Beyond the Endless Frontier

The Future of the University
in an Age of Knowledge

A Quote ...

It was the best of times, it was the worst of times,
It was the age of wisdom, it was the age of foolishness,
It was the epoch of belief, it was the epoch of incredulity,
It was the season of Light, it was the season of Darkness,
It was the spring of hope, it was the winter of despair,
…

Charles Dickens

A Tale of Two Cities

The Good News
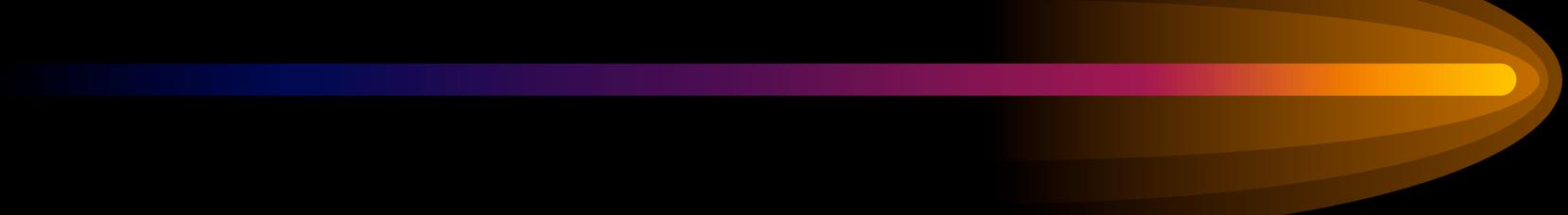
- Importance of knowledge and education
- High payoff of investments in higher ed
- Budget balancing agreement ($40 B)
- 21st Century Research Fund

The Bad News

- Media skepticism, ignorance, hostility
- Erosion in public trust and confidence
- Political intervention
- Faculty stresses

Two quotes...

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

Peter Drucker

"If you believe that an institution that has survived for a millennium cannot disappear in just a few decades, just ask yourself what has happened to the family farm."

William Wulf

Two contrasting futures

Scenario 1: A dark, market-driven future in which strong market forces drive a major restructuring of the higher education enterprise, driving the system toward the mediocrity that has characterized other mass media markets such as television and journalism.

Scenario 2: A culture of learning, in which all our citizens are provided with the education and training they need, throughout their lives, whenever, wherever, and however they desire it, at high quality and at an affordable cost.

The Forces of Change

- Financial imperatives
- Changing societal needs
- Technology
- Market forces

Financial Imperatives

- Increasing societal demand for university services (education, research, service)
- Increasing costs of educational activities
- Declining public support
- Public resistance to increasing prices
- Inability to re-engineering cost structure

Concern: The current paradigms for conducting, distributing, and financing higher education may not be able to adapt to the demands and realities of our times

Changing Societal Needs

- 30% increase in traditional students
- Education needs of high-performance workplace
- The "plug and play" generation
- "Just-in-case" to "just-in-time" to "just-for-you" learning
- Student to learner to consumer

Another issue ...

Over half the world's population is under 20, including two billion teenagers!!! Yet higher education in most of the world is mired in a crisis of access, cost, and flexibility. The United States may have the world's strongest university system, but our high-cost, campus-based paradigms and our belief that quality in education is linked to exclusivity of access and extravagance of resources is irrelevant to the rest of the world.

Concern: There are many signs that the current paradigms are no longer adequate for meeting growing and changing societal needs.

Technology

Since universities are knowledge-driven organizations, it is logical that they would be greatly affected by the rapid advances in knowledge media (computers, networks, etc.)

We have already seen this in administration and research.

But the most profound impact could be on education, as technology removes the constraints of space, time, reality (and perhaps monopoly …)

Concern: The current paradigm of the university may not be capable of responding to the opportunities or the challenges of the digital age.

A Detour: The Evolution of Computers

Mainframes (Big Iron)
…IBM, CDC, Amdahl
…Proprietary software
…FORTRAN, COBOL
…Batch, time-sharing

Minicomputers
…DEC, Data Gen, HP
…PDP, Vax
…C, Unix

Microcomputers
…Hand calculators
…TRS, Apple, IBM
…Hobby kits -> PCs

Supercomputers
…Vector processors
…Cray, IBM, Fujitsu
…Parallel processors
…Massively parallel

Networking
…LANs, Ethernet
…Client-server systems
…Arpanet, NSFnet, Internet

Batch → *Time-sharing* → *Personal* → *Collaborative*

Some Theorems of the Digital Age

Moore's Law: The power of computing for a given price
doubles every 18 months. In ten years, the power
of the technology increases by a factor of 100.

Metcalf's Law: The usefulness of a network increases
as the square of the number of users.

Moore's Second Law: The cost of the manufacturing facility
for chip production also doubles every 18 months.

The Evolution of Computing
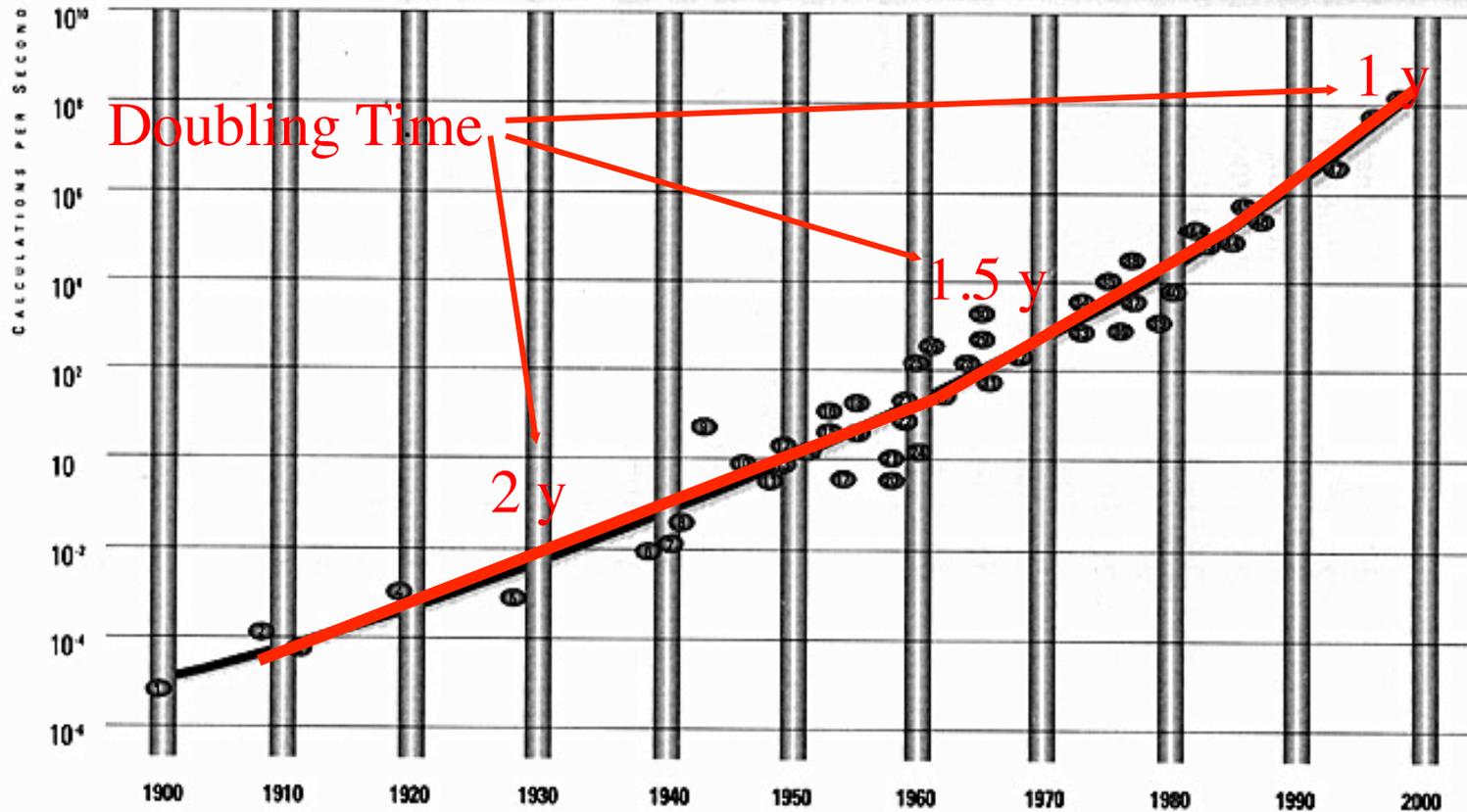
Some Examples

- Speed
  - MHz to GHz (Merced) to THz to Peta Hz
- Memory
  - MB (RAM) to GB (CD,DVD) to TB (holographic)
- Bandwidth
  - Kb/s (modem) to Mb/s (Ethernet) to Gb/s
  - Internet (Project Abilene): 10 Gb/s
- Networks
  - Copper to fiber to cellular to Iridium to Teledysec

Some Extrapolation of the PC

	2000	2010	2020
Speed	10^9	10^{12}	10^{15}
RAM	10^8	10^{11}	10^{14}
Disk	10^9	10^{12}	10^{15}
LAN	10^8	10^{12}	10^{15}
Wireless	10^6	10^9	10^{12}

Computer-Mediated Human Interaction

- 1-D
  - Text, e-mail, chatrooms, telephony
- 2-D
  - Graphics, video, WWW, multimedia
- 3-D
  - Virtual reality, distributed virtual environments
  - MUDs and MOOs, avatars, telepresence
  - Virtual communities and organizations

Another Way to Look at It …

A "communications" technology that is increasing in power by a factor of 1,000 every decade will soon allow any degree of fidelity that one wishes. All of the senses will be capable of being reproduced at a distance … sight, sound, touch, taste, smell … through intelligence interfaces.

At some point, we will see a merging of

> …natural and artificial intelligence

> …reality and virtual reality

> …carbon and silicon …

Evolution of the Net

- Already beyond human comprehension
- Incorporates ideas and mediates interactions among millions of people
- 100 million today; more than 1 billion in 2001
- Internet II, Project Abilene

Some Other Possibilities

- Ubiquitous computing?
  - Computers disappear (just as electricity)
  - Calm technology, bodynets
- Agents and avatars?
  - Fusing together physical space and cyberspace
  - Plugging the nervous system into the Net
- Emergent behavior?
  - … Self organization
  - … Learning capacity
  - … Consciousness (HAL 9000)

A Case Study: the University

Missions: teaching, research, service?

Alternative: Creating, preserving, integrating, transferring, and applying knowledge.

The University: A "knowledge server", providing knowledge services in whatever form is needed by society.

Note: The fundamental knowledge roles of the university have not changed over time, but their realizations certainly have.

Research

- Simulating reality
- Collaboratories: the virtual laboratory
- Changing nature of research
  - Disciplinary to interdisciplinary
  - Individual to team
  - "Small think" to "big think"
- Analysis to creativity
  - Tools: materials, lifeforms, intelligences
  - Law, business, medicine to art, architecture, engineering

Libraries

- Books to bytes (atoms to bits)
- Acquiring knowledge to navigating knowledge
- What is a book?
  - A portal to the knowledge of the world.
  - Minsky: "Can you imagine a time when books didn't talk to one another?"

The Plug and Play Generation
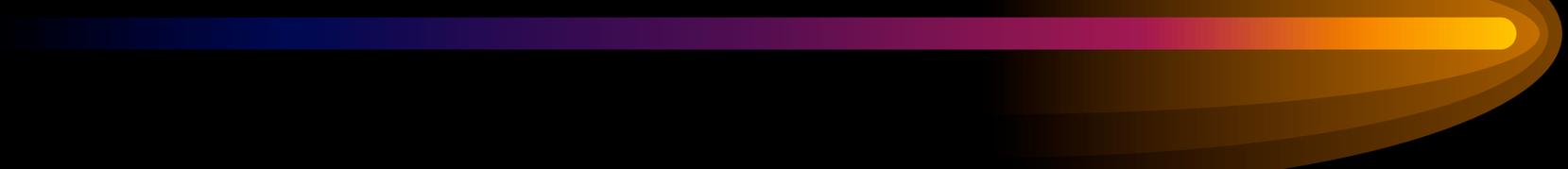
- Raised in a media-rich environment
  - Sesame Street, Nintendo, MTV,
  - Home computers, WWW, MOOs, virtual reality
- Learn through participation and experimentation
- Learn through collaboration and interaction
- Nonlinear thinking, parallel processing

Teaching to learning

- Student to learner
  - Classroom to environment for interactive, collaborative learning
  - Faculty to designer, coach, Mr. Chips
- Classroom
  - Handicraft to commodity
  - Learning communities
  - Virtual, distributed environments
- Open learning
  - Teacher-centered to learner-centered
  - Student to learner to consumer
  - (Unleashing the power of the marketplace!)

The Impact of Technology

- The digital generation will demand interactive, collaborative, nonlinear learning.

- Faculty will have to become designers of learning experiences, motivators of active learning.

- A transition to open learning environments, in which strong market forces challenge the traditional university monopolies.

Scenario 1

A massive restructuring of the higher education industry

or

Swept away by the tsunami of market forces

The current monopoly

Universities operate with a monopoly sustained by geography and credentialling authority.

But this is being challenged by

- demand that cannot be met by status quo

- antiquated cost structures

- information technology

- open learning environments

Restructuring

Hypothesis: Higher education today is about where the health care industry was a decade ago, in the early stages of a major restructuring.

However, unlike other industries such as energy, telecommunications, and health care that were restructured by market forces after deregulation, the global knowledge and learning industry is being restructured by emerging information technology, that releases education from the constraints of space, time, and credentialling.

A quote from a venture capital prospectus

"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."

A possible future

- $300 billion ($3 trillion globally)
- 30 million students
- 200,000 faculty "facilitators"
- 50,000 faculty "content providers"
- 1,000 faculty "celebrity stars"

(compared to 800,000 current faculty serving a $180 billion enterprise with 15 million students …)

Some implications

- Unbundling
- A commodity marketplace
- Mergers, acquisitions, hostile takeovers
- New learning lifeforms
- An intellectual wasteland???

Scenario 2

A Culture of Learning

or

Renewing the Social Contract

A Culture of Learning

Since knowledge has become not only the wealth of nations but the key to one's personal prosperity and quality of life, it has become the responsibility of democratic societies to provide their citizens with the education and training they need, throughout their lives, whenever, wherever, and however they desire it, at high quality and at an affordable cost.

Key Characteristics
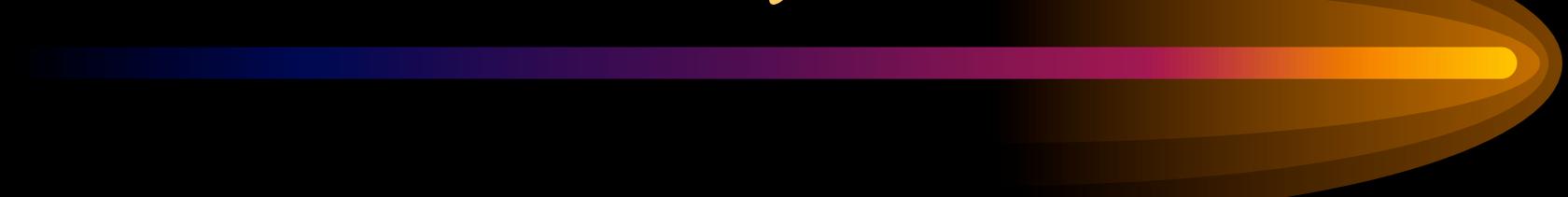
- Learner-centered
- Affordable
- Lifelong learning
- A seamless web
- Interactive and collaborative
- Asynchronous and ubiquitous
- Diverse
- Intelligent and adaptive

Evolution or Revolution?

Many within the academy believe that "this too shall pass".

Others acknowledge that change will occur, but within the current paradigm, i.e., evolutionary.

Some believe that both the dramatic nature and compressed time scales characterizing the changes of our times will drive not evolution but revolution.

Some even suggest that long before reform of the education system comes to any conclusion, the system itself will have collapsed.

The Michigan Strategy

- We created a campus culture in which both excellence and innovation were our highest priorities;

- Restructured our finances so that we became, in effect, a privately supported public university;

- Dramatically increased the diversity of our campus community; and

- 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 became less certain that we could predict the future.

A Time for Experimentation

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

The Michigan Experiments

- We altered very significantly the racial diversity of our students and faculty, thereby providing a laboratory for exploring the themes of the "diverse university".

- We established campuses in Europe, Asia, and Latin America, linking them with robust information technology, to understand better the implications of becoming a "world university".

- We launched major initiatives such as the Media Union (a sophisticated multimedia environment), a virtual university (the Michigan Virtual University), and played a key role in the management of the Internet to explore the "cyberspace university" theme.

- We launched new cross-disciplinary programs and built new community spaces that would draw students and faculty together as a model of the "divisionless university."

- We placed a high priority on the visual and performing arts, integrating them with disciplines such as engineering and architecture, to better understand the challenges of the "creative university".

- And we launched an array of other initiatives, programs, and ventures, all designed to explore the future.

The Michigan Philosophy

All of these efforts were driven by the grass-roots interests, abilities, and enthusiasm of faculty and students. Our approach as leaders of the institution was to encourage strongly a "let every flower bloom" philosophy, to respond to faculty and student proposals with "Wow! That sounds great! Let's see if we can work together to make it happen! And don't worry about the risk. If you don't fail from time to time, it is because you aren't aiming high enough!!!"

To be sure, some of these experiments were costly. Some were poorly understood and harshly criticized by those preferring the status quo. All ran a very high risk of failure, and some crashed in flames–albeit spectacularly. Yet, while such an exploratory approach was disconcerting to some and frustrating to others, fortunately there were many on our campus and beyond who viewed this phase as an exciting adventure. And all of these initiatives were important in understanding better the possible futures facing our university. All have had influence on the evolution of our university.

The Michigan Knowledge and Learning Network

What will happen to other types of social institutions?

- Companies?
- Governments?
- Nation-states?
- Communities?
- New social "life-forms"?

An interesting perspective ...

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, *Millennium*

The Age of Spiritual Machines
Ray Kurzweil

- 2009
  - $1,000 computer has Terahertz speeds
  - Most transactions with machines
  - IT drives continued economic expansion
  - Intelligent courseware is common means of learning.

More Speculations

- 2019
  - $1,000 computer comparable to human brain
  - Computers become invisible and ubiquitous.
  - 3-D virtual displays in glasses and contacts
  - Interaction with computers by speech, gestures.
  - Virtual reality (all senses) enable people to do virtually anything with anybody, any time, any place.
  - Most learning is conducted through intelligent, simulated software-based teachers.

Speculations (continued)

- 2029
  - $1,000 computer = 1,000 human brains
  - Eye and ear implants for I/O
  - First direct neural pathways for high bandwidth connection to human brain (and also to enhance senses)
  - Automated agents now learning on their own (computers have assimilated all knowledge sources)
  - Largest human employment: education and knowledge
  - Machines claim to be conscious. These claims are largely accepted.

Speculation (continued)

- 2099
  - Strong trend toward merger of human intelligence with the world of machine intelligence that human species created.
  - No longer any clear distinction between humans and computers; most conscious entities do not have a permanent physical presence (distributed in Net).
  - Life expectancy is no longer a viable term in relation to intelligent beings.

Speculation (continued)

- The 22nd Century and beyond
    - Intelligent beings consider the fate of the universe.

The remaining questions

How do we respond to the diverse educational needs of a knowledge driven society? Here we must realize that while the educational needs of the young will continue to be a priority, we will be challenged to also address the sophisticated learning needs of adults in the workplace while providing broader lifetime learning opportunities for all of our society.

Is higher education a public or a private good? To be sure, the benefits of the university clearly flow to society as a whole. But it is also the case that two generations of public policy have stressed instead the benefits of education to the individual student.

More questions

How do we balance the roles of market forces and public purpose in determining the future of higher education in America. Can we control market forces through public policy and public investment so that the most valuable traditions and values of the university are preserved? Or will the competitive and commercial pressures of the marketplace sweep over our institutions, leaving behind a higher education enterprise characterized by mediocrity?

Which of the two scenarios will be our future?

The Future of the Research University

Certainly, as a primary source of basic research and the next generation of scholars and professionals, the research university will remain an asset of great value.

Yet the broader higher education enterprise is changing rapidly. While the unique roles, the prestige, and the prosperity of the research university may allow it to defend the status quo for a time, this could pose certain dangers.

As the rest of the enterprise changes, there is a risk that if the research university becomes too reactionary and tenacious in its defense of the status quo, it could well find itself increasingly withdrawn and perhaps even irrelevant to the rest of higher education in America and through the world.

Possible Strategies

- **Isolation:** Some of the most elite institutions may be able to rely on prestige and prosperity to isolate themselves from change. Most will be unable to do this, however.

- **Pathfinders:** Apply the extraordinary intellectual resources of the research university to assist the broader higher education enterprise in its evolution to new learning forms.

- **Alliances:** Research universities might enter into alliances with other types of educational or commercial institutions. This might allow them to respond to the changing needs of society while remaining focused on their unique missions as research universities.

An Action Agenda

- Determine those key roles and values that must be protected and preserved during this period of transformation

  - Roles: education of the young, preservation of culture, research, critic of society, etc.

  - Values: academic freedom, a rational spirit of inquiry, excellence, etc.

- Listen carefully to society to learn and understand its changing needs, expectations, and perceptions of higher education.

An Action Agenda (continued)

- Prepare the academy for change, by removing unnecessary constraints, linking accountability with privilege, redefining tenure, and restructuring graduate education.

- Restructure university governance, particularly lay boards and shared governance models, to allow strong, visionary leadership.

- Development a new paradigm for financing higher education, balancing public and private support, implementing new cost structures, and enhancing productivity.

An Action Agenda (continued)

- Encourage experimentation with new paradigms of learning, research, and service by harvesting the best ideas from the academy (or elsewhere), implementing them on a sufficient scale to assess their impact, and disseminating the results.

- Place a far greater emphasis on building alliances among institutions that will allow individual institutions to focus on core competencies while relying on alliances to address the broader and diverse needs of society. Differentiation among institutions should be encouraged, while relying upon market forces rather than regulations to discourage duplication.

Concluding Remarks

We have entered a period of significant change, driven by a limited resource base, changing societal needs, new technologies, and new competitors.

The most critical challenge before us is to develop the capacity for change.

Only a concerted effort to understand the important traditions of the past, the challenges of the present, and the possibilities for the future can enable institutions to thrive during a time of such rapid and radical change.

A Renaissance?

Certainly the need for higher education will be of increasing importance in our knowledge-driven future. Certainly, too, it has become increasingly clear that our current paradigms for the university, its teaching and research, its service to society, its financing all must change rapidly and perhaps radically.

Hence the real questions is now whether higher education will be transformed, but rather how and by whom.

If the university is capable of transforming itself to respond to the needs of a culture of learning, then what is currently perceived as the challenge of change may become the opportunity for a renaissance in higher education in the years ahead.