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.

The Age of Knowledge
Today our society is undergoing a dramatic shift in fundamental perspective and structure. We are experiencing a transition in which intellectual capital—brain power—is replacing financial and fiscal capital as the key to our strength, prosperity, and social well-being. The key element in this remarkable transformation is the emergence of knowledge itself as the new strategic commodity, as important as mineral ores, timber, and access to low-skilled labor were in earlier times. But this new commodity knows no boundaries. It is generated and shared wherever educated, dedicated, creative people come together. And, as we have learned, it spreads very rapidly. Knowledge and the people who create and use it have become a strategic resource.

Computers, communication networks, and related digital devices—the new knowledge media—have become the infrastructure supporting the modern knowledge-based society. Modern electronic technologies have increased vastly our capacity to know and to do things. They allow us to transmit information quickly and widely, linking distant places and diverse areas of endeavor in productive new ways. These technologies make many things possible. Already we can see the distinct transformation of advanced nations into post-industrial societies with predominant sectors in service and high technology. Professional and technical services are the core of such post-industrial societies. In this sense, a fundamental transformation is underway in our economy that is reshaping every product, every service, and every job in the United States. In our country, as in all developed nations, "knowledge workers" have already become the center of the labor force.

A Communications-Driven Society

In Michigan, in the industrial midwest, we have had a unique vantage point from which to view a particularly important feature of these changes. If there was one sector that most strongly determined the progress of the twentieth century, it was transportation and its related industries—cars, planes, trains, oil, space. Transportation determined prosperity, national security, even our culture—with the growth of the suburbs, international commerce, and so on. During this period Michigan’s automobile industry had no equal, and the state rapidly became one of the most prosperous and powerful industrial regions on earth.

Things are very different today. We have entered a new era in which the engine of progress is not transportation but communication, enabled by the profound advances we are now seeing in computers, networks, satellites, fiber optics, and related technologies. We now face a world in which hundreds of millions of computers easily can plug into a global information infrastructure. These rapidly evolving technologies are dramatically changing the way we collect, manipulate, and transmit information. They change the relationship between people and knowledge.

*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.

Jacques Attali

The implications for our universities are profound. Let me illustrate with three
themes:

**Theme 1: The University as a Knowledge Server**

One frequently hears the primary missions of the university referred to in terms
of teaching, research, and service. But these roles can also be regarded as simply
the 20th-Century manifestations of the more fundamental roles of creating,
preserving, integrating, transmitting, and applying knowledge. 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 the fundamental
knowledge server roles of the university do not change over time, the particular
realization of these roles do change—and change quite dramatically. Consider
the role of “teaching,” that is, transmitting knowledge. We generally think of
this role in in terms of a classroom paradigm, that is, 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. Yet, the
classroom itself may soon be replaced learning experiences enabled by emerging
information technology. 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 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.

Just watch how young people surf through the Net for information. They launch
search engines, scour Gopher and FTP sites, interact through MOOs and Usenet
groups, both following existing links and launching new ones. In a very real
sense, they are on a serious journey of learning, building elaborate information
networks. It is a highly interactive and collaborative process. This is the way
they learn.
There is even research that suggests that there may be a physiological difference between the brains of the “digital generation” and those of us from 20th Century generations. It has been known that early exposure of infants and young children to various stimulation can actually affect their neurological development—the evolution of their neural networks. Children raised in a media-rich, interactive environment tend to think and learn differently because they are physiologically different from us. Our styles of learning are not theirs.

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. We should note that this will require a major change in graduate education, since few of today’s faculty members have learned these skills.

The preservation of knowledge is one of the most rapidly changing functions of the university. The computer—or more precisely, the “digital convergence” of various media from print-to-graphics-to-sound-to sensory experiences through virtual reality—has already moved beyond the printing press in its impact on knowledge. Throughout the centuries, the intellectual focal point of the university has been its library, its collection of written works preserving the knowledge of civilization. Today such knowledge exists in many forms—as text, graphics, sound, algorithms, 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. The role of the library is becoming less that of collecting and more that of a knowledge navigator, a facilitator of retrieval and dissemination. In a sense, the library and the book are merging. One of the most profound changes will involve the evolution of software agents, collecting, organizing, relating, and summarizing on behalf of their human authors. As Minsky puts it, a future scholar may observe, “Can you imagine that they used to have libraries where the books didn’t talk to each other?”

Theme 2: A Shift from Analysis to Creation

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. The driving intellectual activity of the 21st Century will be the act of creation itself.
"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, *Millennium*

This shift in intellectual focus from the preservation or transmission of knowledge to the process of creation itself may be the determining characteristic of the university of the 21st Century. The tools of creation are expanding rapidly in both scope and power. We have the capacity to create objects atom-by-atom. We are developing the capacity to create new life forms through the tools of molecular biology and genetic engineering. And we are creating new intellectual "life forms" through artificial intelligence and virtual reality.

Perhaps the university should strategically restructure itself to nurture and teach the art and skill of creation. Perhaps we should form alliances with other groups, organizations, or institutions in our society whose activities are characterized by great creativity (e.g., the entertainment industry or Madison Avenue?).

**Theme 3: Shifting Social Structures**

A third theme lies in the implications for existing social structures of knowledge-based organizations such as universities. Although the digital age will provide a wealth of opportunities for the future, we must take great care not simply to extrapolate the past, but instead to examine the full range of possibilities for the future. It could well be that our present institutions, such as universities and government agencies, which have been the traditional structures for intellectual pursuits, may turn out to be as obsolete and irrelevant to our future as the American corporation of the 1950s. There is clearly a need to explore new social structures that are capable of sensing and understanding the change and of engaging in the strategic processes necessary to adapt or control it.

Since the business of the university is knowledge—its creation, preservation, transmission, and application—the impact that the extraordinary advances in information technology could have—likely will have—profound implications for universities. Rapidly evolving technologies are dramatically changing the way we collect, manipulate, and transmit information. This directly challenges the traditional paradigms of the university, where processes of knowledge creation, preservation, transmission, and application are still largely based on books, chalk boards, oral lectures, and static images.

New forms of knowledge accumulation are evolving: written text, dynamic images, voices, and instructions on how to create new sensory environments can
be packaged in dynamic modes of communication never before possible. The applications of such new knowledge forms challenge the creativity and intent of authors, teachers, and students. Technology such as computers, networks, HDTV, ubiquitous computing, knowbots, and other technologies may well invalidate most of the current assumptions and thinking about the future nature of the university. Consider, for example, the following questions:

1. Will a “university of the 21st Century” be localized in space and time or will it be a "metastructure" involving people throughout their lives wherever they may be on this planet or beyond?

2. Is the concept of the 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"? Will intelligent software agents roam far and wide through robust networks containing the knowledge of the world and instantly and effortlessly extract whatever a person wishes to know?

3. Will lifestyles in the academy (and elsewhere) become increasingly nomadic, with people living and traveling where they wish, taking their work and their social relationships with them?

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, 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. 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.

The Nature of Human Interaction

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”iii 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.”ix 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, 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. 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. 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 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. 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/).

The Implications for Higher Education

Imagine the reactions of a 19th-Century physician, suddenly transported forward in time to a modern surgery suite, complete with all of the technological advances of modern medicine. Yesteryear’s physician would recognize very little—perhaps not even the patient—and certainly would not be able to function in any meaningful way. Contrast this with a 19th-Century college professor, transported into a contemporary university classroom. Here everything would be familiar—the same lecture podium, blackboards, and students sitting in rows, ready to take notes. Even the subjects—literature, history, languages—would be familiar and taught in precisely the same way.

Universities are supposed to be at the cutting edge of both knowledge generation and transmission. Yet their primary activity, teaching, is conducted today much as it was a century ago. Technologies which were supposed to drive radical change—television, computer-assisted instruction, wireless communications—have bounced off the classroom without a dent. To be sure, information technology has had great impact on the efficiency of administrative operations. It has revolutionized the conduct of research and the storage and synthesis of
knowledge. But it has only had a marginal impact on instruction and learning, primarily being used only at the margins to extend the current classroom-centered paradigm.

Today there are good reasons to believe that digital technology will indeed transform the university, perhaps beyond recognition. Why? What is different? Is it the ability of the new technology to cut the bonds of space and time? Is it its ubiquitous nature? No, it is the ability of the rapidly evolving digital technology to enable new forms of human interaction, to mediate communication, to stimulate the formation of new types of human communities. It will drive the focus of higher education from teaching to learning, and it will transform universities from faculty-centered to learner-centered institutions.

So what are possible paradigms for the “cyberspace university”? How can we create digitally mediated environments for learning?

**Virtual Universities**

Perhaps the most popular new approach is the so-called “virtual university,” most commonly conceived as the Internet extension of conventional distance learning. In cybertalk, “virtual” is an adjective that means existing in function but not in form. A virtual university exists only in cyberspace, without campus or perhaps even faculty. Sophisticated networks and software environments are used to break the classroom loose from the constraints of space and time and make learning available to anyone, anyplace, at any time.

For many years universities have utilized passive telecommunications technology such as television to extend teaching to people unable or unwilling to attend campus-based classes. In its simplest form, such distance learning is really a “talking heads” paradigm, in which faculty lectures are simply delivered at a distance, either through live transmission or videotape. There have been efforts to broadcast such instruction through “sunrise semesters,” augmented by written correspondence. A more effective approach utilizes on site teaching assistants to work directly with the students. Recently, technology has allowed the use of feedback via electronic mail, chatrooms, or two-way video interaction.

The simplest conception of the virtual university uses multimedia technology via the Internet to enable distance learning. Such instruction could be delivered either into the workplace or the home. In one form, this Internet-mediated instruction would be synchronous—in real time with the instructor and the students interacting together. The more interesting teaching paradigms of the virtual university involve asynchronous interactions, in which students and faculty interact at different times. In a sense, this latter form would resemble a correspondence course, with multimedia computers and networks replacing the mailing of written materials.

The initial driving force behind the formation of virtual universities is related both to cost and market. By using an inexpensive delivery mechanism such as the Internet to reach a potentially vast audience, many hope that a virtual
university can provide instruction at costs far lower than campus-based instruction. There are presently for-profit entities\textsuperscript{v} competing directly with traditional colleges and universities in the higher education marketplace through virtual university structures.

Already more than 700 virtual universities are listed in college directories, with over one million students taking courses from these colleges.\textsuperscript{vi} The attractiveness of virtual universities is obvious for adult learners whose work or family obligations prevent attendance at conventional campuses. But perhaps more surprising is the degree to which many on-campus students are now using virtual university communities to augment their traditional education.

Learning Communities

Many believe that effective computer-network-mediated learning will not be simply an Internet extension of correspondence or broadcast courses. John Seeley Brown and John Duguid of Xerox PARC believe that this model of the virtual university overlooks the nature of how university-based learning actually occurs.\textsuperscript{vii}

They suggest that it is a mistake to think of learning as information transfer, the act of delivering knowledge to passive student receivers. Brown and Duguid see the learning process as rooted both in experience and social interaction. Learning requires the presence of communities.

This is the value of the university—to create learning communities and to introduce students into these communities. Undergraduates are introduced to communities associated with academic disciplines and professions. Graduate students and professional students are involved in more specialized communities of experience and expertise. From this perspective, one of the important roles of the university is to certify that students have had sufficient learning experience with a variety of communities.

Distance-Learning Paradigms

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 out 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.

Here we should recognize the importance of asynchronous learning. Face-to-face conversation is both local geographically and synchronous temporally. Throughout human history, the advantages of asynchronous communication have been recognized. In asynchronous communications, words are not heard as they are spoken but repeated at some point later. This allows thought and consideration to mediate the asynchronous communication.

Such asynchronous interactions are ideally suited to the Net, since it allows low-cost ways to hold many-to-many conversations among people who are distributed in both space and time. Beyond simple interactions through E-mail and bulletin boards, role-playing games such as MUDs, MOOs, and MUSEs seem ideal for learning. These software constructions not only provide a virtual environment where interactions occur, but also provide common objects for participants to observe, manipulate, and discuss, making the Net both a medium for conversation and for circulating digital objects.

Such Net-mediated communities allow open learning in which the student decides when, where, and how to interact with the learning community.

Implications for Higher Education

Of course, the use of information technology is already quite pervasive in higher education. Courses are increasingly being offered, both on campus and off, via the Internet. Students in geographically dispersed virtual communities meet together electronically. It is also clear that in most cases these current uses of information technology represent extensions rather than transformations of how we learn and teach.

The university will have to accept the network as the fundamental architectural element of the 21st Century, knowledge-driven society. Successful institutions will increasingly focus on their core responsibility of building learning environments, whether campus-based or distributed across networks. They will rely upon networks of other organizations, some similar, some quite different, to perform the other functions of today’s comprehensive, vertically-integrated university. And perhaps most significant of all, they will have to accept the reality of an educational future centered in learners rather than in learning institutions.

To be sure, the current concept of distance learning, even if implemented via the Internet through virtual universities, is still bound to traditional ideas and approaches. But as true learning communities are constructed in cyberspace, traditional educational institutions will feel increasing competition and pressure to change. The university will continue to be the primary source of “content” for educational programs, but other organizations more experienced in “packaging” content, e.g., entertainment companies, may compete with universities to provide educational services to the mass market. In a similar sense, it could well
be that the role of the faculty member will shift rapidly from that of organizing and teaching individual courses. As higher education shifts from a cottage industry to mass production, faculty may become members of design teams developing content for broader markets.

These changes could well force a structural reorganization of the university, perhaps breaking it up into its component functions such as credentialing, guidance, research, and instruction. The traditional lecture system, intrinsically inefficient in knowledge transmission, will decline in importance as robust electronically mediated technology becomes available. This technology, ironically enough, may enable an expansion of other activities requiring direct human contact, such as guidance, tutorials, and hands-on mentoring.

It is ironic that the cyberspace paradigm of learning communities is a mechanism that will return higher learning to the older tradition of the scholar surrounded by disciples in an intense interrelationship. In a sense, it recognizes that the true advantages of universities are in the educational process, in the array of social interactions, counseling, tutorial, and hands-on mentoring activities that require human interaction.

Liberal arts colleges that continue to stress such mentoring, hands-on, tutorial-based education will be least challenged by the emerging knowledge media. It is the large, comprehensive universities that rely heavily on impersonal mass education that are at great risk. A significant share of this conventional mass education can be offered commercially and electronically. After all, a large part of the function of large universities is mass information transfer, which can be performed quite effectively and efficiently via information technology. Virtual universities, even when constructed along the conventional distance-learning paradigm, may well provide formidable competition to large universities in terms of both quality and price.

**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.

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.

---

2. Neural development
3. Books, Bricks, and Bytes, Daedelus Vol. 125, No. 4, Fall, 1996
4. Minsky, Marvin
5. Attali, Millennium, p. 123
6. Pentaflorp Computer (Science)
10. Distributed virtual environments
15. University of Phoenix
19. MUDs, MOOs, and MUSEs