructured to serve us better in the new century. The Midwest today faces fiscal collapse if we continue to fund our current needs and desires by shifting the cost to future generations.

The Midwest first has to recognize that its old low -skill, factory-based economy is dying, never to return. Yet today many of our towns, cities, and states continue to be plagued by an entitlement culture and increasingly demoralized and hopeless as the low-skill jobs that once provided security and prosperity are swept aside by the global economy. To be sure, economic and social upheaval of the magnitude facing the Midwest is unprecedented. It challenges our basic assumptions about how we live our lives, it changes the rules in mid-game. It displaces and hurts far too many. But the almost certain consequence of this continuing widespread denial of and resistance to change would be to

condemn the Midwest to a future of decline that would soon be irreversible. Why? Because such denial violates a fundamental law of nature that all living systems must continually adapt to their changing environment or risk extinction. To survive let alone prosper, the Midwest has to summon the courage and strength to face up to reality, to see change not as a threat but to seize the opportunities it offered to make a better world for ourselves and our children.

The Midwest faces a particularly serious challenge in producing the human capital–the educated population, the knowledge workers, the scientists, engineers, and other professionals–that will enable it to compete. Not only is our population aging rapidly, but the outmigration of our 25- to 44- year old population creates a brain drain with very serious implications. Certainly our educational institutions have demonstrated the capacity to compensate to some degree by utilizing their quality and reputation to attract and retain both their graduates and those they attract from throughout the nation and around the world. Yet all too often, state politicians object to our public universities enrolling students from other states or nations, apparently oblivious to the fact that over the longer term, the capacity of our academic institutions to attract talented students, knowledge workers, and companies from around the world is of extraordinary importance to our region. As the resource map of Midwest's educational capacity makes painfully apparent (Chapter 3), the region's educational achievement at this level is seriously inadequate and must be improved dramatically if it is to build a workforce of world-class caliber. In the global economy cities prosper by attracting and producing well-educated, highly skilled, and creative citizens. Nearly half the people in Seattle and San Francisco have college degrees. This plunges to 11% in Detroit and Cleveland!

The Midwest also must make additional investments to create the new jobs to employ better-educated graduates. Thus far, too few jobs of this kind—dependent upon skill and knowledge–exist in our region. The old economy is gone, never to return. Furthermore, even if our traditional industries manage to survive the recent recession, albeit with government bailouts, they can never dominate our economy again. The productivity gains made through efforts such as total quality management, lean manufacturing, and right-sizing costs in the old industries unfortunately come at the expense of jobs–and perhaps also at the expense of the R&D necessary to achieve technological innovation and sustain market share.

It seems increasingly clear that new jobs in the Midwest are not going to be spawned by its existing industry but instead will be created by entirely new activities dependent upon technological innovation, both in high-tech areas such as biotechnology, information technology, and nanotechnology, and in knowledge-intensive services. They will require skilled knowledge workers, technological innovation, and energetic, risk-taking entrepreneurs. And it is from this perspective that the most significant players in building the new economy of the Midwest are likely to be its schools, colleges, and universities, since these institutions are the primary source of all three essential elements of the knowledge economy: educated people, new knowledge, and innovation.

K-12 Education: The Crippling Gap

Clearly the quality and performance of K-12 education is a very critical issue for the region. For example today almost half of all Michigan adults are currently hindered by a literacy level too low to function adequately in today's knowledge-driven society. One-fifth of Midwest citizens do not have a high school diploma, while only one-third of high school students graduate with college-ready transcripts. The fact that only one Midwest state, Ohio, has been successful thus far in the federal $4.35 billion "Race to the Top" grant competition suggests that most of the region is still unable to break the stranglehold of local school boards, unions, and state politics to reform K-12 education (Duncan, 2010).

There have been a few bright spots in several of the region's systems of public education, including the adoption by several states of some of the most rigorous requirements for K-12 education in the nation. However the achievement of these goals will be a challenge for many of the region's school systems, particularly those in economically disadvantaged areas where poverty and job losses have taken a serious toll on schools and families.

Furthermore, while state initiatives such as charter schools and federal accountability measures ("No Child Left Behind") are having some impact, this are also largely at the margin because of far more significant socioeconomic issues such as the deterioration of the family and community environment for learning and the student (and family) motivation for academic achievement. Too many parents and citizens are still willing to accept less than the best for our children. Michigan's students now may be able to compete with children from Ohio, but they are far behind children in Asia and Europe–e.g., with the U.S. ranking 25th out of 30 developed nations in high school completion and achievement (OECD, 2010; Lingenfelter, 2009). Here part of the difficulty is the vast difference in standards and assessment measures used among the states.

Inadequate school preparation is compounded by poor alignment between high schools and colleges, which often creates an "expectations gap" between what colleges require and what high schools produce. Compared to the rest of the world, primary and secondary education in the United State is too thin, too brief, and not rigorous enough. The result is a high level of remediation by colleges (and by employers), a practice that is both costly and inefficient.

The fact remains that throughout the Midwest too few citizens prepare for, participate in, and complete the educational programs capable of preparing them for the knowledge economy, especially those underserved and nontraditional groups who make up an ever-greater proportion of our population. More generally, the leakage from our current education pipeline from primary education through secondary school and college into knowledge-intensive employment is clearly unacceptable.

Of comparable importance is the teaching profession itself. It is here that higher education (and our society) simply must do a better job of attracting the best and brightest into teaching careers and providing them with the quality education, attractive pay, and support necessary for these important roles. In Singapore teaching is regarded as the most important profession in contrast with the United States where law and business rule the roost.

Higher Education in the Midwest: A Critical Asset at Great Risk

There is growing evidence that a skilled-worker shortage–created by low birthrates, out-migration of young adults, and poor performance of our educational systems–poses a serious threat. Beyond these current challenges, it is also the reality that a global, knowledge-driven economy is continuing to raise the bar for educational achievement. Some recent reports that suggest that "a vast majority of the emerging high-wage, high-skilled jobs available require a level of skill that can be obtained at the community college or technical school level and do not require a bachelor's degree" (MEDC, 2002). Yet the reality is that a bachelor's degree is already almost a mandatory credential for a job in the new economy, and soon advanced degrees–or at least lifelong learning–will become a necessity. We must take great care not to repeat the mistakes of the 20th century, when we doomed generations to poverty by restricting their educational opportunities to only the level they needed for the low-skilled jobs of that time. The educational demands of a changing world are moving ever higher.

Yet here the challenges are immense. Today the United States ranks in bottom third of developed nation's in the percentage of its population with college degrees. In fact, to achieve President Obama's goal of once again leading the world in college attainment of our population by raising the percentage of adults age 25-64 with college degrees from 37% to the world-class standard of 55% would require an additional 16 million adults with college degrees (Lingenfelter, 2009).

Hence it is at the level of higher education that the Midwest region may be at the greatest risk, since for too long it has taken its colleges and universities–perhaps the most critical assets of the knowledge economy–for granted. Many studies have highlighted the importance of higher education to the ability of regions to compete for prosperity in the global economy. Most agree that the single most important investment that regions–cities, states, nation-states– can make in their future is to invest in colleges and universities, since these will be the key source of an educated workforce, research and innovation, and entrepreneurial activity.

In a recent study, Glazer has determined that the

single most critical factor in driving the growth of private income (i.e., both private sector employment earnings growth and investment earnings) in a state is college degree attainment. States with high college degree attainment (such as Connecticut, Massachusetts, New York, and Minnesota) are leaders in private income growth while those with low degree attainment (Ohio, Michigan, Indiana) rank low in this measure of prosperity. It should also be noted that states with low taxes tend rank low in private income growth, apparently because they fail to invest adequately in higher education. (Glazer, 2010) Hence it is reasonable to conclude that higher education trumps tax policy in driving prosperity in the knowledge economy.

The Midwest region's system of higher education has long been regarded as one of the nation's best. Yet today cracks in the region's higher education capacity are beginning to appear. Although the Midwest's flagship universities and independent colleges have high graduation rates (80% and above), the rest of region's higher education enterprise–community colleges, regional universities, for profit colleges– graduate fewer than 50% of their students, corresponding to roughly one million students who will enter college each year only to fail to graduate.

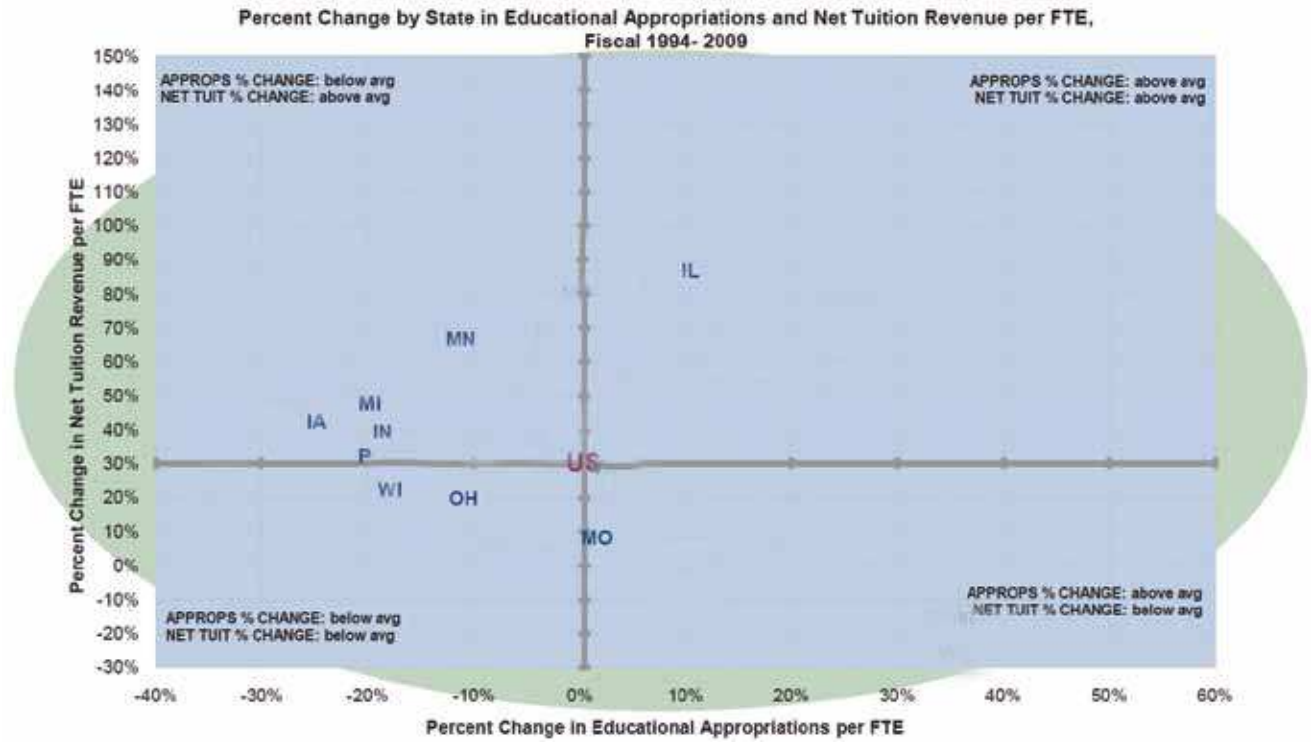
Furthermore, there are increasing signs that leaders of state governments still do not recognize the importance of their public colleges and universities as a strategic investment, either in the magnitude or the nature of the deployment of public funding relative to other states. The Midwest states today spend an average of $5,700 a year on a public university student, significantly below the national average of $6,900 and a statewide average of $7,300 for each K-12 student (SHEEO, 2009). But even more disturbing is that after a massive prison building boom in the 1980s, today the Midwest spends almost 30% more on locking people up (corresponding to $40,000 per inmate) than it does on educating them in our public colleges and universities, a truly tragic statement of the region's priorities. As yet another example of short-sighted thinking by state governments, although the federal government provided $53.6 billion in FY2010 to stabilize state and local funding of critical public services such as education during the recent "Great Recession", most Midwestern states (including Illinois, Michigan, Wisconsin, Indiana, and Missouri) chose to spend less than 10% of these Educational Stabilization Funds on higher education. (Lingenfelter, 2009)

State	FY2004	FY2008	FY2009
Illinois	$7,450	$7,393	$7,777
Wisconsin	$6,637	$6,443	$6,534
Minnesota	$6,064	$6,445	$6,161
Missouri	$6,421	$5,923	$6,084
Iowa	$5,464	$5,847	$5,905
Michigan	$6,167	$5,521	$5,365
Ohio	$5,068	$4,708	$4,858
Indiana	$5,129	$4,814	$4,752
US	$6,881	$7,220	$6,931

State support of higher education (per student) in the Midwest has now dropped below the US average.

State support of higher education on a per student basis has been declining in Midwest states for over two decades. Despite this erosion of state support, public universities have strained to hold tuition increases in check. In fact, when financial aid and inflation are included, the net tuition levels for public higher education in the region have actually declined over the past decade (McPherson, 2010). But with the recent massive cuts to public higher education in the wake of the damage to state budgets by the recession, public universities have had no choice but to begin to raise tuition levels at double-digit rates. Perhaps indicative of the region's myopia concerning education, governors and state legislators continue to blast these tuition increases, pandering to the fears of students and parents, even as state government plans to cut higher education still further. Since state support is the key to enabling leading public research universities to enroll students from impoverished backgrounds, the erosion of state support and consequent increase in tuition has seriously degraded the capacity of these institutions to serve low income students (e.g., as measured by the declining percentage of Pell Grant students they enroll). (Haycock, 2010)

Today there are increasing signs that both the quality and capacity of Midwest's public universities are 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. Student-to-faculty ratios and workloads have been increasing, eroding not only the quality of



Most Midwest states are moving into the low state support high tuition regions of the scatter chart. (SHEEO, 2009)

classroom instruction but also constraining research university faculty from conducting the research critical to economic development in a knowledge economy increasingly 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. Further erosion has occurred in the value of pension plans, medical benefits, life insurance, housing, and other benefits key to faculty recruiting and retention.

Many four-year colleges and universities will face serious challenges from the anticipated decline in college-age students characterizing the Midwest region over the next two decades. While the increased higher education needs of adults in the workplace may balance the demand for higher education, much of this is likely to benefit more community colleges and for-profit institutions that are more experienced and efficient in adult education. The flagship public research universities are likely to compensate for the regional decline in college-age students by using their brand names to aggressively recruit more out-of-state and international students–likely charging them tuition at private levels to compensate for eroding state support. However, independent colleges and regional public universities could well find themselves with declining enrollments that threaten their very existence.

Despite the growing importance of the research and advanced degrees (science, engineering, medicine, etc.) provided by the region's flagship public research universities, these too have experienced serious erosion in state support over the past two decades, now comprising less than 20% of their total operating budget. In fact the University of Michigan's state appropriation in 2010 has declined to less than 11% of its academic budget and 6% of its total budget, relegating the state to the position of the smallest minority stakeholder in the institution. Today most of the major public research universities in the Midwest are being forced by declining state support into following Michigan's evolution into "privately-funded but publicly-committed" universities.

To compound these challenges, several state governments continue to threaten the autonomy of their

public universities by attempting to micromanage admission policies, curriculum, facilities funding, and personnel policies. Particularly insidious has been the impact of recent statewide referenda that now prohibit policies such as affirmative action critical to the ability of the region's universities to serve its increasingly diverse population.

Little wonder that after the cavalier treatment higher education has received from state leaders over the past two decades, university governing boards with fiduciary responsibility for the welfare of the Midwest's public universities have begun to lose confidence in state government as a reliable partner in providing adequate support for this critical state 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 seeking more institutional autonomy to give them control over decisions such as admissions, tuition and fees, faculty and staff compensation, procurement, and other areas sometimes micromanaged by state government.

The logical although disappointing conclusion we can draw from these statistics is that the Midwest region needs and deserves a higher education system that is much better than state government is apparently willing to pay for! So, what to do? Should the region simply allow the myopia and partisan politics of state government to drive down–and perhaps permanently damage–the quality of its public colleges and universities, a legacy established earlier through the commitments of past generations of the region's citizens? Or should it instead challenge the governing boards of our colleges and universities to accept their fiduciary responsibilities, constitutional autonomy, and accountability for tomorrow by taking those actions necessary to preserve these critical institutions for future generations? That may be the choice before us, but we must make it before it is too late.

The Production of New Knowledge: Research and Innovation

New jobs in the Midwest are not going to be spawned by existing industry but instead will be created by entirely new activities, e.g., biotechnology, information technology and computer networking, lasers and ultra-high-speed technology, and an array of knowledge-intensive services such as systems integration and software development. These new jobs will be created by innovation based on research and development. They will require post-graduate education at the master's and doctorate level. They will be created by the new companies spawned by the entrepreneurial efforts of graduates of the region's universities.

A recent study by the National Governors Association finds a growing awareness of these imperatives: "Governors realize that investments in research and development can spur not only new ideas, new products and new technologies, but can increase a state's talent pool, economic bottom line and its success in national and global markets. Innovation can't be left to chance–every state needs a clear strategy for success that applies lessons learned from their peers and from abroad" (NGA, 2007). The study found that the most successful state strategies rely heavily on their core assets: their research universities and their proximity to industries.

From this perspective, it is clear that the most powerful economic engines in the Midwest are likely to be its world-class research universities. Research universities produce all three of the key ingredients in technology-based economic development: technological innovation, technical manpower, and entrepreneurs. Through their on-campus research, they generate the creativity and ideas necessary for innovation. Through their faculty efforts, they attract the necessary "risk capital" through massive federal R&D support (currently in excess of $8 billion/year for the Midwest's research universities). Through their education programs they produce the scientists, engineers, and entrepreneurs to implement new knowledge. They are also the key agent of knowledge transfer, both through traditional mechanisms, such as graduates and publications, and through more direct contributions such as faculty/staff entrepreneurs, the formation of start-up companies, strategic partnerships, and so on.

There is ample evidence to support the impact of world-class research universities. One need only look at MIT's impact on the Boston area, Stanford and UC-Berkeley's impact on Northern California, Caltech, UCLA, and USC's impact on Southern California, and the University of Texas's impact on Austin. These

successful examples offer an important lesson. Only world-class research universities are capable of major impact through technology-driven economic development. A university must be able to play in the big leagues, to compete head-to-head with institutions such as MIT, Stanford, and Berkeley–as well as Beijing's Tsinghua University, France's Ecole Polytechnic, Germany's Max Planck Institutes, and India's Institutes of Technology–if it is to attract the outstanding faculty and students and massive resources necessary for technological leadership.

Fortunately, today the Midwest has one of the most formidable concentrations of research universities in the world, with considerable activity in research and graduate education, that could serve as the source of new knowledge, innovation, and entrepreneurs necessary to act as powerful job creation machines. Unlike many other economic regions that must create world-class research universities, the Midwest region needs only to support its existing concentration of such institutions adequately.

Yet there are several particular caveats. The first concerns the imbalance in R&D investments in the region. In decades past, largely because of the great prosperity of region's manufacturing industry, the Congressional delegations from Midwestern states had relatively little incentive to go after large federal investments in R&D sought by other regions such as the southeast and west coast, preferring instead to give priority to protecting the region's traditional manufacturing industries from intrusive federal regulation. Hence the massive federal investments in R&D facilities stimulated by the Cold War flowed to other states such as California and Texas, leaving the Great Lakes states ranked at the bottom of the nation both in return of federal tax dollars and in federal R&D. In fact, although the Midwest contains 17% of the nation's population and conducts 24% of its industrial R&D, it current receives only 7% of federal R&D funding. To some degree the Midwest has been able to compensate for this lack of federal support and support its technology-dependent industrial base through the development of world-class research universities in the world. Yet, as we have noted, today this critical resource of publicly funded research universities is at some risk as Midwestern states struggle to fund legacy costs such as corrections and unfunded federal mandates such as Medicaid with the declining tax revenues generated by weakening industrial and agricultural economies.

Second, it is important to recognize that while research and scholarship are appropriate activities for all universities, in truth states can afford only a limited number of world-class research universities capable of competing for the very best students, faculty, and public and private support. David Ward, former chancellor of the University of Wisconsin and a distinguished geographer by discipline, estimates that it takes the tax base provided by a population of 5 million to support a single public research university of world-class quality, perhaps best measured by membership in the Association of American Universities (AAU). This rule of thumb appears to work in most states–and most nations–e.g., Wisconsin with its one AAU-class university in Madison; Michigan, with its two AAU campuses in Ann Arbor and East Lansing; and California with the six AAU campuses of the University of California. There is ample evidence that political attempts to feed ambitious institutional aspirations fueling mission creep of community colleges to four-year universities, baccalaureate institutions to add graduate programs, and regional universities to become national research universities not only are doomed to failure, but this effort also tend to create a leveling effect in which all institutions are pushed toward a least common denominator of quality.

Third, it is important to deploy public resources in both a visionary and effective manner. For example, during the 1990s the state of Michigan proposed to use a portion of its tobacco-settlement funds to establish a Life Sciences Corridor, which was promoted as "a billion-dollar investment" in life sciences research. In reality, however, the $30 million/year allocated annually for this purpose was modest in scope compared with both federally funded research in Michigan universities in biomedical research (currently over $1 billion/year annually). Further, it fell considerably short of the investments that other states were making in R&D activities at their research universities, e.g., California's commitment of $300/year million to build several major research centers on its university campuses or the successful referendum to commit $3 billion over the next ten years for stem cell research.

In sharp contrast, the University Research Corridor subsequently established not by state government but rather through the collaboration of Michigan State University, Wayne State University, and the University of Michigan is estimated to have created over 68,000 jobs in 2008 while contributing $12.8 billion/year to the state's economy (Sallee, 2008). Indeed, from this perspective, state government's effort to balance the state budget by cutting higher education is foolish in the extreme, since it is threatening the research capacity of these institutions and hence the geese that lay the golden eggs!

Public Policy Issues at the State Level

A key objective of any policy discussion at the state level is to shift the public conversation away from distracting issues such as Balkanized state politics, culture wars, and bitterly partisan battles to focus instead on the imperatives of a knowledge economy: lifelong learning, research and innovation, and knowledge-age infrastructure. Here our message is deceptively clear:

1. Knowledge and innovation are the drivers of the global economy today and tomorrow.

2. The key inputs to knowledge and innovation are lifelong learning (human capital), new knowledge creation (R&D, innovation), and the infrastructure that supports these two (schools, colleges, research centers, cyberinfrastructure).

3. Public policy and public investment at the regional level are critical in developing and sustaining each of these three capacities. The states and regions that understand this imperative and do it best will be best positioned to succeed in the future. Those that fail will become economic backwaters.

Since public commitments and government action are the longer-term key, it is important to lay out a possible agenda for state leaders, the more specific the better. It is important that state policy makers begin to consider new financing and governance issues within the context of future state needs and priorities rather than past political party ideologies.

Most important, state governments have to begin by getting its fundamental responsibilities aligned with the needs of a knowledge economy:

1. Empowering families, students, and workers with the responsibility and the resources to access lifelong learning opportunities that they determine will be best for themselves, including early childhood, K-12, postsecondary, and continuing education.

2. Providing the infrastructure and the investments necessary to attract federal and private research funding and stimulate innovation and entrepreneurial activities.

3. Developing a tax structure that provides "equitable, predictable, and durable funding of education, research, and innovation" critical to a knowledge economy.

To be sure, many of the challenges driving the tsunami now engulfing the Midwest–globalization, demographic change, a knowledge-driven economy, and ruthlessly competitive markets–are simply the imperatives of a new age. Yet perhaps the greatest and most threatening gap between the trauma and tragedy of the Midwest today and the promise of what it might become tomorrow is unique to our states: the absolute vacuum of leadership we are currently experiencing.

Clearly many of the policy issues reflected in our analysis are closely related to important challenges in state capitals across the Midwest. These include an unwillingness to provide adequate leadership in addressing the issues (e.g., tax and expenditure restructuring) necessary to allow sufficient investment in the future, overly constraining the ability of educational institutions to take actions necessary to cope with an increasingly competitive marketplace (e.g., eliminating affirmative action and bans on stem cell research), and apparently an almost total lack of understanding of the realities and role of education and innovation in a knowledge society. Meanwhile, most of the region's private sector leadership and media have been sitting on the sidelines, largely silent if not oblivious to the key challenges facing the Midwest region.

Related to these issues is the increasing irrelevance

of the region's political parties to the realities of our present and the challenges for the future. Both are largely trapped in the past, driven by the desire to protect old sacred cows (e.g., big business, big labor, big government, and wealthy campaign contributors) or by "value-morality" ideologies (abortion, gay rights, stem cell research, creationism) that are distracting public leaders and public attention from what really matters in a 21st-century global economy. As Midwestern economies crash to the bottom among the states, our elected public leaders continue to back into the future, clinging to the practices and expectations of an obsolete past, instead of facing up to the actions, commitments, and sacrifices that will be necessary to rebuild the Midwest's strength and prosperity in a radically different future.

Particularly serious is the need to restructure obsolete tax systems, designed for a 1950s factory-based manufacturing economy rather than a 21st-century knowledge economy, and restore both integrity and responsibility to the state budget process. To be sure, a weak economy coupled with the burden of unfunded federal mandates has destabilized the budget process in many states. 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).

Yet the Midwestern states' budget problems are largely self-inflicted: the result of tax cuts without corresponding spending cuts, failure to confront overdue government and structural reforms, a pattern of using one-time funds to handle real structural deficits, and the extreme stress placed on the state's manufacturing industry–particularly the automobile industry. Study after study has addressed the misconception that Midwestern states are high-tax states, demonstrating instead that our tax burden both for citizens and business has now declined below the national average, although some would prefer that it crash to the bottom along with states such as Mississippi and Alabama (notably those planning to retire in Florida, leaving behind their children to endure the consequences of the resulting erosion of the state's intellectual, social, and civic infrastructure) (Rothwell, 2010).

Strategic actions by state governments have largely been thwarted by lobbyists and political ideologies moored to the past, resulting in spending cuts of critical services, the use of one-time resources used as Band-Aids to cover the fundamental imbalance between tax revenues and growing expenditures such as corrections and public employee benefits. During the 1980s, Midwestern states launched massive prison construction programs, in response both to ill-considered mandatory sentencing laws and pandering to public concern about crime. As a result, state spending on prisons in the region surpassed that for higher education in the early 1990s and today has become one of the largest uncontrolled mandates for state tax dollars. Moreover, strong political pressure from unions has dissuaded state leaders from taking strong action to restructure public employee benefits (both state employees and teachers) to levels more comparable to those of the nation. In several Midwestern states school finance reform effort of the 1990s created K-12 education as yet another funding mandate, which along with Medicaid and prisons, leaves little for higher education, which is still treated as a discretionary budget item. (Kane, 2003) As a consequence, over the last several years, no state activity has been cut as much as the funding for public higher education–a glaring sign of the lack of strategic vision on the part of state leaders.

The structural deficiencies in state budgets were compounded during the 1990s. During a period of relative prosperity that should have provided state government with the opportunity to restructure antiquated tax systems and begin to invest in the future by restoring funding for key priorities such as higher education and infrastructure, many states decided instead to cut their tax rates. This created permanent budget deficits that become worse each year as the Midwest's foundering economy continues to weaken, while an aging population and a growing population of uninsured, coupled with the rapid increases in health care costs, drive Medicaid burdens into the stratosphere.

Today many Midwestern states find themselves simply unable to meet both their obligations for the present (e.g., Medicaid, corrections, K-12 education, public

employee benefits) while investing adequately in their future (e.g., higher education, research and innovation, knowledge infrastructure). State governments, increasingly manipulated by special interests and subject to the narrow agendas of political parties, have been unable to restructure an obsolete tax system, designed for a factory-based industrial economy that is no longer dominant in our state. Even today most of the region's economic activity involves knowledge-intensive services–e.g., financial services, health services, and professional services such as law and management, generating revenue that is not included in the tax base. All too frequently both state and local governments tend to use tax abatements to bail out or attract traditional industries rather than investing in the new knowledge-driven businesses capable of competing in tomorrow's global economy.

From a more cynical viewpoint, there is absolutely no evidence whatsoever that cutting state taxes has a positive economic impact–although to be sure in the current anti-tax climate, it may generate votes. What is certain, however, is that cutting investments in education, innovation, and knowledge infrastructure is crippling in a knowledge economy. As Bill Gates stresses, "The IT and biotech industries are far more sensitive to quality of talent than incentives. California is No. 1 not because they have the most friendly tax policies there. If you're coming up with a breakthrough in medicine, it doesn't matter if you're paying a little more in taxes" (Gates, 2005).

While any discussion of the "t" word is usually banned in state capitals, it has become increasingly clear that without a major restructuring of state tax policy and public expenditures, the Midwest will simply be unable to balance the obligations created by mandates for state funding with the necessary investments in its future. Future generations will bear the burden of our indecision and myopia.

Public Attitudes: Half Right (Essentially) and Half Wrong (Terribly!)

Despite the actions of state governments, special-interest-driven referenda, and political ideologies, public surveys reveal a far more enlightened perspective on the part of the electorate with respect to investing in the state's future. In recent surveys over 80% of citizens express a serious loss of confidence in the leaders of state government. Midwest voters believe that the region's public universities are critical to its economy, providing job training, economic development, and research that will determine the state's future prosperity.

While families value higher education for the educational opportunities the Midwest's colleges and universities provide to their sons and daughters, in today's highly competitive global economy, the public values our universities even more because of their capacity to create new jobs and stimulate the economy. Recent polling suggests that members of the public may be far ahead of our political leaders in sensing that the primary role of higher education in our state has become job creation rather than simply providing a place to send the kids. They understand, like most economists, that the real cure to globalization, outsourcing, off-shoring, and technological change is the availability of advanced educational opportunities. Despite the rhetoric of state leaders, higher tuition levels are not really a major concern of the public, who understand that as state support erodes, higher tuition levels are inevitable if quality is to be sustained. And they accept that quality and access are the highest priorities at this point in the state's history–not bargain-basement prices for bargain-basement quality.

The Writing on the Wall

Clearly any candid appraisal of the Midwest's current situation does not inspire confidence that the region is headed in the right direction. Our under investment in advanced education, research, and innovation, coupled with short-sighted public policies and corporate strategies that further constrain efforts to build a high-skill workforce and generate the research, innovation, and entrepreneurial zeal necessary to achieve a knowledge economy, should be a matter of great concern to state leaders. The keys to economic growth in a global, knowledge-driven economy are a world-class workforce and a knowledge infrastructure capable of stimulating innovation. These are the assets that will save the Midwest region from becoming a backwater economy, providing a point of liftoff from which we can create new markets, processes, and skills.

Learning and knowledge generation are becoming powerful political forces throughout our nation and around the world, as competitiveness in a global, knowledge-driven economy depends increasingly on a highly educated workforce, new knowledge, and innovative products and services. Just as the space race of the 1960s stimulated major investments in research and education, there are early signs that the skills and innovation race of the 21st Century may soon be recognized as the dominant policy of our times. But there is an important difference here. The space race galvanized public concern and concentrated national attention on educating "the best and brightest," the elite of our society. The skills race of the 21st Century will value instead the skills and knowledge, the innovation, and the capacity for adapting to change of our entire workforce as a key to economic prosperity, security, and social well being.

The Midwest must restore an adequate balance between addressing the priorities of an aging population and investing in the future through education. The challenge to leaders is to develop visionary policies, outstanding institutions, and world-class infrastructure that will produce the knowledge workers, the educated professionals, the new knowledge, and the innovation necessary to build and attract new knowledge-based industries capable of driving future economic growth.

A Roadmap to the Midwest's Future

We now turn to the final phase of the roadmapping process by constructing a roadmap for the Midwest region. This is designed as an organic and evolving plan to suggest paths the region might take to transform itself from the deteriorating industrial and agricultural economy of today to a vibrant, knowledge-driven economy of tomorrow, capable of competing in a global economy and providing our citizens with prosperity, social well-being, and security. The key themes that augment the national agenda include the importance of regional integration (through coordination, mobility, and technology), the globalization of higher education, the educational paradigm shifts required by a knowledge economy, and the role that its flagship research universities can play in both envisioning and creating the future of the region.

We begin with a simple premise: *the key to the Midwest's future lies with its people, with their skills, character, creativity, innovation, and entrepreneurial spirit*. The quality and diversity of our workforce must become our greatest asset. In the past the Midwest has exploited its vast natural wealth–its forests, minerals, lakes, and location–to achieve economic strength and global leadership. But this was possible largely because of the pioneering spirit, gritty courage, and self-reliance of the people who have been attracted to the state by these assets. It was our people who made our farms and factories the best in the world. Over generations we have learned that if we believe and invest in our citizens and those who come to the Midwest–in their education, health, and social well-being–it is our people who will keep us at the forefront of innovation, productivity, and trade.

Hence in the regional roadmap we have stressed setting and achieving higher goals in K-12 education and higher education, restoring adequate public investments in the region's schools, colleges, and universities, and facilitating the technology transfer and high-tech business startups aimed at creating the new industries that will eventually replace the Midwest's declining factory-based manufacturing industries. However even in the near term bold steps to begin to build the necessary knowledge-based workforce are both imperative and appropriate, although it will take time to achieve the necessary progress. Investing in building the necessary infrastructure will also be essential to support and sustain both innovation and workforce development. The challenge will be to provide world-class opportunities for lifelong education, training, and cultural enrichment to all of the region's citizens while demanding, achieving, and sustaining the region's educational institutions at the very highest level of excellence, efficiency, and accountability.

For the longer term, there can be no more compelling priority with a higher rate of return than am investment in our people through both public and private support of educational opportunities at all levels and throughout their lives. The Midwest must build and sustain a culture of learning and innovation. This must span the full range of educational opportunities, from pre-school to K-12 to higher education, to graduate and professional education, to lifelong learning. It must augment this with further public and private

investments in institutions capable of generating new knowledge through R&D and then transferring this into innovative products, processes, and services in the global marketplace.

To be sure, this will be challenging, since it will demand substantial new investments, both in individuals (e.g., financial aid, vouchers) and institutions (appropriations, tuition, and philanthropy), that will almost certainly require new tax revenues. It will also require both the public and private sector to address those legacy costs (e.g., corrections, health care, retirement) that have become excessive and clearly out of line with the best practices of leading economies elsewhere. It will demand new standards for excellence and accountability for institutions, students, and families. It must both encourage and demand that our educational institutions embrace the new paradigms for learning, knowledge creation, innovation, and entrepreneurism that are characterized by the world-class quality, ability, and accountability necessary to compete in the global economy. And it will require a restoration of the Midwest's historic commitment to rebuilding the social safety net for those caught in the inevitable maelstrom associated with the creative destruction of the global economy as new industries appear to replace the old.

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. The urgency of each recommendation has been suggested by assigning to each a timescale of *now* (within months), *soon* (a few years), and *eventually* (a decade hence).

The Regional Roadmap

Regional to National to Global: 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!)

Competition to Collaboration: 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!)

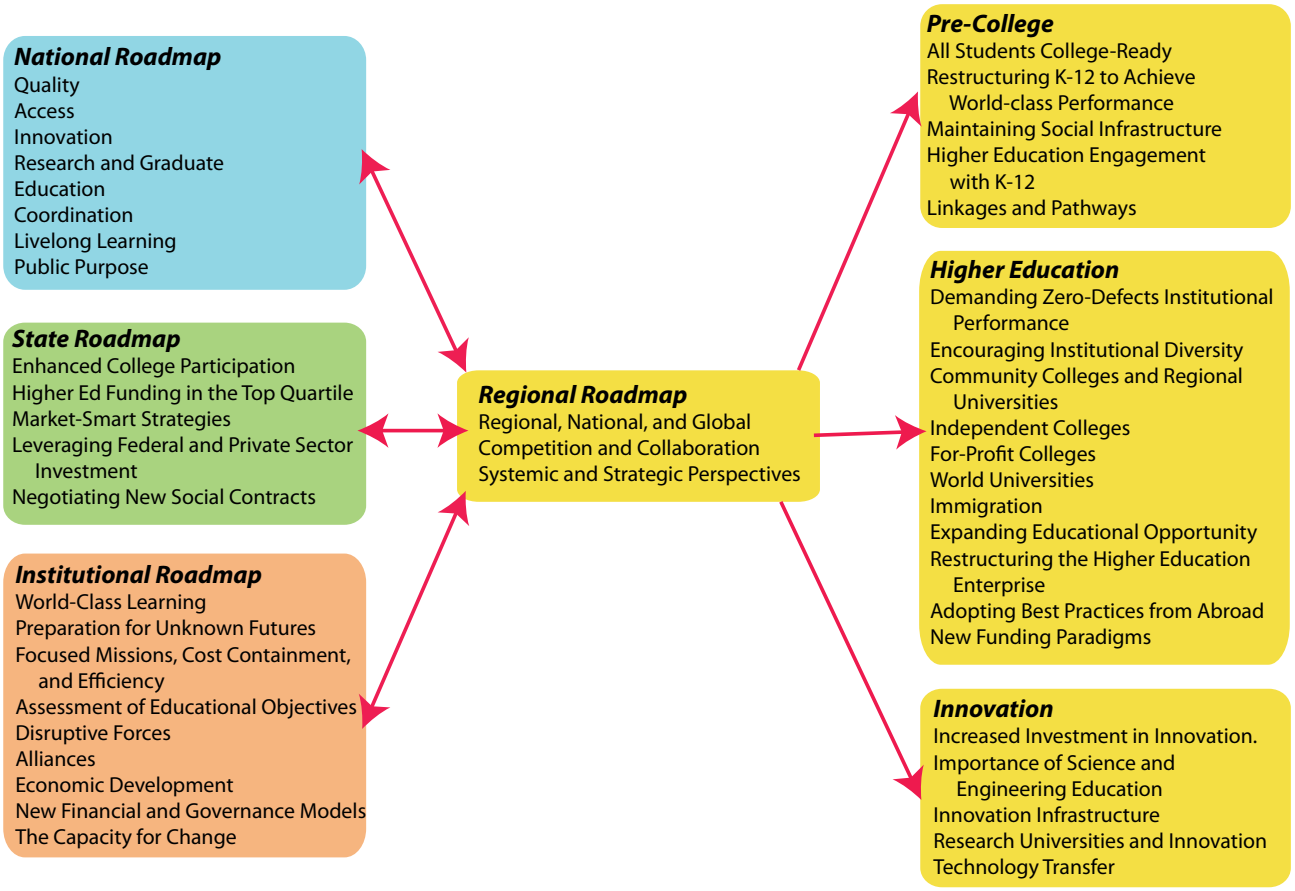
System and Strategic Perspectives: The Midwest needs to develop a more systemic and strategic perspective of its educational, research, and cultural institutions–both public and private, formal and informal–that views these knowledge resources as comprising *a knowledge ecology* that must be adequately 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!)

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 fami-



Various Levels of a Midwest Roadmap

lies 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 counseling support but as well strong incentives and disincen-

tives 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!)

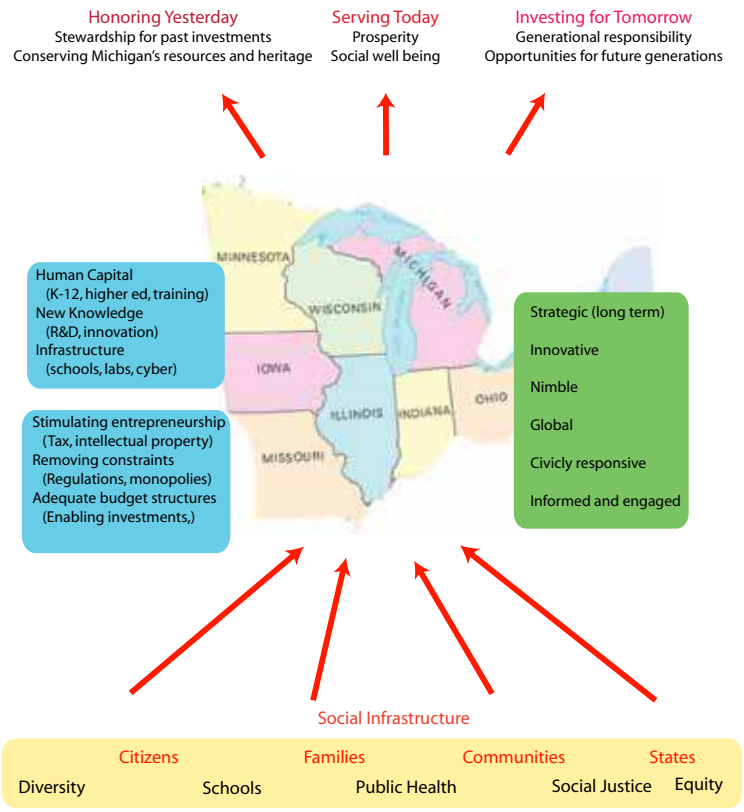
Innovation Infrastructure: Providing the educational opportunities and new knowledge necessary to compete in a global, knowledge-driven economy requires an advanced infrastructure: educational and research institutions, physical infrastructure such as laboratories and cyberinfrastructure such as broadband 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 par-



A strategic roadmap to the Midwest's future

ticipation 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 educational 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 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. (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 edu-

cation 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.

The Last Mile (Or the First?)

While some may continue to debate, to suggest that the status quo will remain intact, to others the choice has become clear. We can either accept the risks and the uncertainties of attempting to transform the higher education enterprise to serve a society with new needs and new imperatives. Or we can wait for the market to reshape our institutions, perhaps even relegating them to a backwater role in the emerging global knowledge industry. Clearly embracing the status quo, treading water, also has very real risks. After all, there are many commercial sharks swimming just below the surface.

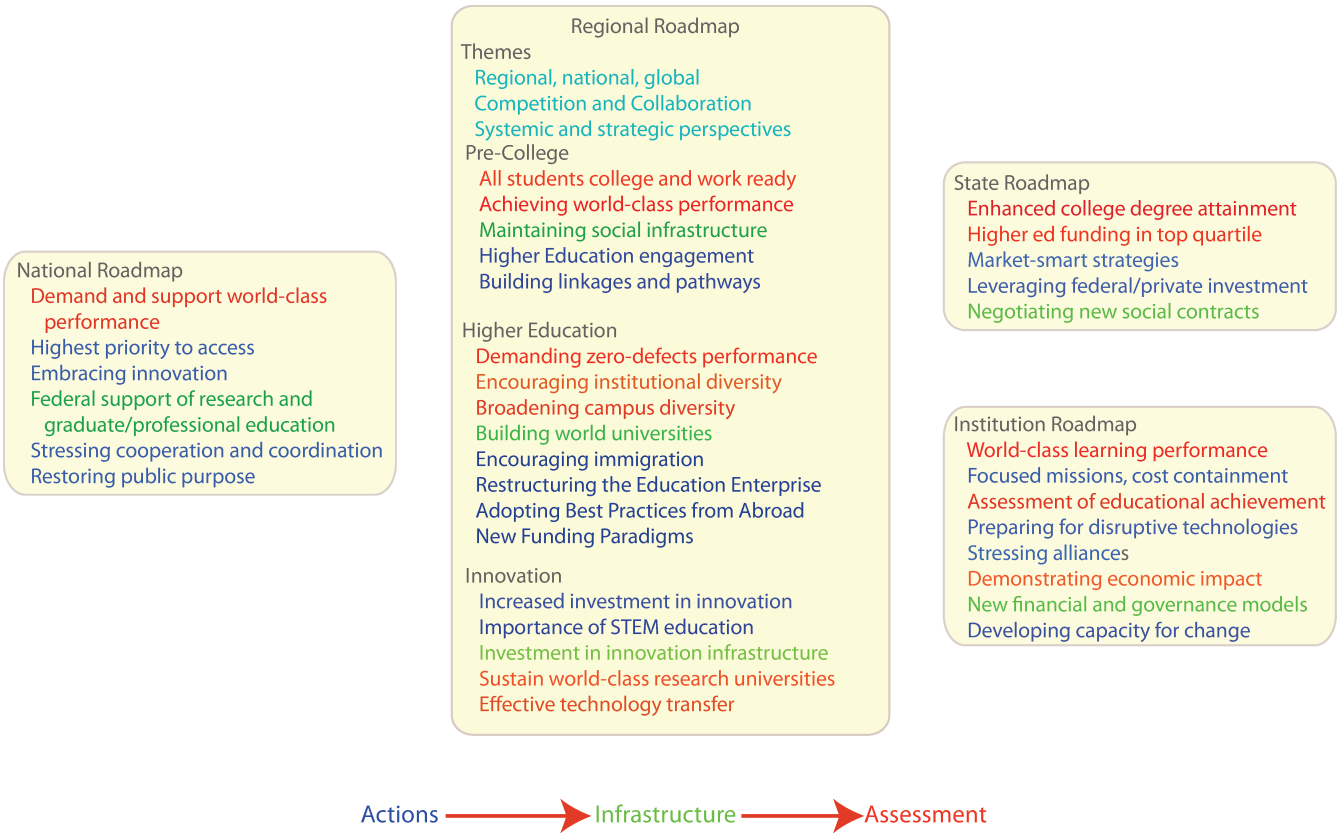
The learners of our future society will demand that their educational experiences prepare them for a lifetime of learning opportunities, fused both with work and with life. They will seek just-in-time and just-for-you learning through networked organizations. They will seek the integration of timeless and timely knowledge.

The systems of higher education that emerge in the decade ahead will almost certainly be far different from today's paradigms. Higher education will either transform itself or be transformed as financial imperatives, changing societal demands, emerging technologies, and new competitors reshape the knowledge enterprise, changing in the process how colleges and universities organize and deliver learning opportunities as well as how they structure and manage their activities (Duderstadt, 2007).

A Process

History has demonstrated the difficulty of achieving structural, functional, and cultural shifts requiring major resource investments and reallocations and funding policy reforms. To ensure funding and implementation, leaders at the state, local, and institution level will likely need to own these reform plans and platforms, and they will need to be instrumental in their design. However they will also need to be advised, encouraged, and possibly even pressured by broader leadership groups.

One of the important components of this effort involves the identification of key policy issues, appropriate for the consideration of leaders in the public and private sectors. Examples might include the provision



A classification of roadmap elements into specific actions, infrastructure investments, and measureable goals.

of community-based extracurricular learning opportunities in underserved communities (perhaps based on evolving technologies such as knowledge networks), better coordination of existing educational resources (K-12, higher education, industrial training, community learning centers), and state government responsibility for providing or stimulating the digital infrastructure necessary to build a 21st Century learning environment. Related to this would be an analysis of necessary investments from both the public and private sector.

Here the first step is to engage the attention and commitment of Midwest leaders from the various sectors of society, e.g., business and industry, state and local governments, higher education, foundations, and the media. The region's research universities might serve as a brain trust, perhaps working closely with other organizations such as the Brookings Institution, to join together to develop a detailed analysis of the economic and social challenges faced by our region as it grapples with the imperatives of a global, knowledge-driven economy, much as we have tried to do through the Midwest Roadmap. The media will play an important role in this effort by raising public awareness of just how much at risk our states will be if they remain trapped in the low-skill industrial economy while the rest of our world evolves into a knowledge economy.

Second, we need to form organizations to link together the leadership of various sectors. This might be a multi-state version of the government-university-industry roundtable groups that exist in other states such as California or at the national level through the National Academies. A coalition of the Federal Reserve Banks (Chicago, Cleveland, Minneapolis) could host such activities. Existing higher education organizations spanning the Midwest region such as the Midwestern Higher Education Compact and the Great Lakes College Association should play key roles in linking colleges and university to such leadership groups.

Third, someone is going to have to bankroll the early work to form these groups, perform the necessary analysis, and develop the roadmap to our future. Here our region is fortunate to have a number of important

and influential foundations, e.g., MacArthur, Spencer, Kellogg, Mott, Lumina, Lilly, and others that have invested in the welfare of our states in the past, and that could join together in investing in just such a multistate effort for the future.

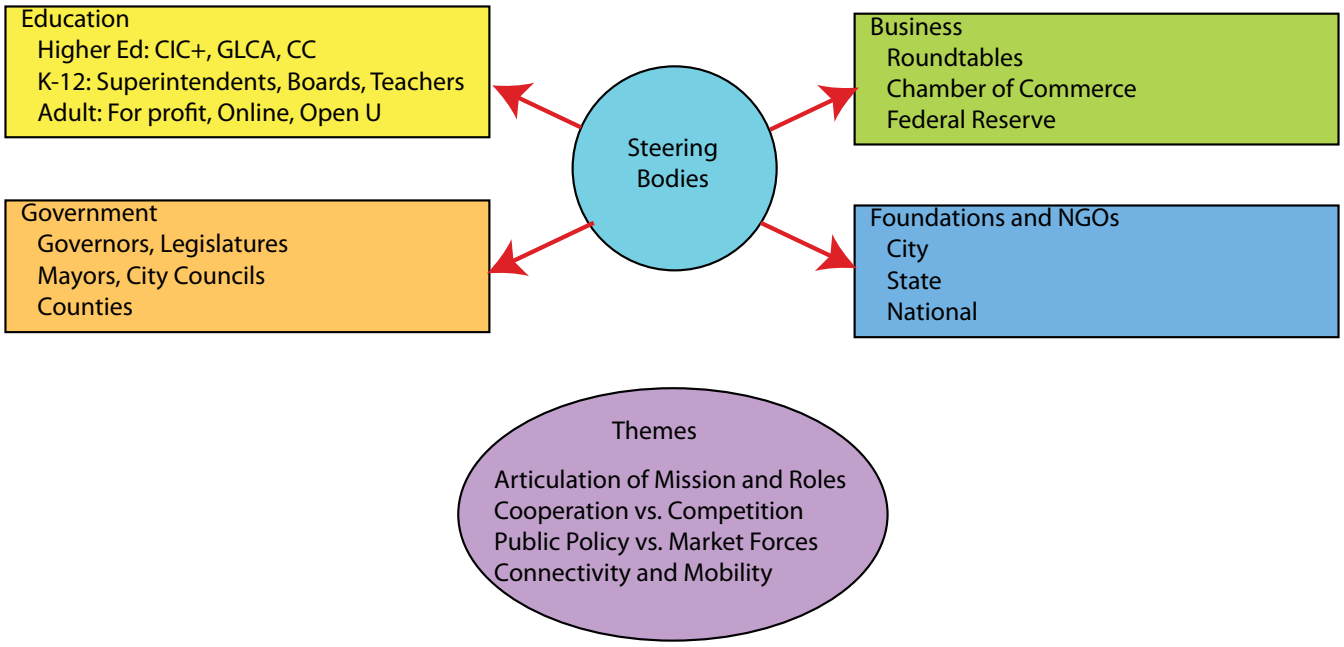
Fourth, there would need to be a broader roadmapping effort within each sector. For example, both state and local governments need to do a better job in identifying and sharing information on best practices, both to provide new ideas to a political system all too frequently backing into the future, and perhaps to provide a political umbrella for the necessary action. Leaders of business and industry–and of course, their shareholders and the investment community–need to look beyond quarterly earnings and consider the longer-term impact of workforce quality, R&D and innovation, and regional prosperity on their future–indeed, their very survival, in the flat world of the knowledge economy.

Key in any such effort is to build a network linking leaders in the public and private sector. Clearly this network would need to be involved in the development of the vision and the plan to gain participation and commitment. Elements of this leadership network would include: K-12 education, higher education, industry, labor, foundations, community leaders, state government, federal government, and media. One might begin by establishing a standing leadership task force, with sufficient authority, resources, and longevity to propose and achieve the necessary strategic policy and fiscal shifts.

The membership of the task force might consist of leaders from both the public and private sector of the Midwest. Unlike other short-term studies, the task force would remain in existence for at least a decade to oversee the development, implementation, and success of the transformation agenda. It would be charged with sustaining continued interaction with key stakeholders, including college and university presidents, governing boards, and campus communities; local, state, and perhaps federal government leaders; the private sector (business, corporate, foundation); and the public. It is crucial to stress here the importance of leadership at the level of the governors, demonstrated through action and reflecting in budget requests and policy statements an understanding of the importance of quality, access, performance, and market flexibility in higher education–priorities that have been woefully absent for several decades. Although such planning activities are not unusual at the state level (e.g., ranging from the California Master Plan of the 1950s to the various K-12 planning efforts stimulated by groups such as the Business Roundtable in recent years), this proposed effort would be distinguished both by its regional character and by an unusually broad vision of a society of learning characterized by pervasive educational opportunities for all citizens.

Key organizations for coordinating the Midwest Roadmap project

Today a major expansion of educational opportunity could have an extraordinary impact on the future of the heartland of America. It is time to take bold action by providing all of our citizens with universal access to lifelong learning opportunities, thereby enabling participation in the world's most advanced knowledge and learning society. The towns, cities, and states of the Midwest should accept a responsibility to enable all of their 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.



A possible steering framework

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Chapter 5

A Roadmap to the Future of American Higher Education

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.

During past eras of challenge and change, our national leaders have acted decisively to enable universities to enhance American prosperity and security. While America 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 America 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.

During the years following the Great Depression and World War II, the United States launched a massive effort to provide educational opportunities to all Americans. Returning veterans funded through the GI Bill (Serviceman's Readjustment Act of 1944) tripled college enrollments. The post-WWII research strategy developed by Vannevar Bush transformed our campuses into research universities responsible for most of the nation's basic research (Bush, 1945). The Truman Commission proposed that all Americans should have the opportunity of a college education (Thelin, 2004), and California responded with its Master Plan, which not only provided all Californians with the opportunity of at least a community college education, but simultaneously created the University of California system, perhaps today the leading research university system in the world (Douglass, 2000).

America benefited greatly from these visionary investments in the future aimed at providing both the educational opportunity and new knowledge necessary for economic prosperity, social well-being, and national security. Our nation saw spectacular achievements, such as sending men to the Moon, decoding the human genome, and, of course, creating the Internet and the digital age. Over the past half century, our nation, and, indeed, the world, have benefited greatly from the extraordinary commitments of our parents, the "Greatest Generation", to educational opportunity and the sup-

port of university research.

The results of this federal-state-industry-university partnership have had great impact on our nation's economy, health, and other national achievements. Talented graduates of these institutions have created and populated many new businesses that go on to employ millions of Americans.

In addition to their high productivity, the exceptional stature of American research universities globally can be measured in several additional ways. In global rankings, U.S. research universities typically account for 35 to 40 of the top 50 such institutions in the world. Since the 1930s, roughly 60 percent of Nobel Prizes have been awarded to scholars at American institutions. More international students enroll in U.S. research universities than their counterparts elsewhere.

Yet, today, much of this earlier commitment to investment in education and research seems to have waned. Not only the quality of our primary and secondary education, but also the skills of our workforce, lag many other nations. Over the past decade, government support of our public universities has dropped by roughly 35%, putting leading research universities such as U. California, U. Wisconsin, and U. Michigan at risk (Holliday, 2012). After a brief surge during the late 1990s with the doubling of the budget of the National Institutes of Health, both federal and corporate support of basic and applied research have fallen significantly, while fields such as the social sciences have been savaged by conservative political forces. And perhaps most telling of all, the inequities characterizing educational opportunity in America have become extraordinary. (Haycock, 2010) The unfortunate reality facing young students today can be summarized by observing, "If you are poor and smart, you have only a one-in-ten chance of obtaining a college degree. In contrast, if you are dumb and rich, your odds rise to nine-in-ten!" (Vest, 2005)

More fundamentally, an extraordinary shift has occurred in the public perception of the purpose of American higher education over the past half century. In early decades following World War II, higher education was viewed primarily as a public good because of the critical role it played by an educated population and the knowledge generated on our campuses in determining the welfare of our nation merited strong support from public tax revenues. Today, our nation seems to no longer understand that the support of educational opportunity and campus-based research represents investments in the future, not burdensome expenditures from public resources. Instead, most Americans view a college education primarily as a private benefit, which enables students to compete for high-paying jobs, as evidenced in part by the rapidly increasing income differential between those with and without a college degree. Hence, it is not surprising that public policy has shifted to view a college education as something that students should pay for themselves through fees, enabled, in part, through loans and debt.

So, too, as the compelling challenges of the post-World War II economic recovery, the Cold War, and the space race subsided, federal support of the research and development needed for prosperity and security has weakened in the United States. Rather than the "peace dividend" anticipated during the 1990s, the nation's R&D investment relative to the nation's GDP has dropped. Faced with the financial pressures of quarterly earnings that demand corporate priorities shift away from long-term research to product development, great research organizations such as Bell Laboratories have disappeared. Even more seriously, federal policies no longer place a priority on university research and graduate education, as basic research funding has dropped by roughly 20% over the past decade. Most recently, a conservative Congress has adopted rigid constraints, such as a sequestration on all federal expenditures, putting at serious risk not only on basic research but also the capacity and quality of the nation's research universities (Lane, 2014).

Both the irony and tragedy of this situation flows from the realization that 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 strength, prosperity, and welfare 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, to develop innovative applications of these discoveries, and transfer them into the marketplace through entrepreneurial activities. Hence, current American higher

education policy represents a dramatic disinvestment in its future.

Throughout most of our history, education in America has been particularly responsive to the changing needs of society during early periods of major transformation, e.g., the transition from a frontier to an agrarian society, then to an industrial society, through the Cold War tensions, and to today's global, knowledge-driven economy. As our society changed, so too did the necessary skills and knowledge of our citizens: from growing to making, from making to serving, from serving to creating, and today from creating to innovating. With each social transformation, an increasingly sophisticated world required a higher level of cognitive ability, from manual skills to knowledge management, analysis to synthesis, reductionism to the integration of knowledge, invention to research, and, today, innovation and entrepreneurship. Our nation's challenge today is to understand that once again it is time to challenge current public policy and make new commitments to education to enable our nation to achieve prosperity, health, and security.

More generally, it is clear that as the pace of change continues to accelerate, our schools, colleges, and universities will need to become more adaptive if they are to survive. 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.

This strategic roadmap lays out a set of higher education objectives for the nation and recommends a series of actions necessary to achieve these objectives. These include 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.

U.S. Higher Education Today

Higher education in the United States is characterized both by its great diversity in university profiles and an unusual degree of institutional autonomy–understandable in view of the limited role of the federal government in tertiary education. As The Economist notes, "The strength of the American higher education system is that it has no system." (Economist, 2005) In the United States our colleges and universities, both public and private, are relatively free from government control, at least compared to institutions in other nations. We have no ministry of higher education or national system of education, relatively few federal regulations, and essentially no broad federal higher education policies.

The American university's 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 (e.g., as spectators at athletic events). To address this diversity—indeed, incompatibility—of the values, needs, and expectations of the various constituencies served by higher education, the United States has encouraged a highly diverse array of tertiary educational institutions to flourish. From small colleges to immense multi-campus universities, religious to secular institutions, vocational schools to liberal arts colleges, land-grant to urban to national research universities, public to private to for-profit universities, there is a rich diversity both in the nature and the mission of America's roughly 3,600 post-secondary institutions.

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.

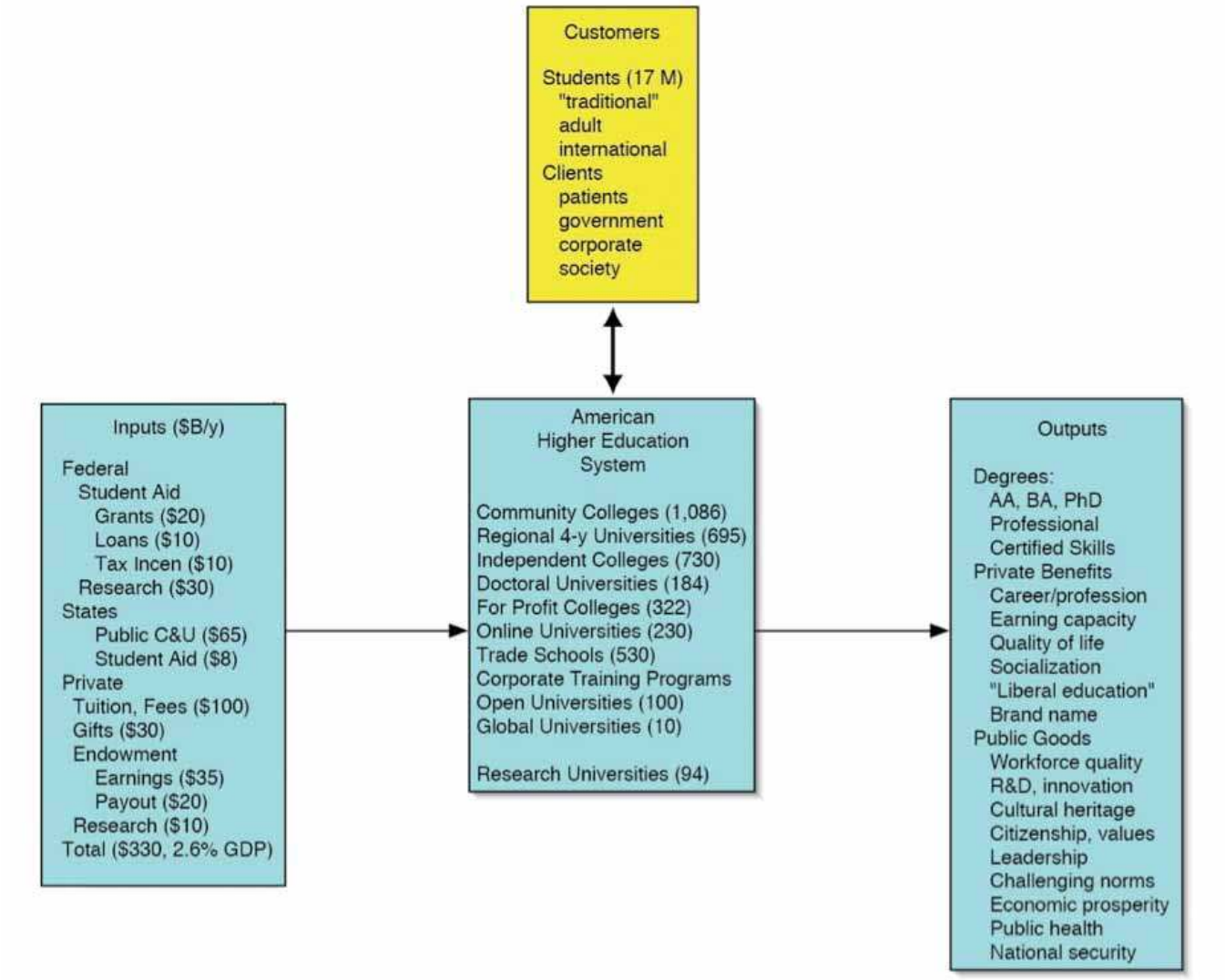
From an economic perspective, today the United States spends roughly 2.6% of its GDP on higher education ($335 billion/year). Public sources provide 45% of this support: the states provide 24% ($75 B/y) primarily through appropriations directly to public colleges and universities; the federal government provides the remaining 21% ($70 B/y) through student financial aid, subsidized loans, and tax benefits ($40 B/y) and research grants ($30 B/y). Here it is important to stress that federal support of American higher education is primarily channeled to individuals (students and faculty research investigators) rather than to institutions. In contrast, the states play a more direct role in supporting and governing institutions, providing significant funding to their public universities and imposing governance structures ranging from rigidly controlled systems (e.g., New York and Ohio) to strategic master plans (e.g., California and Texas) to anarchy and benign neglect (e.g., Michigan).

Over 55% of the support of American higher education ($190 B/y) comes from private support, including tuition payments ($95 B/y), philanthropic gifts ($30 B/y), endowment earnings ($35 B/y on the average), and revenue from auxiliary activities such as medical clinics and athletics ($30 B/y). This very large dependence on private support–and hence the marketplace–is a major reason why on a per-student basis, higher education in America is supported at about twice the level ($20,545 per year) as in Europe. There is a caveat here, however, since roughly half of this cost is associated with non-instructional activities such as sponsored research, health care, student housing, intercollegiate athletics, and economic development–missions unique to American universities. After subtracting the sources earmarked for nonacademic missions, one finds that the actual instructional costs of American higher education today are quite comparable to those of many European nations.

A few other characteristics of American institutions should be mentioned. Beyond their fundamental purpose of teaching and scholarship, American colleges and universities have inherited from their British antecedents the mission of the socialization of young students, or in the words of Lord Rugby, "transforming savages into gentlemen". Not only does this require a very substantial investment in residence halls, community facilities, and entertainment and athletic venues, but it can also distract the university from its more fundamental knowledge-based mission. Nevertheless, American parents now see college as "the place where we send our children to grow up".

Furthermore, American 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. Today only 26% of high school graduates are college-ready across the full spectrum of academic disciplines (English, reading, math, and science). (ACT, 2013) While many leaders of American universities sometimes wish they could shift to the "no-frills" approach of European universities and focus their activities on teaching and scholarship for more mature students, this has proved difficult for all but the highly focused for-profit and online colleges designed for adult learners (e.g., the University of Phoenix and the Western Governors University).

The reality faced by most American universities is that many of the valuable academic services they provide to society–e.g., educating low income students, offering instruction in the arts and humanities, and conducting research and scholarship–are inherently unprofitable and hence must be subsidized either through government support or through other activities capable



A "system diagram" of higher education in the United States

of generating a profit. American universities are continually adding new activities only marginally related to their fundamental educational mission in an effort to generate new revenues, e.g., aggressive management of endowment assets and intellectual property, equity interest in spinoff high-tech companies, conducting commercial entertainment activities (football, concerts, theatre), and providing educational services to wealthy clients (e.g., oil-rich nations).

Our nation's primary source of both new knowledge and graduates with advanced skills continues to be its research universities. These institutions, with the strong and sustained support of government and working in partnership with American industry, are widely recognized as the best in the world, admired for both their research and their education. America's research universities are a key asset for our nation's future. They are so because of the considered and deliberate decisions made in the past by policy makers, even in difficult times.

Traditionally, the higher education enterprise has been pictured as a learning pyramid, with the community colleges at the base, the accredited public and private four-year colleges at the next level, the institutions offering graduate degrees next in the pyramid, and the research universities at the pinnacle. In some states these roles are dictated by a master plan. In others, the role and mission of educational institutions are

not constrained by public policy but rather determined by available resources or political influence.

In reality, however, institutional roles are far more mixed. It is true that community colleges serve primarily local communities, but they provide quite a broad range of educational services, ranging from two-year associate degrees to highly specialized training. They also provide an increasing amount of postgraduate education to individuals currently holding baccalaureate degrees who wish to return to a college in their community for later specialized education in areas such as computers or foreign languages.

Many small liberal arts colleges strongly encourage–in some case, even pressure—their faculty to be active scholars, seeking research grants and publishing research papers in addition to teaching. Certainly too, many four-year colleges have added graduate programs and adopted the title "university" in an effort both to serve regional interests and to acquire visibility and prestige. At the other end of the spectrum, many research universities have been forced to take on significant responsibilities in remedial education at the entry level, particularly in areas such as language skills and mathematics, as a result of the deterioration of K–12 education. Many have even moved directly into the K–12 education arena, creating and managing charter schools or even entire school systems. These trends will only increase an already significant blurring of roles among various types of institutions.

Some suggest that we need to think of higher education in the 1990s and beyond as a mature industry. After all, most states are already providing postsecondary education to 60 percent or more of high school graduates. Public support of higher education for traditional purposes, whether from state or from federal governments, is unlikely to increase. And as is happening with other mature industries such as health care, both the public and private sector are asking hard questions about the cost, efficiency, productivity, and effectiveness of our colleges and universities.

To view higher education only from the perspective of its traditional constituencies, however, is to miss the point of the transformation that must occur as we enter an age of knowledge. For example, if lifetime education becomes a necessity for job security—as it has in many careers already—the needs for college-level education and training will grow enormously. So too American higher education could well be one of this nation's most significant export commodities, particularly if we can take advantage of emerging technologies to deliver high-quality educational services on a global scale. Higher education could be—should be—one of the most exciting growth industries of our times, but this will depend on the development of new models of higher education that utilize far more effective systems for financing and delivering learning services.

Yet, today, much of this earlier commitment to investment in education and research seems to have waned. Not only the quality of our primary and secondary education but also the skills of our workforce lag many other nations. Over the past decade, government support of our public universities has dropped by roughly 35%, putting leading research universities such as U. California, U. Wisconsin, and U. Michigan at risk (Holliday, 2012). After a brief surge during the late 1990s with the doubling of the budget of the National Institutes of Health, both federal and corporate support of basic and applied research have fallen significantly, while fields such as the social sciences have been savaged by conservative political forces. And perhaps most telling of all, the inequities characterizing educational opportunity in American have become extraordinary. The unfortunate reality facing young students today can be summarized by observing: "If you are poor and smart, you have only a one-in-ten chance of obtaining a college degree. In contrast, if you are dumb and rich, your odds rise to nine-in-ten!" (Vest, 2010)

More fundamentally, an extraordinary shift has occurred in the public perception of the purpose of American higher education over the past half century. In early decades following World War II, higher education was viewed primarily a public good because the critical role played by an educated population and the knowledge generated on our campuses in determining the welfare of nation merited strong support from public tax revenues. Today our nation seems to no longer understand that the support of educational opportunity and campus-based research represents investments in the future, not burdensome expenditures from public resources. Instead most Americans view a college education primarily as a private benefit, which enables students to compete for high-paying jobs, as

evidenced in part by the rapidly increasing income differential between those with and without a college degree. Hence, it is not surprising that public policy has shifted to view a college education as something that students should pay for themselves through fees, enabled in part through loans and debt.

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Both the irony and tragedy of this situation flows from the realization that 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 strength, prosperity, and welfare 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, develop innovative applications of these discoveries, and transfer them into the marketplace through entrepreneurial activities. Hence current American higher education policy represents a dramatic disinvestment in its future.

Throughout most of our history, education in America has been particularly responsive to the changing needs of society during early periods of major transformation, e.g., the transition from a frontier to an agrarian society, then to an industrial society, through the Cold War tensions, and to today's global, knowledge-driven economy. As our society changed, so too did the necessary skills and knowledge of our citizens: from growing to making, from making to serving, from serving to creating, and today from creating to innovating. With each social transformation, an increasingly sophisticated world required a higher level of cognitive ability, from manual skills to knowledge management, analysis to synthesis, reductionism to the integration of knowledge, invention to research, and, today, innovation and entrepreneurship. Our nation's challenge today is to understand that once again it is time to challenge current public policy and make new commitments to education to enable our nation to achieve prosperity, health, and security

U. S. Higher Education Tomorrow

Premises

We begin with several important premises:

• *The degree to which higher education has become both a key determinant of one's personal standard of living and quality of life in an increasingly knowledge-intensive society and a critical factor as well in determining the nation's economic prosperity, social well being, public health, and security.*

• *The provision of broad access to quality higher education as a shared responsibility among colleges and universities that seek both quality and efficiency; students and other clients of higher education who act as informed consumers; the availability of private capital; and the commitment of federal, state, and local agencies to provide adequate and equitable financial support.*

• *The critical role of the nation's research universities in providing the world-class research and innovation, outstanding scientists, engineers, and other knowledge professionals, and the world-class research and learning infrastructure necessary for the nation to sustain its leadership in a global, knowledge-driven economy.*

• *The capacity of higher education to adapt to changes driven by forces such as the emerging knowledge 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 universities), and new paradigms (e.g., distance learning, open educational resources).

• T*he importance of public understanding of higher education as both an individual benefit to students through development of not only skills and knowledge but also the values and discipline of the educated mind and as a public good to society through its broader roles of producing the leaders of our governments, commerce, and professions, defending and propagating our cultural and intellectual heritage, challenging our norms and beliefs, creating and applying new knowledge to serve our society, and 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.*

Goals Higher Education in the United States

1. To demand and sustain a higher education system characterized at all levels by 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.

2. To sustain and enhance the world's leading system of research universities, capable of attracting and educating the world-class scientists, engineers, and other knowledge professionals while providing and applying new knowledge necessary for national prosperity and security through basic research, development, and innovation of world-class quality.

More Specific Goals

1. The nation should demand that all elements of its higher 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, access, learning outcomes, efficiency, and relevance. While setting quantitative objectives for such a highly decentralized enterprise runs the risks of creating unrealistic expectations, it is important to acknowledge and strive to improve performance in those metrics that will be used in international benchmarks (e.g., fraction of secondary school students continuing on to college, graduation rates of enrolled students, fraction of the population achieving various degree levels, learning outcomes including literacy and higher order cognitive processes, the cost of education relative to GDP per capita, and return on investments in higher education in earning capacity and economic impact).

2. The nation must address and correct 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.

3. While colleges and universities should be responsive to the projected needs 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).

4. Colleges and universities should develop and demonstrate 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 both quality and capacity.

5. The post-secondary enterprise should develop and demonstrate the capacity for continuous innovation and quality improvement at both the institution and enterprise level. In particular, American higher

education should commit itself to developing new pedagogies, curricula, and technologies to solving major problems like the near absence of scientific and mathematical literacy among today's college generation. It should also embrace and apply to learning the rapidly growing knowledge generated areas such as neuroscience, cognitive science, and organizational sciences. This will require not only seed funding for new initiatives, but a greater tolerance for experimentation and risk taking.

6. While the United States currently has many of the leading research universities in the world, along with demonstrated leadership in key academic disciplines such as science, engineering, medicine, and other knowledge-intensive professions, sustaining this leadership in the face of growing international competition will require both sustained public and private investment and institutional change. The strength and contribution of U.S. research universities will depend on their capacity to attract the very best faculty and students from our nation and abroad while earning the public understanding, trust, and confidence in their increasingly central role in a knowledge economy.

7. While academic reputation will continue to be an important factor in driving institutional competition, of far more importance to the nation is global leadership by our entire research enterprise (including research universities, corporate R&D organizations, and national laboratories) in various academic disciplines of key strategic importance to the welfare of the nation (e.g., information technology, nanotechnology, mathematics, materials science, brain science, genomics, proteomics, and knowledge services).

8. Research universities, government, and industry should develop and implement effective mechanisms for ensuring that the new knowledge developed on the campuses serves society through technology transfer, innovation, and entrepreneurial activities.

9. Both public and private research universities should embrace a social contract that establishes their public purpose and responsibility to society as their highest priority, enabled through a competitive spirit that strives to enhance excellence and institutional reputation.

Strategic Intent (Stretch Goals)

1. It is time to challenge American higher education 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).

2. To play the role it must in America's future, higher education must continually earn a high level of public trust and confidence by doing in the future what it is not doing today. This will require the postsecondary education enterprise both to address its current challenges and demonstrate its responsiveness to public needs and concerns. It will also require a very substantial effort to build the necessary public understanding of higher education's essential role in contributing to economic prosperity, public health, national security, and social well-being, hence re-establishing higher education as a public good to all of society rather than simply a private benefit to students and their employers.

3. Earlier federal initiatives to expand access to educational opportunities have had great impact on this nation, e.g., the Land-Grant acts, universal access to secondary education, and the G.I. Bill. It is our belief that the logical goal for a 21st century global, knowledge driven economy would be universal access to lifelong learning opportunities at the post-secondary level. The nation should embrace this challenge and develop and implement measures to achieve it.

A Gap Analysis for U.S. Higher Education

Concerns

Today we live in an era of rapid and profound change, in which all social institutions are challenged to

consider anew their capacity to serve. And here higher education must address many concerns:

1. The changing needs of the nation

"The flattening of the world is moving ahead apace, and nothing is going to stop it. What can happen is a decline in our standard of living if more Americans are not empowered and educated to participate in a world where all the knowledge centers are being connection. We have within our society all the ingredients for American individuals to thrive in such a world, but if we squander these ingredients, we will stagnate." (Thomas Friedman, 2005)

Recent reports raise serious concerns about the implications for national prosperity and security should United States leadership erode in research, innovation, and education, particularly in key strategic areas such as science and engineering and (National Academy of Science's *Rising Above the Gathering Storm* project, the Council on Competitiveness's National Innovation Initiative, and similar reports from the President's Council of Advisors in Science and Technology, the National Science Board, and the National Academy of Engineering).

Is the nation (government, industry, higher education) prepared to respond to the urgent recommendations of these groups? Is higher education prepared to launch the major transformations of its educational programs necessary to prepare its students for a much different world, e.g. providing them with the knowledge and skills necessary for the jobs of tomorrow and the abilities to face future problems not yet even identified.

2. Quality, excellence, and leadership in higher education

"There is no shortage of things to marvel at in America's higher-education system, from its robustness in the face of external shocks to its overall excellence. However what particularly stands out is the system's flexibility and its sheer diversity…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!" (The Economist, 2005)

While some elements of American higher education are clearly world-class, such as its leading research universities, there are numerous concerns about the quality and performance of the broader higher education system (e.g., graduation rates, learning outcomes, efficiency, cost, innovation). What is the most effective balance among public policy and market forces necessary to drive the commitment to and achievement of world-class quality throughout the American higher education system?

Will the leading American research universities be able to retain their global leadership in the face of international competition from abroad and resource constraints at home (a particular concern for flagship public research universities)?

To what degree is the quality of American higher education influenced by the quality of primary and secondary education and what is the responsibility of colleges and universities to address this?

3. Access to higher education

"The breakpoint between those who succeed in college and those who fail is perhaps the most critical decision point in one's life. Yet today students from the top economic quartile are three times more likely to attend college and eight times more likely to enroll in selective schools than students from the lowest quartile." (McPherson and Schapiro, 2005)

There is evidence that both the access to and the distribution of students within American higher education are becoming alarmingly stratified based upon economic status, race, and ethnicity. The limited access to the elite elements of American higher education on the part of growing populations in the lowest socioeconomic quartile has serious implications for the future of the nation. Only 8% of the bottom quartile will graduate from a four-year institution, compared to 75% of the top quartile. The changing nature of students (e.g., more diverse in all dimensions, more adult learners) and their learning experience (e.g., competency-based learning, technology-mediated interaction, asynchronous and ubiquitous learning environments) will require very significant change in both institutions and the higher education enterprise.

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.

4. Affordability of higher education

"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"…in the face of unfunded federal mandates such as Medicaid and the priorities of an aging baby boomer population." (Thomas Kane, 2003)

Despite the fact that public spending on higher education grew more slowly than the national economy during the 1980s and 1990s, American higher education continues to lead the world in cost, at almost twice the level ($20,245 per student per year) of other developed nations (OECD). 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.

Are colleges and universities paying attention to cost containment, productivity, and efficiency in higher education? Do they have the mechanisms (including governance, leadership, and culture) to achieve these goals? Do current financial aid programs conducted by the federal government, the states, and individual institutions adequately address the goals of increased access by those students who would otherwise be unlikely to attend, increased retention or graduation by those who might otherwise drop out because of cost, and reduced debt burdens that might otherwise prevent lower-income students from pursuing low-paying and socially beneficial areas?

As public support of higher education is increasingly limited by the other social priorities (health care, Social Security, national defense, homeland security), will higher education have the ability to shift to market-driven support from the private sector? Would a shift from public funding and public policy to private sector funding and market forces erode still further higher education's character as a public good (i.e., its broader public purpose)?

5. Accountability of higher education

"The university is the custodian, not only of knowledge, but also of the values on which that knowledge depends; not only of professional skills, but of the ethical obligations that underlie those professional skills; not only of scholarly inquiry, disciplined learning and broad understanding, but also of the means that make inquiry, learning and understanding possible. In its institutional life and its professional activities, the university must reaffirm that integrity is the requirement, excellence the standard, rationality the means, community the context, civility the attitude, openness the relationship, and responsibility to society the obligations upon which its own existence and knowledge itself depend." (Glion Declaration, 1999)

The inadequate performance of much of the higher education enterprise as measured by graduation rates, time to degree, learning outcomes, and even literacy is of great concern. So too is the limited capacity of post-secondary education to innovate and adapt to changing needs and conditions. We need far greater transparency in providing public information about costs, prices, and value.

And of most concern is the reluctance of many higher education institutions to recognize their public purpose and respond to the changing needs of the nation.

6. Education for an Unknowable Future

"Colleges have their indispensable office, to teach elements. But they can only serve us when they aim not to drill but to create, when they gather from afar every ray of various genius to their hospitable halls, and by the concentrated fires, set the heart of their youth aflame." (Ralph Waldo Emerson)

Global connectivity has enabled easy access to information and knowledge by a significant part of the global population. The ability to integrate that information to create value by solving problems with greater speed,

reduced resources, and greater application is the new competitive discriminator for individuals, companies, communities, and nations. Yet we must also preserve traditional objectives such as ethics and moral reasoning as well as an understanding of culture and human values.

The higher education system must transform itself to develop new teaching pedagogies and educational paradigms that will ensure students have the capacity and capability not just as ones who can recount information, but as ones who can apply that information through complex critical thinking. The challenge to higher education today is no less than redefining the nature of a liberal education for a 21st century global society.

7. The erosion in public trust and confidence in American higher education

"A significant gap has developed between the public purposes of higher education, the needs of society that should be met by universities, and the actual performance of these institutions. The growing power of market forces will, in the absence of skilled intervention in the functioning of the market, make a difficult situation worse." (Frank Newman)

For higher education to play the role it should in the nation's future prosperity and security, it must earn an adequate degree of public trust and confidence. Yet like many other social institutions, the perception of the American university today suffers from many public concerns including about, questions about values and integrity, and the eroding credibility of university leaders.

The shift in public perception of higher education from a public good for all of society instead to primarily a private benefit to students threatens to erode support for the broader roles of the university, e.g., defending and propagating our cultural and intellectual heritage while challenging our norms and beliefs; producing the leaders of our governments, commerce, and professions; and preparing the educated citizenry necessary for a democracy.

The Roadmap for the Nation's Higher Education

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.

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 ad-

aptation 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 pri-

ority 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 mecha-

nisms 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 under-

stand 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 com-

mit 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.

Some Remaining Questions

1. Is it time to launch a major conversation both within the academy and across society more generally about the nature of the college education appropriate to prepare citizens for a 21st century world? Are the objectives of those currently in leadership positions in our society who were educated in a century past, valuing traditional paradigms such as liberal learning or more focused professional training, relevant to the challenges and opportunities of a rapidly changing world faced by the new generations of students? How would one go about launching, sustaining, and harvesting ideas from this conversation?

2. What are the best quantitative goals to set out for the U.S. postsecondary education enterprise as a whole? The fraction of the population with college educations? Degrees? Graduation rates? Participation based on socioeconomic status? Literacy measures? More sophisticated measures of learning value-added from higher education?

3. What are the best performance measures for individual institutions? Success (graduation rates, placement statistics)? Educational "value-added" (e.g., evidence-based measures of educational effectiveness or student acquisition of cognitive skills)? Cost-productivity-efficiency measures? Innovation measures? How would one collect and compare this information?

4. How should the quality and performance of colleges and universities be assessed and certified? Through traditional institutional accreditation processes? Through the certification process of professional organizations (e.g., law, business, medicine, engineering)? Through popularity contests such as those conducted by US News & World Report? Or through a new and far more rigorous public process that provides evidence-based assessments of educational effectiveness on a student-by-student basis?

5. Are there specific actions that could be taken to stimulate the market pressures necessary to drive change in the university culture in areas such as cost-containment, productivity, and innovation, beyond simply creating better-educated consumers (students, employers, public agencies)?

6. American higher education is highly bimodal, characterized by a small number of extremely expensive institutions attracting the best students and faculty with little incentive to become more efficient, and a very large number of more modestly supported colleges and universities attempting to educate the bulk of college students with increasingly limited resources that tend to erode quality rather than stimulate productivity. The challenge is to provide stronger incentives to wealthy institutions to stimulate greater efficiency, while providing the resources (financial, expertise, leadership) to enable productivity enhancement across the broader higher education enterprise. Possibilities include greater cost-sharing requirements for federal grants, restructuring tax policy to shift the tax expenditures associated with charitable giving and endowment earnings to priorities such as student financial aid, and disentangling the cross-subsidies of the various missions of higher education to better identify where to demand cost containment and productivity.

7. By developing recommendations based on the pessimistic assumption of seriously constrained public resources, will we, in effect, undercut the possibility of making a strong case for enhanced public support?

8. Are there more creative ways to tap capital markets? For example, the success of for-profit postsecondary education companies (e.g., University of Phoenix) in highly selective markets (adults, professional training, etc.) will almost certainly be a growth area. Could for-profit enterprises be created that serve as human capital brokers by supporting workforce development in key disciplines of particularly high need (e.g., info-bio-nanotechnology, knowledge services management) and then becoming a supplier of these graduates to employers? How could conventional universities more effectively tap the capital markets? (Perhaps they also could become compensated suppliers of human capital to employers…)

9. Since many of the proposed objectives are strongly dependent upon the quality of K-12 education, how do we better use the resources of American higher education to dramatically improve the quality of primary and secondary education? To what degree should higher education take on other major social challenges such literacy?

10. The Commission has approached its task (and this report) with a broad swath encompassing all elements of the American postsecondary education enterprise. However an alternative would be to provide a more detailed analysis and recommendations for each component of the American higher education enterprise that acknowledges the distinct missions, challenges, and opportunities of each tier.

Two Remaining Caveats

Caveat 1: The strength of American higher education depends upon characteristics such as:

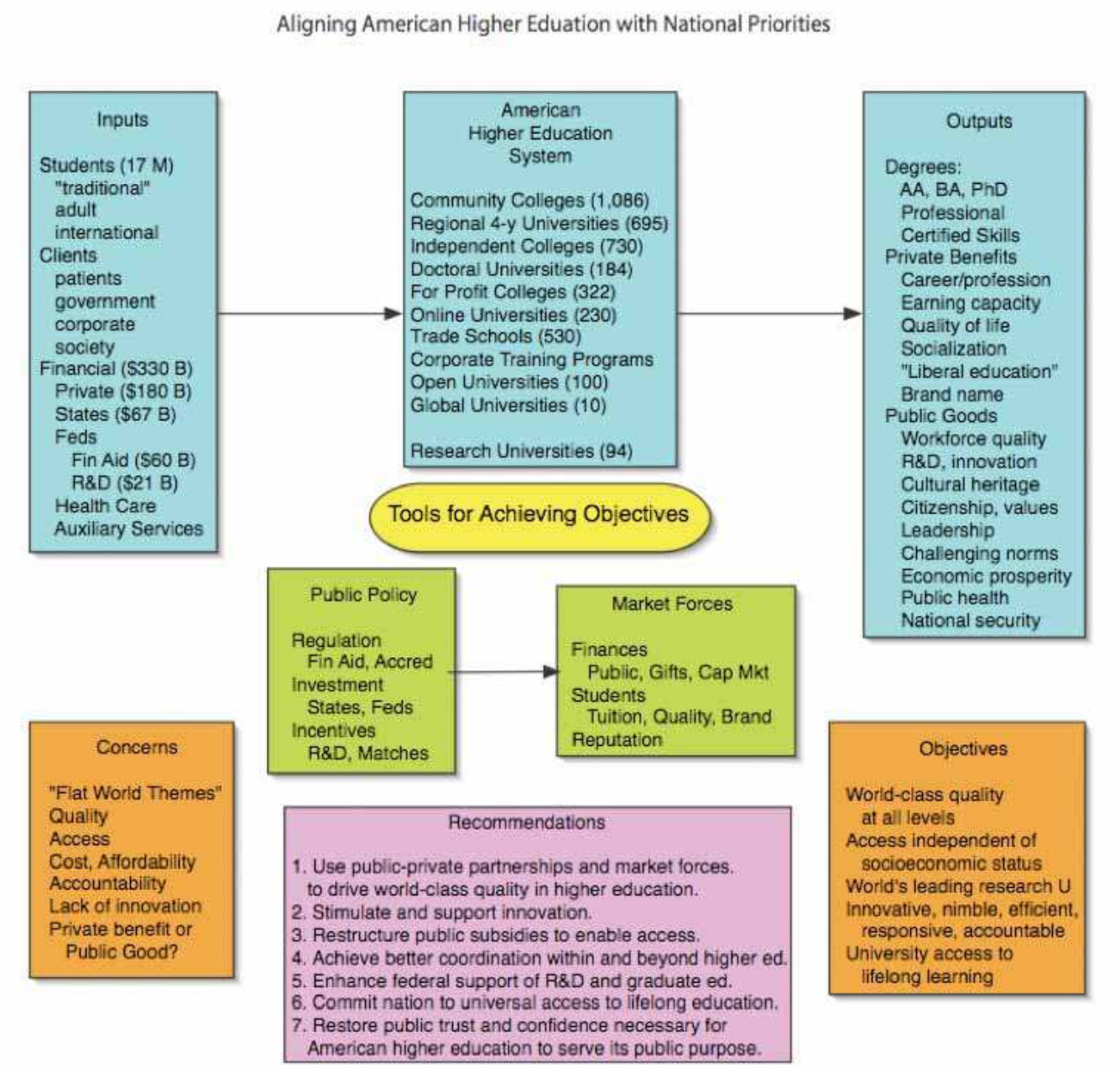
- The great diversity among institutions and missions.
- The balance among funding sources (private vs. public, state vs. federal).
- The influence of market forces (for students, faculty, resources, reputation).
- Its global character (attracting students and faculty from around the world)
- The absence 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.



A diagram summarize key aspects of the Roadmap for American Higher Education

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Chapter 6

A Roadmap for the Global University

Today our world has entered a period of rapid and profound economic, social, and political transformation based upon a emerging new system for creating wealth that depends upon the creation and application of new knowledge and hence upon educated people and their ideas. It has become increasingly apparent that the strength, prosperity, and welfare of a nation in a global knowledge economy will demand highly educated citizenry enabled by development of a strong system of tertiary education. 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.

Yet the traditional institutions responsible for advanced education and research–colleges, universities, research institutes–are being challenged by the powerful forces characterizing the global economy: hypercompetitive markets, demographic change, increasing ethnic and cultural diversity, and disruptive technologies such as information, biological, and nanotechnologies. 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. The populations of most developed nations in North America, Europe, and Asia are aging rapidly while developing nations in Asia, Africa, and Latin America are characterized by young and growing populations. 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, driving major population migration and all too frequently the clash of cultures and ethnicity. New technologies are evolving at an exponential pace, obliterating bot h historical constraints such as distance and political boundaries and enabling new paradigms for learning such as open educational resources, virtual organizations, and peer-to-peer learning networks that threaten traditional approaches to learning, innovation, and economic growth.

On a broader scale, the education investments demanded by the global knowledge economy are straining the economies of both developed and developing regions. Developing nations are overwhelmed by the higher education needs of expanding young populations at a time when even secondary education is only available to a small fraction of their populations. In the developed economies of Europe, the tax revenues that once supported university education only for a small elite are now being stretched thin as they are extended to fund higher education for a significant fraction of the population (i.e., massification). Yet their aging populations demand highest priority for public funding be given to health care, security, and tax relief, forcing higher education systems to become more highly dependent on the private sector (e.g., student fees, philanthropy, or intellectual property). More fundamentally, in a knowledge-driven economy, many governments are increasingly viewing higher education primarily as a private benefit to students and other patrons of the university rather than a public good benefiting all of society, shifting the value proposition from that of government responsibility for supporting the educational needs of a society to university responsibility for addressing the economic needs of government–an interesting reversal of traditional responsibilities and roles.

In many respects the challenges facing higher education in developed nations (e.g., OECD) are quite simi-

lar and perhaps incompatible: the need to dramatically broaden participation in higher education to build a competitive workforce (massification), to enhance the quality of both education and scholarship to compete in a knowledge-driven economy, and to reduce the relative burden on tax payers who face other public spending priorities such as health, retirement, and national security. All create strong pressures on universities to diversify their funding sources through mechanisms such as raising student fees, building relationships with industry, encouraging philanthropy, and expanding the market for educational services through adult education or international students.

Within this context, the opportunities afforded by globalization look quite significant. Current estimates suggest that the number of students seeking university degrees will roughly double over the next two decades to as high as 250 million, with most of this growth in the developing world. Some nations such as Australia have already launched aggressive efforts to not only recruit fee-paying international students but to establish overseas campuses to generate additional resources, finding that as the proportion of these students rises above 15%, their institutions begin to exhibit a more global character not only in funding but also in governance and management.

Both national and institutional aspirations for quality also have acquired a global character with the appearance of numerous surveys (USN&WR, Shanghai Joao Tong, London Times) attempting to establish a world ranking of major universities. This has caused some consternation as established universities with long histories of educational excellence have fallen in the rankings. It is certainly the case that an over emphasis on such rankings can distract both institutions and governments from more fundamental roles and objectives. But it is also clear that the concerns about the competitive quality of higher education have stimulated initiatives such as the Bologna Process in Europe aimed at overcoming fragmentation, increasing cooperation and competition, increasing investment in both universities and research systems, preparing for demographic change (particularly aging populations), and encouraging innovation and risk-taking.

Global competition among universities has also raised an awareness of the need to provide both a greater degree of institutional autonomy to enable the agility, flexibility, and innovation required by today's fast-changing world as well as a more sophisticated and strategic framework for higher education systems. Key in the latter is the acceptance of 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 (with annual budgets typically in the range of $1 billion or more). A differentiated system of higher education helps to accomplish both the goals of massification and promoting quality, but assigns different roles in such efforts for various institutions. Enabled both by the continental scale and its decentralized nature, the United States has achieved the most diverse system, enabling it to focus significant public and private resources to create a small set (less than 100) of world-class research universities, while distributing the broader roles of mass education and public service among a highly diverse collection of public and private institutions, albeit with an inevitable tendency toward "mission creep". Although such strategic diversification is beginning to appear in Asia, it will be particularly difficult to achieve in Europe where the Humboldt tradition of universities still resists defining the role of a college or university as primarily teaching (as opposed to scholarship).

Today's World

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

The Glion Colloquium on the future of the research university

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 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 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.

Tomorrow's Higher Education

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.

To illustrate, let us suggest several possibilities that could totally change the nature of the university, game changers that introduce new challenges for higher education.

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 industry. 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.

Higher education is rapidly globalizing..

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). 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 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 of our institutions may evolve into a new paradigm, the world university.

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 – remain rich, relevant and accessible.

The Changing Nature of Discovery, Learning, and Innovation

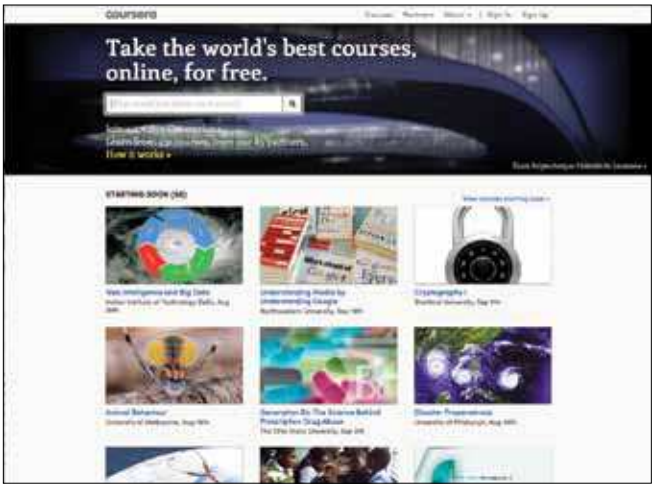
The fundamental intellectual activities of discovery and learning enabling these goals are being transformed by the rapid evolution of information and communications technology. Rapidly evolving digital technology, so-called cyberinfrastructure, consisting of hardware, software, people, and policies, 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 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, technol-

MIT's OpenCourseware Project



Coursera MOOCs

ogy 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

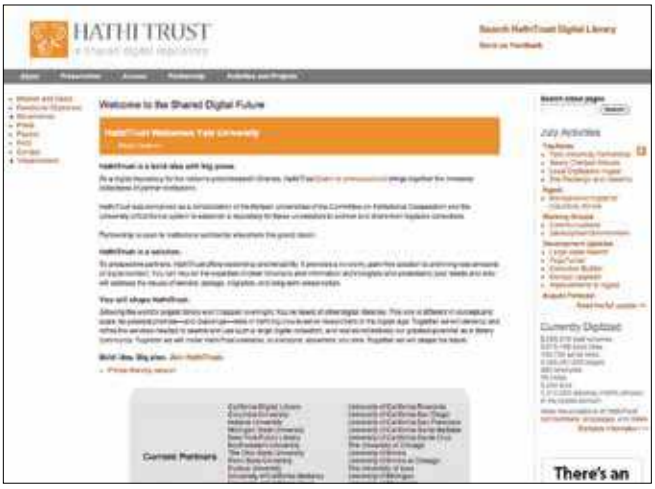
Ironically, while we generally think in terms of this in terms such as terabit/sec networks and exaflop supercomputers, the most profound changes in our institutions may be driven not by the technology itself but rather the philosophy of openness and access it enables–indeed, imposes–on its users. Of 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.

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)

Google Books



Hathi Trust

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 new avian flu virus or air-borne Ebola, that 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.

A Gap Analysis

Challenge 1: Caught Between Massification, League Tables, and Tax Relief

In many respects the challenges facing higher education throughout the world are similar:

The need to dramatically broaden participation in higher education *(massification)* to build a competitive workforce (massification);

The desire to enhance the quality of both education and scholarship to compete in a knowledge-driven economy (as measured by university ratings or *league tables*); and

The pressures to reduce the relative burden on tax payers who face other public spending priorities such as health, retirement, and national security.

The incompatibility of these objectives create strong and conflicting demands on universities for greater accountability in areas such as cost containment, productivity, and learning outcomes. Many national and regional governments continue to view public support of higher education and research not as an investment but rather as an expenditure competing with other current needs (e.g., health care, retirement pensions). Furthermore, many of today's universities are being encouraged to reduce the burden on limited tax revenues by diversifying their funding sources through mechanisms such as raising student fees, building relationships with industry, encouraging philanthropy, and expanding the market for educational services through adult education or international students (or including the possibility of establishing international campuses).

Challenge 2: Mission Differentiation and Profiling

It is increasingly 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. David Ward, former president of the American Council of Education and the University of Wisconsin, estimates that supporting a public world-class research university with annual budgets typically in the range of $1 billion or more requires the tax base of a population of five million or greater. (Ward, 2010)

A differentiated system of higher education helps to accomplish both the goals of massification of educational opportunity and the conduct of research of world-class quality, but it assigns different roles in such efforts for various institutions. Enabled both by continental scale and its decentralized nature, the United States has achieved such a highly diverse system, enabling it to focus significant public and private resources to create a small set (less than 100) of world-class research universities, while distributing the broader roles of mass education and public service among a highly diverse collection of public and private institutions (roughly 3,600 in number), albeit with an inevitable tendency toward "mission creep".

But such diversity in institutional profiles is a major challenge for most nations where differentiation among the missions and character of universities faces formidable challenges of both tradition and political pressures. Stratification is a particular challenge in Europe, where broad distribution of resources leads to the illusion that the continent has one thousand quality research universities, with the result being that only a handful are truly world-class. Yet shifting from an egalitarian to a more elitist system that focuses resources to build and sustain only a small number of world-class research universities, likely excluding some EU nations entirely, will encounter political resistance.

Challenge 3: A Myopic Preoccupation with the Flat World

Many governments are now realigning higher education policies to address the challenges presented by the knowledge and innovation economy (as Tom Friedman would call it, the "flat world") by focusing priorities almost entirely on degree production (massification) and building research reputation (league tables) to the exclusion of the broader roles of the university. For example, there is a growing utilitarianism associated with the role of higher education in addressing the need for human capital that could overwhelm the university's traditional social and cultural impact on society and civilization and its transformative potential through the creation, retention, and dissemination of knowledge. It is ironic that this shifts the value proposition from that of government responsibility for supporting the educational needs of a society to university responsibility for addressing the economic needs of government–an interesting reversal of traditional responsibilities and roles.

As a consequence, a serious gap can appear between national and regional higher education policies. For example, in America there is a mismatch between the priorities of the federal government for world-class excellence in graduate education and research and those of the states that are primarily focused on baccalaureate degree production. Fortunately in the United States such focused efforts by federal or state governments to demand that higher education address particular near term priorities (e.g., economic competitiveness, national defense, public health, the needs of underserved minority communities, etc.) are less influential. While the cacophony of demands from the highly diverse stakeholders attempting to influence American higher education (students, politicians, media, business, patients, sports fans…) can be a headache for university leaders and governing boards, it does have a moderating effect on dominance by any particular constituency or agenda because of the diversity of funding sources. Part of the challenge is balancing the needs of various stakeholders in higher education, predominantly the state, students, and business–and keeping all three satisfied without distorting the fundamental purpose of the university. Fortunately, the intensely competitive American higher education marketplace in which faculty, students, and resources move easily from one institution to another, has a self-correcting effect. If some institutions lose their way and become too focused on an agenda far removed from their core academic competence, they will quickly lose faculty, students, and eventually reputation.

This phenomenon may be a more serious issue in

Europe because of the strong influence of government (support and regulation) on higher education. The cultural constraints on a freely operating market for faculty and student talent in Europe, coupled with the much stronger role that governments play in both financing and governing higher education, put European universities at somewhat greater risk in the face of such present day imperatives as the innovation economy.

Challenge 4: Collapsing Financial Paradigms

There are growing concerns that the current model for financing higher education in most nations, almost entirely dependent upon public tax support, is simply incapable of sustaining massification while achieving world-class quality. For example, currently the investment in higher education in European countries ranges from 0.9% to 1.8% of GDP, of which only approximately 10% comes from private sources (e.g., student fees). European university leaders express many concerns about the financial vulnerability of their institutions, still primarily dependent on tax support without appreciable student fees or gift income, and insufficiently entrepreneurial compared to the massive research universities in America.

Since tax revenues are already stretched thin sustaining the strong social programs of many developed nations, it seems it is likely that many will be challenged to provide the advanced educational opportunities required by a knowledge-driven economy without appreciable changes in tax policies (to encourage private philanthropy) and student/family expectations (to accept significantly higher student fees). It has also become increasingly clear that with public tax support of higher education constrained by the burdens of generous social services and weak economic growth, further massification will only erode the support of research universities. While increasing student fees and modifying tax policies to encourage philanthropic support of higher education will be challenging, there may no alternative to enhancing private support if Europe's universities are to remain competitive.

Yet there are similar fears that the more balanced financial model that has sustained American higher education for the past several decades is also beginning to fray. Traditionally, the support of American higher education 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. However today the tuition and fees charged for private universities are now beyond the capacity of most families (e.g., $40,000/year for tuition and $60,000/year including housing). The tuition levels at public universities are also rising rapidly. For example, at both the Universities of California and U Michigan state residents pay $15,000 a year while out-of-state students pay private tuition levels at $45,000 a year.

A Brookings Institution study has concluded: "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 and Orzag, 2003).

Challenge 5: Public Policy vs. Markets

This combination of powerful economic, demographic, and technological forces could well drive a massive restructuring of the higher education enterprise on a global scale similar to that experienced by other economic sectors such as health care, transportation, communications, and energy. Nations are moving toward revenue-driven, market-responsive higher education systems because their current tax systems are increasingly unable to support the degree of universal access to post-secondary education required by knowledge-driven economies in the face of other compelling social priorities–particularly the needs of aging populations. Furthermore, there is growing willingness on the part of political leaders to use market forces as a means of restructuring higher education in an effort to increase both efficiency and quality. Put another way, market forces are rapidly overwhelming public policy and public investment in determining the future course of higher education.

Whether a deliberate or involuntary response to the tightening fiscal constraints and changing priorities for public funds, the long standing recognition that higher

education is a public good, benefiting all of society, is eroding. Higher education is increasingly viewed in many nations as a private benefit that should be paid for by those who benefit most directly, namely the students. Without the constraints of public policy, earned and empowered by public investments, market forces could so dominate and reshape the higher education enterprise that many of the most important values and traditions of the university could fall by the wayside, including its public purpose. (Newman, 2004) (Zemsky, 2005)

Challenge 6: Agility, 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 technology, 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.

Yet the governance and leadership of most universities throughout the world are far more inclined to protect the past than prepare for the future. Furthermore, all of higher education faces a certain dilemma related to the fact that it is 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.

In developed economies there is increasing government and stakeholder pressure for capable governance, leadership, and accountability of higher education, particularly in view of the expansion of participation and the increasing importance of education to prospering in the global knowledge economy. Paradoxically, in some states (and nations) even as relative government support has declined, the effort to regulate universities and hold them accountable has increased. Although some of this is rationalized by the sub-optimal activities of a relatively small number of institutions, it is perhaps also evidence of governments attempting to retain control over the sector through regulation even as their financial control waned. (SHEEO, 2005)

While it is certainly true that cost-containment and accountability are important issues, it is also the case that in many nations, universities can rightly counterargue that the main problem for them is that they are overregulated and underfunded. In the United States most public university governing boards view their role as one of oversight to ensure public or political accountability rather than stewardship to protect and enhance the university so that it is capable of serving both present and future generations. Similarly faculties and students tend to resist change. (AGB, 2006)

In the United States there has been a recent chorus of demands for increased transparency, accountability and commitment to public purpose (meaning cost containment) in the operation of our institutions. Of particular concern was the need for more evidence-based assessment of educational outcomes, particularly in the accreditation process. There have been numerous attempts to use the accreditation process as more active mechanism for quality improvement rather than simply to determine whether institutions meet the minimum qualifications for accrediting academic programs. In contrast, the European approach of quality assurance actually seems better aligned to driving quality enhancement, although it is my understanding that even in Europe is a movement toward greater use of accreditation. From the U.S. experience with the bureaucracy that inevitably infects such accreditation efforts in the United States, our recommendation to nation's exploring this practice can be captured in a single word: BEWARE!

Challenge 7: Research Strategies and Opportunities

While the long-standing partnership among research universities, business, and government in the United States continues to maintain global leadership in measures such as the percentage of GDP invested in R&D, the number and productivity of researchers, the volume of high-tech production and exports, and the global rankings of its research universities, there are several worrisome trends that have developed over the

past decade. These include the decline in federal funding for basic research and the imbalance in the national research portfolio, with roughly two-thirds of university research now in the biomedical sciences; the erosion of basic research in both corporate R&D laboratories and federal agencies; the increasing complexity of intellectual property policies; and the adequacy of the nation's supply of scientists and engineers in the wake of the changing immigration policies in the aftermath of the terrorist attacks of 2001.

The concerns raised by leaders of industry, higher education, and the scientific community, culminating in the National Academies' Rising Above the Gathering Storm study (Augustine, 2005), stimulated the federal government to launch two major efforts aimed at sustaining U.S. capacity for innovation and entrepreneurial activities: the Bush 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 would 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. Unfortunately, in a 2007 year-end budget skirmish between President Bush and Congress, the funding for the America COMPETES effort was eliminated, and federal R&D continued to decline across all agencies funding university research.

A second major effort was launched in 2012 with the release of a major study by the U.S. National Academies of Science, Engineering, and Medicine concerning the future of the American research universities. Again bold recommendations were proposed to stabilize research funding, strive for greater cooperation between universities and industry, and demonstrate greater cost effectiveness. However, once again progress was limited by the reluctance of an increasingly conservative Congress to increase these public investments in the nation's future.

European nations have adopted the Lisbon Agenda (2000) "to become the most competitive and dynamic knowledge-based economy with more and better jobs and social cohesion by mobilizing the brainpower of Europe". Such initiatives are both pan-European like the European Higher Education Area (e.g., the Bologna process) or at the level of the European Commission (e.g., the Lisbon agenda) with initiatives such as the European Research Area (better integration of National and European research policies and the project of the European Research Council). The Lisbon agenda tends to use as a benchmark the United States investments in higher education and research (currently at levels of 2.6% and 3.0 % of GDP, respectively) while the Bologna process and ERC tend to emulate characteristics of the American research universities (e.g., standardizing university degrees upon the bachelors, masters, and PhD while basing the envisaged European Research Council research programs on competitive, peer-reviewed grants much like the U.S. National Science Foundation. While this establishes major investments in higher education and research as priorities, with the goal of bringing Europe up to the level of the United States by 2010, there are serious concerns that such an ambitious objective may be inconsistent with the low economic growth of national economies. It furthermore will likely require major structural changes in how European universities are organized, governed, and financed.

The Challenge to Humankind

Of course history has always been characterized by periods of both change and stability–war and peace, intellectual progress and decadence, economic prosperity and contraction–today, both 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 throughout the world. Modern 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 continue to appear in all parts of the world. Indeed, many believe that the impact of human activities, ever more intense, more globally distributed, and more interconnected than ever, today threaten 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 both multiplying in number and intensifying in severity: the destruction of forests, wetlands, and other natural habitats by human activities, the extinction of millions of biological species and the loss of biodiversity; the buildup of greenhouse gases such as carbon dioxide and their impact on global climates; and 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.

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 the past two years. Again, the sustainability of current business practices, government policies, and public priorities must be questioned.

Of comparable concern are the substantial and 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, 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. Technological advances such as the "green revolution" have lifted a substantial portion of the world's population from the ravages of extreme poverty. Yet, it is estimated that roughly one-sixth of the world's population, 1.5 billion people, still live in extreme poverty, suffering from the ravages of diseases such as malaria, tuberculosis, AIDS, diarrhea, respiratory inflections, and other diseases that prey on bodies weakened by chronic hunger, claiming more than 20,000 lives each day (Sachs). 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 challenge of global sustainability is not limited to environmental, economic, heath, and poverty issues. It is real in many other domains, in particular in social policies and in geo-politics. Therefore, economic, social and political sustainability are today becoming as important for our societies as sustainable development. This situation has grown from the fact that economic and military world powers and big corporations have become extremely powerful and that globalization and the new communication means and forms has made the world extremely interdependent. Identifying the causes of unsustainability and defining the conditions of sustainability are raising extremely complex questions at the frontier of available knowledge.

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 millions 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 interactional 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. And these institutions are also 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.

As the declaration of the Glion Colloquium in 2009, drafted by Frank Rhodes, assures us:

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.

A Roadmap to the Future for Higher Education

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 all 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 opportunities 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.

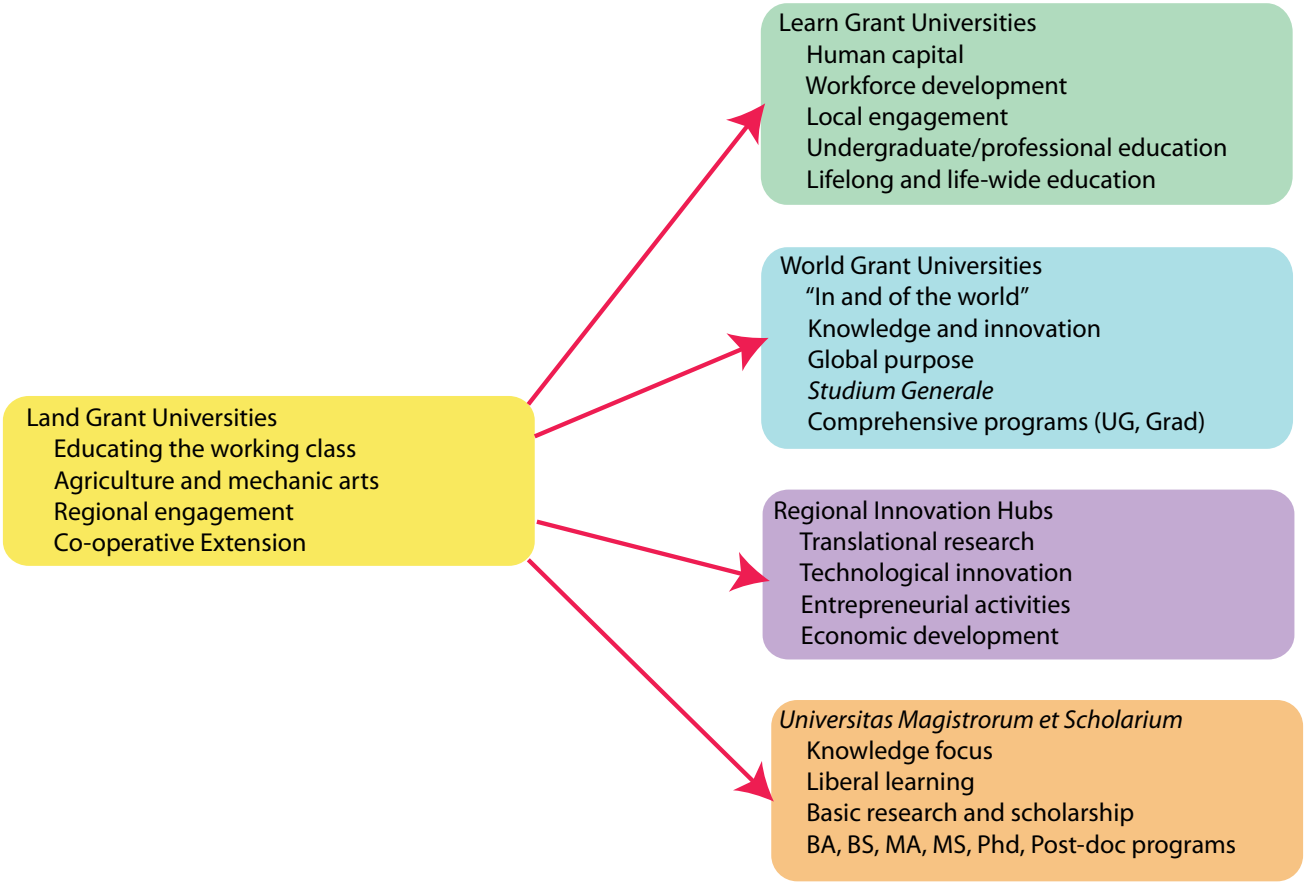
We will continue to develop and practice interactive and collaborative learning, appropriate for the digital age, the "plug and play" generation.

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,



Alternative forms of the land-grant philosophy

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.

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 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 be-

yond 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 gover-

Most European universities are designed for upper division (adult) students (here at the Sorbonne U. Paris).

nance 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 Europe-

an 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 education 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 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 Connexion 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.

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.

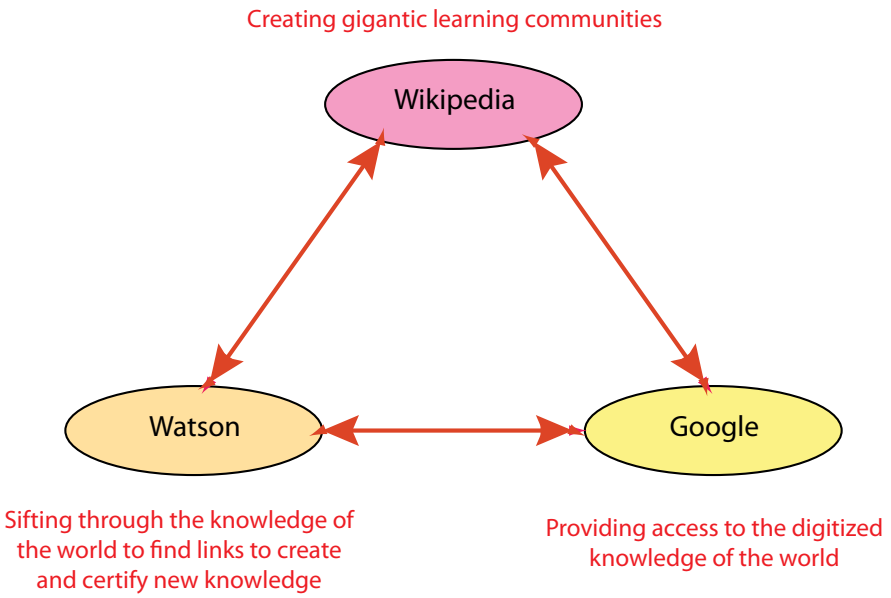
Once we have realized that the core competency of the university is not simply transferring knowledge, but developing it within intricate and robust networks and communities, we realize that the simple distance-learning paradigm of the virtual university is inadequate. The key is to develop computer-mediated 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-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.



A puzzle: Is this a possible future for the university?

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

The emergence of new learning ecologies

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.

Whence and Whether the Revolution

Yet today university today looks very much like it has for decades–indeed, centuries in the case of distinguished European universities such as the University of Vienna. We are still organized into academic and professional disciplines; we still base our educational programs on the traditional undergraduate, graduate, and professional discipline curricula; we are still finance, manage, and lead the university as we have for ages. (Duderstadt, 2000)

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 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. And, as we have suggested 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, al-

though 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 information technology revolution is more a tsunami that universities can float through rather a tidal 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 cyberinfrastructure now transforming scholarship or the communications technology enabling new forms of student learning and faculty scholarship 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 frequently 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 nanotechnology makes almost any scenario possible.

Certainly the monastic character of the ivory tower is 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. So too, 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. (Duderstadt, 2007)

Even in the near term, we should again recall Christensen's innovators's dilemma, (Christensen, 1997) as these disruptive technologies, which initially appear rather primitive, stimulate 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?

Hence, perhaps it is best to conclude by recalling the closing passage of the Glion Declaration, adopted by a group of leaders of European and American universities in 1998. "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." (Rhodes, 1999)

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Chapter 7

A Roadmap for the American Research University

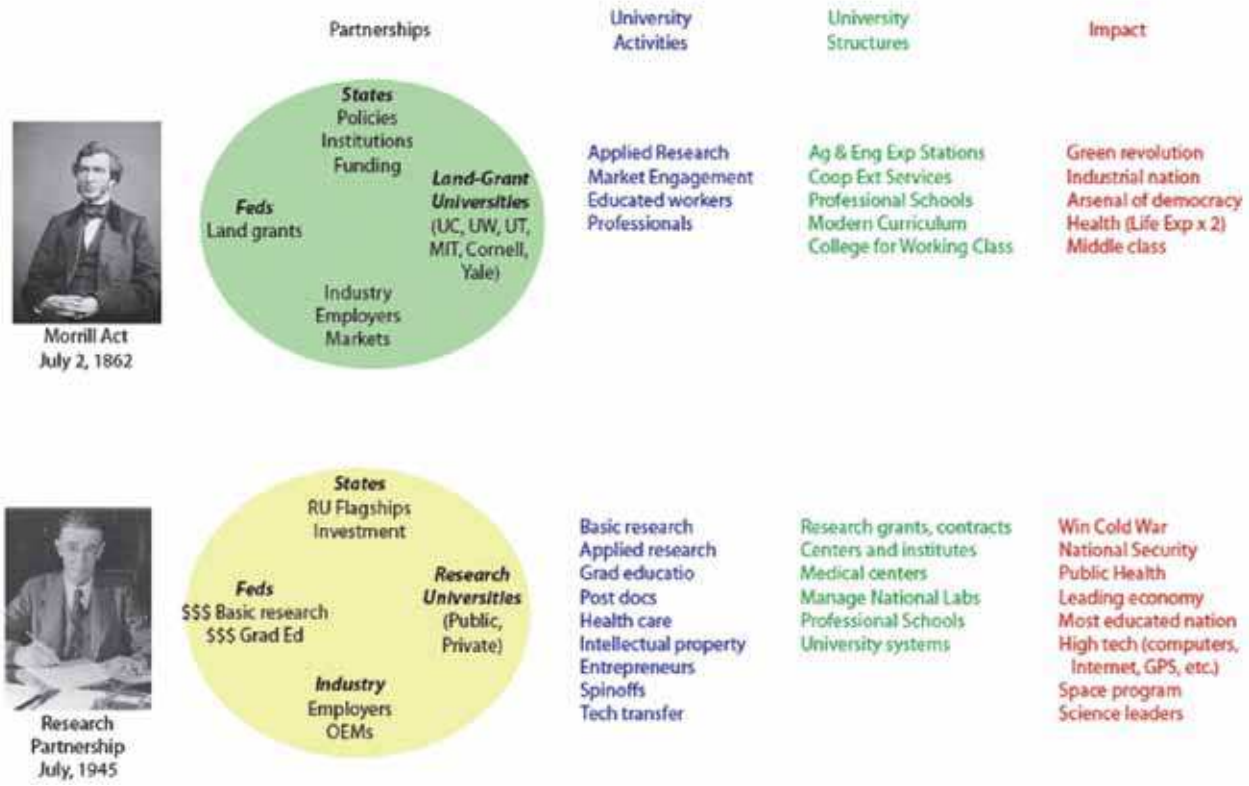
One generally thinks of the research role of the university as a more recent characteristic of higher education in the twentieth century. However, the blending of scholarship with teaching occurred first in European universities, and it was introduced into American higher education in the mid–nineteenth century. As the nineteenth century advanced, knowledge began to expand at a staggering rate, driven by new scientific methods and responding to the demands of the Industrial Revolution. Scholars returning to America from Europe brought a new vision of research and academic freedom to higher education. Throughout this era, as researchers became more specialized, departments were created in a great burst of energy to form the basic intellectual topography of the university that is familiar to us today.

The university, through on-campus scholarship and off-campus extension activities, was key to the agricultural development of the United States and then our transition to an industrial society. World War II provided the incentive for even greater activity as the universities became important partners in the war effort, achieving scientific breakthroughs in areas such as atomic energy, radar, and computers. During this period our universities learned valuable lessons in how to develop and transfer knowledge to society and how to work as full partners with government and industry to address critical national needs. In the postwar years, a new social contract evolved that led to a partnership between the federal government and the American university aimed at the support and conduct of basic research. This led to a new institutional form, the American research university.

The seminal report, *Science, the Endless Frontier,* produced by a World War II study group chaired by Vannevar Bush, stressed the importance of this partnership: "Since health, well-being, and security are proper concerns of government, scientific progress is, and must be, of vital interest to government." At the heart of this partnership was the practice of federal support of competitive, peer-reviewed grants, and a framework for contractual relationships between universities and government sponsors. In this way the federal government supported university faculty investigators to engage in research of their own choosing in the hope that significant benefits would accrue to American society in the forms of military security, public health, and economic prosperity.

The resulting partnership between the federal government and the nation's universities has had an extraordinary impact. Federally supported academic research programs on the campuses have greatly strengthened the scientific prestige and performance of American research universities. The research produced on our campuses has had great impact on society. This academic research enterprise has played a critical role in the conduct of more applied, mission-focused research in a host of areas including health care, agriculture, national defense, and economic development. It has made America the world's leading source of fundamental scientific knowledge. It has produced the well-trained scientists, engineers, and other professionals capable of applying this new knowledge. And it has laid the technological foundations of entirely new industries such as electronics and biotechnology.

The American university continued to evolve and change throughout the postwar decades. Although the formation of new academic disciplines and professional schools slowed, the tendency toward specialization increased. Departments became more splintered, made up, in some cases, of loose confederations of faculty in rarefied subfields who had more in common with peers



The goverment-industry-university partnerships that built American in the 19th and 20th Centuries

in their disciplines at other universities than with campus colleagues. Generous funding for the sciences also widened the gulf between the social sciences, the natural sciences, and the humanities.

The focusing and specialization that began at the end of the nineteenth century and intensified after World War II was one of the great advancements in the history of higher education, allowing scholars to gain expertise and engage in coherent debate amid a growing cacophony of intellectual voices. Today, however, as the speed of change increases, it has become more evident that we need to make basic alterations in the discipline-focused culture and structure of the university. New funding policies have made this even more imperative, as agencies move increasingly toward supporting more multidisciplinary teams of scholars. We have entered another period of rapid intellectual change in higher education.

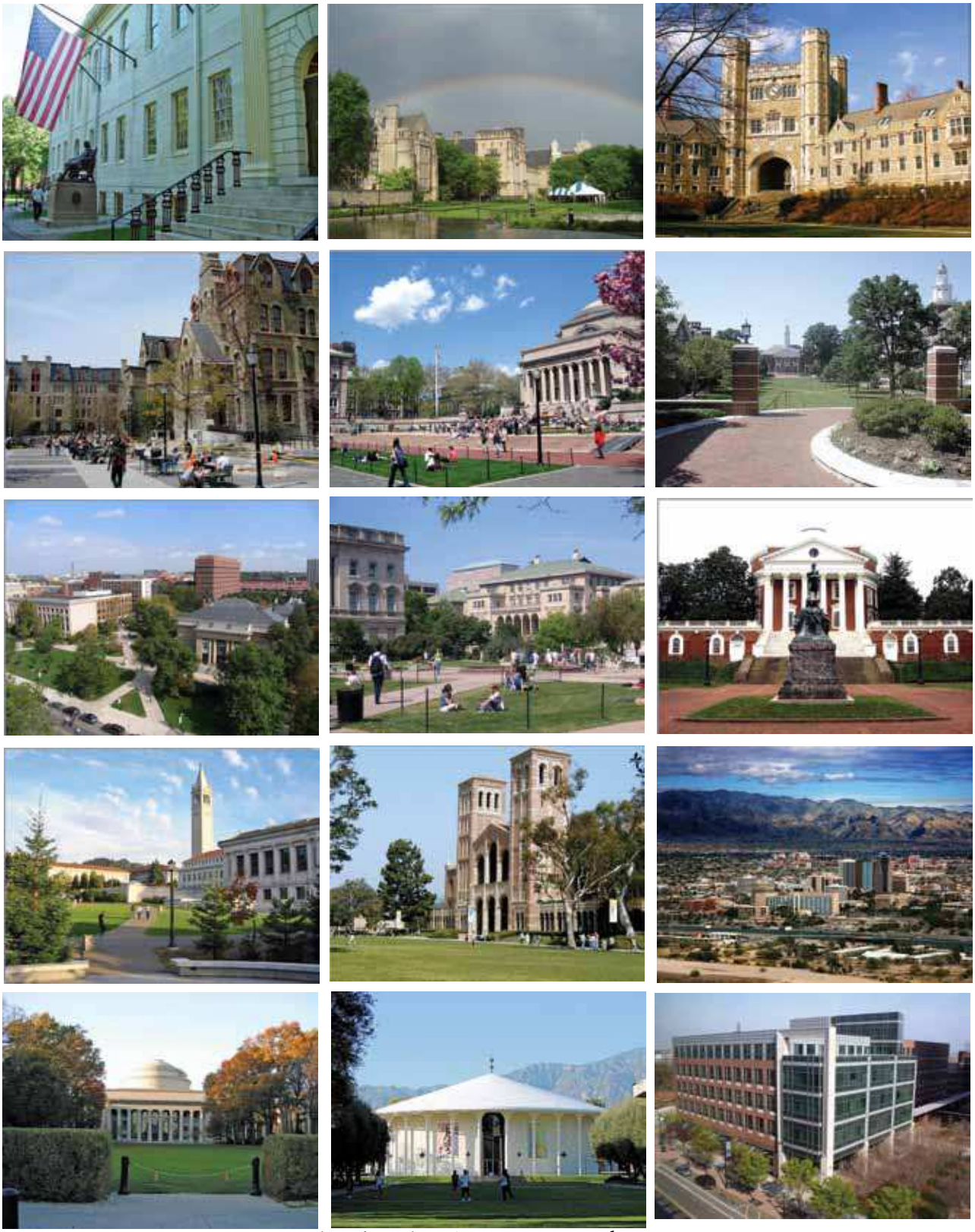
All of these factors–changing national priorities, shifting intellectual currents, and the evolving character of the university itself–suggest that a primary mission of higher education in America, research and scholarship, is likely to change as well.

Today's Research University

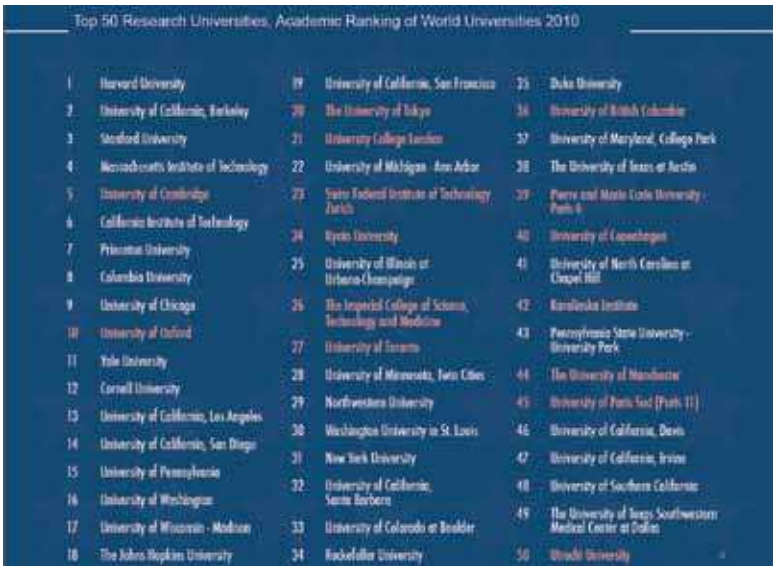
The Government-University-Industry Partnership

The basic structure of the academic research enterprise of the past half-century was set out in the Bush report some fifty years ago. The central theme of the document was that the nation's health, economy, and military security required continual deployment of new scientific knowledge and that the federal government was obligated to ensure basic scientific progress and the production of trained personnel in the national interest. It insisted that federal patronage was essential for the advancement of knowledge. It stressed a corollary principle—that the government had to preserve "freedom of inquiry," to recognize that scientific progress results from the "free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for explanation of the unknown."

Since the federal government recognized that it did not have the capacity to manage effectively either the research universities or their research activities, the re-



Examples of Leading American Research Universities



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

lationship became essentially a partnership, in which the government provided relatively unrestricted grants to support part of the research on campus, with the hope that "wonderful things would happen." And, indeed they did, as evidenced by the quality and impact of academic research.

Federal support was channeled through an array of federal agencies: basic research agencies such as the National Science Foundation and the National Institutes of Health; mission agencies such as the Department of Defense, the Department of Energy, the National Aeronautics and Space Administration, and the Department of Agriculture; and an assortment of other federal units such as the Departments of Commerce, Transportation, and Labor. In most cases, the mechanism used to support research was the merit-reviewed research grant, where faculty submit unsolicited proposals detailing the research they were interested in conducting. The funding agency then asks various experts, including peers of the investigators, to review the proposal and evaluate its quality and importance. Based on this review and available funding, the agency then decides whether to fund the work or decline the proposal. If the decision were to fund, a grant would be provided to the host institution for the support of the work, typically for a one to several-year period.

Although grants arising from unsolicited proposals were the most common form of support, some funding agencies did approach select institutions with requests-for-proposals to conduct research directed toward specific needs. For example, NASA might seek a particular type of scientific instrument for a space mission, or the Department of Defense might need a better understanding of radar reflection from unusual aircraft wing geometries. Such procured research was usually provided through research contracts between the agency and the host institution rather than through relatively unrestricted grants.

The most common form of research support was through research grants to individual faculty—so-called single-investigator research grants. The grants would support a portion of the faculty member's salary; the wages paid to student research assistants and research staff; equipment and facilities; and incidental expenses such as travel, publications, and such. In addition, the grants would provide support for those institutional costs associated with the research that were difficult to identify on a project-by-project basis, termed indirect costs or overhead, at rates established through negotiation between the host institution and the federal government.

Although funding was also provided through research grants and contracts to larger groups of investigators, particularly through various research centers and laboratories supported by federal agencies, most funding was channeled directly to a single investigator

or a small team of investigators. Hence, a culture rapidly developed on university campuses in which faculty were expected to become independent "research entrepreneurs," capable of attracting the federal support necessary to support and sustain their research activities. In many areas like the physical sciences, the capacity to attract substantial research funding became an even more important criterion for faculty promotion and tenure than publication. Some institutions even adopted a freewheeling entrepreneurial spirit, best captured in the words of one university president who boasted, "Faculty at our university can do anything they wish—provided they can attract the money to support what they want to do!"

Of course, there were many drawbacks to the research university culture. Faculty soon learned that the best way to attract funding for their research was to become as specialized as possible, since this narrowed the group of those likely to review their proposals to the few peers in the field. Universities encouraged faculty to seek more sponsored research support for a portion of their academic salary, thereby freeing up funds to hire more faculty members. As a result, many universities soon walked far out on the limb of dependence on sponsored research to support their faculty. In many fields, the pressures on faculty to generate research funding became extreme. And, understandably, many faculty soon became more loyal to their discipline—and their funding agency—than to their university.

Although the Carnegie classification identifies 170 institutions as research universities, in reality there are fewer than 60 universities among the 3,600 institutions of higher education in America that would be truly identified as research/graduate-intensive. These institutions are the envy of both the nation and the world. A few years ago, a New York Times editorial referred to our nation's research universities as the "jewel in the crown" of our national economy. It went on to assert that university research "is the best investment taxpayers can ever make in America's future."

In fact, in our increasingly knowledge-intensive society, the rate of return from investment in research is rising. While the average rate of return on capital investment in the United States today is roughly 10 percent to 14 percent, the private rate of return of R&D investment is estimated to be 25 percent to 30 percent. The social rate of return—the rate that accrues to society more generally—is estimated to be as high as 50 percent to 60 percent, roughly four times the rate for other types of investment. In a recent survey, 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.

The importance of publicly financed scientific research on economic prosperity was made even more evident in a recent study of American industrial patents. It found that 73 percent of the primary research papers cited in these patents were based on research financed by government and nonprofit agencies. Such publicly financed science, the study concluded, has turned into a "fundamental pillar" of industrial advance and pays handsome dividends to society.

Perhaps the best way to understand both the importance and the diversity of American research universities is to consider them from several perspectives:

From 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.

The National Academies: 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."

James Duderstadt: 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. 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 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.

From Industry: 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.

Tomorrows Research University

> "*The world has changed. In a single generation, revolutions in technology have transformed the way we live, work and do business. The future is ours to win. But to get there, we can't just stand still. As Robert Kennedy told us, "The future is not a gift. It is an achievement." Sustaining the American Dream has never been about standing pat. It has required each generation to sacrifice, and struggle, and meet the demands of a new age. And now it's our turn. We know what it takes to compete for the jobs and industries of our time. We need to out-innovate, out-educate, and out-build the rest of the world."*
> President Obama, 2011 State of the Union Address

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. Educated people, the knowledge they produce, and the innovation and entrepreneurial skills they possess, particularly in the fields of science and engineering, have become key to America's future.

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. Economists estimate that 40 to 60 percent of economic growth each year in the Untied States 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. (Augustine, 2007) 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.

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. (Cole, 2009)

As in our earlier chapters, the changing nature of research and scholarship once again suggests that the status quo is no longer an option for the American research university. As we enter the new century, there is an increasing sense that the social contract represented by the government-university research partnership simply may no longer be viable. The number and inter-

ests of the different constituencies have expanded and diversified, drifting apart without adequate means to communicate and reach agreement on priorities. Political pressures to downsize federal agencies, balance the federal budget, and reduce domestic discretionary spending may reduce significantly the funding available for university-based research. Government officials are concerned about the rapidly rising costs of operating research facilities and the reluctance of scientists and their institutions to acknowledge that choices must be made to live with limited resources and set priorities.

While the research partnership has had great impact in making the American research university the world leader in both the quality of scholarship and the production of scholars, it has also had its downside. Pressures on individual faculty for success and recognition have led to major changes in the culture and governance of universities. The peer-reviewed grant system has fostered fierce competitiveness, imposed intractable work schedules, and contributed to a loss of collegiality and community. It has shifted faculty loyalties from the campus to their disciplinary communities. Publication and grantsmanship have become a one-dimensional criterion for academic performance and prestige, to the neglect of other important faculty activities such as teaching and service.

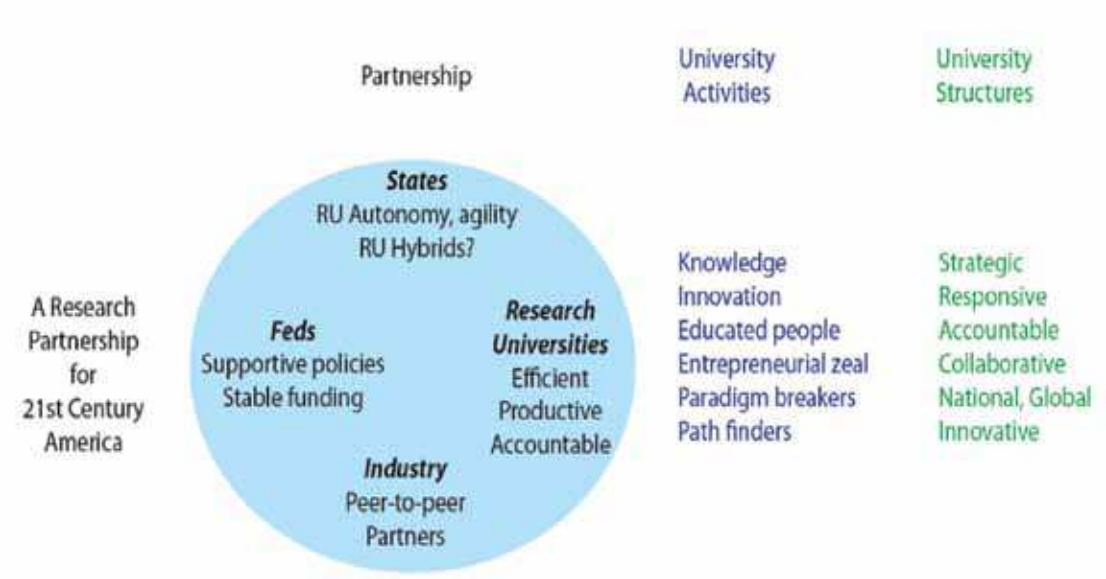
There has been a similar negative impact on the higher education enterprise, as faculties pressure more and more institutions to adopt the culture and value system of research universities. To put it bluntly, there are many more institutions that claim a research mission, that declare themselves "research universities," and that make research success a criterion for tenure, than our nation can afford. With hundreds of institutions seeking or claiming this distinction, the public is understandably confused. The immediate result is a further eroding of willingness to support or tolerate the research role of our most distinguished universities.

Furthermore, the government-university partnership has not adequately taken into account other key stakeholders in the scientific enterprise. Academic researchers often seem to place the support for the specialized pursuit of their self-initiated projects well above the importance of addressing the social and economic challenges of our nation. Others, however, including some in Congress, are beginning to view the persuasiveness of the research methods and its cost to taxpayers as a prerogative that faculty claim for themselves—almost an entitlement—regardless of the particular mission of the host institution or the importance of the research undertaking. They question whether the faculty is upholding its end of the social contract represented by the research partnership, since even curiosity-driven research is expected to benefit society over the long term.

Interestingly enough, other elements of the national research enterprise have faced similar challenges in recent years. Industrial research laboratories have had, and continue, to engage in a thorough reexamination of their past effectiveness and their present relevance to corporate goals. Federal research laboratories have had to reconsider and refocus their missions, particularly in the wake of the end of the Cold War. The academic sector is just beginning this agonizing but inevitable reappraisal.

Something else may also be happening, however. We may be seeing a shift in public attitudes toward higher education that will place less stress on values such as "excellence" and "elitism" and more emphasis on the provision of cost-competitive, high-quality services—from "prestige-driven" to "market-driven" philosophies. For the past half-century, the Bush paradigm of the government-university research partnership has been built upon the concept of relatively unconstrained patronage: The government provided faculty members with the resources to do the research they felt was important in the hopes that this research would benefit society in the future. Since the quality of the faculty, the programs, and the institution was felt to be the best determinant of long-term impact, academic excellence and prestige were valued.

Today society seems reluctant to make such long-term investments, preferring instead to seek short-term services from universities. While quality is important, even more so is cost, the marketplace seeks low-cost, quality services rather than prestige. The public is asking increasingly, "If a Ford will do, then why buy a Cadillac?" It could be that the culture of excellence, which has driven both the evolution of and competition among research universities for over half a century, will no longer be accepted and sustained by the American



The need for a new government-industry-university partnership for the 21st century.

public.

Rather than moving ahead to a new paradigm, we may find ourselves returning to the paradigm that dominated the early half of the twentieth century—the "land-grant university" model. Recall that a century and a half ago, America was facing a period of similar change, as we left behind an agrarian, frontier society for the industrial age. At that time, a social contract was developed between the federal government, the states, and public colleges and universities designed to assist our young nation in making this transition. This social contract was best manifested in the series of Land Grant acts and contained the following commitments: First, the federal government provided federal lands as the resources to fund higher education. Next, the states agreed to create public universities designed to serve both regional and national interests. As the final element, these public or "land-grant" universities accepted new responsibility to broaden educational opportunities for the working class while launching new programs in applied areas such as agriculture, engineering, and medicine aimed at serving an industrial society.

Today our society is undergoing a similarly profound transition, this time from an industrial society to a knowledge-based society. Hence it may be time for a new social contract aimed at providing the knowledge and the educated citizens necessary for prosperity, security, and social well-being in this new age. Perhaps it is time for a new federal act, similar to the land grant acts of the nineteenth century, which will help the higher education enterprise address the needs of the twenty-first century.

Other national priorities such as health care, the environment, global change, and economic competitiveness might be part of an expanded national service mission for universities, forming the basis for a new social contract. 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, academics would be called upon to set new priorities, collaborate across campus boundaries, and build upon their diverse capabilities.

Of course, a 21st Century Land Grant Act is not a new concept. Some have recommended an industrial analog to the agricultural experiment stations of the land-grant universities. Others have suggested that in our information-driven economy, perhaps telecommunications bandwidth is the asset that could be assigned to universities much as federal lands were a century ago. Unfortunately, an industrial extension service may be of marginal utility in a knowledge-driven society. Furthermore, Congress has already given away most of the bandwidth to traditional broadcasting and telecom-

munications companies.

Frank Rhodes, former president of Cornell University, has taken a somewhat different approach by observing that the land-grant paradigm of the nineteenth and twentieth centuries was focused on developing the vast natural resources of our nation. The agricultural and engineering experiment stations and the cooperative extension programs were enormously successful. Today, however, we have come to realize that our most important national resource for the future will be our people.

A land-grant university for the next century might 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 could be directed to the needs and the development of the people in the region. While traditional professional fields would continue to have major educational and service roles and responsibilities, new interdisciplinary fields should be developed to provide the necessary knowledge and associated problem-solving services in the land-grant tradition.

In an era of relative prosperity in which education plays such a pivotal role, it may be possible to build the case for new federal commitments. But certain features seem increasingly apparent. New investments are unlikely to be made within the old paradigms. For example, while the federal government-research university partnership based on merit-based, peer-reviewed grants has been remarkably successful, this remains a system in which only a small number of elite institutions participate and tend to benefit. The theme of a 21st Century Land Grant Act would be to broaden the base, to build and distribute widely the capacity to contribute both new knowledge and educated knowledge workers to our society, not simply to channel more resources into established institutions.

Second, although both Congress and the White House seem increasingly confident in the strength of our economy, they are unlikely to abandon entirely the budget balancing constraints that many believe contributed to today's prosperity. Hence, major new investments via additional appropriations seem unlikely. However, there is another model, provided, in fact, by the 1997 Budget Balancing Agreement, in which tax policy was used as an alternative mechanism to invest in education.

An example illustrates one possible approach. Suppose the federal government were to provide a permanent R&D tax credit to industry for those research and development activities undertaken jointly with public universities in special research parks. The states would commit to matching the federal contributions, perhaps by developing the research parks and assisting their public universities in building the capacity to partner with industry. The participating universities would not only agree to work with industry on projects of interest, but would restructure their intellectual property ownership policies to facilitate such partnerships. Participating universities would go beyond this to build the capacity to provide more universal educational opportunities, perhaps through network-based learning or virtual universities. Universities would also agree to form alliances, both with other universities as well as with other parts of the education enterprise such as K-12 education and workplace training programs.

This is but one example. There are many others. But the point seems clear. At the dawn of the age of knowledge, it may be time for a new social contract, linking together federal and state investment with higher education and business to serve national and regional needs, much in the spirit of the Land Grant Acts of the 19th Century.

The Gap Analysis

Despite the past impact of research universities on our nation, today America 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 the former Bell Laboratories.

Yet today, each member of the national research partnership appears to be backing away from the ear-

lier commitments that created and sustained the American research university. The policies and practices of our federal government no longer place a priority on university research and graduate education. (Berdahl, 2010) In the face of economic challenges and the priorities of aging populations, our states no longer are either capable or willing to support their public research universities at world-class levels. American business and industry have largely abandoned the basic and applied research that drove American industrial leadership in the 20th century (e.g., Bell Laboratories), largely ceding this responsibility to research universities but with only minimal corporate support. Finally, our research universities themselves have failed to achieve the cost efficiency and productivity enhancement in teaching and research required of an increasingly competitive world.

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

The Key Concerns

Despite their current global leadership, American research universities are facing critical challenges. First, their financial health is endangered as each of their major sources of revenue has been undermined or contested. Federal funding for research has flattened or declined; in the face of economic pressures and changing policy priorities, states are either unwilling or unable to continue support for their public research universities at world-class levels; endowments have deteriorated significantly in the recent recession; and tuition has risen beyond the reach of many American families. At the same time, research universities also face strong forces of change that present both challenges and opportunities: demographic shifts in the U.S. population, transformative technologies, changes in the organization and scale of research, a global intensification of research networks, and changing relationships between research universities and industry.

In addition, U.S. universities face growing competition from their counterparts abroad, and the nation's global leadership in higher education, un-assailable for a generation, is now threatened. Our research universities have brought to this country the most outstanding students and scholars from around the world and these individuals have contributed substantially to our research and innovative capacity. Now, other nations recognize the importance of world-class research universities and are rapidly strengthening their institutions to compete for the best international students and for faculty, resources, and reputation. These countries have developed national strategies for education and research and are also offering attractive opportunities to repatriate their citizens who are graduates of U.S. universities.

With these developments in mind, we have identified a set of specific challenges and opportunities that a reasoned set of policies must address in order to produce the greatest return to our society, our security, and our economy. The first group identifies issues in the partnership among the federal government, states, business, and universities:

- Federal funding for university research has been unstable and, in real terms, declining at a time when other countries have increased funding for R&D, both in nominal terms and as a percentage of gross domestic product;
- State funding for higher education, already eroding in real terms for more than two decades, has been cut further in the recent recession.
- Business and industry have largely dismantled the large corporate research laboratories that drove American industrial leadership in the 20th century (e.g., Bell Labs), but have not yet fully partnered with our research universities to fill the gap at a time when we need to more effectively translate, disseminate, and transfer into society the new knowledge and ideas that emerge from university research;
- Research universities need to be responsive to stakeholders by improving management, productivity, and cost efficiency in both administration and academics.

The second group identifies issues that affect the operations of universities, the efficient administration of university research, the effectiveness of doctoral education, and the robustness of the pipeline of new talent:

- Insufficient opportunities for young faculty to launch academic careers and research programs;

• Underinvestment in campus infrastructure, particularly in cyberinfrastructure, that can lead to long-term increases in productivity, cost-effectiveness, and innovation in research, education, and administration;

• Research sponsors that do not pay the full cost of research they procure, meaning that universities have to cross-subsidize research from other sources;

• A burdensome accumulation of federal and state regulatory and reporting requirements that increases costs and sometimes challenges academic freedom and integrity;

• Opportunities to improve doctoral and postdoctoral preparation that increase both its productivity and its effectiveness in providing training for highly-productive careers;

• Demographic change in the U.S. population that necessitates strategies for increasing the success of female and underrepresented minority students; and

• Competition for international students, researchers, and scholars.

The principles and recommendations that follow are designed to help federal and state policymakers, universities, and businesses overcome these hurdles and capitalize on these opportunities. Strong leadership – and partnership – will be needed by these parties if our research universities and our nation are to thrive.

Yet today, each member of the national research partnership appears to be backing away from the earlier commitments that created and sustained the American research university. The policies and practices of our federal government no longer place a priority on university research and graduate education. (Berdahl, 2010) In the face of economic challenges and the priorities of aging populations, our states no longer are either capable or willing to support their public research universities at world-class levels. American business and industry have largely abandoned the basic and applied research that drove American industrial leadership in the 20th century (e.g., Bell Laboratories), largely ceding this responsibility to research universities but with only minimal corporate support. Finally, our research universities themselves have failed to achieve the cost efficiency and productivity enhancement in teaching and research required of an increasingly competitive world.

Below we consider several of these challenges in more detail:

The Erosion of Public Support

Faculty are concerned that the growing imbalance between revenues and expenditures in both state and federal government threatens to undermine investment in priorities such as higher education as governments struggle to meet short-term demands at the expense of long-term needs. These financial stresses are particularly threatening to the research university.

Federal outlays for R&D declined throughout most of the 1990s. The strength of the American economy in the late 1990s has allowed some reinvestment in federally sponsored basic research, particularly in the life sciences with major increases in the budget of the National Institutes of Health. However most federal research programs, particularly those conducted by mission agencies such as the Department of Defense and the National Aeronautics and Space Administration, have still not recovered to the level of the 1980s. Furthermore, there remains concern that discretionary domestic spending, research and education programs, and federal support of the research university are at some risk over the longer term as long as entitlement programs remain unchecked, particularly as the baby boom generation approaches retirement.

The unanimous conclusion reached early in 2012 National Academy study was that the most vulnerable component of the nation's knowledge, research, and innovation infrastructure was the unwillingness of the states to sustain the world-class quality of their flagship public research universities. As the president of Stanford 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

The message here is a call to arms to the states, since their devastating cuts to public research universities (ranging from 20% to well above 50% over the past decade) is not only harming their own future but putting at great risk the nation's prosperity, health, and security

It is very important that the states understand that their flagship research universities are of vital importance to the welfare of the nation. Just as in two world wars, it is time to challenge them to step up to their responsibilities to the nation, not simply to their state

constituencies!!! Cutting support of public research universities in a knowledge-driven global economy is almost an act of treason with respect to the welfare of the nation. This is really a message we need to get out, since usually state governments and citizens think only in the most local of terms. One of our most important messages is that "As goes the public research universities of the states, so goes the nation itself!"

Cost Shifting

Another dilemma arises here. The constituencies we serve seek to minimize the resources they provide while maximizing the services they receive from the university. Each party wants more out of the system than it is willing to put in and seeks to leverage other contributors. Few of these constituencies seem to be able to perceive the university and its diverse missions. Most state and federal agencies picture the university only in terms of the part they perceive and interact with, e.g. research procurement or student financial aid. This is particularly true in Washington, where each element of the federal government attempts to optimize the procurement of the particular products or services they seek from our research universities. There seems to be little recognition that shifting federal priorities, policies, or support aimed at one objective will inevitably have an impact on other roles of our institutions.

Two examples illustrate the point: First, recent efforts to reduce the costs of federally sponsored research by imposing limits on indirect cost reimbursement rates are an example of cost shifting. While complex to calculate, indirect costs are nevertheless real costs associated with the conduct of federally sponsored research and must be paid by someone. Indeed, many of these costs are driven directly by the federal government through layer after layer of regulation, accounting, audits, and policy shifts. To put it in the starkest of terms, most institutions have only one recourse in responding to federal efforts to pay less than the full costs of the university research they procure: increasing student tuition and fees. If the federal government decides it wants to reduce federal research expenditures by several hundred million dollars by capping indirect costs, in reality it is asking students and parents to pick up this much of the tab for federal research projects, since this is the only alternative funding source for most universities.

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

A Change from Partnership to Procurement

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

To be sure, we must all be concerned about the proper expenditure of public funds. But we also must be concerned about restoring the mutual trust and confidence of a partnership and move away from the adversarial contractor/procurer relationship that we find today. Surely, the most ominous warning sign for academic research is the erosion, even breakdown, in the extraordinarily productive fifty-year partnership uniting government and universities. Scientists and universities are questioning whether they can depend on the stable and solid relationship they had come to trust and that has paid such enormous dividends in initiative, innovation, and creativity. It is alarming that the partnership that has been in large measure responsible for our

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

Intellectual Forces

The curiosity-driven search for new knowledge and the publication of results in scholarly journals has become a one-dimensional criterion for academic performance and prestige. It emphasizes primarily publication activity and grantsmanship all too frequently works against the synergy that should exist between research and education. Beyond that, the scientific method itself favors a reductionist process that depends upon greater and greater specialization to discover new knowledge.

While the social contract underlying the government-university research partnership was based on the premise of practical benefits to society, it was also based on a linear model in which basic research successively led to innovation, development, production, and societal benefit. In reality, however, the process of innovation and application is far less straightforward, involving a fusion of activities and ideas. There is less of a distinction between basic and applied research, since commercial application frequently enables basic research. In fact, benefit to society involves the integration of knowledge across many disciplines, just the type of activity that is falling through the cracks in the university reward system.

Global competition:

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. (Rick Levin)

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.

The Roadmap

In 2012 leaders of our Congress made the following request to the National Academies of Science, Engineering, and Medicine (Holliday, 2012):

> 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 assemble a distinguished group of individuals to assess the competitive position of

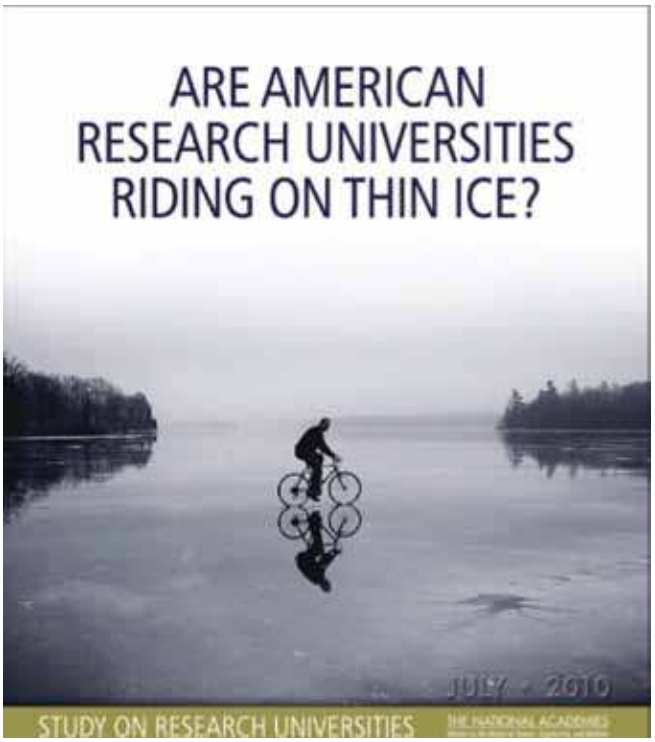
American research universities, both public and private, and to respond to the following question:

"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?"

In response, the National Academy leadership recruited a group of top national leaders, roughly balanced among those from American research universities, industry, government, and science, to serve on a committee to respond to the request made by Congress. This committee, chaired by Chad Holliday, former CEO of DuPont, met frequently to receive testimony and written input from an array of stakeholders from both the public and private sectors. Supported by a strong team of National Academy staff, the committee also conducted a number of studies of both key issues and possible actions. Those exercises influenced the committee's decision to frame its recommendations within the theme of the research partnership—among universities, the states, the federal government, and business and industry—that has been key to the evolution and leadership of the American research university.

Hence, the National Academies study stressed as its key theme the importance of both reaffirming and revitalizing the unique partnership that has long existed among the nation's research universities, the federal government, the states, and business and industry.

The approach taken in our roadmap was framed by several key principles. We sought 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. To this end, we attempted to create linkages and interdependencies among these commitments that provide strong incentives for participation at comparable levels by each partner. We sought sufficient flexibility in our recommendations to accommodate the differences among research universities and the diversity of their various stakeholders.



Congress is worried...

While merit, impact, and need should continue to be the primary criteria for awarding research grants and contracts by federal agencies, we believed that investment in infrastructure should consider additional criteria such as regional and/or cross-institutional partnerships, program focus, and opportunities for building significant research capacity. Furthermore, we stressed the importance of supporting the comprehensive and interdependent nature of the research university, spanning the full spectrum of academic and professional disciplines including the arts and humanities. Finally, we believed success would require 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.

In particular, we framed our recommendations of actions involving each member of the research partnership to accomplish these three broad goals. The first four actions were aimed at strengthening 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

The National Academies Report..

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

Revitalizing the Partnership

Recommendation 1: 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. (COMPETES, 2010) That would double the level of basic research conducted by the 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 funded by the National Institutes of Health. 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.

Recommendation 2: 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 their public research universities, cutting appropriations per enrolled student by an average of 35 percent, totaling more than $15 billion each year nationally. (McPherson, 2009) 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 regulations. 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." (Holliday, 2012)

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. While strongly encouraging the states to begin to restore adequate support of these institutions as the economy improves, we also urged them to move rapidly to provide their public research universities with sufficient autonomy and agility to navigate an extended period with limited state support.

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 and requiring joint commitment of resources. Strong support of a permanent federal tax for research and development 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 concerns of the American public 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 or less through improved efficiency and productivity. This will require the development of more powerful, 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.

Strengthening Research 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. (Atkins, 2003) 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 of the research they procure from the nation's research universities, they, in turn, could hold steady or reduce the amount of funding from other sources they have had to provide to subsidize this federal research. 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. (COGR, et. al., 2011)

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. (COGR, 2011) Furthermore, the federal government should also harmonize regulations and reporting requirements across all 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.

Building Talent

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. (Wendler, 2010) 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. This 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").

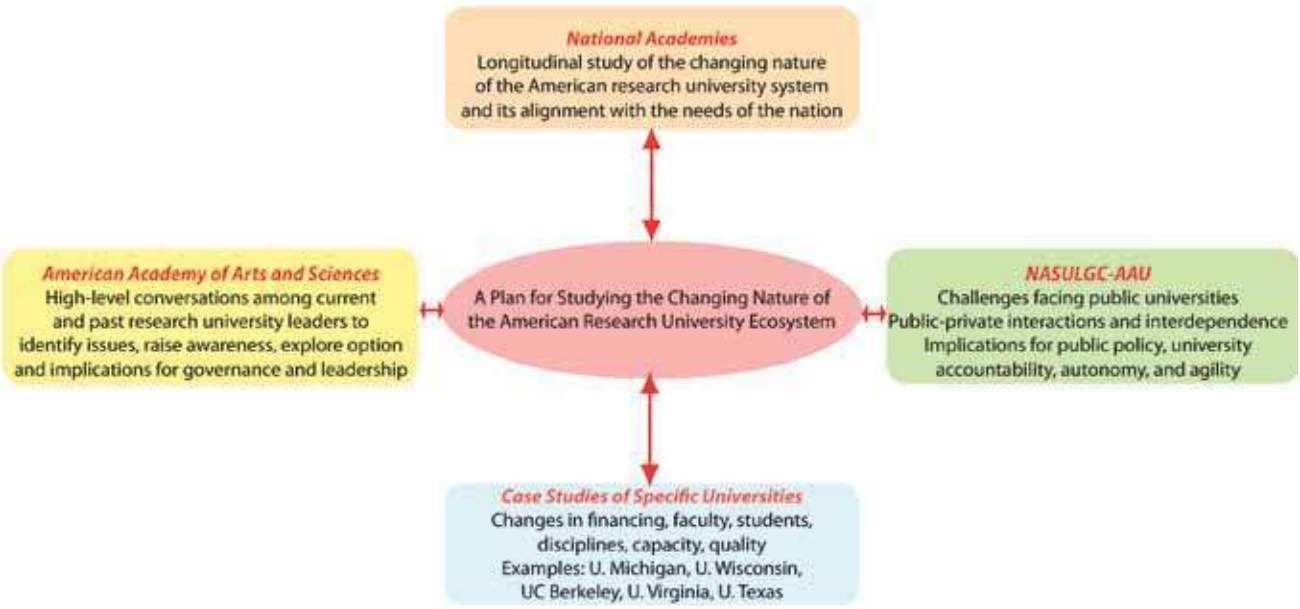
Concluding Remarks

American universities have always responded to the needs and opportunities of American society. In the nineteenth century they responded to the federal land-grant acts with the establishment of professional schools and the development of applied knowledge in essential areas. In the post–World War II years, they responded again by developing a thriving capability in basic research and advanced training in response to the federal initiatives embodied in the Bush report, Science, the Endless Frontier.

This is not at all surprising, considering the individualistic, entrepreneurial nature of the faculty and the loosely coupled, dynamic organizational structure of universities. We can argue that these institutions have taken on far too many missions as a result, but we cannot deny that they do respond to the opportunities and challenges presented by society. Today, universities are evolving rapidly, responding once again to their faculties' perception of the marketplace.

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



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

But there is a danger here. While they may not like it, the faculty is remarkably sensitive to the criticisms voiced about the academy: too much emphasis on research over teaching, too many Ph.D.s and not enough jobs, the need for a shift toward more applied activities. And they are responding, quite rapidly, to adapt to this brave, new world. Just survey any group of junior faculty members.

There are already signs of concern. The key drivers of prosperity in a knowledge driven economy are factors which contribute to innovation such as federal R&D expenditures, the production of R&D personnel, the share of our GDP spent on secondary and tertiary education, steps taken to protect intellectual property, and international openness. All of these increased in the 1980s, which some believe lay the foundation for our remarkable national prosperity during the 1990s. Yet the indicators for each of these areas point downward during the 1990s, which raises serious concerns about the continued growth of our innovation- and technology-driven economy in the decade ahead.

The world and the structure of academic research have changed greatly since Vannevar Bush wrote his report. However, the major principles he advanced merit reaffirmation. Now more than ever before, the national interest calls for an investment in human and intellectual capital. As Bush so clearly put it, the government-university partnership is not simply about the procurement of research results. It is also about nurturing and maintaining the human strengths of a great technological nation and sowing the seeds that will ultimately bear fruit in new products and processes to fuel our economy and improve our quality of life.

We need to sound the wake-up call to America sufficiently loudly and clearly that our faculty can hear the reverberations, before the American research university has evolved into some new paradigm, perhaps responding to other societal needs, but no longer with the capacity to respond to our intellectual needs. While it may indeed be time to develop a new social contract that rebalances the priorities given to education and research, we must not lose the capacity of our nation's research universities to produce the new knowledge necessary to respond to national needs.

The research partnership between the university and the federal government continues to be a relationship of great value to our nation and the world. The American public, its government, and its universities should not surrender the long-term advantage of this research partnership because of a short-term loss of di-

rection or confidence. At a time when many of society's other institutions do not seem to be working well, the research university is a true success story. We must get that message across to the American public. We must re-articulate and revitalize the remarkably successful partnership that has existed between our government, our society, and our research universities over the past half-century.

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Chapter 8

A Roadmap for the Public University

A Case Study: the University of Michigan

Our world is once again entering a period of dramatic social change, perhaps as profound as earlier periods, such as the Renaissance and the Industrial Revolution—except, while those earlier transformations took decades, if not centuries, today's often take only a few years. We live in an era of breathtaking and accelerating change. If education was once simpler, our world was simpler too. The most predictable feature of modern society is its unpredictability. We no longer believe that tomorrow will look much like today. Universities must find ways to sustain the most cherished aspects of their core values, while at the same time finding new ways to respond vigorously to the opportunities and challenges of a rapidly evolving world.

The recurrent theme of this report, and, indeed, of 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. Yet Michigan's challenge is greater than simply institutional change, since throughout its history it has been one of the most progressive forces in American higher education. Michigan's unique combination of quality, size, breadth, innovation, and pioneering spirit is particularly well suited to exploring and charting a course for higher education as it evolves to serve a changing world. And soon it will have an important opportunity to embrace this mantle of leadership as a pathfinder, trailblazer, and pioneer once again.

In many ways the University of Michigan has not only provided leadership for American higher education, but its impact frequently has extended far beyond the campus to have world-wide implications. It was one of the first attempts to build a true university in the New World, stressing scholarship in addition to teaching in contrast to the colonial colleges that were still focused on the collegiate model for educating young students. The University also provided one of the earliest examples of a public university, although since it was established by federal action through the Northwest Ordinance two decades before Michigan's statehood, one might suggest it began as a territorial or national public university rather than a "state" university. It was also one of the earliest examples of a research university, building one of the three largest telescopes in the world in the 1850s for scientific work, the first university hospital, and the first chemistry laboratory for teaching.

The broader impact of the University on society has been immense. Beyond introducing new disciplines ranging from bacteriology, meteorology, sociology, and modern history to computer engineering, nuclear engineering, and information science, Michigan has also had broader impact on the world through its educational and research activities. It was the first university in the world to promote the peaceful uses of atomic energy with the Michigan Memorial Phoenix Project, leading to the world's first academic program in nuclear science and engineering and new discoveries such as the use of I-131 in nuclear medicine and the bubble chamber detector for nuclear physics. It conducted the clinical trials that confirmed the effectiveness of the Salk vaccine and identified the genetic causes of diseases such as cystic fibrosis. Michigan was a leader in space exploration and astronaut education, e.g., the entire crew of Apollo 15 lunar mission consisted of Michigan graduates. Through its Willow Run Laboratories, the University developed much of the technology of remote sensing including holography and the maser.

More recently, Michigan partnered with IBM and MCI to build and operate the backbone of the Internet from the mid-1980s until this role was transferred to the commercial sector in 1993. The University's role in

advanced networking continued with its leadership in the founding and development of Internet2 during the 1990s. Today, Michigan is pioneering in the digitization of the great libraries of the world and the provision of access to their collections through its leadership role in digital libraries, the JSTOR project, the Google Book project, and the HathiTrust (which is today the largest digital library in the world with over 14 million volumes).

Hence the approaching bicentennial of the University of Michigan will provide an important occasion to recall, understand, and honor its remarkable history. But it 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 UM Bicentennial should be viewed as a compelling challenge to develop a new vision for Michigan's third century!

The University of Michigan Today

Long-enduring institutions such as universities need to begin with an understanding of their history, traditions, and values, i.e., their institutional saga. A university cannot escape reckoning with its history, especially when it comes to developing a planning process. For example, a consideration of both the fundamental public purposes and values of the institution is essential–e.g., have these been followed; have they changed over time. Equally important is an assessment of the availability and deployment of resources—human and physical, tangible and intangible—as the outcome of dynamic processes occurring over time. It is important always to consider the evolutionary path that has brought the University to its current situation. 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 U-M's case, a faltering Michigan economy that is no longer able to support a world-class public research university is clearly a serious concern. But so, too, are 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 positions us well to address the growing trends of globalization, just as the university's leadership in developing and implementing new technologies, such as the Internet, has given us a good perspective of technological change.

Data and other indicators characterizing the University of Michigan today can be found in recent University publications such as the *Michigan Almanac*. (Schweitzer, 2014) We have summarized this material in this section taken directly from this resource (indicated in blue).

Academic Programs

The University of Michigan has grown to include 19 schools and colleges covering the liberal arts and sciences as well as most professions. The fall 2015 enrollment of undergraduate, graduate and professional students was 43,625. The current faculty consists of 3,051 individuals who are tenured or on a tenure-track. Lecturers, clinical faculty, research professors, librarians, archivists, and post-doctoral fellows add 3,801 bringing the total academic staff to the Ann Arbor campus 6,852. The staff count is 14,003, bringing the total personnel to 20,855. The FY2014 operating revenues from the state appropriation, tuition, research grants and contracts, gifts and other sources reached $3.37 billion for the Ann Arbor campus. The U-M Health System revenues added $3.0 billion for a grand total of $6.37 billion. (The projected budget for 2015 is $7.1 B.) According to the latest national data, the U-M expenditures on research–$1.3 billion in FY2014 – represent more than any other U.S. university. The U-M provides housing to 9,300 undergraduate students in 18 residence halls and apartment buildings. Graduate students are accommodated through 1,100 apartments in the Northwood housing complex.

Undergraduate Students

A central priority for the University is access; its goal is to enable qualified students to attend regardless of socioeconomic background. For a number of years, the

U-M has provided financial aid packages that meet full cost of attendance to admitted students from Michigan. Freshmen application numbers have nearly doubled since 2004, growing to 49,776 in 2014 due in part to the switch to the Common Application. As a highly selective institution, U-M offers admission to fewer than half of those who apply. The size of the enrolling freshmen cohort has hovered around 6,000 for the past five years, which met or exceeded annual targets. The U-M offers more than 250 academic programs for undergraduates, opportunities for international study, more than 1,200 student clubs, 26 NCAA Division I teams, and art and theatre offerings by and for students and professionals. The University actively pursues students from the state of Michigan, the nation and around the globe. In 2014, the 28,395 undergraduate students on campus came from 82 of 83 Michigan counties, all 50 states, and 90 countries. 59% of currently enrolled undergraduates are in-state students. The diverse origins, backgrounds and experiences found in every entering class contribute to the varied interests and characteristics of the student body.

More than two-thirds of Michigan undergraduate students complete their first degree within four years of enrolling as freshmen. After six years, that figure is nearly 90 percent. University of Michigan students' completion rates are 20 percentage points higher than the average of public Association of American Universities (AAU) member institutions. U-M undergraduates are surveyed during their senior year and report very positive opinions of the University as a whole and of their individual academic programs. Ninety percent of seniors surveyed say that if they had it to do over, they would attend the University of Michigan again. Lastly, nearly half of all undergraduates continue their academic careers by enrolling in graduate or professional school within four years of completing a degree at the U-M.

The University of Michigan is a firm proponent of the educational value provided by a diverse, multicultural and inclusive campus community. Although the U.S. Supreme Court ruling in 2003 on the Admissions lawsuits and the 2006 passage of Proposal 2 put limits on the University's actions, the U-M remains committed to fostering racial, ethnic, gender and socioeconomic diversity at the institution by all legal means possible.

Graduate and Professional Students

The University of Michigan offers a remarkably broad and rigorous array of graduate and professional degree programs that are among the very best in the country in each field of study. The University attracts outstanding students to graduate study, and prepares them to make lasting contributions to society through successful careers in professions and academic disciplines. Interdisciplinary study and joint degrees are a special strength of the University. The vibrant community of graduate and professional students on campus is highly diverse in citizenship, demographic background, and intellectual perspective.

The Horace H. Rackham School of Graduate Studies oversees graduate academic education in partnership with the schools and colleges. For fall 2014, the University enrolled 8,501 students in 108 Ph.D., 87 master's, and 33 graduate-level certificate programs offered by the University's schools and colleges. In addition to obtaining an education, graduate students contribute significantly to the conduct of research, scholarship and teaching on campus. The research enterprise at the U-M benefits enormously from the talent and intelligence of these students.

Another 6,831 students enrolled in professional degree programs in medicine, law, business, public health, dentistry, pharmacy, nursing, information, engineering, social work and architecture and urban planning in fall 2014. The schools or colleges administer these degree programs in keeping with each profession's requirements and standards. Compared to its peers, the University of Michigan awards a high number of graduate and professional degrees. Among its peers, only the combined total of Columbia University's advanced degrees is higher than Michigan's.

Post-graduation plans vary along disciplinary lines. Ph.D. graduates in the humanities and the arts often find academic positions immediately after graduating. Graduates in the biological, physical and social sciences frequently take a postdoctoral training position before moving into other employment. Industry positions attract a large number of graduates from engineering and the physical sciences. U-M's international students tend to remain in the U.S. after graduation, probably

reflecting the kind and number of opportunities available in this country for those holding advanced degrees. In several professions, prospective practitioners must pass one or more examinations before becoming a full member of his or her chosen career; U-M students in medicine, law and dentistry have high pass rates.

Faculty and Staff

AA great university is defined in large part by its outstanding faculty. The University of Michigan attracts faculty members with commitment to excellence in both teaching and research, as shown by the high quality of its graduates and the superior research and scholarship by its faculty. The faculty headcount at the University of Michigan is 6,852 while the total of faculty full-time equivalents (FTEs) is 5,757. Instructional appointments comprise 3,293 FTEs, and another 2,460 FTEs are individuals with clinical, research and other titles who are primarily involved in health care, research, and related scholarly activities.

U-M faculty members are primarily involved in teaching, research and scholarship. However, the faculty also have service responsibilities to the university and broader academic community and society at large, as well as administrative duties and an important role in setting academic policies for admissions, the granting of degrees, and the content of the curriculum. The staff of the University currently number 13,475 and play key roles in the efficient and productive operation of nearly all facets of the University. Staff members are involved in the conduct and administration of research; they provide academic, housing, and other services for students; handle financial operations of the institution; manage the physical and digital infrastructure of the campus; and monitor the many federal, state, and professional compliance rules the institution must follow.

Research

Excellence in research and scholarly activity is a central tenet of the University of Michigan's mission. The broad scope and overall size of the U-M's research program, along with its emphasis on interdisciplinary approaches, contributes to Michigan's standing as one of the world's leading research universities. As such, the faculty attracts generous financial support from the public and private sectors. Total research expenditures by the University exceed $1.32 billion per year. However it is important to note that more than 70 percent of the money that the University spends on research in any given year is funding provided by outside sources. The biggest share of that research funding comes from the federal government. When research funding from all sources is counted, U-M ranks No. 1 in the nation among all universities. The University's largest fraction of grant-supported work occurs in the biomedical and clinical sciences. The U-M Medical School alone regularly attracts several hundred millions of dollars each year to support research by its faculty. In 2013, the Medical School's $302 million in new grant funding was 11th highest of all U.S. medical schools.

Space

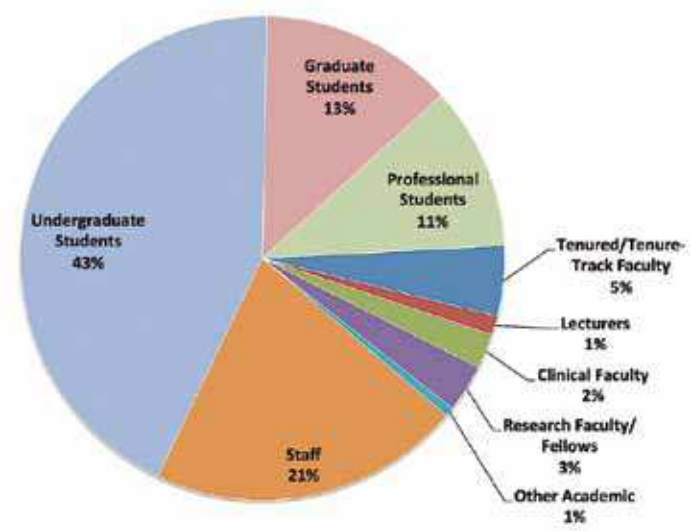
The physical plant of the University of Michigan's Ann Arbor campus is extensive (in 2015 numbers):

35 M gsf of buildings and core infrastructure
601 buildings, 2,125 classrooms and labs
900 study rooms, and 6,300 labs
7 miles of utility tunnels
150 miles of fiber optic cables
137,200 networked desktop computers
660 elevators and escalators
25 miles or roads
4.7 M sf of sidewalks, steps, and plazas
280 acres of parking lots and decks
16,100 trees and 13 M sf of turf

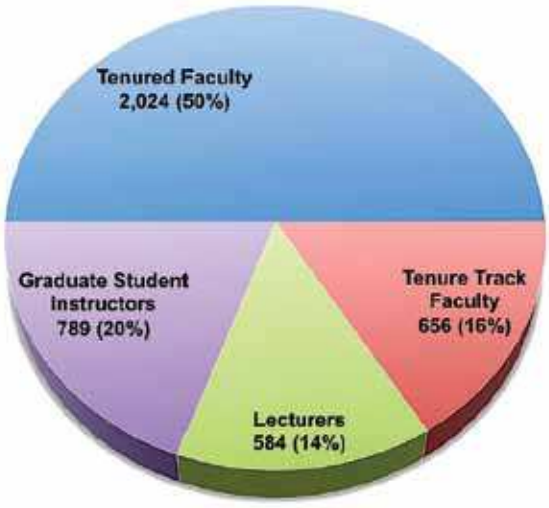
Space utilization guidelines have been established for classrooms, food services, research activities, and offices. In particular, effective classroom scheduling is critical to the academic mission of the University.

Spires of Excellence

Michigan's character as leader through its pathfinding and trailblazing also requires it to build spires of excellence in key fields, rather than trying to achieve a uniform level of lesser quality across all of its activities.



Composition of UMAA Community



Composition of UMAA Faculty

Only by attempting to be the best in these fields can we develop in our students, faculty, and staff the necessary intensity and commitment to excellence. Furthermore, only by competing with the best can it establish appropriate levels of expectation and achievement.

It must be stressed here that it is not the University's goal to build a few isolated spires of excellence in the manner of smaller private universities. Rather, it seeks to achieve within each of its academic units–its schools, departments, centers, and institutes–a number of spires of focused excellence. In other words, the general level of quality in each of our academic units can be achieved through the development of a series of sharply focused peaks of excellence within the units. Thus, even for those programs where the University is unable to provide the resources to be national leaders, it aspires to achieve some peaks of extraordinary excellence through the focusing of resources. It is determined to make every effort to avoid mediocrity, but constrained resources suggest that it will inevitably have some areas that were very good as opposed to excellent.

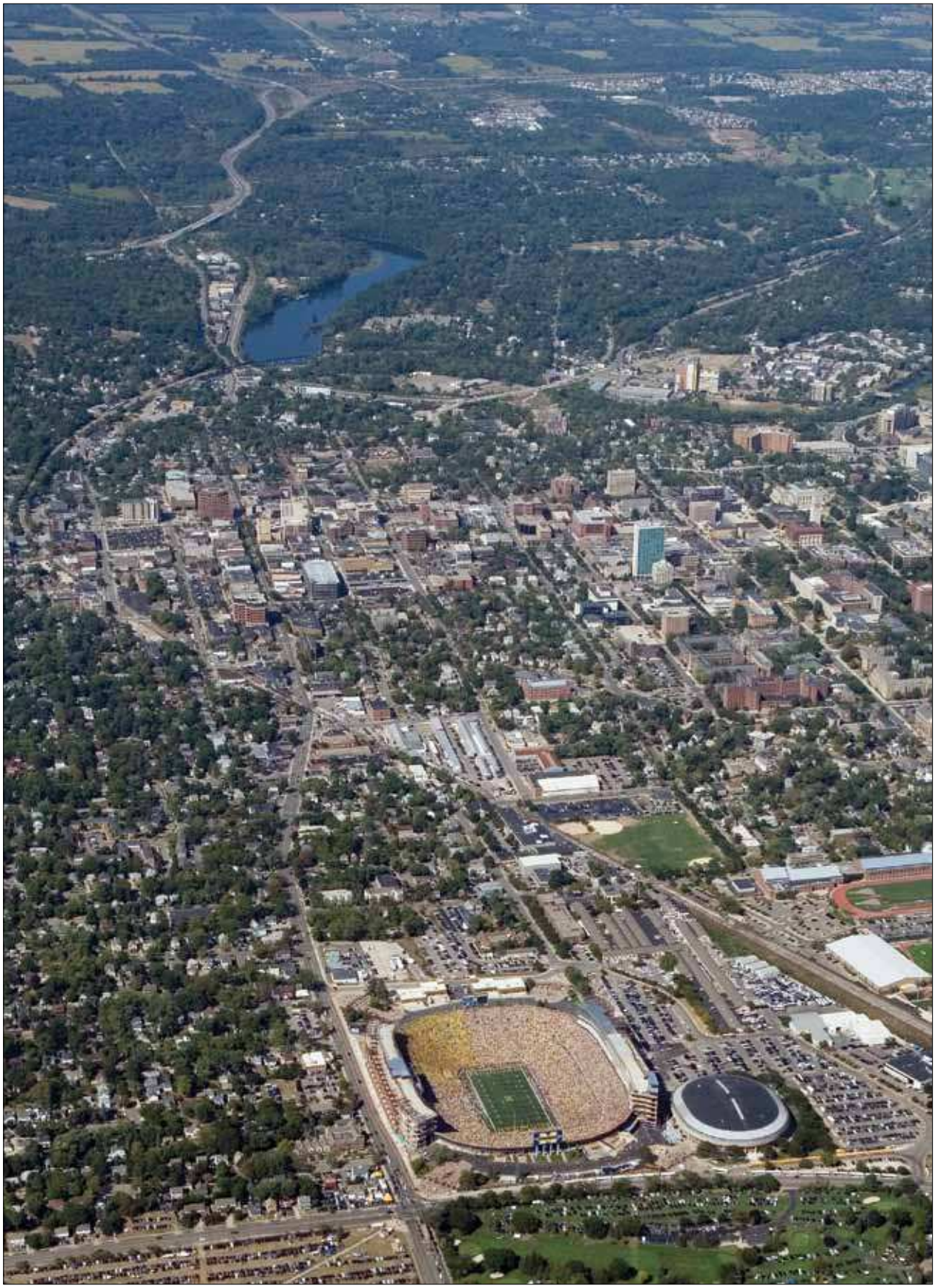
The theme of pathfinding leadership influences the focus of emphasis within Michigan's traditional endeavors of education, scholarship, and service. For example, it requires that the University become even more committed to the concept of a liberal education for its students. The development of leaders among its students demands challenging intellectual experiences, both in formal instruction and in the extracurricular environment.

In order to develop leaders among its faculties, at least some fraction of its scholarship needs to be shifted to venturesome intellectual activities at the cutting edge of inquiry. Some of the University's faculty should be encouraged to work in seminal, cross-disciplinary areas where extraordinary insight and intellectual breadth can lead to the creation of entirely new fields of knowledge.

The University continues to have important service roles. Leadership requires that such activities be justified as important experiences for its students and faculty, as models to be propagated to other institutions, and as sources of important questions for basic investigation.

The quality of the University of Michigan academic programs is the most fundamental determinant of its ability to develop and maintain leadership. However, a comprehensive and diverse array of intellectual, social, and cultural experiences is also important for its leadership role in higher education. And, the scale of our programs not only contributes to the richness and quality of the University (e.g., the size and quality of central resources such as libraries, computing networks, and athletic facilities), but it also determines its potential impact on society.

Rather than viewing the quality, breadth, and scale of the University as competing objectives–or possibly even as constraints on what it can accomplish within a world of limited resources–instead these characteristics, when linked together creatively, can provide



an unusual opportunity. By building leadership in an environment that demands commitment to all three characteristics, with a particular stress on academic excellence, it can distinguish the University from other institutions that tend to focus on only one of these factors.

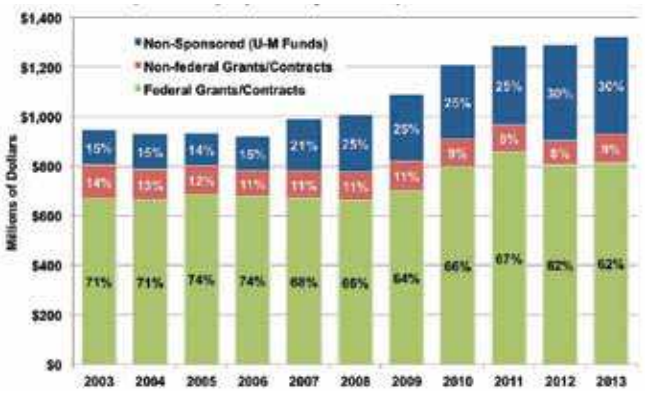
For example, highly selective private institutions sometimes sacrifice breadth and size in an effort to achieve absolute excellence in a small number of fields. This results in institutions highly focused in an intellectual sense, which while certainly capable of conducting distinguished academic programs, are nevertheless unable to provide the rich array of opportunities and diverse experiences of "multiversities" such as Michigan. At the other end of the spectrum, the University can also set itself apart from many other large, comprehensive public universities by the degree to which it chooses to focus its resources on academic quality.

A Vision for the University's Future

Developing a vision for the future of the University of Michigan is a challenging exercise, both because of the unusual size, breadth, and complexity of the institution and because of the important leadership role it is expected to play as a pathfinder in American higher education. During the past two centuries of its history, Michigan has responded time and time again to the changing needs of an evolving nation by transforming itself and higher education more generally.

Today the University of Michigan faces yet another pivotal moment in its history, a fork in the road. Taking one path can, with dedication and commitment, preserve the University as a distinguished–indeed, a great–university, but only one among many such institutions. There is another path, a path that will require bold visions, courage, and creativity in addition to dedication and commitment. By taking this second path, the University would seek not only to sustain its quality and distinction, but it would seek to achieve leadership as well, embracing its long history–its saga–as a pathfinder and trailblazer for higher education.

Of course, there are always those who believe that Michigan should settle for achieving excellence and leadership within the confines of the current American research university paradigm. The University of Michigan, they argue, should take the necessary steps



UMAA research expenditures (constant dollars)

to preserve its options, to create flexibility, to develop the capacity to adapt to and control change, and to open up opportunities during the decades. They prefer more modest strategies to clearly identify the goals that would enable the University of Michigan to adapt to a changing world in a far more organic, evolutionary manner.

But such a laissez-faire approach to the future is not the Michigan style. The University tends to flourish when it has been enlivened and emboldened by challenging visions of the future. While acknowledging the difficulties and the risks inherent in long-range planning exercises, the University's heritage as a leader in higher education demands the development and articulation of a bold vision for its third century. It is a fitting exercise for an institution aspiring to become "the leader and best."

Hence we contend that as the University approaches its third century, it should embrace once again its heritage as a pathfinder, a saga established two centuries ago in the late 19th century when the University of Michigan became a primary source for much of the innovation and leadership in higher education. Once again Michigan has the opportunity to influence the emergence of a new paradigm of what the university should become in our 21st Century world to respond to the changing needs of our society. But this will require a bold vision, an unusual commitment to excellence, a challenge and engaging strategy, and strong and dedicated leadership.

Earlier chapters in this report have provided the foundation for this effort, scanning the environment in which the University now (or soon will) finds itself and assessing our current assets and challenges. In

this chapter we turn our attention toward developing an appropriate vision for the University of Michigan as it begins its third century of service to the state, the nation, and the world. It is true that formidable challenges of our time understandably frame current priorities, e.g., the loss of state support, the need to restore Michigan's public purpose, the effort to control costs while competing with leading private institutions characterized by great wealth. But a vision for the future must be built upon a message of hope, optimism, excitement, and empowerment, just as it has been at important moments in Michigan's past, e.g., the 19th Century vision to provide "an uncommon education for the common man" or the late 20th Century vision to "re-invent the university to better serve a rapidly changing society and world".

The Foundations of a Vision

So, how might we construct an appropriate vision for the University as it enters its third century? Clearly this exercise must begin by articulating the most important values of the institution:

Excellence
Leadership
Critical and Rational Inquiry
Liberal Learning
Diversity
Community
Innovation
Excitement
Spirit

Key, as well, are our fundamental aspirations for the future of the University, those actions and goals that must receive high priority to achieve our vision. From Michigan's history we might suggest characteristics such as the following:

"The leaders and best"
"An uncommon education for the common man"
"A broad and liberal spirit"
"Diverse, yet united in a commitment to academic excellence and public service"
"A center of critical inquiry and learning"
"An independent critic and servant of society"
"A relish for innovation and excitement"
"Freedom tempered by responsibility for students and faculty"
"Control of our own destiny comparable to private universities"

During the planning effort of the 1990s, we took a somewhat different approach by turning to the late Michigan Professor of Business Administration. C. K. Prahlahad, for his concept of *strategic intent*. (Prahlalad, 1994) 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 that requires institutional transformation to build new capabilities.

The Strategic Intent (Vision 2017): To provide the university with the capacity to re-invent itself as an institution more capable of serving a changing state, nation, and world.

Vision 2017 depended for its success upon 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.

Around the core of values and characteristics are arranged a number of possible paradigms, actually cartoonish characterizations exaggerating particular missions of the university, e.g.

the world university
the diverse university
the creative university
the divisionless university
the adult university
the university college
the lifelong university
the ubiquitous university

the laboratory university

While none of these alone would appropriately describe the university as it enters 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 21st Century. Each was also a pathway we believed should be explored in our effort to better understand our future.

Finally, and most important, during a time of great change in society, Michigan's most important saga will once again be that of a pathfinder, a trailblazer, building on its tradition of leadership, and relying on its unusual combination of quality, capacity, and breadth to re-invent the university, again and again, for new times, new needs, and new worlds.

With this foundation, we now introduce the key themes of the vision we suggest for the future of the University of Michigan, arranged in three time epochs: *now*, *soon* (2017), and the University's *third century*.

The Theme for the Near Term: *Reflection*

For the near term, from now until the Bicentennial Year 2017-2018, 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, but 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 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.

The Theme for the Next Generation: *Renaissance*

The world is changing rapidly, driven by the role played by educated people, new knowledge, innovation, and entrepreneurial skill. 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. Put another way, the future university must add to its traditional motto of *lux et veritas*, the scholarship to discover *truth* and the learning to *enlighten* society, the mission of *genius* itself, of the creativity demanded by an ever changing world.

In fact, Ralph Waldo Emerson suggested the importance of creativity to the university's mission almost two centuries ago in his 1837 Address to Phi Beta Kappa that to the traditional missions of veritas (the search for truth) and *lux* (the enlightenment provided by learning), one should add *genius*, the power of creativity:

> "Colleges have their indispensable office, to teach elements. But they can only serve us when they aim not to drill but to create; when they gather from far every ray of various genius to their hospitable halls, and by the concentrated fires, set the hearts of their youth aflame."

Of course while learning and scholarship have long been viewed as missions of the university, so too has been the creation of new knowledge across all intellectual and professional disciplines. Developing new approaches to scholarship, great works in literature and the arts, ingenious approaches to investigating physical and social phenomenon, these have long been the goal of most scholars. Not just to preserve and transmit knowledge, but to actually create it.

The professions that have dominated the late 20th Century—and to some degree, the late 20th Century university—have been those which manipulate and rearrange knowledge and wealth rather than create it; professions such as law, business, accounting, and politics. Yet it is becoming increasingly clear that the driving intellectual activity of the 21st Century will be the act of creation itself, as suggested by Jacques Attali in his provocative forecasts for the 21st century at the turn of the Millennium:

> "The winners of this new era will be creators, and it is to them that power and wealth will flow. The need to shape, to invent, and to create will blur the border between production and consumption. Creation will not be a form of consumption anymore, but will become work itself, work that will be rewarded handsomely. The creator who turns dreams into reality will be considered as workers who deserve prestige and society's gratitude and remuneration." (Jacques Attali, 2000)

But today the new tools of creativity are appearing characterized by extraordinary power. We have the capacity to create new objects literally atom by atom. With new methods in molecular biology such as CRISPR and gene drive, we can not only precisely modify the

DNA code for a living organism, but actually cause it to propagate through a species to change future generations (a frightening thought when human gene editing is considered). The dramatic pace of evolution of information technology shows no sign of slowing, continuing to advance in power from 100 to 1000 fold a decade, enabling not only new forms of analysis such as augmenting the traditional tools of experiment and theory with the sophisticated tools of data analysis (big data). Indeed, the tools of artificial intelligence not only are rapidly progressing but have stimulated fears of eventual sentient behavior of machines. These tools also have changed the opportunities available in literature, performance, and art, with powerful tools of investigation and display (e.g., the CGI techniques increasingly dominating the film industry.)

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.

Since universities will play such a critical role as the source of these assets of the age of knowledge, perhaps the university of the 21st century will also shift its intellectual focus and priority from the preservation or transmission of knowledge to the process of creation itself. A determining characteristic of the university of the 21st Century may be a shift in intellectual focus, from the preservation or transmission of knowledge, to the process of creation itself. Thus, our vision for the early 21st century should stress the following characteristics among our people and our programs:

Creativity
Innovation
Ingenuity and Invention
Entrepreneurial Zeal

But here lies a great challenge. As noted earlier, creativity and innovation are key not only to problem solving but more generally to achieving economic prosperity, social well being, and national security in a global, knowledge-driven economy. Yet, while universities 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 creation and innovation. This would probably imply a shift away from highly specialized disciplines and degree programs to programs placing more emphasis on integrating knowledge. There is clearly a need to better integrate the educational mission of the university with the research and service activities of the faculty by ripping instruction out of the classroom–or at least the lecture hall–and placing it instead in the discovery and tinkering environment of studios or workshops or "hacker havens".

Actually, as John Seely Brown points out, today's students are already using technology to function much like artists – disciplined, focused, pushing boundaries, challenging assumptions and creating meaning. (Brown, 2009) They are willing to engage with multiple viewpoints before synthesizing their own. But beyond that, they look for meaning not just in what they create or own but in addition through what they contribute back to society-at-large. They are engaged, first and foremost, in fostering what might be called the creative class. Not only do they want to create for themselves, but they also want others to build on their creations.

The platforms they use are mostly digital: instant messaging to keep in constant contact with one's own intimate community; blogging to let one experiment by exposing their ideas to others and getting rapid feedback; by participating in the rapidly expanding worlds of open source, open content (e.g., Wikipedia), and remixing the work of others; rich media capable of expressing complex ideas; and a vast network characterizing cyberinfrastructure that lets one access communities, instruments, and databases all over the

The Renaissance Campus: Music, Art, Architecture, and Engineering

world (an infrastructure that the University of Michigan has played a key role in creating). These are the power tools of the Net Generation.

Here, the University of Michigan provides an interesting example of how academic programs characterized by technology-driven creative activities might evolve. On the University's North Campus, we already are fortunate to have several schools–music, dance, and the performing arts; art and design; architecture; and engineering–that focus on the creative activities that increasingly require new tools. The Media Union (aka Duderstadt Center) and Walgreen Center on the North Campus provide unique "commons" facilities, gathering places that support interdisciplinary activities in "making things"–3-D objects, virtual reality simulations, new art forms, CGI-based performances, responding to a growing need for both student learning and faculty participation in such activities. 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 (whether objects of art, performances, buildings, or new technologies). In fact, the four deans of these schools who created the concepts for the Media Union and Walgreen Center in the 1990s used to refer to the North Campus as the University's "Renaissance Campus.

Drawing together aspects of hardware and software, inquiry and discovery, tinkering and invention, and creativity and innovation, experimentation and performance, the Duderstadt Center and Walgreen Center provide tremendous interactive playground for imaginative scholars and students. The tools in these facilities are so easy to use that ideally they become natural extensions to everyday activity. For example, an artist, an engineer, and a choreographer should be able to think up a new staging for a performance together, sketch it out in three dimensions on a computer, then show it off and discuss it in real time with colleagues both here and across the world, all without noticing the complex technology that allows them to collaborate.

This model of "creativity and innovation" commons facilities that enable faculty members and students from diverse schools to work together is now being propagated to other parts of the University, including the arts and humanities and social sciences of the Central Campus and the natural sciences and biomedical programs.

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.

To adapt its pedagogy to the challenge of a "renaissance" education, universities may form

strategic alliances with other groups, organizations, or institutions in our society whose activities are characterized by great creativity, for example, the art world, the performing arts, and high-tech industry.

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? 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) Just what a world-class research university characterized by great socioeconomic diversity such as the University of Michigan can offer!

The Theme for the Third Century: *Enlightenment*

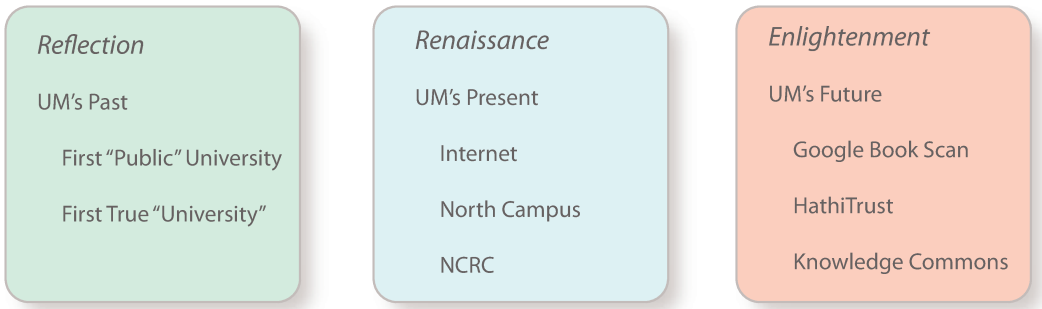
Any vision proposed for the University's third century must consider the extraordinary changes and uncertainties of a future driven by exponentially evolving information and communications technology. The extraordinary connectivity provided by the Internet already links together the majority of the world's population. To this, one can add the emerging capacity to capture and distribute the accumulated knowledge of our civilization in digital form and provide opportunities for learning through new paradigms such as MOOCS and cognitive tutors. This suggests the possible emergence of a new global society no longer constrained by space, time, monopoly, or archaic laws and instead even more dependent upon the generation of new knowledge and the education of world citizens. In such an era of rapid change, it has become the responsibility of democratic societies to provide their citizens with the learning opportunities they need throughout their lives, at costs they can afford, as a right rather than a privilege.

What the nation (and the world) needs today is a 21st century version of the Enlightenment movement of the 17th and 18th century that swept aside the divine authority of kings by educating and empowering the public, stimulating revolution, and creating the liberal democracies that now characterize most developed nations. Our nation and our world needs once again the "illumination" provided by distributing "the light of learning and knowledge" to counter the ignorance (e.g., today's "denier" culture) and address the challenges of our times.

More specifically, the goals of the Enlightenment were to provide for a rational distribution of freedom, universal access to knowledge, and the formation of learning communities. Rational and critical thought was regarded as central to freedom and democracy. Knowledge and learning were regarded as *public goods*, to be made available through communities such as salons, seminars, and academies. These dreams of the universal and the collective, L*iberte, Egalite, and Fraternite* for the French Revolution–or perhaps better articulated by Jefferson's opening words from our Declaration of Independence: "We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness."–remain as important today as they were three centuries ago.

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. In a sense, the word "university" itself conveys the elements of this vision: both the sense of a "union" or community of learners (i.e., *universitas magistrorum et scholarium*) and the "universality" or totality of knowledge and learning as the key to social well-being in an age of knowledge. Furthermore, since these have been regarded as *public* goods, one might even suggest that the *public* universities have a particular responsibility in providing these.

Our proposition is that the Enlightenment theme would be a particularly compelling and appropriate goal for the University of Michigan's third century. After all, our future will continue to be one in which freedom and prosperity depend upon widespread distribution of "the light of learning and knowledge", and hence this should become a key component of our



Linking Future Themes to Past Accomplishments

extended public purpose.

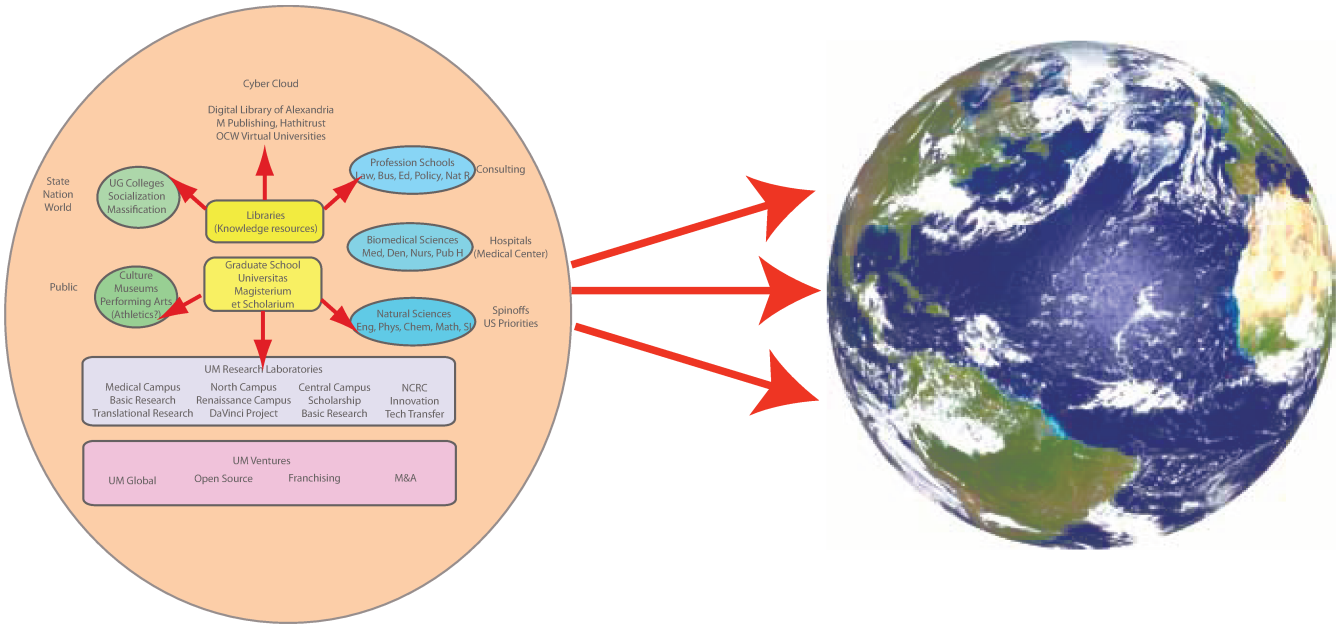
Actually, this theme traces its origin to the earliest days of the University of Michigan, since its original incarnation as "the Catholepistemiad or University of Michigania" was a utopian vision stimulated by the principles of the Enlightenment that undergirded the Northwest Ordinance of 1787, e.g., "religion, morality, and knowledge being necessary to good government and the happiness of mankind, schools and the means of education shall forever be encouraged".

Michigan's early evolution was heavily influenced by Henry Tappan's efforts to build a true university, based not simply on learning but on scholarship laid the foundation for the research university in America. And, perhaps most important, its public character was shaped by the Jeffersonian ideal of education for all to the extent of the individual's capacity, i.e., "providing an uncommon education for the common man". These fundamental principles, along with its unusual secular character, established Michigan as one of the nation's first and most prominent "public" "research" universities and continues to define its public purpose today in terms of both creating and distributing learning and knowledge to society. Hence, it is most appropriate that any vision for the University's future embrace and extend its character as a truly "public university" to address the nature of our changing world.

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, immersive environments, "sim-stim". And learning communities are no longer constrained by space and time but rather propagated instantaneously by rapidly evolving technologies (e.g., cyberinfrastrucure) and practices (e.g., open source, open knowledge). The ancient vision of the Library of Alexandria to collect all of the books of the world in one place is rapidly becoming true–except the "place" has now become a cloud in cyberspace. Learning communities are evolving into knowledge generating communities–wikis, crowd sourcing, hive cultures that span the globe.

William Germano suggests yet another argument for such a theme as the possible next stage in speculating about the evolution of the "book", from the invention of writing to the codex to the printed volume to the digital revolution. As he explains:

> "Right now we are walking through two great dreams that are shaping the future of scholarship, even the very idea of scholarship and the role "the book" should play within it. Great Dream No. 1 is universal access to knowledge. This dream means many things to many people, but for knowledge workers it means that scholarly books and journals can, and therefore should, be made available to all users. New technologies make that possible for the first time in human history, and as the argument goes, the existence of such possibilities obligates us to use them. Great Dream No. 2 is the ideal of knowledge building as a self-correcting, collective exercise. Twenty years ago, nobody had Wikipedia, but when it arrived it took over the hearts and laptops for undergraduates and then of everyone else in the education business. Professional academic life would be poorer, or at least much slower, without it. The central premise of Wikipedia isn't speed but infinite self-correction, perpetually fine-tuning what we know. In our second dream, we expand our aggregated knowledge quantitatively



A Public Purpose for the Third Century: Providing the light of knowledge and learning to the world!

and qualitatively". (Germano, 2010)

Germano continues on to suggest that "these two dreams–the universal and the collective–should sound very familiar since they are fundamentally the latest entries in Western culture's utopian tradition."

In a sense, then, the concept of a 21st century analog to the Enlightenment combines several themes that we suggested earlier might characterize the university of the future:

- The emergence of a *Universitas Magistrorum et Scholarium* in cyberspace.
- The power of network architectures in distributing knowledge and learning
- The increasing access to knowledge and learning resources through the massive digitization and access to printed materials and other sources of information
- The perspective of learning organizations as ecologies that evolve and mutate into new forms
- The university as the prototype of an emergent global civilization

Today, the University of Michigan is already playing a leadership role in achieving just such a vision. Its efforts during the 1980s (together with IBM and MCI) to build and manage the backbone of the Internet, its role in creating Internet2, and most recently the early effort to create a "national learning, research, and innovation network" linking together the nation's research universities, national laboratories, federal agencies, and industry with advanced cyberinfrastructure all provide strong evidence of the leadership role it plays in linking together people and institutions around the world.

The University of Michigan has also played a leadership role in redefining the nature of the "library" for a digitally connected world, first with the NSF digital library project in the 1990s–a consortium of universities that stimulated the development of the Page Rank search algorithm and the creation of Google, and helping to build the JSTOR project, the first major effort to digitize a massive collection of scholarly publications in disciplines such as economics and history. Today, Michigan serves as the lead partner in the Google Books project, to provide search access to the printed knowledge of the world, and the HathiTrust, a collection of 80 leading libraries with the further goal of providing full-text access to large inventories of scholarly materials. Furthermore, as a participant in the OpenCourseWare and MOOC movements to provide global access to learning resources, the University has firmly established its leadership role in providing both knowledge and learning on an unprecedented

global scale. Its leadership in promoting open access to research data and intellectual property through efforts such as the Creative Commons has potential for redefining the public university as a "knowledge commons" serving the world.

Hence, it is appropriate (and provocative) to suggest that the University is well-positioned to participate in a contemporary version of the Enlightenment, spreading knowledge and learning throughout the world. We suggest that this might become the primary mission of the University for its Third Century!

A Gap Analysis

In this section we will examine these challenges in more detail through the fourth stage of the strategic roadmapping process, the *gap analysis*, where we compare the current status of the university with the vision of Reflection, Renaissance, and Enlightenment proposed for its third century. Through such a process, we will identify the actions, resources, and transformations required to achieve this vision in the broadest sense as they involve our people, finances, facilities, quality, values, and spirit. These will form the basis of the development in the next chapter of the *roadmap* to the University's third century.

Centralization vs. Decentralization

The key to Michigan's successful adaptation to a rapidly changing era while sustaining both its public purpose and its institutional saga of pathfinding has been a decentralization of authority over resources and personnel to the lowest level where resources are generated and costs are incurred. As state support declined during the 1970s and 1980s, Harold Shapiro embraced this philosophy of decentralization to the level of deans and directors. This philosophy was continued throughout the 1990s by implementing the practice of many leading private universities by adopting *responsibility center management*, and appointing deans and directors of the highest quality who were capable of leading their units in such an environment.

Yet, despite the fact that today over 95% of the resources of the University are generated by academic and auxiliary units, in recent years there has been an alarming effort to "recentralize" the University by pulling back key administrative staff from the units and weakening the authority of deans and directors. External consultants have been retained (at great expense) to apply corporate management methods to an academic institution, with devastating impact on faculty and staff morale as resources and staff critical to research and teaching have been withdrawn from academic units.

Auxiliaries vs. Academics

We have noted many signs of the erosion of the academic priorities of the University: the rapid expansion (and expenditures) of auxiliary units relative to academic programs, the relative priority given administrative and auxiliary needs relative to academic needs in investment decisions such as cyberinfrastructure, the rapid growth of administrative salaries during a period of relatively stagnant faculty and staff salaries (now lagging 20% below leading private universities), the extraordinary growth in staffing in nonacademic functions such as communications, marketing, and "advancement" (now numbering well over 1,000 employees), largely at the expense of adequate staffing for faculty academic needs such as teaching and research (compounded by the negative impact of the "shared services" initiative).

It is probably not surprising that at a time when the academic programs continue to be seriously constrained by available funds and overloaded by the rapid enrollment growth, the University leadership has turned its attention instead to the auxiliary units (hospitals, housing, and athletics), which not only have the advantage of a price-insensitive market unconstrained by Regent politics, but can use the unusually low interest rates charactering the University's top credit rating earned during the 1990s to go on a debt-financed building spree amounting to billions of dollars.

There is also the related issue as to whether the aggressive growth of the auxiliary units actually competes with and draws resources away from the academic core. To be sure, the strong influence of the clinical units in the medical center on fund raising is understandable and probably beneficial to the

Medical School. However the aggressive fund-raising of the Athletics Department through devices such as skyboxes and seat taxes clearly draws private giving that in the past has benefited academic units. So too, the recent aggressive fundraising activities of the UM-related units such as the Athletics Department, the Alumni Association, and the University Musical Society almost certainly competing with the academic units for donors. While there is disagreement about how damaging this has been to academic priorities, it is certainly appropriate to raise the policy issue of the priority given auxiliary unit fund-raising activities relative to that given academic units.

An Erosion of Academic Priorities

This concern about the erosion of academic priorities applies not only to resource allocation but even more to the attention of governance (the Regents), leadership (the Executive Officers), and management. Too many universities have seen the quality of their academic programs deteriorate through the distraction of important but clearly secondary activities such as fund-raising and marketing (e.g., donor cultivation and influence), the management of billion-dollar enterprises such as health systems, and, of course, the politics and public visibility of intercollegiate athletics.

While much of this is driven both by the differing financial opportunities and challenges facing academic, auxiliary, and administrative activities, it is also due to an erosion of the academic voice in University leadership. For example, there has been a decided shift away from long tradition of appointing senior administrators (including the Executive Officers of the University) with significant faculty experience. So, too, the long-standing practice of achieving a balance between the appointment of internal and external candidates for senior leadership positions such as deans in an effort to balance both the continuity provided by long-standing University employees with new viewpoints from outside seems to have been abandoned, with a decided preference toward external candidates in recent years.

But perhaps most important has been the weakening of the voice and influence of the University's deans in recent years. The University of Michigan has long been known as a "deans' university", in which the authority and responsibility of deans as academic leaders is unusually strong. Deans are the key academic leaders most responsible for the priority, quality, and integrity of the University's academic programs. They select department chairs, recruit and evaluate faculty, seek resources for their school both within the university (arguing for their share of university resources) and beyond the campus (through private fundraising or research grantsmanship). As the key line officers for the faculty of the university, they have rather considerable authority that usually aligns well with their great responsibilities. Good things happen in the University's academic programs because of good deans, at least over the long term–and vice-versa, of course.

Yet, despite this dispersal of power, Michigan is also an institution where team building and cooperation is greatly valued. Deans come together quite easily as teams, particularly if encouraged by the provost and president, and willingly work together on university-wide priorities. Although technically the deans report to the provost, the wise provost will join the deans' team as a member and captain rather than as its coach–and certainly not as its owner!

Since the influence of faculty governance at the University is primarily concentrated in powerful elected faculty executive committees at the school, college, and department level rather than with a University-wide faculty senate, the deans also have primary responsibility for making certain that academic priorities dominate the attention of the University administration and governing board. To weaken the access and influence of the deans relative to both the Executive Officers and Regents of the University is tantamount to weakening the academic priorities of the institution.

Financial Sustainability

Despite the success of the University during the past decade in compensating for the loss of over 50% of its state support through major expansion of enrollments since the 1990s (10,000 students, most of whom are paying out-of-state tuition), private fund-raising and endowment management, cost containment and staff benefits reductions, there are growing concerns about both the sustainability of the current financial model

and their impact on the quality of the University.

Ratings agencies such as Moody's have warned higher education about serious trends such as a ceiling on public acceptance of tuition increases, continued weakness in state appropriations, constraints on federal spending on research and student financial aid, volatility of the capital markets characterizing endowments, weakening of philanthropic support, and risks to health care revenues.

But there are also several concerns specific to the current financial model characterizing the University of Michigan:

1) Since much of the State of Michigan's tax revenue base has been eliminated by the tax policies of recent conservative state governments, it is unlikely that there will be significant restoration of state appropriations for higher education for many years, that is, unless the University recommits itself to a leadership role in making the case for adequate investment in higher education across the state (similar to the "treetops" campaign of the 1990s).

2) Although there will likely be strong pressures to continue to grow enrollment while holding tenure-track faculty size constant, the concerns about the negative impact on academic quality of further enrollment growth, the adequacy of current University facilities (classroom and study space), the pressure on faculty retention driven by increasing instructional load, and the fact that out-of-state tuition rates are approaching the ceilings experienced by private universities, suggests that this option may be limited.

3) Much of the recent savings of the University have come largely out of faculty-staff benefits, cutting health care, retirement benefits, salary programs, and budget cuts imposed on academic and administrative units. Hence there is a serious concern that further cuts in benefits could cripple UM's efforts to attract and retain outstanding faculty and staff.

4) Although the UM has launched a major $4 billon fund-raising campaign associated with the Bicentennial, this will largely provide only marginal resources and could well result in launching new initiatives demanded by donors that not only increase University costs but actually dilute academic programs. Furthermore, in recent years Michigan has been able to achieve only an average annual fund-raising activity, lagging not only leading privates but several publics as well (Wisconsin, UC, etc.) While it is understandable that a very large university like Michigan would not attract the deep loyalty and commitment of Ivy League institutions, it also does not seem to be attracting the support characterizing other leading public institutions. The most successful fund-raising is by clinical units, understandable because of the personal impact they have on donors. Perhaps the problem is that there are just not enough exciting opportunities happening on other parts of the campus to attract the interest of donors.

5) On a much more positive note, the effort of the 1990s that created one of the largest endowments in public higher education (and led to the University's exceptional AAa credit) rather has now become on of the primary resources supporting the University. In 2016 its current size of $10 B, this ranks highest among public universities and 7th among all universities. At current payout policies of 4.5% per year, the endowment is now generating considerably more than state support ($300 M/y) and cash gifts received ($250 M/y). Although it still falls far short of the wealthiest private institutions, particularly on a per student basis, it is certainly one of the bright spots in an otherwise questionable financial future.

In summary, the University's current financial model looks increasingly unsustainable: Its academic programs are largely sustained by high tuition revenues from out-of-state students, which are approaching both enrollment and tuition ceilings. Fund-raising seems increasingly suspect, inadequately aligned with university priorities and insufficient to have the major impact characterizing private universities. Although the University faculty remains highly successful in attracting sponsored research support, roughly 30% of the $1.3 billion of annual research expenditures is currently provided by the University itself. While the University has taken advantage of its high credit rating low interest rates to enable massive investments

in auxiliary enterprises ($650 million of resident hall renovations, $2 billion of medical center expansions, and $500 million in new or renovated athletic facilities), the capacity of longer term revenues to support both the debt and operating costs of these facilities is questionable. Only its large endowment stands out as a key positive feature.

Issues of Scale

The rapid growth in student enrollments coupled with the unbridled expansion of auxiliary activities (hospitals, housing, and athletics) has triggered concern that the University is on a determined path toward becoming big, bigger, and biggest at the expense of the quality of its academic program. Comparisons with the size of the highest rated public research universities (UC-Berkeley at 35,000, UC-Virginia at 21,000, and UNC-Chapel Hill at 30,000) and private universities (Harvard at 21,000, Stanford at 23,000, and Yale at 12,000) suggest that as the size of Michigan swells to 45,000 or greater, its peer group will shift to large campuses such as Michigan State, Ohio State, and U Texas) rather than the elite public and private institutions that have sustained a commitment to focus resources to achieve excellence rather than disperse them to drive scale.

There are other "phase transitions" that occur with changing institutional scale. On the positive side, once endowments reach the $1 M/student, a university becomes essentially independent of traditional revenues (tuition, gifts, etc.), although clearly this goal moves farther away with each increase in enrollment. However more generally, one can imagine that there is another phase transition should the endowments of the rich private institutions become so large (e.g., Harvard passing $100 B) that the "tax expenditures" become sufficiently large to attract the attention of Congress.

A similar phase transition may occur when a university becomes sufficiently large that centralized leadership and governance becomes impossible, requiring a highly decentralized structure to withstand stresses that might cripple smaller institutions. Here the University of Michigan may become a good test case (as has the University of California at the system level).

A third scale issue concerns the relative balance between undergraduate and graduate/professional enrollments. Leading private universities (Harvard, Stanford) typically have a majority of graduate and professional students. For most of its recent history, Michigan led all public universities with 40% grad/prof compared to 25% to 30% for other leading public research universities. But with the recent dramatic increase in undergraduate enrollments, this has dropped to 35%, suggesting a shift in academic focus.

Management Culture and Priorities

The budget growth of auxiliary units (hospitals, housing, athletics) raises the important issue of university priorities and balance. But more serious is the issue of how one sustains the highest priority for the academic core of the university in an increasingly resource-driven (and for many academic units, resource-starved) environment, particularly when there is a very significant difference in management philosophy characterizing auxiliary (centralized) and academic (decentralized) units.

To be sure, the tension between centralization (e.g., "rationalization") and decentralization (where cacophony leads to innovation) can be very threatening, particularly to those parts of the University that need to make sure that the trains run on time (e.g., financial services, hospitals, etc.) They prefer a coordinated approach at the enterprise level, a so-called "rationalization" of services that seeks to reduce redundancy. Yet this approach has generated great concerns within the academic community. In fact, many academic units are under the impression that as the University's rationalization juggernaut moves ahead, it will attempt to pluck out the top talent in their units and relocate it to the enterprise level through "shared services" operations. Were this to occur, it would be both an absolute disaster to the academic units and seriously undermine the confidence of faculty and staff in the role played by the central administration itself.

The spirit of "rationalization" that may work quite well in some areas of corporate management could turn into a disaster if it pulls our best staff away from the academic units where the real innovation is driven by the interests of faculty and students working closely with outstanding staff with extraordinary skills. Similarly, to impose on the University's academic

programs an enterprise-level of shared services unable to respond rapidly to the unique needs and technologies required for cutting-edge learning and discovery would cripple the University's leadership as a research university. The recent petition in which the majority of Michigan faculty opposed the efforts of the University administration to impose a shared services plan on academic units revealed the faculty concern about such corporate approaches, a reaction seen in other peer institutions.

The Importance of Communication in Loosely-Coupled, Adaptive Ecosystems

This report has stressed the importance of Michigan's organizational culture as a loosely coupled, adaptive ecosystem that evolves and excels based on the extraordinary talents, dreams, and commitment of faculty, staff, and students. During my inauguration address in 1988, I repeated what I had learned from my predecessors, particularly Harold Shapiro, Robben Fleming, Frank Rhodes, Billy Frye, and Chuck Vest, that the true secret of leading an academic institution is simply. "You recruit outstanding people. You provide them with the resources to achieve their dreams. And then you get out of their way!!!" We must never forget this basic principle, particularly when we select those for leadership roles. We must also take care that those joining our institution are not only educated about but also accepting the principles of the Michigan's historical character of decentralization to tap the great strength and energy of faculty, students, and staff engaged in academic activities.

But there are other important principles that must be present for the success of the Michigan approach. And perhaps none is more important that the availability of open, accurate, pervasive, and accessible information throughout the entire University. After all, a university is the ultimate knowledge organization, and any attempt to hide, distort, or manipulate information can seriously damage its most fundamental activities of discovery, learning, and engagement.

To be sure, such an open form of communications can be alien to those from backgrounds such as advertising, marketing, public relations, fund raising, and politics. Yet without complete access to accurate information, both good news and bad news, universities are seriously hindered. Any attempt to sequester information, replacing truth with fiction, or attempting to propagate myths or distortions to further a particular agenda should be challenged and revealed as damaging to the academic process. This is particularly important in these times when the role of the traditional media supporting investigative journalism and openness has been challenged by the pervasive character of electronic media and social networking.

Therefore it is with a sense of both frustration and warning that we must recognize that the massive recent investment in communications, public relations, marketing, and branding effort (almost 600 staff strong) that has emerged at Michigan over the past decade to manipulate both internal and external opinions is both highly inappropriate and damaging to the long-standing traditions and quality of one of the world's great academic institutions. While such media manipulation is common in the world of commerce or politics, it has no place on this camp–or any university campus, for that matter. Both the leadership of the university and its governing board must accept their responsibility to restore truth and openness to Michigan before the most fundamental missions and values of this university are distorted and weakened.

The Bottom Line

So what has been the trajectory of the University over the past 15 years? On the positive side we have managed to preserve much of our quality and most of our reputation while losing over 50% of our state support. But much of the preparation for this effort came from fundamental changes implemented in the 1980s and 1990s, e.g., decentralization of resource control (e.g., responsibility center management), major fund-raising efforts (the campaigns of the 1980s and 1990s), and sophisticated management of University financial assets including endowment (which was taken from $250 million to over $3 billion over a decade).

More recently we have taken a series of short term actions that may have walked us out onto a limb, e.g., expanding enrollments by 20%, ramping up out-of-state tuition that has reshaped the socioeconomic character of our student body and perhaps eliminated the

"common man" that helped to define our earlier public purpose, making massive investments in auxiliary enterprises (hospitals, housing, athletics) to take advantage of low interest rates and market-insensitive pricing but incurring long-term debt and perhaps marginalizing academic priorities in the process.

And, whether intentionally, or through oversight, we have largely silenced both the voice and influence of the deans, faculty, and students on the future evolution the University. Not a good thing!

A Roadmap to Michigan's Third Century

We now turn to the development of a strategic roadmap for the University of Michigan as it approaches its third century. This is designed as an evolving framework of actions aimed to guide the University through its vision trilogy of *Reflection, Renaissance, and Enlightenment*.

Earlier chapters in this report have provided the foundation for this effort, scanning the environment in which the University now finds itself, assessing our current assets and challenges, and proposing a vision for our future, based upon our values, characteristics, and opportunities. In this chapter we begin by suggesting a framework for the recommendations that will comprise the University's roadmap for the third century, drawing from the experience of earlier strategic planning efforts both at Michigan and other venues. Key in this framework effort is the establishment of goals involving the most critical assets of the university: people, resources, culture, and the capacity for change. These will shape the subsequent recommendations of the roadmap.

The roadmap itself will be structured into three time-frames or "event horizons" associated with each element of the vision proposed in Chapter 6: *Reflection*, (to be accomplished by 2017); *Renaissance*, (launched over the next several years but guiding the University as it moves into its third century; and *Enlightenment* phase, launched over the next decade and lasting well into the University's third century.

Clearly, the various phases of the roadmap associated with the trilogy of visions are interdependent. In the sense one might think of the roadmap as a path through a series of mountain ranges. Until one successfully climbs the first range, it is impossible to see far enough to set the course for climbing the next. Hence in the next chapter, we will also suggest a series of plans, processes, and tactics for keeping the roadmap effort on track as we move from one range to the next.

Always Begin with the Basics

So how to begin? How does one grapple with the many issues and concerns swirling about higher education in general, and the University of Michigan in particular, to chart a course toward the visions for its third century? Let us suggest the following framework drawn from experience in higher education and other contexts.

It is critical to first determine those key roles and values of the institution that must be protected and preserved in the years ahead. While it is important to engage the university community in an ongoing discussion of these guiding principles, one might begin with the canonical roles of the research university, namely education of the young, preservation of culture, basic research and scholarship, serving as a critic of society, and so forth. The starting point for a discussion of fundamental values could also be drawn from the academy, e.g., academic freedom, a rational spirit of inquiry, a community of scholars, a commitment to excellence, and shared governance.

The next phase would be to identify actions to help the university better understand and respond to the changing needs of the society we serve rather than defending and perpetuating an obsolete past. Key here is listening carefully to our stakeholders and patrons to learn and understand their changing needs, expectations, and perceptions of higher education, along with the forces driving change.

Since roadmapping is very much an exercise in institutional change, it is important to prepare the academy for change and competition, e.g., by removing unnecessary constraints, linking accountability with privilege, redefining tenure as the protection of academic freedom rather than lifetime employment security, etc. This includes developing a tolerance for strong leadership and instituting the best practices of governance, leadership, and management.

When the road ahead becomes uncertain, experimentation becomes an important element of the plan-

ning framework. The university should strongly encourage experimentation with new paradigms of learning, research, and service, harvesting the best ideas from within the academy (or elsewhere), implementing them on a sufficient scale to assess their impact, and disseminating their results.

Finally, in today's hyper-connected world, universities must place a far greater emphasis 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. Here, alliances should be encouraged not only among institutions of higher education (e.g., consortia of peer institutions such as the CIC or AAU universities, partnering research universities with liberal arts colleges and community colleges. and developing relationships with universities abroad) but also between higher education and the private sector (e.g., information technology and knowledge services companies). Differentiation among institutions should be encouraged as an important objective.

The Fundamental Goals

We propose several simply stated goals to provide a foundation for the roadmap that will guide the University toward the vision for its third century:

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, excitement, risk-taking, leadership, excellence, diversity, caring, concern, and community.

Goal 4: The Capacity for Change

To develop the flexibility, the ability to focus resources necessary to serve a changing society and a changing world.

These four concrete goals have profound implications, and each will be deceptively challenging to execute. While we have always sought to attract high-quality students and faculty to the University, we tend to recruit those who conform to more conventional measures of excellence. If we are to seek "paradigm breakers," then other criteria such as creativity, intellectual span, and the ability to lead become important.

We need, as well, to acquire the resources to sustain excellence, a challenge at a time when public support is dwindling. Yet, this goal also suggests that we need to focus resources on our most creative people and programs. And we need to acquire the 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 priority to striving for 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. We need to discard the status quo as a viable option, challenge existing premises, policies, and mindsets, and empower our best people to drive the evolution—or revolution—of the University.

This capacity for change, for renewal, is the key objective that we must strive to achieve in the years ahead—a capacity that will allow us to transform ourselves once again as the university has done so many times in the past, to become an institution capable of serving a changing society and a changing world. Such institutional transformation has become commonplace in other sectors of our society. We frequently hear about companies "restructuring" themselves to respond to rapidly changing markets. Government is also challenged to transform itself to be more responsive and accountable to the society that supports it. Yet trans-

formation for the university is necessarily more challenging, since our various missions and our diverse array of constituencies give us a complexity far beyond that encountered in business or government. It must be approached strategically rather than reactively, with a deep understanding of the role and character of our institutions, their important traditions and values from the past, and a clear and compelling vision for their future.

The Roadmap to *Reflection*

For the near term, from now until the Bicentennial Year 2017, our vision of *Reflection* suggests the University of Michigan should focus on understanding, assessing, and embracing those values and characteristics that have played such an important role throughout its history:

Academic quality
Academic priority
Diversity
Public Purpose
Spirit
Leadership:
The Michigan Saga as pathfinder and trailblazer

Renewing our 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. Yet it is nevertheless this near term vision that the University should set out as today's most important challenge. We suggest the following elements of a roadmap to achieve this near term vision:

Preparing for the University's Bicentennial in 2017: We should use the remaining years prior to 2017 to gather resources that capture the University of Michigan's remarkable history; make these materials available to scholars, the University community, and the public more broadly; and use this history archive to more firmly establish the key elements of the University's significance to both those on the campus (students, faculty, staff) and beyond.

Here it is important to give highest priority to viewing the UM Bicentennial as an opportunity to understand, honor, and build upon the University's history as an academic institution, similar to the historical celebrations mounted by other distinguished institutions such as Harvard, Yale, MIT, and Cambridge. For example, Harvard used its 1936 tercentennial to redefine the purpose of a liberal education; Yale's celebration, at the time of the 9-11 attack, stressed the impact of Yale on the security of the nation; MIT's centennial helped to stimulate and shape federal research policy; while Cambridge's 800th anniversary was a celebration of the extraordinary impact of the university to the development of western civilization.

Reflecting upon the Michigan saga

To this end, the University should develop a bold plan for a series of events and activities during the 2017 Bicentennial Year to enable the University to lead major discussions on the future of the public university in America and the world more broadly, thereby re-establishing the visibility of the University's role as a pathfinder and trailblazer in American higher education. Possible themes might be:

What is a public university in the knowledge-driven global society of the 21st century? What is its public purpose? Whom does it serve? Who are its stakeholders and patrons?

What are the role and responsibility of the flagship state university in a world characterized by increasing connectivity and mobility of people and knowledge?

What is the appropriate balance among undergraduate, graduate, and professional education in a compre-

Recommitting Michigan to Diversity

Recapturing the Michigan Spirit

hensive research university, and how should these be interrelated?

Here a caution is appropriate: While such milestones such as a bicentennial also present an opportunity for other agendas such as fund-raising or marketing the institution, it would be tragic if these ancillary activities were to overwhelm a more substantive celebration of the true academic character of the University and a consideration of its future.

Better Engagement of Faculty in University History Projects: It is very important to provide strong encouragement to senior faculty to participate in University history activities, since many have very important and unique perspectives through their own experiences. To this end:

Faculty History and Tradition Committees should be created in each school or college.

The efforts of senior and emeritus faculty to share their own contributions to the history of the University should be strongly encouraged. In particular, funds should be created at both the University and school or college level to provide subventions for such faculty history projects (books, archives, etc.)

The University of Michigan Press should consider creating a special series of historical publications by Michigan faculty (similar to those at several leading private universities).

Restoring a Sense of Public Purpose: The University has drifted too far from its early public purpose of providing "an uncommon education for the common man". In fairness, much of this has been a consequence of eroding state support that has forced the University to develop alternative revenue streams, e.g., increasing the enrollments of out-of-state students paying higher tuition, promoting "premium" services for those activities with strong market appeal (e.g., college athletics, student housing, parking). But these decisions have had a significant impact on the University's "public" character, as the fraction of the student body from low-income backgrounds has declined and community participation in activities such as Michigan football and theatrical productions (e.g., University Musical Society) has become increasingly rarefied with skyrocketing ticket prices.

As it has throughout its history, the University needs to acknowledge its public character and be attentive to the needs of the society it serves. New financial paradigms will be necessary to enable the University to achieve a student socioeconomic balance that better reflects society. It is also clear that the University needs to take a more strategic approach toward public service and engagement. In the years ahead, the institution will be called upon to provide a broad array of public services consistent with our public mission. Developing the capacity to assess such opportunities and responsibilities and then to make rational decisions about which to accept is crucial. We need to develop the capacity to say "no" when a societal request does not align well with our academic mission or could better be performed by other institutions.

Strengthening the University's Commitment to Diversity: The University needs to reaffirm and broaden its commitment to creating a institution characterized by great diversity. As with biological organisms or ecosystems, the diversity of the University may well be the key characteristic that will allow it to flourish in a rapidly changing environment. Diversity goes far beyond racial and ethnic representation to include almost every aspect of the human condition: race, gender, nationality, economic circumstances, and beliefs. The challenge is to build an institution in which people of different backgrounds, ethnicities, cultures, and beliefs come together in a spirit of respect and tolerance for these differences while working together to learn and to serve society.

During the 1990s the University made great progress in achieving diversity through major strategic efforts such as the Michigan Mandate, the Michigan Agenda for Women, and other initiatives aimed at responding to the increasing diversity of our society. Yet today, much of this progress has been lost. Undergraduate enrollments of underrepresented minorities have dropped to half their previous levels. Several of the University's professional schools (notably Law, Business, and Medicine) have experienced ever more dramatic declines in minority enrollments. While external factors such as Michigan's constitutional referendum opposing affirmative action (Proposition 2), the decline of state support, and the shift of state financial aid programs from need-based to merit-based have played roles, there is a growing concern that the decline of campus diversity has also been the result of an erosion of institutional commitment to diversity. The University should strive to renew its commitment and develop and implement new strategies to restore a sense of progress

Building a Sense of Pride in, Respect for, Excitement about, and Loyalty to the University: The increasing specialization of the academic and professional disciplines, the University's long tradition of decentralization, and the increasing mobility of faculty, students, and staff can sometimes erode personal commitment to general institutional goals and the values of a learning community. All too frequently, faculty, students, and staff focus primarily on personal or professional goals rather than on the welfare of the University. It is important to seek opportunities to engage the University community in both discussions of and active participation in determining the future of the institution. Beyond this, we need to develop a sophisticated and strategic internal communications effort to give members of the University a better understanding of the challenges, opportunities, and responsibilities facing the University rather than simply marketing the party line.

Re-igniting the Michigan "broad and liberal" spirit: Every effort should be made to rekindle the activist spirit that has long animated Michigan students, faculty, and staff, leading them to both identify with key issues facing our society and challenging the establishment to address these. While sometimes disruptive for the institution (and the community), this should be regarded as an appropriate and important element of the University's role as both servant and critic of society. Such activism should not only be tolerated but encouraged both as an element of the learning environment and an important responsibility of the University. Today's issues such as global sustainability, social justice, wealth inequity, and generational responsibility provide compelling opportunities for such activist engagement.

Reaffirming the Michigan Saga as a Pathfinder and Trailblazer: As we have stressed, the perception of Michigan as a trailblazer appears again and again throughout its history, as the university explored possible paths into new territory and blazed a trail for others to follow. At times, it has also been a pioneer, building the roads that others can follow. Whether in academic innovation, social responsiveness, or its willingness to challenge the status quo, Michigan's history reveals this trailblazing character. During an era of profound and rapid change, it is more important than ever that the University recapture this saga as a pathfinder.

The *Renaissance* Roadmap

As we have noted throughout this report, the world is changing rapidly, driven by the role played by educated people, new knowledge, innovation, and entrepreneurial zeal. These characteristics are driving profound changes in our world and its social institutions. They also contain the elements of what could be a re-

naissance in the 21st century. Since universities will play such a critical role as the source of these assets of the age of knowledge, our vision for the early 21st century involves stressing the following characteristics among our people and our programs:

Creativity
Innovation
Ingenuity and Invention
Entrepreneurial Zeal
Risk-taking
Tolerance of Failure as a Learning Experience

People

The first and most important goal of the roadmap for the Renaissance time frame is to attract and sustain exceptional students, faculty, and staff:

Recruit Outstanding Students: The University should place greater emphasis on identifying and attracting students of truly exceptional ability and creativity. This effort may require special scholarship or fellowship programs (such as the Morehead Scholars at the University of North Carolina) to augment existing need-based programs. It might also involve extending the dual admission practice (which our Medical School used to provide through its Inteflex programs) to other professional and graduate programs to attract outstanding undergraduate students. We need to reduce the disciplinary barriers between various graduate and professional programs to attract the very best graduate students.

Recruit Paradigm-Breaking Faculty: We should allocate more resources toward the recruitment and development of truly exceptional faculty through a University-wide effort. Although endowed chairs are important, this recruiting of paradigm-breaking faculty might be better served through the introduction of institution-wide appointments as University Professorships reporting directly to the Provost similar to those at leading institutions such as the University of California (University Professors) and MIT (Institute Professors) since much of the creative teaching and research will occur across disciplinary lines (convergence).

Strengthen the Emphasis on Human Resource Development: The University should continue efforts to give high priority to human resource development throughout all areas of the institution. It is important that we sustain the University's commitment to education, training, and career planning for both staff and faculty.

Intellectual

Enabling Intellectual Change: The University needs to take steps to assist its students and faculty in responding to the extraordinary pace of intellectual change. As our society increasingly values creativity and innovation, the university will be called upon to augment its traditional emphasis on "learning to know" with "learning to do", "learning to create", and "learning to become". Of course these latter skills have always been valued by studio- or laboratory-based disciplines such as engineering, architecture, and the arts ("doing" and "creating") and the professional disciplines ("becoming"). In fact, much of the campus infrastructure has evolved to support "doing" and "creating" (e.g., the North Campus) and "becoming" (e.g., the Medical Center). 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 and innovation to ALL of its students. This would probably imply a shift away from highly specialized disciplines and degree programs to programs placing more emphasis on integrating knowledge.

Lowering Disciplinary Boundaries: Beyond the changing needs of a knowledge-driven society, the activities of the disciplines are rapidly converging as their boundaries become more diffuse. Biomedical advances depend increasingly on the physical sciences (atomic, molecular, and even nuclear physics) and engineering (complex systems analysis). Similarly, professional practice is changing rapidly (e.g., medical practice evolving more toward the team-based system approaches of engineering, engineering requiring the perspective of the social sciences, etc.). Key will be efforts to break down the constraints posed by disciplinary organizations, e.g., academic units such as departments, schools, and

colleges, and academic degree programs at the undergraduate, graduate, and professional level. To allow faculty and students to teach, study, and learn where the need and interest are highest, we need greater flexibility. In this regard, Michigan should encourage more flexibility that spans disciplinary boundaries (e.g., centers and institutes), and university faculty appointments that could span multiple disciplines. More effort also needs to be made to coordinate faculty appointments, academic programs, research activities, and resource allocation among academic units.

"T" Graduates: An increasingly complex and rapidly changing world requires what some call "T" graduates, capable of both depth in a particular discipline as well as intellectual breadth to provide perspective. This counters the current educational philosophies adopted by many academic programs, particularly in more applied areas such as engineering, business administration, and allied heath professions, where a growing disciplinary knowledge base has largely pushed aside the "liberal education" component of an undergraduate education that is particularly important for creativity and innovation. These programs must heed the wisdom that "the purpose of an undergraduate education is not to prepare a student for their first job but rather prepare them for the last job" and restore the philosophy of a liberal education to their curriculum to produce "T" graduates.

Restructuring the Ph.D.: While the Ph.D. degree continues to be superb preparation for a research career, it has become clear that most Ph.D. students will continue on to other careers in the public or private sectors. Recent national reports have challenged the excessive specialization, attrition rate, and time-to-degree characterizing today's Ph.D. programs. (Holliday, 2012) The university should provide leadership in examining and perhaps restructuring its Ph.D. programs to better serve the students enrolling in them and the society they will serve. A similar assessment and restructuring of the postdoctoral experience is also urgently needed, and the University should provide leadership for such an effort.

Transformative Research: The University should give more priority in both student and faculty recruiting and resource allocation to areas with the potential for truly transformative research, i.e., breaking the current knowledge paradigms. This will require both the development of flexible funding to stimulate high-risk research, as well as organizational structures similar to the "advanced research project agencies" (e.g., ARPA, ARPA-E) now appearing in several federal research agencies.

Translational Research: In a similar sense, the University should also build organizations and programs capable of translational research, i.e., linking fundamental scientific discovery with the use-inspired technological innovation to serve society. The recently acquired Pfizer Global Research Center (the North Campus Research Center) provides an ideal site for the translational research sought by federal sponsors through new programs such as regional innovation hubs.

Strategic Alliances: Over a longer time frame, the higher education enterprise in America will clearly undergo significant restructuring. Anticipating this, the University of Michigan should give high priority to forming and sustaining strategic alliances with regional institutions (e.g., the CIC universities), national institutions (e.g., the AAU), and international institutions (e.g., Europe and Asia). We also should establish alliances with other knowledge-based institutions in the public and private sector (e.g., software and entertainment companies or national laboratories and institutes.)

Culture

Stimulate a Sense of Adventure, Excitement, and Risk-taking: During a period of rapid change, the University's capacity to try new things, to be adventurous and experimental, has become increasingly important. The unusual size, comprehensiveness, and quality of the institution provide us with an unusual capacity for such risk-taking. But, ironically, Michigan's culture at times can become quite conservative and adverse to risk, particularly during times of financial stress or preoccupation with growth (enrollments, campus, bureaucracy). Hence, an early objective should be to create a

more fault-tolerant community, in which risk-taking is encouraged, failure is anticipated and tolerated, and creativity and innovation are prized.

Next-Generation Leadership: Throughout the University, the selection and appointment of leaders who have bold visions, energy, and a sense of adventure is key to preparing for the future. Simply selecting leaders to maintain the status quo is dangerous for an institution such as Michigan, particularly during an era of rapid change. The University needs to build a leadership team that is committed to the necessary transformations in the University and that relishes the role of leading during a time of challenge and change.

Possible Path-Finding Initiatives

A University College: The University should consider developing a more coherent academic program for all undergraduates, reducing the amount of specialization offered in degree programs, and striving to provide instead a more general liberal learning experience. It should expand experiments in pedagogical alternatives to classroom learning, including collective learning experiences based on studio or laboratory paradigms, greater use of social networking (e.g., wikis and MOOCs), immersive environments such as those characterizing the gaming world (e.g., World of Warcraft, Minecraft), as well as more advanced learning technologies such as AI-based cognitive tutors and learning analytics.

The presence of an unusually broad array of professional schools is one of the great strengths of the University and clearly one of the major factors in attracting outstanding undergraduates. We need to develop closer linkages between undergraduate education and the faculty of these schools, so that students could have the opportunity to explore and choose among various careers. Indeed, many professional-school faculty members seek more direct interaction with undergraduate students.

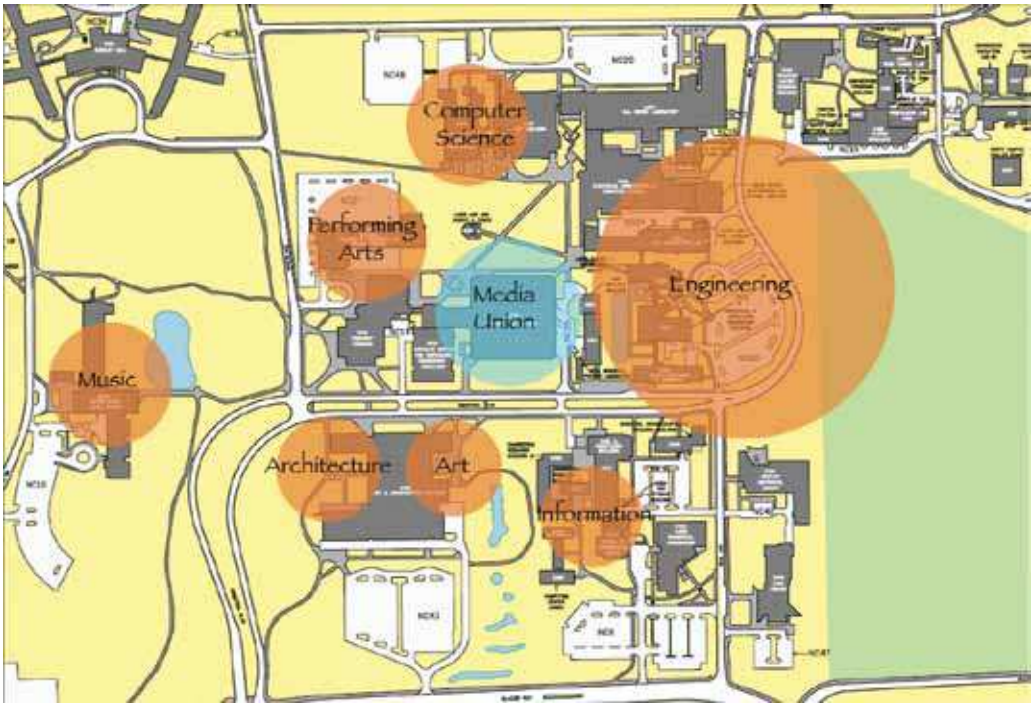
Yet here one of the great strengths of the University in pursuing a vision of creativity is its deep commitment to the liberal arts. Ironically, perhaps Steve Jobs of Apple stated this best: "It is in Apple's DNA that technology alone is not enough. It is technology married with the liberal arts, with the humanities, that yields us a result that makes our heart sing in our devices. The reason why Apple is able to create produces like the iPad is because we always try to be at the intersection of technology and the liberal arts, to get the best of both!"

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 "New" University: Experience has revealed the difficulty of approaching university transformation by changing existing programs and activities. While such a direct approach may suffice for incremental changes at the margin, an effort to achieve more dramatic change usually creates so much resistance that little progress is possible. It is sometimes easier to take a "green-field" approach by building separately a model of the new paradigm, developing the necessary experience with it, and, then, propagating successful elements of the model to modify or, perhaps, replace existing programs.

One possible approach to major university transformation taken in earlier and more affluent times was to



The Renaissance Campus

build a separate campus. The efforts of the University of California in the 1960s to explore academic colleges built around research themes at UC-San Diego and residential learning at UC-Santa Cruz, are examples of this approach. However, today's resource-limited environment make it difficult to justify such separate new campuses to explore new educational paradigms–not to mention finding sites comparable to the bluffs overlooking the Pacific. But there is a more important reason to consider an alternative approach: we believe that it is far more effective to develop and explore such new paradigms of the university directly, within an existing university community, since this more quickly propagates successful efforts to the host institution.

To this end, the University might consider creating a "New University" within its existing organization to provide an environment in which creative students and faculty could join with colleagues from beyond the campus to develop and test new paradigms of the university. In some ways, the New University would be a laboratory where the fundamental missions of the university—teaching, research, service, extension—could be redeveloped and tested. But it would also be aimed at developing a new culture, a new spirit of excitement and adventure that would propagate to the university at large. In such an academic enterprise, the University would hope to build a risk-tolerant culture in which students and faculty were strongly encouraged to "go for it," in which failure is accepted as part of the learning process, and is associated with ambitious goals rather than poor performance.

The New University could have both a physical and a virtual presence. In terms of structure, the New University might be organized with convergent themes among the disciplines. Furthermore, while it could offer academic degrees, such programs would stress stronger linkages among undergraduate, graduate, professional, and lifetime education programs than those offered by the traditional university. The New University could strive to more effectively integrate the various activities of the University by engaging its students in an array of teaching, research, service, and extension activities. The New University would almost certainly involve an array of outreach activities, e.g., linking alumni to the on-campus activities of the University or providing richer and more meaningful international experiences for students.

While the New University would enroll a significant number of students, it would not have a large cohort of permanent faculty or staff. Rather, it would draw fac-

ulty members from across the University and around the world who would become associated with the New University for specific programs. This would allow it far greater flexibility, since it could avoid the constraints posed by faculty appointments and tenure.

The success of the New University would depend in large part upon its governance and advisory structure. Although it would report through the normal University channels, it could also have its own steering board comprised of leaders from many sectors of society. It would also make extensive use of external advisory groups for its various activities.

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 the public purpose for its third century. Here we suggest major elements of a possible roadmap to this future based upon several of the paradigms discussed in Chapter 5:

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.

Capturing and distributing knowledge to the world: We have noted the leadership role that the University has in the massive digitization of printed materials and the use of these digital repositories (e.g., JSTOR, Google Book, HathiTrust). In fact, since the University's leadership of the HathiTrust has led to it creating the largest digital library in the world, one might suggest that Michigan is already serving as the nucleus of what may become a 21st century analog to the great Library of Alexandria.

The University is also playing an important leadership role in the open resource movement, using its influence to push for open access to research data and other scholarly materials. Finally, its School of Information, one of the first such academic programs merging traditional library science with informatics and other digital age technologies, provides leadership in both education and research in areas that will be critical to unprecedented access to the world's knowledge.

Open Education Resources: Although the University has some participation in efforts such as the OpenCourseWare movement and digital course development and distribution through iTunes, Amazon, and other mechanisms, its recent involvement is limited to only a few academic units (most notably the School of Medicine). However, the University's involvement in new efforts such as massively open online courses (MOOCs) through organizations such as Unizen and Coursera will hopefully catalyze a greater leadership role in these important areas.

Cyberinfrastructure: In recent years, the University has once again begun to develop strategies and make investments to restore the position of leadership it once had in developing and deploying advanced cyberinfrastructure in partnerships with leading IT companies. The recent decision to select Google as the lead system integrator for collaboration technology is an important step in this direction. But here the University must embrace a balanced strategy, both utilizing advanced technology in an efficient and cost-effective manner, and partnering with leading companies in both technology development and application for academic environments (much as it has in the past through efforts such as MTS, CAEN, NSFnet, Internet2, and Sakai).

Networking: Clearly advanced network development is key to the Enlightenment vision. The University has long had leadership in the development of national and international networks (e.g., NSFnet, the Internet,

Internet2). Yet, simply providing high-speed network links between campuses and other knowledge institutions is only the first step, since such connectivity must be distributed to the desktop, laptop, and laboratory on the campus and to the homes of faculty and students in the surrounding community. Here the University is also participating in the Gig U effort to assemble a coalition of the nation's leading research universities to challenge industry (e.g., carriers such as AT&T, Verizon, and Comcast and technology companies such as Google and IBM) to provide ultra-high bandwidth connectivity through the campuses and surrounding communities (much like the Goggle community fiber program).

Advanced Learning Environments: The University should launch a major effort to develop and deploy advanced learning environments–particularly those enabling social networking and immersive environments (including "sim-stim"–high fidelity simulation of all the senses at a distance). Its past experience with the development of open source curriculum management software such as CTools and Sakai positions it well for this effort.

Establishing a Global Footprint: Clearly the University of Michigan will need to establish a global footprint to achieve this vision. While it certainly has a strong international reputation in higher education, its current strategy of developing selected partnerships at the institution level will need to be expanded considerably. To some degree this is a "branding" exercise, but more significantly, it will require developing strategic relationships with key international higher education and technology organizations such as OECD, the European University Association, and the LERU universities and their counterparts in Asia.

Building the Necessary Scholarly Foundation for the Effort: To enable such a bold effort, the University will have to establish a strong intellectual foundation of faculty scholarship in areas key to a global knowledge and learning enterprise. Here the University's great strength in the social sciences, along with its many research institutions and professional schools position it well for such an effort.

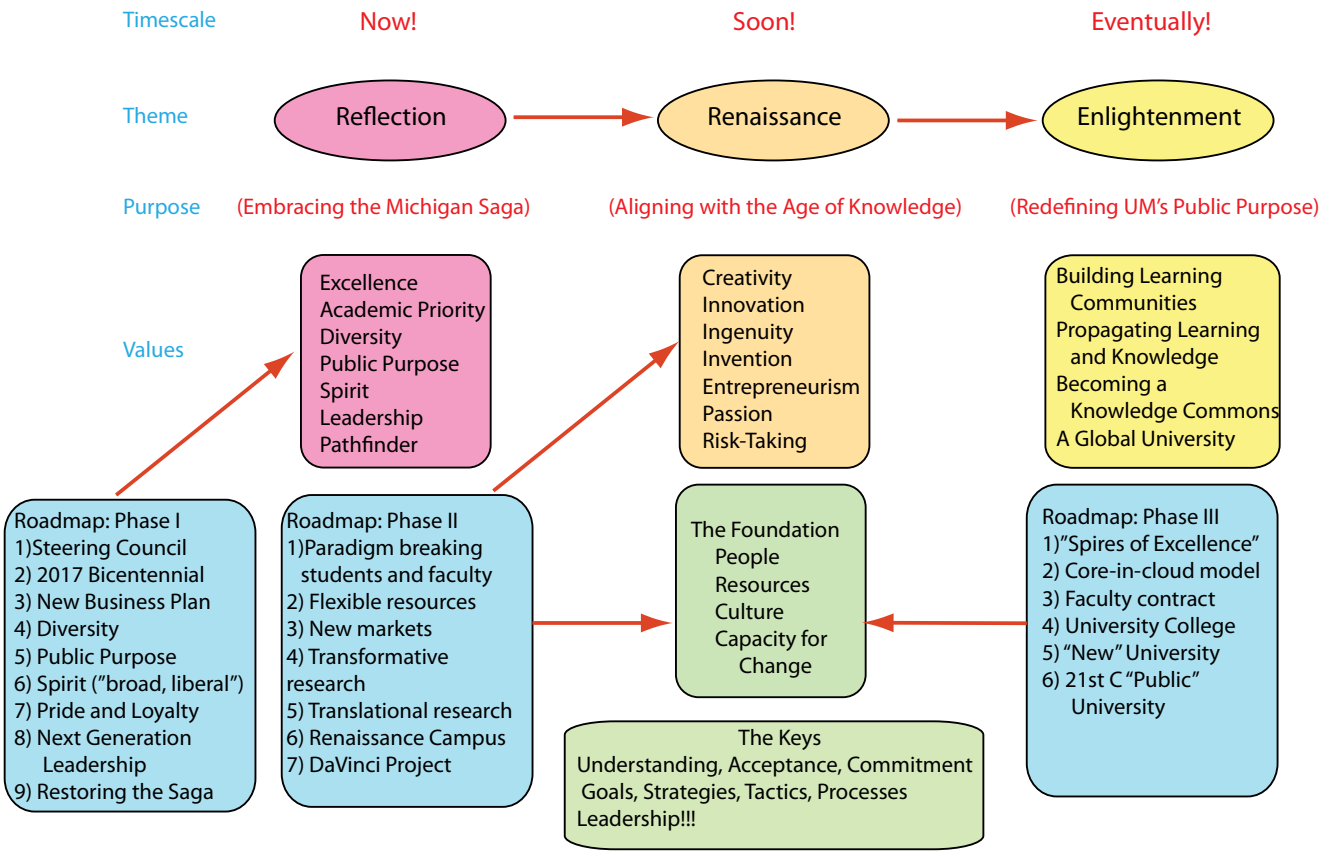
Taking Advantage of the University's Structure: As we have noted, the University of Michigan is characterized by a highly decentralized organizational structure, in effect, as a loosely coupled adaptive ecosystem. Interestingly enough, this is also similar to the structure of the Internet itself, which has little central control and instead depends upon activity on the edge as it adapts to changes and demands. Hence the unusual structure of the University provides it with an extraordinary capacity to propagate knowledge and learning similar to the Internet itself.

The Public Character of the University of Michigan: The key themes of the 18th Century Enlightenment, the rational distribution of freedom, the universal access to knowledge, and the use of collective experiences stressed that knowledge, learning, and connectivity were public goods. The public communities of those eras, the salons, seminars, and academies, today have evolved into new forms such as social networks and data clouds. Yet they remain very much public "unions" characterized by "universality", much as the University of Michigan is very much a public institution (although clearly not longer restricted to a state but rather serving the world itself).

Concluding Remarks

The visions we have suggested for the future of the University of Michigan, captured by the terms Reflection, Renaissance, and Enlightenment, become more challenging as we move into the future. Not surprisingly, the roadmaps to these visions for each epoch become less detailed and more uncertain, as does our speculation about the future itself.

This should not be surprising. Such eras of dramatic change have happened many times throughout the history of higher education in America. In this spirit, then, perhaps we should end by noting a discussion that occurred with a large group of provosts hosted by the National Academies IT Forum in 2004. While university presidents were reluctant to put speculation about the survival of the university on the table, this was not so with provosts, who were quite comfortable talking about very fundamental issues such as the values,



Strategic roadmaps to a vision for the University of Michigan's Third Century.

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 Oxbridge model of educating only the elite, were joined by the public universities, with the mission of educating the working class. (Lohmann, 2004) 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. University enrollments increased 10-fold and then 100-fold. 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 provosts was that higher education in America was facing a very similar period of dramatic change. 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 this is certainly a question deserving of very careful consideration, at least by those responsible for leading and governing our institutions.

Tactics, Strategies, and Transformation

A roadmap is just that, a set of possible directions to the future. Of course, the destination we have proposed for the University's third century, the vision, has been stated for a series of timeframes in deceptively simple terms:

1. *Reflection*: Reaffirming the Michigan Saga. (Now)

2. *Renaissance*: Stressing creativity and innovation in academic programs. (Soon)

3. *Enlightenment*: Extending the University's public

purpose to be that of providing knowledge and learning to the world. (Eventually)

But setting a direction, even with a roadmap, is far from arriving at one's destination. Furthermore, recommendations that require major institutional change are not spontaneously or miraculously implemented. The acceptance of and action upon the recommendations in this proposed roadmap to the University of Michigan's third century require active involvement and commitment from a variety of stakeholders and patrons. Without commitment at all levels–faculty, administration, Regents, stakeholders, and patrons–long-term or sustained innovation and change on the scale recommended in this report cannot be achieved–unless, of course, revolution becomes an option (remember earlier experiences during the Age of Enlightenment, e.g., the French and American Revolution).

Institutions and their stakeholders require a more definitive operational plan that addresses key questions such as: What are the first steps to be taken? What policy actions are necessary? Are there follow-on studies that need to be commissioned? What about an ongoing process or framework to assess and sustain progress?

Furthermore, we acknowledge that this roadmapping study has been stated in straightforward–sometimes even blunt–terms. To survive in the political environment of campus, state, national, and international policy, it must be reclothed in more Machiavellian garb.

Finally we must also acknowledge that both the proposed vision and roadmap for the University of Michigan's third century is, in reality, a call for institutional transformation. It is clear that we are entering an era of great challenge and opportunity for higher education, characterized by a rapid and profound transformation into a global knowledge society in which creativity and innovation are prized. The task of transforming the University of Michigan to better serve such a society and to move toward a new vision for its third century would be challenging under any circumstances. But perhaps the greatest challenge of all will be the university's very success. It will be difficult to convince those who have worked so hard and successfully to build one of the world's great universities for the twentieth century, that they cannot rest on their laurels when the old paradigms will no longer work. The challenge of the University's third century will be to reinvent the university once again to serve a new generations in a new world.

The capacity for intellectual change and renewal has become increasingly important to us as individuals and to our institutions. Our challenge, as an institution, and as a faculty, is to work together to provide an environment in which such change is regarded, not as threatening but rather as an exhilarating opportunity to conduct teaching and scholarship of even higher quality and impact on our society.

To succeed, we strive for a more flexible culture, one more accepting of occasional failure as the unavoidable corollary to any ambitious effort. We must learn to adapt quickly while retaining the values and goals that give us a sense of mission and community. Many view the current rigid and hierarchical structure of the university as obsolete. To advance, we must discover ways to draw upon the unique and vibrant creativity of every member of our community.

As financial resources become increasingly constrained, and as competition for students globally increases, especially with the advent of "virtual" technology, we cannot afford to hide our heads in the sand. Increasingly, many fear an age of attrition in higher education similar to that of the post-Civil War period, those institutions that cannot re-establish their sense of purpose for a new society will begin to disappear. As we ask our students to critique the received authority of their society, to examine and decide rather than accept the status quo, so must we also re-open debates about the structure and goals of our common institution.

It is often scary and difficult to let go of old and comfortable roles, to open ourselves to new possibilities and ways of being. Yet change brings with it the possibility of deeper connections to our students and the potential for serving a much broader range of our society. Growth, both for an institution and for the individuals that comprise it, can come only with a step into the unknown.

Our challenge is to tap the great source of creativity and energy of entrepreneurial activity at the University in a way that preserves our fundamental mission, our fundamental values. We need to continue to encourage our tradition of natural evolution, which has been so successful in responding to a changing world, but do

so with greater strategic intent. We must also develop a greater capacity to redirect our resources toward our highest priorities. 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.

The Challenge and Opportunity

The University of Michigan is an institution that should not only respond to this challenge but provide leadership for higher education in this endeavor, just as it has during earlier eras of change in America. Michigan possesses a unique combination of characteristics, particularly well suited to exploring and charting the course for higher education as it evolves to serve a changing world. Former Michigan Professor David Hollinger captured this character of the university well in an address celebrating the 75th anniversary of the founding of its graduate school: (Hollinger, 1988)

> "Michigan is a more impressive university as a whole than in those of its parts that are measured by conventional indices of excellence. The principled constraint has been the University's effort to govern itself by the standard academic values of free and open inquiry, veracity, objectivity, reasoned argument, and reliance on evidence… Multitudinous, sprawling, decentralized, contingent, imperfect, Michigan retains its capacity to inspire. That capacity derives not from any claims to uniqueness but from its strivings toward cosmopolitanism, from the enormous range of learned pursuits and doctrines available here. If there is a Michigan mystique, it is more democratic than exclusive, more egalitarian that hierarchical; it is a mystique more of pluralism than of uniqueness of any sort. Michigan's tradition is pre-eminently national rather than local. The chiefly historical significance of the University of Michigan is an embodiment of the national academic culture, as an institution successfully devoted to both excellence and comprehensiveness."

It is this unique character that should shape the University's mission, vision, and goals as the University of Michigan enters its third century.

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.

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.

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Chapter 9

A Roadmap to the Future of Engineering

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.

During the past several years there have been numerous studies conducted by organizations such as the National Academies, federal agencies, business organizations, and professional societies suggesting the need for new paradigms in engineering practice, research, and education that better address the needs of a 21st-century nation in a rapidly changing world. Despite the growing importance of engineering practice to society, the engineering profession still tends to be held in relatively low regard compared to other learned professions such as law and medicine. Unfortunately, many global corporations tend to view engineers as disposable commodities, discarding them when their skills become obsolete or replaceable by cheaper engineering services from abroad. There are concerns that the increasing trends of outsourcing engineering services and off shoring engineering jobs are eroding this nation's fundamental technological competence and its capacity to innovate, not to mention eroding the attractiveness of engineering careers to many of our most talented US-born students who opt instead for more secure and better rewarded professions such as law, medicine, or business administration.

The fundamental knowledge undergirding engineering practice increasingly requires research at the extremes, from the microscopic level of nanotechnology to the mega level of global systems such as civil infrastructure, energy, and climate change as well as the mastery of new tools such as cyberinfrastructure and quantum engineering. It also requires far greater attention by government and industry to the support of the long-term basic engineering research necessary to build the knowledge base key to addressing society's needs.

Despite the considerable progress made in recent years, engineering education remains predominantly dependent upon narrow, discipline-focused undergraduate programs. These are increasingly challenged both by the relentless pace of new technologies and their declining ability to attract a diverse cadre of the most capable students compared to other professional programs such as law, medicine, and business administration.

The Challenges to American Engineering Today

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 para-

digms 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; NSB 2003, 2007). 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 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 quar-

terly 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 recent 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).

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

Engineering students of today...

Engineering students of tomorrow...

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.

The Future of Engineering

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 necessary 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 engineer-

ing: 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.

The Gap Analysis: How Far to Go?

Engineering Practice

Engineering practice is changing rapidly. The United States is part of a global economy driven increasingly by technological innovation and hence engineering. Multinational corporations manage their technology activities to take advantage of the most capable, most creative, and most cost-efficient engineering and scientific talent, wherever they find it. Smaller U.S. firms

without global resources are facing stiff competition from foreign companies with access to talented scientists and engineers–many of them trained in the United States with technical skills rivaling the best U.S. graduates. Relentless competition is driving a faster pace of innovation, shorter product life cycles, lower prices, and higher quality than ever before.

In a global economy increasingly driven by technological innovation and the creation of new business, the role of the engineer as innovator and entrepreneur becomes ever more important. Unlike the 20th century, when the large systems engineering projects characterizing the defense industry set the pace for engineering practice, today most of the excitement is in small business development within collaborative-competitive global networks. While many corporations still require a large engineering workforce for product development and manufacturing, others are pushing their engineering activities off-shore to take advantage both of lower labor costs and the rapidly increasing engineering sophistication of nations in Asia making major commitments to science and engineering education for large populations. Clearly American engineers face the challenge of elevating their activities to a higher level of sophistication and value added if they are to be competitive in the global economy.

The prestige of the profession of engineering in our nation requires particular attention, since most Americans tend to view engineers as employees of industry or government rather than learned professionals such as physicians and lawyers. We tend to portray engineers as problem solvers rather than creators and innovators who address the grand challenges of our time–environmental sustainability, world hunger, energy dependence, and the spread of disease. Journalists report scientific achievements and engineering failures, ignoring the profound contributions that engineers have made to dramatically extending the human life span through public infrastructures (Wulf, 2003). How did we let this happen? To some degree the lack of prestige of the engineering profession reflects its continued reliance on undergraduate programs. But it also is due to the tendencies of many companies to treat engineers as commodities, similar to other white-collar employees subject to lay-offs or off-shoring whenever near-term financial pressures arise. Like most professions, compensation reveals the value the marketplace places on engineers. While starting salaries are attractive, at least when compared to most of those received by other baccalaureate majors, compensation flattens off in later years for engineers, falling far behind those of lawyers, physicians, and business executive officers. Clearly for engineering to play the role it must in the future of our nation, the prestige and influence of the engineering profession needs to be significantly enhanced.

Of course there continues to be debate over whether the United States faces a shortage of scientists and engineers, and such arguments threaten to undermine the necessary national investments in research and STEM education. While there is little doubt that there has been a decline of interest in these fields, particularly at the graduate level, by top students who instead seek the rewards, prestige, and security of other learned professions such as medicine, law, and business administration, economists tend to argue that in a global economy, the needs for scientists and engineers are being met either by immigrants or outsourcing and off shoring research and engineering services (Wadha, 2006; Teitelbaum, 2007). Of course, this ignores the vulnerability of our national economy and security to a disruption of overseas talent, such as that which occurred following the 9-11 attacks. It also ignores the needs of the defense and intelligence sector, where security clearances require U.S. citizenship. Finally, such narrow assessments also ignore the importance of getting more individuals with science and engineering backgrounds into key leadership positions in business and government, similar to their leadership roles in Europe and Asia where the importance of technology to economic and public policy seems better understood. Just as it would be foolish to limit undergraduate majors in economics because we have too many economists, such assessments of the national need for scientists and engineers usually ignore the fact that the nation desperately needs more leaders with these backgrounds if it is to face the challenges of an increasingly technology-driven world.

As suggested by Lynn and Salzman, the United States must also develop strategies that are less focused on competitive advantage and become more focused on collaborative efforts that leverage increasing global capabilities (Lynn, 2006). In fact, learning how to achieve "collaborative advantage" will replace the 20th-century

goal of "competitive advantage" for most companies. For example, as other nations build strong capabilities in engineering research and development, the United States must abandon its goals of scientific and technological hegemony in all areas. Rather it should adopt the philosophy of the Press Report of the National Academies (Press, 1995) by seeking leadership only in those areas of highest national priority and seeking only to be among the leaders in other areas, i.e., "ready to pounce" should the need arise. Key in all activities will be a greater reliance on collaboration with scientists and engineers in other nations.

Yet it is also essential that through both public policy and corporate leadership our nation resist the bandwagon trend to outsource and off shore a dominant amount of our technological activity. It is increasingly clear that economic prosperity, national security, and social well being require a high degree of technological competence as the key to innovation. Short-sighted business leadership more driven by near-term profits or investor pressures toward excessive outsourcing of technological competence will almost certain lead in the long term to financial failure and national vulnerability in an increasingly technology-dependent society.

The Engineering Knowledge Base

Key to the nation's prosperity and security in a global, knowledge-driven economy will be its leadership in technological innovation, which, in turn, requires global leadership in engineering research and education. Technological innovation will also be essential in addressing future challenges such as the health care needs of an aging population, homeland security, and global sustainability while exploiting new opportunities presented by rapidly evolving technologies such as info, bio, and nano technology.

While our American culture, based upon a highly diverse population, democratic values, and free-market practices, provides an unusually fertile environment for technological innovation, history has shown that significant federal investment is needed to produce the essential ingredients necessary for innovation to flourish: new knowledge (research), human capital (education), infrastructure (e.g., physical, cyber), and policies (e.g., tax, property).

Even though current measures of technological leadership–percentage of gross domestic product invested in R&D, absolute numbers of researchers, labor productivity, and high-technology production and exports–still favor the United States, a closer look at the engineering research and education enterprise and the age and makeup of the technical workforce reveals several interrelated trends indicating that the United States may have difficulty maintaining its global leadership in technological innovation over the long term. 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. These well-documented 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 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 science, engineering, and other technical fields; and (5) growing uncertainty about the ability of the United States to attract and retain gifted science and engineering students from abroad at a time when foreign nationals account for a large, and productive, component of the U.S. R&D workforce.

Numerous recent studies (COSEPUP 1998-2003, Vest 2003, Augustine 2005) have warned that federal investment in basic engineering research and engineering education, key to technological innovation, has been stagnant for the past three decades, raising the question of whether the current level of federal investment is adequate to meet the challenge of an increasingly competitive, knowledge-driven, global economy. Although federal support of engineering research and education is provided by numerous federal mission agencies (e.g., DOD, DOE, NASA), the National Science Foundation plays a particularly significant role in linking basic engineering research and education to fundamental scientific discoveries in the physical, natural, and social sciences. There are also increasing concerns that the relatively modest funding of the NSF Engineering Directorate is inadequate to enable NSF to play a significant leadership role in creating the new knowledge, human

capital, and infrastructure necessary to sustain the nation's objectives of global leadership in innovation.

Current federal R&D priorities have led to a situation today in which over 65% of all federal support of academic research flows to the biomedical sciences. Beyond its impact on faculty priorities and student interest, there is some evidence that this imbalance in federal research support is also distorting university funding and capital expansion priorities, thereby eroding even further support for programs in physical science and engineering essential to technological innovation. Most engineering research and education is conducted in public universities, already under great strain from state budget cuts. Without enhanced federal support, the ability of these programs to contribute to the nation's capacity for technological innovation could be seriously threatened by inadequate state support.

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. Too 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 sophisticated laboratories, cyberinfrastructure, or instrumentation necessary for today's technological leadership. Research in many fields of engineering requires sophisticated, expensive equipment and instruments that rapidly depreciate. Effective research in many areas of microelectronics, bioengineering, and materials science requires Class 10 and Class 100 clean rooms and precision instruments; costs for these can exceed $100 million. Research and education in emerging fields, such as quantum computing, as well as established fields, such as nuclear engineering, are suffering for want of resources for the development and/or maintenance of facilities. In fact, it will take billions of dollars to update facilities at hundreds of engineering schools nationwide. This investment, however, would create geographically dispersed, world-class research facilities that would make engineering attractive to more students (at home and from abroad), stimulate cooperation, and maybe competition, among research groups working on related problems, and provide a locus for networks of researchers and clusters of industry across the nation.

Over the past several decades a similar imbalance has arisen in which industrial R&D (primarily applied research and development) now dwarfs federal R&D, raising a serious concern about whether sufficient applications-driven basic research is being conducted to translate new scientific discoveries into innovative products, processes, and services that address national priorities.

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 long-term, 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 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 (Engardio, 2005). Consequently, federal investment in long-term research in universities and national laboratories has become increasingly important to sustaining the nation's technological strength. But just as industry has greatly reduced its investment in long-term engineering research, engineering-intensive mission agencies have also shifted their focus to short-term research.

Our nation's leadership in science, engineering, and technological innovation has been due, in part, to the capacity of our universities and industry to attract outstanding students, scientists, and engineers from around the world. Cumbersome immigration policies implemented in the wake of 9-11, along with international reaction to U.S. foreign policy are threatening the ability of the nation's universities and industry to attract and retain the top engineering and scientific talent from around the world, key to its innovation capacity.

As other nations invest in their knowledge infrastructure-universities, research laboratories, high tech industry–an increasing number of students, scientists, and engineers are finding attractive career opportunities in their home countries and no longer have the desire to immigrate to America.

To meet the demands of global competition, other countries are investing heavily in the foundations of modern innovation systems, including research facilities and infrastructure and strong technical workforces (NSB, 2003). Some of the innovations that emerge from these investments will be driven by local market demands, but many will be developed for export markets. As other countries develop markets for technology-laden goods and international competition intensifies, it will become increasingly difficult for the United States to maintain a globally superior innovation system. Only by increasing its investment in engineering research and education can the United States retain its competitive advantage in high-value, technology-intensive products and services, thereby encouraging multinational companies to keep their R&D activities in this country.

Engineering Education

Despite the profound changes occurring today in engineering practice and engineering science and technology, we continue to educate and train engineers much as we have for the past several decades. In the curricula of our engineering schools we still stress analytical skills involving scientific and mathematical analysis to solve well-defined problems rather than the broader skills of engineering design, systems integration, and innovation. Bowing to industry and student pressure, we continue to pretend that one can become an engineer with only a four-year undergraduate education, despite the fact that the curriculum has become overloaded, pushing aside the opportunities for the broader type of liberal education required to address the changing nature of engineering practice. A recent summit meeting on the status of mechanical engineering education in the United States concluded that the primary emphasis of engineering programs on scientific fundamentals has led to "a weak link to engineering practice and a lack of emphasis on industrial innovation and the commercialization of technology. Engineering education must be transformed to embrace both fundamentals and practice; both the procedural knowledge of the problem-solving engineer as well as the declarative knowledge of the applied scientist" (Ulsoy, 2007).

So what should we stress as the core competencies of the education of American engineers as we aim to enhance their value-added and hence their value in the global marketplace? More intensive technical training? Perhaps not. Rather we should strive for broader intellectual span, consilience, building on the unusual breadth of American universities. This should be combined with strong skills in knowledge integration, synthesis, innovation, communication, and teamwork.

Engineering students should gain both the capacity and the commitment for lifelong learning, since the technology treadmill is accelerating, and those relying on old skills and past learning will quickly fall off. But even broader skills and abilities are necessary, including the social skills of relating to different cultures, functioning in a global enterprise, and thriving in a world of ever-accelerating change. In a sense, we must shift from emphasizing the mastery of technical content to mastering the process of learning, since the shelf life of the content learned early in college will erode rapidly. Experiential learning will become increasingly important, whether in the laboratory, the design studio, or through internships. Global awareness will place a higher premium on international experiences such as study-abroad programs. And, perhaps as important as anything, we must infuse in our students a new spirit of adventure, in which risk-taking and innovation are seen as an integral part of engineering practice, and where bold solutions are sought to the major challenges facing our world.

Finally we must make engineering education, engineering practice, and the profession of engineering itself more attractive to young people. Today students sense both the narrowness of engineering education and the commodity nature of engineering careers. Why do they prefer professions such as business and law? Not because they find these subjects intellectually stimulating, but because they open doors to further opportunities rather than close down options as an engineering education is perceived to do. We must instead reshape engineering education as the route to creativity

and innovation, developing the capacity to understand and control those technological forces driving change in our world. Students need to understand that engineering has become the most important profession in addressing the grand challenges of our time–promoting global sustainability, addressing world health and poverty, and stimulating a new spirit of adventure, exploration, and hope for the future.

Hence to attract the best students, we must strive to create undergraduate engineers who are sufficiently well-balanced to serve a much broader range of student career options than simply professional practice.

Numerous workshops on engineering education have identified possible actions for the near term (e.g., Ulsoy, 2007; NSF, 2007). Yet any such actions will encounter strong opposition. Of course the engineering faculties will immediately insist that the engineering curriculum is already overloaded with necessary material and that removing anything would water down undergraduate programs. Worth noting here, again, is the fact that most engineering faculty members are engineering scientists engaged in research rather than professional practice and sometimes give short shift to broadening the education to include material and develop skills important to the profession. Furthermore such actions will require substantial investment in resources, faculty effort, and, if professional education is shifted to the graduate level, additional expenditures by students and parents. Many universities today tend to view engineering education as a cash cow, much like business administration, and they have been reluctant to make the investments necessary to facilitate change. Most engineering faculty are already on a treadmill, under pressure to teach larger classes, to generate more research funding to support not only their laboratories and graduate students but even part of their own salaries, and to be a good university citizens by participating in the myriad faculty committees and governance characterizing the contemporary university. Furthermore both the lockstep nature of the engineering curriculum and restrictive university policies frequently prevent engineering students from participating in the broader array of educational opportunities available to other students such as study abroad, programs restricted to majors (music, art, business), and an array of extracurricular activities.

Yet another barrier to innovation in engineering education is the dearth of rewards and recognition of achievement in this activity. Most engineering schools are located in research universities, where faculty rewards such as compensation, promotion, and tenure are determined more by research reputation and grantsmanship than contributions to engineering education. Although the National Academy of Engineering has recently created the Bernard M. Gordon Prize for innovation in engineering education, most awards from academic institutions and engineering societies fall far short in prestige of the peer recognition provided by honors such as election to membership in the National Academy itself. In fact, one of the most significant actions that might be taken by the National Academy of Engineering is to recognize extraordinary achievement and leadership in *engineering education* as a criterion sufficient for membership and to create a new section for such members.

Employers also present a challenge, since they will likely resist anything that extends engineering education, making it more expensive. Unlike medicine, where licensure requirements were utilized by the profession to overcome resistance to cost, industry is likely to turn, at least initially, to further outsourcing of engineering services and off shoring of engineering jobs should the domestic supply become more expensive–at least until greater value-added can be demonstrated. Furthermore they will continue to seek baccalaureate graduates with narrowly defined skills capable of immediate implementation in preference to more broadly educated graduates capable of eventually rising to leadership positions. So too, students and parents are likely to resist the increased costs of an expanded engineering education paradigm, particularly if it requires graduate education for the professional degree–although ironically many are already bearing the additional cost burden of the 4.5 to 5 years it takes to complete today's engineering degree programs.

But the strongest resistance to change is likely to come from the profession itself. Engineers are usually a conservative lot, frequently moored to the past, and will insist that the traditions of engineering practice are not only well established but also time-tested and successful (ignoring the implications of engineering's increasing globally competitive character). They will

complain that significant dislocation will occur from any major restructuring of the nature and requirements for professional practice, even with grandfathering clauses. While some disciplines such as civil and mechanical engineering may be more receptive, others such as electrical and computer engineering, which tend to downplay the importance of licensure, will see little advantage to such restructuring. Furthermore, many are likely to raise concerns about the impact such restructuring would have on student interest in engineering majors, particularly among women and minority students, already badly underrepresented in the engineering workforce.

To be sure, an important key to any strategy for strengthening U.S. engineering capacity will be attracting into science and engineering careers an increasing number of women and underrepresented minorities. This will require both a major new commitment and more effective strategies for diversifying the nation's science and engineering workforce. We also must make a concerted effort to re-establish the United States as a destination for talented students, scientists, and engineers from around the world. In particular, our immigration policies need a major overhaul to give far higher priority to immigrants with advanced education and skills who can contribute at a very high level to our knowledge economy rather than simply opening our borders to low skill workers willing to assume American jobs at wages too low for domestic workers. While acknowledging the importance of homeland security in the wake of the 9-11 attacks, we also need to once again encourage visits and collaboration between American scientists and colleagues from abroad through more rational visa policies.

Yet here the challenges will be great. An increasing number of Americans oppose the traditional approaches to achieving diversity such as affirmative action or opportunity programs based upon race or gender. Voters are taking aim through referenda at an earlier generation's commitment to civil rights. Courts are pondering cases that challenge programs based on race or gender. Despite a landmark decision by the U.S. Supreme Court in 2003 involving the University of Michigan that stressed the importance of diversity in higher education, there remain reasons for great concern (Duderstadt, 2007). The Court ruled that "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." Yet in the aftermath of this decision, many successful programs aimed at extending opportunity and participation of underrepresented groups have been discontinued as institutions have chosen to accept a very conservative and restrictive interpretation of the Supreme Court decision as the safest course. This retrenchment has been accelerated by efforts in numerous states (including Michigan) to pass referenda banning the use of race or gender in public institutions, an effort that could eventually reach the federal level and seriously hinder existing affirmative action programs aimed at diversifying educational and career opportunities in fields such as engineering.

Similar constraints hinder the ability to attract talented engineers and scientists from abroad. Unlike most other nations, current U.S. immigration policy favors family relationships over education level and technical skills. Although there are currently efforts underway to reform immigration policy to better address the human resource needs of the nation in these critical fields, these modifications face an uphill battle in an intensely political environment.

Today we are still falling far short of preparing engineering graduates for practicing–and leading–in a change-driven, knowledge-intensive, global society that will characterize the decades ahead. Few would disagree that the current undergraduate curriculum emphasis on engineering science continues to produce graduates with strong technical skills. But much more is needed not only for engineering practice but for the many other careers likely to attract engineers. Furthermore, many of our best and brightest students tend to turn away from the current narrowly defined engineering curriculum, despite their strong interest in science, mathematics, and technology. The sad fact is that all too many students–and members of the public more broadly–continue to see engineering as more a trade or even a commodity service than a learned profession of immense importance to an increasingly technology dependent world.

It is also the case that in large engineering schools, significant change such as the introduction of more research opportunities for undergraduates or engineering project teams requires substantial investment in faculty time and resources. Hence it is not surprising that much of the innovation in engineering education occurs in smaller programs where the resource requirements associated with change are considerably less–albeit frequently significant relative to the resource base of these programs.

While recent efforts taken to improve engineering education by groups such as ABET are moving in the right direction with their stress on learning outcomes rather than simply resource input, many question their impact on innovation in engineering education. To be sure, the new engineering accreditation criteria were designed to encourage greater innovation. Yet such goals can only be achieved if evaluation teams can rise above simple bean counting demanded by rigid criteria, an aspiration that many deans feel they fail to achieve. Many contend that the current accreditation process continues to discourage radical departure from the status quo. This is particularly ironic in view of the fact that such a rigid approach to standardization flies in the face of one of the great strengths of American higher education, its very diversity, and in an ever-flattening world, makes American engineering and practice even more susceptible to off shoring.

Here it is also important to heed the warnings of academic leaders such as former Harvard president Derek Bok on the dangers of imposing vocational goals on undergraduate majors (Bok, 2006). One might well make the argument that the accreditation of professional (or pre-professional) is antithetical to the purposes of a liberal education and should be avoided at the undergraduate level. In reality, professional accreditation agencies such as ABET are simply not qualified to evaluate or accredit the broader objectives of undergraduate education, a task more appropriate for regional institution-level accreditation groups.

In summary, then, it is clear that entirely new paradigms for engineering education are needed:

* To respond to the incredible pace of intellectual change (e.g., from reductionism to complexity, from analysis to synthesis, from disciplinary to multidisciplinary, from local to global.

* To permeate engineering education with new levels of innovation and continuous improvement informed by scholarly research and based upon evidence-based guidance from validated practices.

* To provide engineering students with the ability to adapt to new technologies (e.g., from the microscopic level of info-bio-nano to the macroscopic level of megacities and global systems).

* To 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.

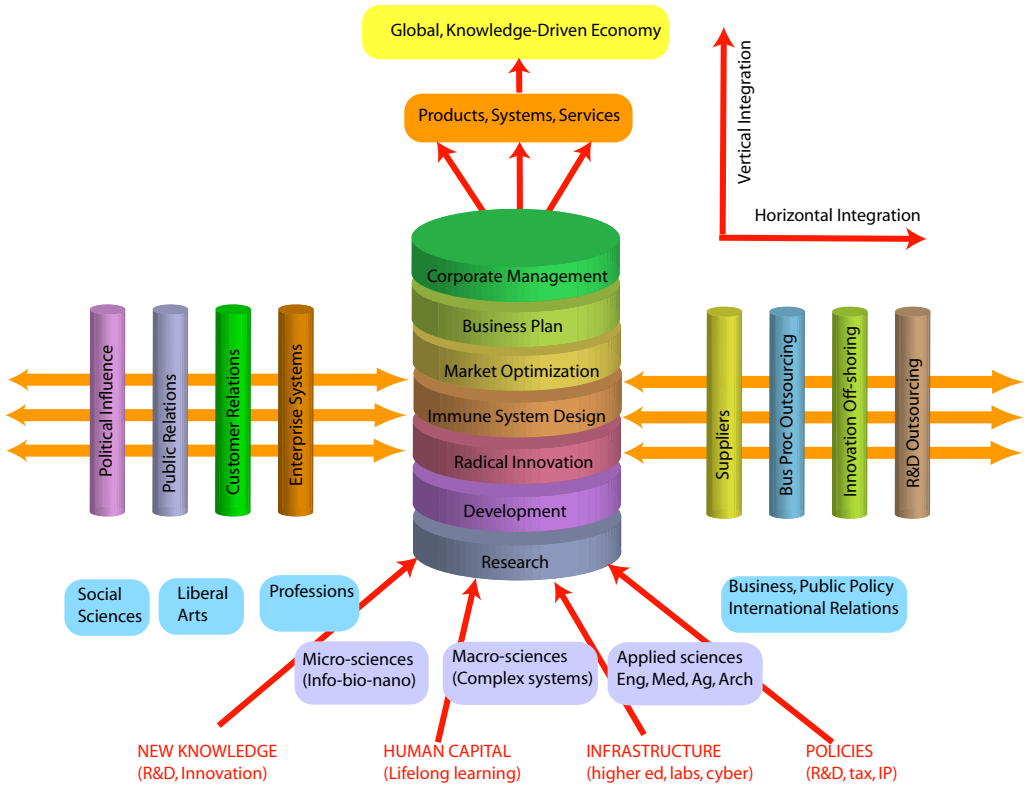
* To prepare engineering graduates for a lifetime of continuous learning, while enabling them to enjoy the prestige and influence of other learned professions.

* To reflect in its diversity, quality, and rigor the characteristics necessary to serve a 21st century nation and world.

* To infuse in our students a new spirit of adventure, in which risk-taking and innovation are seen as an integral part of engineering practice, and where bold solutions are sought to the major challenges and opportunities facing our world.

Why Is Change So Slow? And What Can We Do About It?

Change in engineering has proceeded at glacial speed for many decades despite study after study and the efforts of many individuals and groups (e.g., ABET, NAE, and NSF). There are many barriers to change. Considerable resistance comes from American industry, which tends to hire most engineers for narrow technology-based services rather than for substantive leadership roles. All too many companies continue to prefer to hire engineers on the cheap, utilizing them as com-



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modities, much like assembly-line workers, with narrow roles, preferring to replace them through younger hires or off-shoring rather than investing in more advanced degrees.

Resistance to change also comes from university faculty, where the status quo is frequently and strongly defended as the best option. Engineering educators tend to be particularly conservative with regard to pedagogy, curriculum, and institutional attitudes. This conservatism produces a degree of stability (perhaps rigor mortis is a more apt term) that results in a relatively slow response to external pressures. The great diversity of engineering disciplines and roles has created a chaotic array of professional and disciplinary societies for engineering that, in turn, generates a cacophony of conflicting objectives that paralyze any coordinated effort to drive change.

Furthermore today's industrial strategies, educational programs, and government policies are increasingly out-of-date for supporting the key needs of an innovation-driven nation, e.g., generating new knowledge (research), human capital (education), building infrastructure, and putting into place policies that encourage innovation and entrepreneurs. As a result, there are signs that the United States' leadership in engineering research, education, and practice, and consequently capacity for technological innovation is declining relative to other nations.

The stakes are high and the time is short. Other nations are making strategic commitments to challenge America's long-standing leadership in technology and innovation. Many enlightened leaders of business and industry are beginning to question whether a blind commitment to further outsourcing and off shoring could leave their company–and their nation–behind with an empty cupboard for technological competence and world-class innovation. Students are beginning to seriously question whether an engineering education is worth the effort and the expense when the projected compensation is so low compared to that of other professions (business, law, medicine) and the risk of obsolescence or off shoring so high. In fact, what is really at stake is the continued existence of American engineering as a world-class asset of this nation.

Yet we face a dilemma: To produce higher value in a hypercompetitive global economy, U.S. engineers clear-

ly need a broader and more integrative undergraduate education, followed by a practice-based professional education at the post-baccalaurate level, and augmented throughout their career with lifelong learning opportunities. Yet they also face a marketplace governed by a business model that seeks the cheapest talent that will accomplish a given short-range goal. Hence the key question: How do we motivate U.S. (or global) companies to pay more for better educated engineers? Can practice-based professional education increase the value of American engineering sufficiently to justify the investment of time and resources? And what will happen to those American engineers without this advanced education? Will they face the inevitability of their jobs eventually being off shored through global sourcing? Could it be that the future of American engineering will become similar to other exportable services: that most routine engineering services and engineering jobs will eventually be off shored, leaving behind a small cadre of well-educated "master engineers" managing global engineering systems to address complex engineering challenges?

Hence our challenge is to overcome this resistance to change and provide recommendations that can comprise a roadmap to a future of engineering more aligned with the imperatives and challenges faced by our world.

A Roadmap to the Future of Engineering

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.

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, that 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 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 absolutely 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 edu-

cation 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 develop 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.

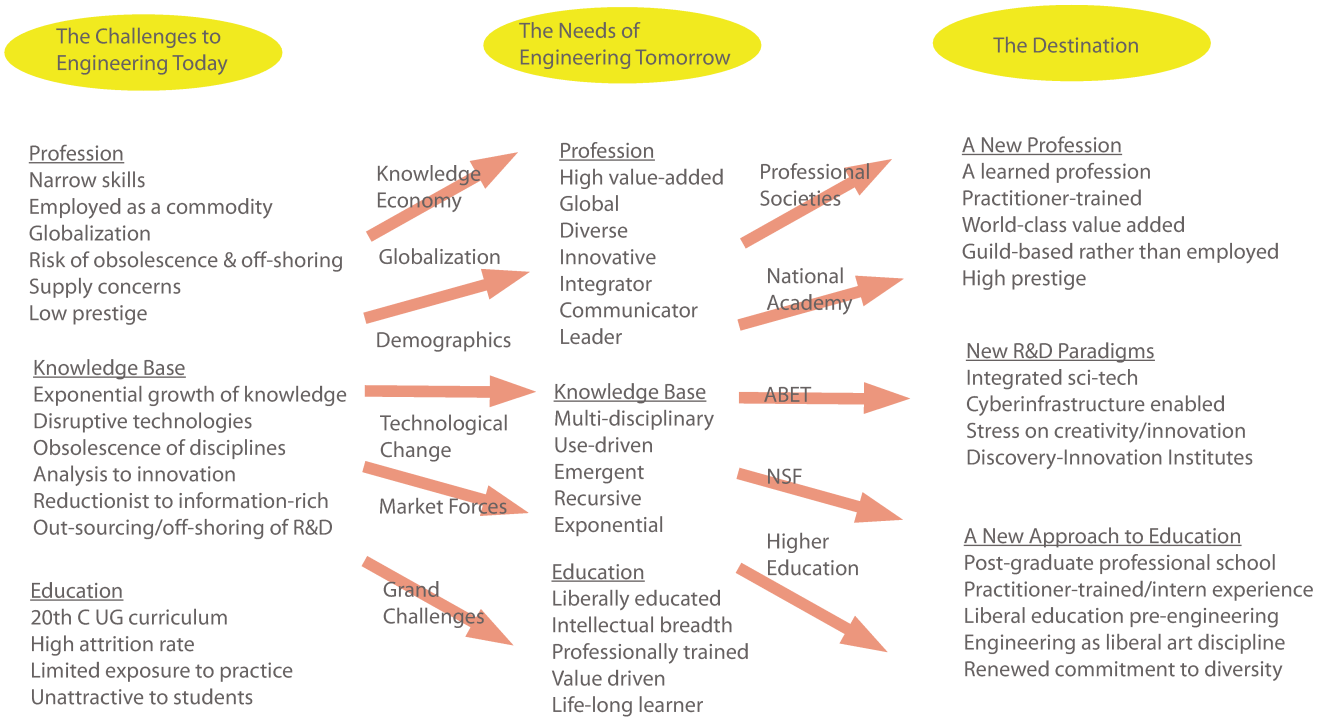
This brings us to a broader proposal for a 21st-century college education. The liberal arts is an ancient concept that has come to mean studies that are intended to provide general knowledge and intellectual skills, rather than more specialized occupational or professional skills. The term liberal in 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 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



A Roadmap to 21st Century Engineering

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. ." (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, and professional societies) 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.

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Chapter 10

Plans, Tactics, and Processes

A roadmap is just that, a set of possible directions to the future. But setting a direction, even with a roadmap, is far from arriving at one's destination. Furthermore, recommendations that require major institutional change are not spontaneously or miraculously implemented. The acceptance of and action upon the recommendations in a proposed roadmap require active involvement and commitment from a variety of stakeholders and patrons. Without commitment at all levels, long-term or sustained innovation and change cannot be achieved–unless, of course, revolution becomes an option (remember earlier experiences during the Age of Enlightenment, e.g., the French and American Revolution).

Institutions and their stakeholders require a more definitive operational plan that addresses key questions such as: What are the first steps to be taken? What policy actions are necessary? Are there follow-on studies that need to be commissioned? What about an ongoing process or framework to assess and sustain progress?

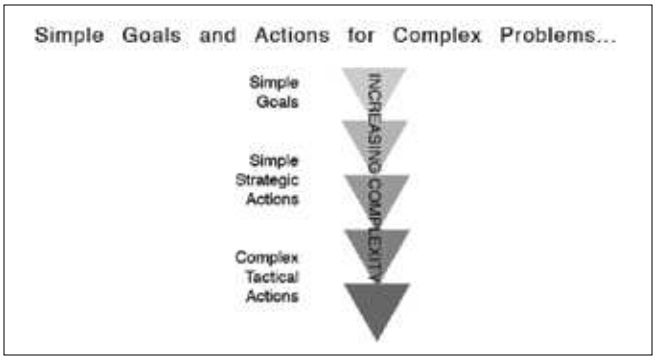
Furthermore, we should acknowledge that most roadmapping studies such as those in this book are stated in straightforward–sometimes even blunt–terms. To survive in the political environment of campus, state, national, and international policy, they must be reclothed in more Machiavellian garb.

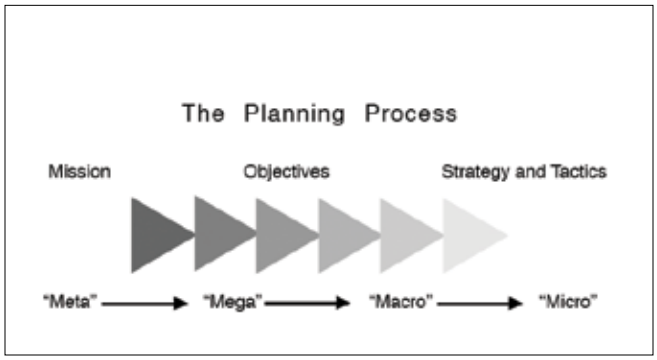
Strategic Planning

Today's rapidly changing environment requires a far more strategic approach to the evolution of our institutions at all levels. Simply encouraging and supporting planning at the unit level, perhaps augmented by occasional initiatives from on high, is both inadequate and dangerous indeed, both for the institution and those dependent upon it. It is important to give thoughtful attention to the design of institutional processes for planning, management, and governance. The ability of institutions to adapt successfully to the profound changes occurring in our society will depend a great deal on their 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. We must seek a progressive, flexible, and adaptive process, capable of responding to a dynamic environment and an uncertain—indeed, unknowable—future.

Here, there is an important distinction to make. *Strategic planning* is deciding what should be done, that is, choosing objectives ("What do we want to do"); *tactics* are operational procedures for accomplishing objectives ("How do we go about doing it?"). Note, as well, that *long-range planning* is not the same thing as strategic planning. Long-range planning establishes quantitative goals, a specific plan. Strategic planning establishes qualitative goals and a philosophy. Because strategic planning should always be linked to operational decisions, some prefer to use the phrase strategic management, rather than strategic planning, to denote it.

Key to any planning effort is an assessment of the planning environment. In large and complex institutions or systems, it is particularly important to tap the wisdom of a variety of groups to help evaluate both the current and past state of the university, as well as the internal and external environment issues that should be considered in planning activities. All of these factors are time-dependent, of course. Hence, it is important to consider not only the current environments for planning, but also the historical context that led to these environments and the possible futures that might evolve. Furthermore, it is essential to recognize that the inter-





nal and external environments are tightly connected. Hence, external conditions that might first appear to be constraints can be altered through appropriate modifications of the internal environment and related activities. Rather than view environmental factors as absolute constraints, they can be recast as challenges or opportunities subject to modification. That is, one can adopt the mindset that the university can influence its planning environment. The key is to begin with the challenging question of asking what can be done to modify the planning environment.

There are always opportunities to control constraints—and the future—if one takes a proactive approach. One is rarely playing in a zero-sum game. Instead, they may have the opportunity to increase (or decrease) resources with appropriate (or inappropriate) strategies. Higher education organizations are never a truly closed system. Put in more engineering terms, any complex system can be designed in such a way as to be less sensitive to initial and/or boundary conditions. (In the language of systems engineering, a system can be designed with sufficiently short time constants or decay lengths so that it evolves rapidly into an asymptotic state where the constraints imposed by initial and boundary conditions are no longer controlling.)

A successful strategic planning process is highly iterative in nature. While the vision remains fixed, the goals, objectives, actions, and tactics evolve with progress and experience. During a period of rapid, unpredictable change, the specific plan chosen at a given instant is of far less importance than the planning process itself. Put another way, one seeks an "adaptive" planning process appropriate for a rapidly changing environment and a loosely coupled adaptive system such as a university.

In an institution characterized by the size and complexity of the contemporary university, it is usually not appropriate (or possible) to manage centrally many processes or activities. 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.

To this end, it is important to create a high-level steering group with strong representation from the leadership of both the administration and the academic units. Furthermore, each of the major components of an institution should be encouraged to utilize similar strategic planning organizations, either adding these missions to existing bodies or new organizations created for this role. The various levels of the planning process should be coupled and highly interactive. The planning processes should be highly iterative in nature. Each step would be viewed as a learning process with the power to influence not just subsequent stages of the process, but to feed back information to revise and sharpen the results of earlier stages.

Institutional Transformation

How does one employ such planning strategies and tactics to drive transformation in an institution? 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 block- buster goals. And, there are times when, weary of the endless meetings with group after group to build consensus, including, at times, it is best to take the Nike approach and "just do it," that is, to move ahead with top-down decisions and rapid execution–although in these latter cases, one usually bears the burden of blame and hence the responsibility for the necessary apologies.

Here it might be useful to consider several examples from personal experience at the University of Michigan. First, we 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.

Second, it was important to achieve true faculty participation in the design and implementation of the transformation process, in part since the transformtion of the faculty culture is the biggest challenge of all. Here we believed that the faculty participation should involve its true intellectual leadership rather than the political leadership 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 on the table (e.g., tenure reform). Unfortunately, universi ties—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, a university president 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, this presidential leadership had to be out in front of the troops leading them into battle rather than far behind the front lines tossing out an occasional initiative (e.g., leading by presidential whim).

Our experience during suggests the im-portance of the several factors in achieving successful transformtion. First, it is important that any transfo mation 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 of the fundamental values so necessary to the nature and role of the university at a time when it is so desperately needed. It is the role of the president to stimulate this dialog 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 step off the train before it leaves the station. This includes not only the executive officers and deans, but 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 key issues such 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 who are effective in leading such transformation efforts.

Clearly, significant resources are required to fuel the transformation process, probably at the level of 5 percent 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 we noted earlier in our consideration of financial issues, usually the only sources of funding at the levels required for such major transformation are tuition, private support, and auxiliary activity revenues, so that reallocation must play an important role.

Large organizations will resist change. They will try to wear leaders down, or wait them out ("This, too, shall pass."). We must give leaders throughout the institution every opportunity to consider carefully the issues compelling change, and encourage them to climb on board the transformation train. For change to occur, we 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 we establish sufficient confidence in the long-term support and vitality of the institution, even as we 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

Numerous experiences with institutional change revealed that the early stages of transformative leadership, one can make a great deal of progress simply because most people do not take you very seriously, and those who do are usually supportive. However, as it becomes more apparent that one not only means what they say, but that they can deliver the goods, resistance begins to build from those moored to the status quo. Those driving change becoming increasingly dangerous to those who feared it.

At Michigan as we broke our thinking out of the box, pushing the envelope further and further, we began to worry that it was increasingly awkward and perhaps even hazardous for the president to be carrying the message all the time. As the awareness grew about just how profound the changes occurring in our world were becoming, we worried that our speculation about the future of higher education was beginning to approach what some might consider the lunatic fringe. 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. True, 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.

Concluding Remarks

While many academics are reluctant to accept the necessity or the validity of formal planning activities, we became convinced that those institutions that turned aside from strategic efforts to determine their futures would be at great risk. The ability of a university to adapt successfully to the revolutionary challenges it faced would depend a great deal on the institution's collective ability to learn and to continuously improve its core activities. It was critical that higher education give thoughtful attention to the design of institutional

processes for planning, management, and governance. Only a concerted effort to understand the important traditions of the past, the challenges of the present, and the possibilities for the future would enable institutions to thrive during a time of such change.

Those institutions that could step up to this process of change would likely thrive. Those that buried their heads in the sand, that rigidly defended the status quo or even worse, some idyllic vision of a past that never existed, were at very great risk. Those institutions that were micromanaged, either from within by faculty politics or governing boards, or from without by government or public opinion, stood little chance of flourishing during a time of great change.

To be sure, both the character and needs of our nation had changed dramatically over the past two centuries since the founding of the first public universities. Yet the major principles that undergirded these important institutions remained as valid today as they were at earlier times—a bond between the society and its universities to educate, to discover, and to serve. While the details of the social contract might change, its fundamental character remained intact.

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