The Challenges and Opportunities
of the Digital Age
for Higher Education

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The impact of information technology will be even more radical than the harnessing of steam and electricity in the 19th century. Rather it will be more akin to the discovery of fire by early ancestors, since it will prepare the way for a revolutionary leap into a new age that will profoundly transform human culture.

<div align="right">Jacques Attali[1]</div>

After fifteen years as a university bureaucrat, I looked forward to leaving the inferno of a university presidency. However, before returning to a faculty paradise, it seemed appropriate to come back up to speed on the nature of today's students. It was in that context that I was a bit taken back by a flyer I spotted in my academic building that advertised the following curriculum:

> "Students will begin by learning the C programming language and corresponding operating system on their choice of platforms, including Unix, Macintosh, and Windows-NT on state-of-the art systems including Pentium, Macintosh, Sun, and HP workstations and Convex Exemplar and IBM SP-2 supercomputers. In addition they will learn HTML, Javascript, and create a home page on the World Wide Web. Next they will learn object-oriented C++ programming, including DOS graphics calls, while creating stand-alone Windows NT applications with menus, dialog boxes, and graphics. They will explore computer graphics and animation, including still imagery and video with Macromedia Director and Photoshop."

Sounds pretty advanced for college students, doesn't it? Perhaps. But this was not directed toward college students. Instead it was an advertising brochure for a summer camp run by the Michigan College of Engineering for high school students of ages thirteen to seventeen!

Not only is the technology of computers and networks driving change in our world, but it is also changing substantially the knowledge base of the students we will be teaching. From a broader perspective, we find that four important themes are converging in the final decade of the 20th Century:

1. The importance of the university in an age in which knowledge itself has become a key factor in determining security, prosperity, and quality of life

2. The global nature of our society

3. The ease with which information technology—computers, telecommunications, and multimedia—enables the rapid exchange of information

4. Networking—the degree to which informal cooperation and collaboration among individuals and institutions are replacing more formal social structures, such as governments and states

These themes of change present both great challenges and opportunities to the university. In fact, Peter Drucker suggested in an interview in Forbes magazine this past spring that:

> "Thirty years from now the big university campuses will be relics. Universities won't survive. It's as large a change as when we first got the printed book."

While most educators would disagree with Drucker, the forces of change on our institutions are powerful indeed.

The Forces of Change

There are many ways to group the challenges of change in higher education. For our purposes today, let me suggest the following framework:

Financial Imperatives

Since the late 1970s, higher education in America has been caught in a financial vise.[2] On the one hand is the magnitude of the services demanded of our colleges and universities have increased considerably. Enrollments have grown steadily; the growing educational needs of adult learners have compensated for the temporary dip in the number of high school graduates associated with the post-war baby boom/bust cycle. University research, graduate education, and professional education have all grown in response to societal demand. Professional services provided by colleges and universities also continue to grow in areas such as health care, technology transfer, and extension—all in response to growing needs.

The costs of providing education, research, and service have also grown and at an even faster rate, since these university activities are dependent upon a highly skilled, professional workforce (faculty and staff); they require expensive new facilities and equipment; and they are driven by an ever-expanding knowledge base. To be sure, higher education has yet to take the bold steps to constrain cost increases that have been required in other sectors of our society such as business and industry. This is in part because of the manner in which our colleges and universities are organized, managed, and governed. But, even if our universities should acquire both the capacity and the determination to radically restructure costs, it is debatable whether those industrial sector actions designed to contain cost and enhance productivity could have the same impact in education. The current paradigm of higher education is simply too people- and knowledge-intensive.

As the demand for educational services has grown and the operating costs to provide these services have risen, public support for higher education has flattened and then declined over the past two decades.[3] The growth in state support of public higher education peaked in the 1980s and now has fallen in many states, in the face of limited tax resources and the competition of other priorities such as entitlement programs and corrections. While the federal government has sustained its support of research, growth has been modest in recent years and is likely to decline as discretionary domestic spending comes under increasing pressure from federal budget-balancing efforts. There has been a significant decline in federal financial aid programs over the past two decades, with a corresponding shift from grants to loans as the predominant form of aid. While the new federal budget agreement is good news to middle-class parents, it is unlikely to bring new resources to higher education.

To meet growing societal demand for higher education, at a time when costs are increasing and public support is declining, most institutions have been forced to sharply increase tuition and fees—substantially faster than the CPI. While this provided short-term relief, it has also triggered a strong public concern about the costs and availability of a college education, along with growing forces to constrain or reduce tuition levels at both public and private universities.[4] As a result, most colleges and universities are now looking for ways to control costs and increase productivity, but most are also finding that their current organization and governance makes this very difficult.

It seems increasingly clear that the higher education enterprise in America must change dramatically if it is restore a balance between the costs and availability of educational services needed by our society and the resources available to support these services. The current paradigms for conducting, distributing, and financing higher education simply cannot adapt to the demands and realities of our times. An enterprise the size of higher education in America, with over fifteen million students enrolled, three million faculty and staff, and annual expenditures in excess of $175 billion, simply cannot escape the dramatic restructuring that has occurred in other industries, such as health care, transportation, and telecommunications.

Societal Needs

Yet the needs of our society for the services provided by our colleges and universities will continue to grow. Significant expansion will be necessary just to respond to the needs of a growing population that will create a 30 percent growth in the number of college-age students over the next two decades. Beyond this traditional role, we should recognize the impact of the changing nature of the educational services sought by our society.

Today's undergraduate student body is no longer dominated by eighteen to twenty-two year-old high school graduates from affluent backgrounds. It is comprised also of increasing numbers of adults from diverse socio-economic backgrounds, already in the workplace, perhaps with families, seeking the education and skills necessary for their careers. When it is recognized that the

magnitude of this need for higher education may be significantly larger than that for traditional undergraduate education, it is clear that either existing institutions will have to change significantly or new types of institutions will have to be formed. The transition from student to learner, from faculty-centered to learner-centered institutions, from teaching to the design and management of learning experiences, and from student to a lifelong member of a learning community—all suggest great changes are ahead for our institutions.

The students entering college today require a different form of education in which interactive and collaborative learning will increasingly replace the passive lecture and classroom experience. The student has become a more demanding consumer of educational services, although frequently this is directed at obtaining the skills directed toward more immediate career goals.

We are beginning to see a shift in demand from the current style of "just-in-case" education in which we expect students to complete degree programs at the undergraduate or professional level long before they actually need the knowledge, to "just-in-time" education in which education is sought when a person needs it through non-degree programs, to "just-for-you" education in which educational programs are carefully tailored to meet the specific lifelong learning requirements of particular students. So too the shift from synchronous, classroom-based instruction to asynchronous computer network-based learning, to the provision of ubiquitous/pervasive learning opportunities throughout our society will demand major change.

The nature of the needs for other higher education services also is changing dramatically. The relationship between the federal government and the research university is shifting from a partnership in which the government is primarily a patron of discovery-oriented research to a process of procurement of research aimed at addressing specific national priorities. The academic medical center has come under great financial pressure as it has been forced to deal with a highly competitive health-care marketplace and the entry of new paradigms such as managed care. While the public appetite for the entertainment provided by intercollegiate athletics continues to grow, our colleges also feel increasing pressures to better align these activities with academic priorities and national imperatives (such as the Title IX requirements for gender equity).

Even as the nature of traditional activities in education, research, and service change, society is seeking new services from higher education, e.g., revitalizing K-12 education, securing economic competitiveness, providing models for multicultural societies, rebuilding our cities and national infrastructure. All of this is occurring at a time when public criticism of higher education is high, and trust and confidence in the university is relatively low.

Technology Drivers

As knowledge-driven organizations, it is not surprising that colleges and universities should be greatly affected by the rapid advances in information technology—computers, telecommunications, networks. This technology has

already had dramatic impact on campus research activities, including the creation an entirely new form of research: computer simulation of complex phenomena. Many of the administrative processes have become heavily dependent upon information technology—as the current concern with the approaching date reset of Year 2000 has made all too apparent. There is an increasing sense that it will have an even more profound impact on the educational activities of the university and how we deliver our services. To be sure, there have been earlier technology changes such as television, but never before has there been such a rapid and sustained period of change with such broad social applications.

Most significant here is the way in which emerging information technology has removed the constraints of space and time. We can now use powerful computers and networks to deliver educational services to anyone at anyplace and anytime, no longer confined to the campus or the academic schedule. The market for university services is expanding rapidly, but so is competition, as new organizations such as virtual universities and "learning-ware" providers enter this marketplace to compete with traditional institutions.

The Changing Nature of Academic Activities

It is common to refer to the primary missions of the university in terms of the honored trinity of teaching, research, and service. But these roles can also be regarded as simply the 20th Century manifestations of the more fundamental roles of *creating, preserving, integrating, transmitting,* and *applying* knowledge. If we were to adopt the more contemporary language of computer networks, the university might be regarded as a "knowledge server," providing knowledge services (i.e., creating, preserving, transmitting, or applying knowledge) in whatever form needed by contemporary society.
From this more abstract viewpoint, it is clear that while these fundamental roles of the university do not change over time, the particular realization of these roles do change—and change quite dramatically, in fact.

Teaching

Consider, for example, the role of "teaching," that is, transmitting knowledge. We generally think of this role in terms of a professor teaching a class of students, who in turn respond by reading assigned texts, writing papers, solving problems or performing experiments, and taking examinations. We should also recognize that classroom instruction is a relatively recent form of pedagogy. Throughout the last millennium, the more common form of learning was through apprenticeship. Both the neophyte scholar and craftsman learned by working as apprentices to a master. While this type of one-on-one learning still occurs today in skilled professions such as medicine and in advanced education programs such as the Ph.D. dissertation, it is simply too labor-intensive for the mass educational needs of modern society.

The classroom itself may soon be replaced by more appropriate and efficient learning experiences. Indeed, such a paradigm shift may be forced upon the faculty by the students themselves. Today's students are members of the "digital generation."   They have spent their early lives surrounded by robust, visual, electronic media—*Sesame Street*, MTV, home computers, video games, cyberspace networks, MUDs, MOOs, and virtual reality. Unlike those of us who were raised in an era of passive, broadcast media such as radio and television, they expect—indeed demand—interaction. They approach learning as a "plug-and-play" experience, unaccustomed and unwilling to learn sequentially—to read the manual—and instead inclined to plunge in and learn through participation and experimentation. While this type of learning is far different from the sequential, pyramid approach of the traditional university curriculum, it may be far more effective for this generation, particularly when provided through a media-rich environment.

It could well be that faculty members of the 21st Century university will find it necessary to set aside their roles as teachers and instead become designers of learning experiences, processes, and environments. Tomorrow's faculty may have to discard the present style of solitary learning experiences, in which students tend to learn primarily on their own through reading, writing, and problem solving. Instead, they may be asked to develop collective learning experiences in which students work together and learn together, with the faculty member becoming more of a consultant or a coach than a teacher. Faculty members will be less concerned with identifying and then transmitting intellectual content and more focused on inspiring, motivating, and managing an active learning process by students. Here we should note that this will require a major change in graduate education, since few of today's faculty members have learned these skills.

Research

One can easily identify other similarly profound changes occurring in the other roles of the university. The process of creating new knowledge—of research and scholarship—is also evolving rapidly away from the solitary scholar to teams of scholars, perhaps spread over a number of disciplines. Indeed, is the concept of the disciplinary specialist really necessary—or even relevant—in a future in which the most interesting and significant problems will require "big think" rather than "small think"? Who needs such specialists when intelligent software agents will soon be available to roam far and wide through robust networks containing the knowledge of the world, instantly and effortlessly extracting whatever a person wishes to know?

There is also increasing pressure to draw research topics more directly from worldly experience rather than predominantly from the curiosity of scholars. Even the nature of knowledge creation is shifting somewhat away from the *analysis of what has been* to the *creation of what has never been*—drawing more on the experience of the artist than upon analytical skills of the scientist.

The Library

The preservation of knowledge is one of the most rapidly changing functions of the university. The computer—or more precisely, the "digital convergence" of various media from print-to-graphics-to-sound-to-sensory experiences through virtual reality—has already moved beyond the printing press in its impact on knowledge. Throughout the centuries, the intellectual focal point of the university has been its library with its collection of written works preserving the knowledge of civilization. Yet today such knowledge exists in many forms—as text, graphics, sound, algorithms, and virtual reality simulations—and it exists almost literally in the ether, distributed in digital representations over worldwide networks, accessible by anyone, and certainly not the prerogative of the privileged few in academe.

Service

Finally, it is also clear that societal needs will continue to dictate great changes in the applications of knowledge it expects from universities. Over the past several decades, universities have been asked to play the lead in applying knowledge across a wide array of activities, from providing health-care to protecting the environment, from rebuilding our cities to entertaining the public at large (although it is sometimes hard to understand how intercollegiate athletics represents knowledge application).

The abstract definition of the "knowledge server" roles of the university has existed throughout the long history of the university and will certainly continue to exist as long as these remarkable social institutions survive. But, the particular realization of the fundamental roles of knowledge creation, preservation, integration, transmission, and application will continue to change in profound ways, as they have so often in the past. And the challenge of change—of transformation—is in part a necessity simply to sustain our traditional roles in society.

The Digital Age

The Evolution of Information Technology

Information technology is evolving rapidly; in the next several years we will see yet another 1,000-fold increase in the power of computers and networks. In the same time frame, massive parallel computation servers will offer tera-operations per second, while the price/ performance ratio of workstations will continue to improve. Efforts are already underway to build a "petaflop" supercomputer,[5] with a million times more computing power than today's machines. Within several years, widely available international networks capable of point-to-point multi-media (including video) will be available. Wide-area networks in the gigabit-per-second range will be in routine use, although still well short of the 25,000 gigabit potential of third-generation fiber optic technology. Wireless communication will support remote computing and communication.

Already a modern $1,000 notebook computer has more computing horsepower than a $20 million supercomputer of the late 1980s. For the first several decades of the information age, the evolution of hardware technology followed the trajectory predicted by "Moore's Law"—that the computing power for a given price doubles every eighteen months.[6] However, in recent years, with new computer architectures and chip design, the evolutionary curve has become even steeper, with roughly a 1,000 times increase in computing speed, storage capacity, and network transmission rates every decade. At such rates, by the year 2010, the $1,000 notebook computer will have a computing speed of 1 terahertz, a RAM memory of hundreds of gigabits, extended optical storage of terabits, and linkages to networks at data transmission speeds of gigabits per second.

Software is also evolving rapidly, with new genetic algorithms that improve themselves with experience. As networks threaten to overwhelm us with a knowledge-rich environment, we are beginning to use intelligent software "agents" as our personal interface with the digital world, with the capacity to roam the electronic globe, hunting down answers to any question or request we may have.

<u>The Nature of Human Interaction</u>

But the most dramatic impact on our world today is not in the continuing increase in computing power. It is in a dramatic increase in "bandwidth," the rate at which we can transmit digital information. From the 300 bits-per-second modems of just a few years ago, we now routinely use ten megabit-per-second local networks in our offices and houses. Gigabit-per-second networks now provide the backbone communications to link local networks together, and with the rapid deployment of fiber-optics cables and optical switching, terabit-per-second networks are just around the corner.

As a consequence, the nature of human interaction with the digital world—and with other humans through computer-mediated interactions—is evolving rapidly. We have moved beyond the simple text interactions of electronic mail and electronic conferencing to graphical-user interfaces (e.g., the Mac or Windows world) to voice to video. With the rapid development of sensors and robotic actuators, touch and action-at-a-distance will soon be available. The world of the user is also increasing in sophistication, from the single dimension of text to the two-dimensional world of graphics to the three-dimensional world of simulation and role-playing (MUDs and MOOs). With virtual reality, it is likely that we will soon communicate with one another through simulated environments, through "telepresence," perhaps guiding our own software representations, our "avatars," to interact in a virtual world with those of our colleagues.

This is a very important point. When we think of digitally mediated human interactions, we generally think of the awkwardness of e-mail or perhaps videophones. But as William Wulf[7] puts it, "Don't think about today's teleconference technology, but one whose fidelity is photographic and 3-D.

Don't think about the awkward way in which we access information on the network, but about a system in which the entire world's library is as accessible as a laptop computer. Don't think about the clumsy interface with computers, but one that is both high fidelity and intelligent."[8] It is only a matter of time before information technology will allow human interaction with essentially any degree of fidelity we wish—3-D, multimedia, telepresence. Eventually, we will reach a threshold of fidelity sufficient to allow distance education (and most other human activities) that will be comparable to face-to-face interaction.

Computer-mediated human interaction could eventually evolve to the point at which natural and artificial intelligence begin to merge. Our interaction with each other could be mediated by intelligent software agents, which would allow our real and virtual worlds to begin to merge across the carbon-silicon interface.

Virtual Environments

Virtual reality—the use of visual, audio, and tactile sensations to create a simulated total sensory experience—has become common both in training and simulation and in gaming. But higher education is more likely to first make use of distributed virtual environments,[9] in which computers create sophisticated three-dimensional graphical worlds distributed over networks and populated by the representations of people interacting together in real time. Such software representations of people in virtual worlds are known as avatars. Here the goal is not so much to simulate the physical world, but to create a digital world more supportive of human interaction. The software required for such distributed virtual environments is social in nature. It is not so much designed to simulate reality as to enable conversation and other forms of human collaboration.

These shared virtual worlds could radically alter the way we work, learn, and play. For example, one might imagine teaching a course in French language and culture through a distributed virtual environment representing a street in Paris. The virtual street could be lined with buildings, shops, restaurants, museums, and apartments. Language students and teachers would be represented by avatars in this world, along with native speakers or even software agents. Students entering this virtual world could practice a foreign language and experience its culture by speaking with other people in a non-threatening environment.

One can imagine a host of other virtual environments that could support the human interactions necessary in learning communities. Even today we already have environments that simulate university campuses, complete with registration offices, classrooms, coffee houses, and recreation facilities.

Ubiquitous Computing

Here is an interesting exercise. Think through your day's activities, from the moment you wake until you return to bed at the end of the day. Try to identify the various ways that you encounter computers. While most of us first think of the trusty old work-station on our desk top, it doesn't take much further

reflection to realize that we are surrounded by computers. Our radio-alarm clock contains a computer. Our watch is really a computer with a timing circuit. Our house is chock full of computers—they control the temperature, make our coffee and toast, tune our television. The modern car is more computer and electronics these days—at least by cost—than it is metal and plastic. Our pager and cellular phone are computers. Our workplace is filled with computers. Even our credit card has become a tiny computer, capable of tracking our expenditures.

Information technology—computers, telecommunications, and such—is rapidly becoming ubiquitous, disappearing into the woodwork just as electricity did a century earlier.[10] Today we don't look for the wires to hook a light bulb up to a power source. Rather we just throw a switch (or perhaps just enter a room that senses our presence), and the light goes on. Now that chips with supercomputer power and high bandwidth networks are becoming cheap commodities, information technology also is becoming so pervasive in our everyday life that it is becoming invisible, taken for granted even as we become more dependent upon it.

Perhaps the ultimate example of ubiquitous computing will be the myriad of computers and networks that attach themselves to us to extend our personal capabilities. Imagine a "bodynet" of computers and other devices distributed throughout our clothing—perhaps even imbedded in our body—seamlessly linked in a wireless bodynet that allows them to function as an integrated system and connected to the worldwide digital network.[11] At some point our very nervous system may plug into the Net. This fusion of the carbon and silicon worlds may or may not evolve into a Neuromancer[12] blend of physical space and cyberspace such that electronic existence masks the physical world. However, it is clear that these two personal "realities" will be superimposed and intertwined in very complex ways.

Changing Lifestyles

Information technology has already stimulated profound changes in our lifestyles.[13] We already sense the loosening constraints of space and time. Many of us have already discarded the burden of the daily commute in favor of "telecommuting" via our computer, modem, and fax. Others are finding that they have become tethered to their workplace with the electronic umbilical cord of pager and cellular phone. Electronic mail, voice mail, and fax are rapidly replacing "snail mail." Whether it is a university department, a commercial enterprise, or an individual, all are increasingly identified not by phone number or address but rather by the URL of their Website (*e.g.,* http://milproj.ummu.umich.edu/).

Other aspects of our daily activities have changed dramatically. In the digital age, economic activity is driven by the bit business, producing, transforming, distributing, and consuming digital information. The physical marketplace is rapidly disappearing, while "virtual" marketplaces based on networks and computers are emerging as the site of economic activity. Yet here there is an

important difference; digital information is unlike any other type of economic good—natural resources, human labor, property—in the very interesting respect that it cannot be used up. Use actually multiplies rather than diminishes digital products. Digital products can be reproduced an infinite number of times with perfect accuracy at zero cost.[14] The concepts of property, copyright, patents, and laws—all based on physical manifestations—simply do not apply any longer.

The Need for Agents in a Knowledge-Rich World

This tendency of digital information to multiply and propagate rapidly through digital networks can also be a challenge. Already the vast scale of the Internet and the access it provides to vast storehouses of information threaten to overwhelm us. As anyone who has "surfed the Net" can testify, it is easy to be amused but usually difficult to find exactly what you need. Further, living and working in a knowledge-rich—indeed, knowledge-deluged—world will overload our limited human capacity to handle information.

The Net is already a complex and interesting organism, something which has evolved far beyond the comprehension of any human. It is more than just a media incorporating text, graphics, and sound. It incorporates ideas and mediates the interactions among millions of people. It can do things no human has enough knowledge to explain.

As a result, it will become necessary to depend on intelligent software agents to serve as our interface with the digital world. Many already use primitive constructs such as filters for electronic mail or web-crawlers to search through databases on the Net. But with the use of artificial intelligence and genetic algorithms, one can imagine intelligence agents dispatched by a user to search the digital networks for specific information. These agents can also represent their human user, serving as avatars, in mediating the interaction with the agents of other human users.

There are a couple of interesting possibilities here. Since software agents are easy to reproduce, one can imagine a cyberspace quickly flooded with billions of agents—similar to the software viruses that can propagate and cripple computer systems. There is already evidence of "wars" between software agents, where agents from one group of users seek out and destroy those from others. Perhaps the most significant evolutionary stage will occur when the distributed processing power of networks allows the appearance of "emergent behavior," wherein agents begin to exhibit self-organization, learning capability, and intelligent behavior. The predictions of science fiction of Clarke's HAL 9600 in *2001: A Space Odyssey* or Gibson's *Neuromancer* and the possibility that we may be unable to distinguish which of our colleagues in cyberspace are flesh-and-bones and which are silicon, may be only decades away.

The Bitsphere

The most important feature of information technology is its ability to release people and their activities from the constraints of space and time. The Internet,

the World Wide Web, and their successors are evolving rapidly into a global digital network, a "bitsphere" interrelating people and their activities through robust, albeit ubiquitous, computers, networks, and intelligent hardware and software. As Mitchell puts it, this will be a community "unrooted to any definite spot on the surface of the earth, shaped by connectivity and bandwidth constraints rather than by accessibility and land values, largely asynchronous in its operation, and inhabited by disembodied and fragmented subjects who exist as collections of aliases and agents."[15]

The bitsphere will be an international community, with physical infrastructure and users scattered widely across different political and cultural units, increasingly free from the norms and laws of nation-states. Because its electronic structure is so modular, geographically dispersed, and redundant, the bitsphere is essentially indestructible. After all, its antecedents were designed to withstand nuclear attack. It grows and propagates like weeds in a field rather than a carefully planted and nurtured crop.

In this worldwide electronically mediated environment, networks are everywhere and most of the artifacts that function within it have intelligence and communications capabilities. This will pose great challenges to traditional societal institutions, but it will also create extraordinary opportunities. Nations that seek to remain economically competitive and prosperous will race to invest in the new electronic infrastructure, just as in the past they have invested in public infrastructures such as railroads, highways, and airports.

The Changing Nature of the Higher Education Enterprise

Universities have long enjoyed a monopoly over advanced education because of geographical location and their monopoly on certification through the awarding of degrees. However, today all of these market constraints are being challenged, as information technology eliminates the barriers of space and time and as new competitive forces enter the marketplace to challenge credentialling.

In the current paradigm, our colleges and universities are faculty-centered. 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. If they complete the gauntlet of requirements, they are finally awarded a certificate to recognize their learning—a college degree. This process is sustained by accrediting associations, professional societies, and state and federal governments.

Yet this carefully regulated and controlled enterprise could be blown apart by several factors. First, the great demand for advanced education and training simply 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. Perhaps

most important of all will be the impact of information technology, which will not only eliminate the constraints of space and time but will create open learning environments in which the learner has choice in the marketplace.

More specifically, tomorrow's student will have access to a vast array of learning opportunities, far beyond the faculty-centered institutions characterizing higher education today. Some will provide formal credentials, others will provide simply knowledge, still others will be available whenever the student—more precisely, the learner—needs the knowledge. The evolution toward such a learner-centered educational environment is both evident and irresistible.

As a result, higher education is likely to evolve from a loosely federated system of colleges and universities serving traditional students from local communities into, in effect, a knowledge and learning industry. Since nations throughout the world recognize the importance of advanced education, this industry is global in extent. With the emergence of new competitive forces and the weakening influence of traditional regulations, higher education is evolving like other "deregulated" industries, e.g., health care or communications or energy. In contrast to these other industries, which have been restructured as government regulation has disappeared, the global knowledge industry will be unleashed by emerging information technology that releases education from the constraints of space, time, and credentialing monopoly. As our society becomes ever more dependent upon new knowledge and educated people, upon knowledge workers, this global knowledge business must be viewed clearly as one of the most active growth industries of our times.

While many in the academy would undoubtedly view with derision or alarm the depiction of the higher education enterprise as an "industry" or "business," operating in a highly competitive, increasingly deregulated, global marketplace, this is nevertheless an important perspective that will require a new paradigm for how we think about postsecondary education. Furthermore, it is clear that no one, no government, is in control of the higher-education industry. Instead it responds to forces of the marketplace.

Will this restructuring of the higher education enterprise really happen? If you doubt it, just consider the health care industry. While Washington debated federal programs to control health care costs and procrastinated taking action, the marketplace took over with new paradigms such as managed care and for-profit health centers. In less than a decade the health care industry was totally changed. Today, higher education is a $175 billion a year enterprise. It will almost certainly be "corporatized" similarly to health care. By whom? By state or federal government? Not likely. By traditional institutions such as colleges and universities working through statewide systems or national alliances such as AAU or ACE? Also unlikely. Or by the marketplace itself, as it did in health care, spawning new players such as virtual universities and for-profit educational organizations? Perhaps. Just note a brief passage from a recent venture capital prospectus analyzing possible investments in education:

"As a result, we believe education represents the most fertile new market for investors in many years. It has a combination of large size (approximately the same size as health care), disgruntled users, lower utilization of technology, and the highest strategic importance of any activity in which this country engages . . . . Finally, existing managements are sleepy after years of monopoly."

<u>Unbundling</u>

The modern university has evolved into a monolithic institution controlling all aspects of learning. Universities provide courses at the undergraduate, graduate, and professional level; they support residential colleges, professional schools, lifelong learning, athletics, libraries, museums, and entertainment. They have assumed responsibility for all manner of activities beyond simply education—housing and feeding students, providing police and other security protection, counseling and financial services . . . even power plants on many midwestern campuses!

Today comprehensive universities, at least as full-service organizations, are at considerable risk. These institutions have become highly vertically integrated. We are already beginning to see the growth of differentiated competitors for many of these activities. Universities are under increasing pressure to spin off or sell off or close down parts of their traditional operations in the face of this new competition.

The most significant impact of a deregulated higher education "industry" will be to break apart this monolith, much as other industries have been broken apart through deregulation. As universities are forced to evolve from faculty-centered to learner-centered, they may well find it necessary to unbundle their many functions, ranging from admissions and counseling to instruction and certification.

An example might be useful here. Consider the rapid growth of cyberspace or virtual universities, institutions without a campus or faculty that provide computer-mediated distance education. The virtual university might be viewed as the "Nike approach" to higher education. Nike, a major supplier of athletic shoes in the United States and worldwide, does not manufacture the shoes it markets. It has decided that its strength is in marketing, and that it should outsource shoe manufacturing to those who could do it better and cheaper. In a sense, the virtual university similarly stresses marketing and delivery. It works with the marketplace to understand needs, then it outsources courses, curriculum, and other educational services from established colleges and universities—or perhaps individual faculty—and delivers it through sophisticated information technology.

There are many other examples. While we are very good at producing intellectual content for education, there may be others who are far better at packaging and delivering that content. While in the past universities have had a monopoly on certifying learning, there may be others, whether they be

accreditation agencies or other kind of providers, more capable of assessing and certifying that learning has occurred. Many of our other activities, e.g., financial management and facilities management, are activities that might be outsourced to specialists.
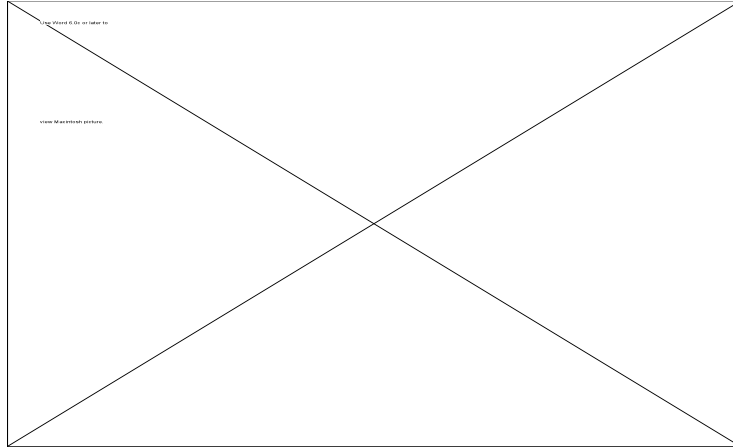
Clearly higher education is an industry ripe for the unbundling of activities. Universities, like other institutions in our society, will have to come to terms with what their true strengths are and how those strengths support their strategies— and then be willing to outsource needed capabilities in areas where they do not have a unique competitive advantage.

The Emergence of a Commodity Market

Throughout most of its history, higher education has been a cottage industry. Individual courses are a handicraft, made-to-order product. Faculty members design from scratch the courses they teach, whether they be for a dozen or several hundred students. They may use standard textbooks from time to time— although many do not—but their organization, their lectures, their assignments, and their exams are developed for the particular course at the time it is taught. In a very real sense, the industrial age has largely passed the university by. Our social institutions for learning, schools, colleges, and universities, continue to favor programs and practices based more on past traditions than upon contemporary needs.

The nature of higher education will be changed by our ability to introduce new, more effective avenues for learning, rather than just new media in which to convey information. This will bring with it new modes of organization, relationships among universities and between universities and the private sector. The individual handicraft model for course development may give way to a much more complex method of creating instructional materials. The standard packaging of an undergraduate education into "courses" in the past was required by the need to have all the students in the same place at the same time. This may no longer be necessary with new forms of asynchronous learning.

As we have noted, universities—more correctly, faculty—are skilled at creating the content for educational programs. Indeed, we might identify this as one of their core competencies. But they have not traditionally been particularly adept at "packaging" this content for mass audiences. To be sure, many faculty have written best-selling textbooks, but these have been produced and distributed by textbook publishers. In the future of multimedia Net-distributed educational services, the university may have to outsource both production and distribution from those most experienced in reaching mass audiences—the entertainment industry.

As distributed virtual environments become more common, one might even conceive of a time when the classroom experience itself becomes a "commodity," provided to anyone, anywhere, at any time—for a price. You want to take Vincent Scully's course in history of architecture? Just sign up here and become an "avatar" student, as Professor Scully leads you and other virtual classmates on a fascinating journey through the ages, touring through 3-D simulations of great architectural masterpieces. How about Stephen Jay Gould's "Life on Earth" course? Available as well. If students could actually obtain the classroom experience of these talented teachers, why would they want to take classes from the local prof—or, in many cases, the local teaching assistant?

In such a commodity market, the role of the faculty member would change very substantially. Rather than developing content and transmitting it in a classroom environment, a faculty member might have to manage a learning process in which students use an educational commodity, e.g., the Microsoft Virtual History of Architecture Course. This would require a shift from the skills of intellectual analysis and classroom presentation to those of motivation, consultation, and inspiration. Hello, Mr. Chips!

<u>Mergers, Acquisitions, and Hostile Takeovers</u>

The perception of the higher education enterprise as a deregulated industry has several other implications. As we have noted, there are over 3,600 four-year colleges and universities in the United States, characterized by a great diversity in size, mission, constituencies, and funding sources. Not only are we likely to see the appearance of new educational entities in the years ahead, but as in other deregulated industries, there could well be a period of fundamental restructuring of the enterprise itself. Some colleges and universities might disappear. Others could merge. Some might actually acquire other institutions.

A case in point: The Big Ten universities (actually there are twelve, including the University of Chicago and Penn State University) have already merged many of their activities, such as their libraries and their federal relations activities. They are exploring ways to allow students at one institution to take courses—or even degree programs—from another institution in the alliance in a transparent and convenient way. Could one imagine the Big Ten universities becoming a university system "of the heartland of America"?

One might also imagine affiliations between comprehensive research universities and liberal-arts colleges. This might allow the students enrolling at large research universities to enjoy the intense, highly personal experience of a liberal arts education at a small college while allowing the faculty members at these colleges to participate in the type of research activities only occurring on a large research campus.

One might even imagine a Darwinian process emerging with some institutions devouring their competitors in "hostile takeovers." All such events have occurred in deregulated industries in the past, and all are possible in the future we envision for higher education.

Perhaps the most profound question of all concerns the survival of the university in the face of the changes, the emergence of new competitors. Could an institution such as the university which has existed for a millennium disappear in the face of such changes? As William Wulf suggests, if you have doubts, just think of the family farm, a social institution existing for centuries which has largely disappeared over the past three decades. [16]

Evolution or Revolution?

In spite of the growing awareness of these social forces, many within the academy still believe that change will occur only at the margins of higher education. They stress the role of the university in stabilizing society during a period of change rather than leading those changes. This too shall pass, they proclaim, and demand that the university hold fast to its traditional roles and character.[17]

Leading in the introduction of change can be both a challenging and risky proposition. The resistance can be intense, and the political backlash threatening. As one who has attempted to illuminate the handwriting on the wall and to lead an institution in transformation, I can attest to the lonely, hazardous, and usually frustrating life of a change agent. I am reminded of the quote from Machiavelli:

> *There is no more delicate matter to take in hand, nor more dangerous to conduct, nor more doubtful of success, than to step up as a leader in the introduction of change. For he who innovates will have for his enemies all those who are well off under the existing order of things, and only lukewarm support in those who might be better off under the new.*

Amen!

Yet, history suggests that the university must change and adapt in part to preserve these traditional roles. It is true that many, both within and outside the academy, believe that significant change must occur not simply in the higher education enterprise but in each and every one of our institutions. Most of these see change as an evolutionary, incremental, long-term process, compatible with the values, cultures, and structure of the contemporary university.

There are a few voices, however, primarily outside the academy, who believe that both the dramatic nature and compressed time scales characterizing the changes of our times will drive not evolution but revolution. They have serious doubts about whether the challenges of our times will allow such gradual change and adaptation. They point out that there are really no precedents we can draw upon. Some even suggest that long before reform of the educational system comes to any conclusion, the system itself will have collapsed.[18]

It is my belief that the forces driving change in higher education, both from within and without, are far more powerful than most realize. It seems likely that both the pace and nature of change characterizing the higher education enterprise both in America and worldwide will be considerably beyond that which can be accommodated by business-as-usual evolution. As one of my colleagues put it, while there is certainly a good deal of exaggeration and hype about the changes in higher education for the short term—meaning five years or less—it is difficult to stress too strongly the profound nature of the changes likely to occur in most of our institutions and in our enterprise over the longer term—a decade and beyond.

The Importance of Experimentation

For the past decade we have led an effort at the University of Michigan to transform ourselves, to re-invent the institution, if you will, so that it better serves a rapidly changing world. We created a campus culture in which both excellence and innovation were our highest priorities. We restructured our finances so that we became, in effect, a privately supported public university. We dramatically increased the diversity of our campus community. We launched major efforts to build a modern environment for teaching and research using the powerful tools of information technology. Yet with each transformation step we took, with every project we launched, we became increasingly uneasy.

As we came to understand better the forces driving change in our society and its institutions, we realized that these were stronger, more profound that we had first thought. Change was occurring far more rapidly that we had anticipated. The future was becoming less certain as the range of possibilities expanded to include more radical options.

We came to the conclusion that in a world of such rapid and profound change, facing a future of such uncertainty, the most realistic near-term approach was to begin to explore possible futures of the university through experimentation and discovery. Rather than continue to contemplate possibilities for the future through abstract study and debate, it seemed a more productive course to actually build several prototypes of future learning institutions as working experiments. In this way we could actively explore possible paths to the future.

At Michigan we have launched or participated as partners in a number of such experiments aimed at understanding and possibly defining the nature of higher education in the 21st Century. Let me illustrate with several examples:

Experiment #1: The School of Information

Several years ago, at the University of Michigan, we became so convinced of the potential impact of information technology for the future of our institution that we thought about launching a "skunkworks" operation to explore and develop various paradigms for what a 21st Century university might become. Rather than building an independent research center, we instead decided to take our smallest academic unit, the former School of Library Science, and put at its helm one of our most creative scientists, Dan Atkins, with the challenge of developing new academic programs in "knowledge management." The result has been the rapid evolution—indeed, revolution—of this unit into a new School of Information.[19]

Put simply, this school is committed to developing leaders for the information professions who will define, create, and operate facilities and services that will enable users to create, access, and use information they need. It intends to lead the way in transforming education for the information professions through an innovative curriculum, drawing upon the strengths of librarianship, information and computer science, business, organizational development, communication, and systems engineering. Its activities range from digital libraries to knowledge networks to virtual educational structures.

Experiment #2: The Media Union

At the University of Michigan we have launched another such experiment to create the type of physical environment that might characterize the future of education: a fascinating new center known as the Media Union.[20] This is designed to be a laboratory, a testbed, for developing, studying, and perhaps implementing the new paradigms of the university enabled by information technology.
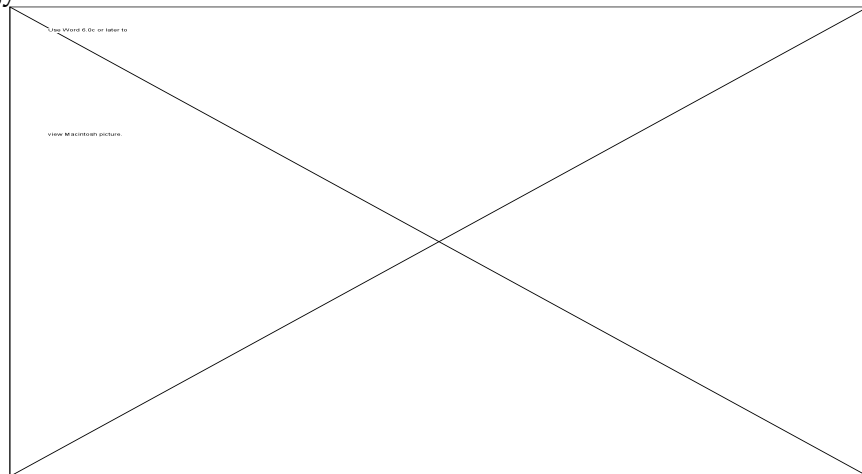
The University of Michigan Media Union

More specifically, this 250,000 square foot facility, looking like a modern version of the Temple of Karnak, contains 600 workstations along with thousands of more network jacks for students. The facility contains both a 1,000,000-volume science and engineering library (in the basement!), but perhaps more significantly, it is the site of our major digital library projects. There is a sophisticated teleconferencing facility, design studios, visualization laboratories, and a major virtual reality complex with several CAVEs. Since art, architecture, and music students work side-by-side with engineering students, the Media Union contains sophisticated recording studios and electronic music studios. It also has a state-of-the-art sound stage for "digitizing" performances, as well as numerous galleries for displaying the results of student creative efforts. The Media Union is a facility open twenty-four hours a day, seven days a week, primarily designed for students.

Experiment #3: The Michigan Virtual Automotive College

Last year we launched a venture known as the Michigan Virtual Automotive College (MVAC) as a private, not-for-profit, 501(c)3 corporation aimed at developing and delivering technology-enhanced courses and training programs to the automobile industry. The MVAC is a college without walls that serves as an interface between higher education institutions, training providers, and the automotive industry. Courses and programs can be offered from literally any site in the state to any other technologically connected site within the state, the United States, or the world. Although technologies are rapidly emerging, it is expected that MVAC will, during the pilot phase, broker courses which utilize a wide array of technology platforms including satellite, interactive television, Internet, CD-ROM, videotape, and combinations of the above. The MVAC will seek to develop common technology standards between and among providers and customers for the ongoing delivery of courses. MVAC will offer courses and training programs, ranging from the advanced post-graduate education in engineering, computer technology, and business administration to entry level instruction in communications, mathematics, and computers.

MVAC has made considerable progress in its first year. After the negotiation of a governance structure and the development of a business plan in summer and fall of 1996, MVAC was formally incorporated in December, 1996. Capitalization for MVAC is provided by members of the partnership: the State of Michigan ($5 million), the universities ($2 million), and an as-yet-to-be-determined contribution from the automobile industry. A staff was recruited and facilities were obtained in Ann Arbor. Meetings were held with all of the key members of the executive committee, including the leadership of the Big Three, the presidents of Michigan's colleges and universities, and key suppliers. Extensive market studies were performed, both through the use of MVAC marketing staff and through the use of consultants (Coopers & Lybrand). Based on this market survey, a request for proposals was distributed to higher education institutions for the development of courses for fall of 1997. MVAC will be offering sixty to seventy courses this fall across a broad spectrum of disciplines and levels.

Experiment #4: The Millennium Project

The Millennium Project[21] is a center with the dual missions of studying the forces of change in higher education and exploring possible paradigms for future universities. In some ways, the Millennium Project is the analog to a corporate R&D laboratory, an incubation center, where new paradigms concerning the fundamental missions of the university—teaching, research, service, extension— can be developed and tested.
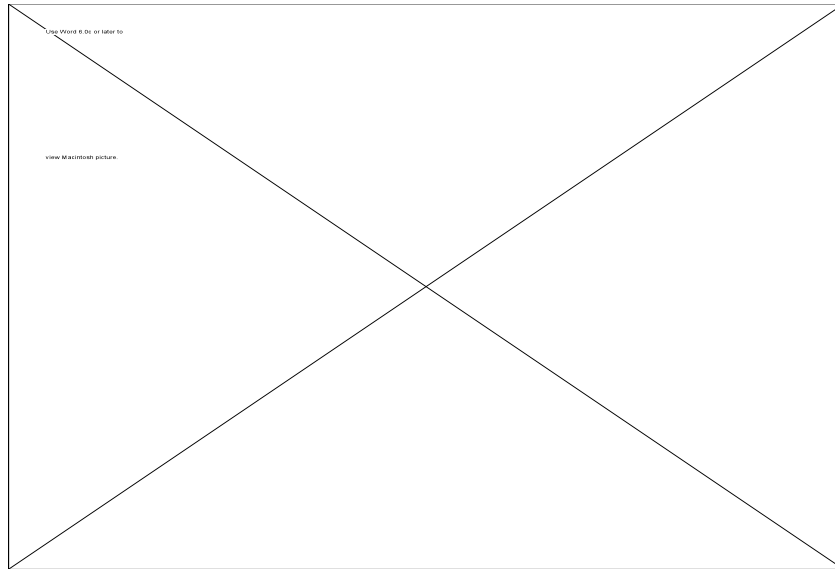
Rather than being a "think-tank," where ideas are generated and studied, the Millennium Project is a "do-tank," where ideas lead to the actual creation of new social life forms, which are then available for study. The project draws together scholars and students to develop working models or prototypes to explore possible futures of the university. Like the famous Lockheed Skunkworks, every so often the hanger doors of the Millennium Project will open, and something really weird is wheeled out and flown away.

For example, rather than simply exploring the various issues characterizing computer-mediated distance learning, the Millennium Project has instead participated in the development of a virtual or cyberspace university, the Michigan Virtual Auto College. Rather than examining various elements of international education, the Millennium Project has joined others in an effort to build a truly global university. And rather than simply studying the various social, political, and economic issues swirling about the ever more pervasive use of information technology in our society, the Millennium Project is actually trying to build new types of learning communities in which information technology provides people and their institutions with ubiquitous and robust access to rich knowledge resources and powerful learning opportunities.

A Glimpse of the Future

Clearly, 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 . . . .

Perhaps the most profound question of all involves the survival of the university, at least as we know it. And that, of course, is the question that Drucker raised. Of course, most of us disagree quite strongly with Drucker's contention that the university as we know it will cease to exist. On the other hand, I certainly believe there will be forms of the university that you and I might not recognize from our perspective today.

It is difficult to suggest a particular form for the university of the 21st Century. The great and ever-increasing diversity characterizing higher education in America makes it clear that there will be many forms, many types of institutions serving our society. But there are a number of themes that will almost certainly characterize at least some part of the higher education enterprise:

- A 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
- *Affordable*, within the resources of all citizens, whether through low cost or societal subsidy
- *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
- *A seamless web*, in which all levels of education not only become interrelated, but blend together
- *Asynchronous* (anytime, anyplace) *learning,* breaking the constraints of time and space to make learning opportunities more compatible with lifestyles and needs
- *Interactive and collaborative learning*, appropriate for the digital age, the "plug and play" generation
- *Diversity*, sufficient to serve an increasingly diverse population with diverse needs and goals

There is one further modifier that may characterize the university of the future: *ubiquitous*. Let me explain:

In today's world, knowledge has become the coin of the realm, determining 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.

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, the community colleges. But today we must do even more to serve an even broader segment of our society.

For the past half a century, national security was America's most compelling priority, driving major public investments in social institutions such as the research university. Today, however, in the wake of the Cold War and on the brink of the age of knowledge, one could well make the argument that education will replace national defense as the priority of the 21st Century. Perhaps this will become the new social contract that will determine the character of our educational institutions, just as the government-university research partnership did in the latter half of the 20th Century. We might even conjecture that a social contract, based on developing 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 research university in importance.

Once again we need a new paradigm for delivering the opportunity for learning to even broader segments of our society. 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. Modern information technology has largely cut us free from the constraints of space and time, and has freed our educational system from these constraints as well. The barriers are no longer cost or technology but perception and habit. 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.

But this may not be enough. Instead of asynchronous learning, perhaps we should instead consider a future of "ubiquitous learning"—learning for everyone, every place, all the time. Indeed, in a world driven by an ever-expanding knowledge base, continuous learning, like continuous improvement, has become a necessity of life.

Rather than "an age of knowledge," could we instead aspire to a "culture of learning," in which people were continually surrounded by, immersed in, and absorbed in learning experiences. Information technology has now provided us with a means to create learning environments throughout one's life. These environments are able not only to transcend the constraints of space and time, but they, like us, are capable as well of learning and evolving to serve our changing educational needs. This may become not only the great challenge but the compelling vision facing higher education as it enters the next millennium.

Concluding Remarks

The 1990s will represent a period of significant change on the part of our universities if we are to respond to the challenges, opportunities, and responsibilities before us. A key element will be efforts to provide universities with the capacity to transform themselves into entirely new paradigms that are better able to serve a changing society and a profoundly changed world.

This time of great change, of shifting paradigms, provides the context in which we must consider the changing nature of the academic research enterprise itself. We must take great care not simply to extrapolate the past but to examine the full range of possibilities of the future.

From this perspective, it is important to understand that the most critical challenge facing most institutions will be to develop the capacity for change; to remove the constraints that prevent institutions from responding to needs of rapidly changing societies; to remove unnecessary processes and administrative structures; to question existing premises and arrangements; and to challenge, excite, and embolden all members of the university to embark on what I believe will be a great adventure.

Those institutions that can step up to this process of change will thrive. Those that bury their heads in the sand, that rigidly defend the status quo or even worse some idyllic vision of a past that never existed, are at very great risk. Those institutions that are micromanaged, either from within by faculty politics or governing boards, or from without, by government or public opinion, stand little chance of flourishing during a time of great change.

There is no question that the need for learning institutions such as the university will become increasingly important in a knowledge-driven future. The real question is not whether the higher education will be transformed, but rather *how* . . . and by *whom*. It is my belief that the challenge of change before us should be viewed not as a threat, but as an opportunity for a renewal, perhaps even a renaissance in higher education.

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