

Phi Beta Kappa

Introduction

Let me first convey my congratulations to you...

In an institution in which academic excellence is
our most prized objective,

Election to Phi Beta Kappa--and the honor societies
which characterize our professional schools--
is among the most significant honors that our
students can achieve.

You are to be commended for your achievements...
...and we will look on with great anticipation and
pride as you continue on to assume leadership
roles in our society.

You are graduating at a very interesting moment in
history.

In a very real sense, you will become the first citizens of a
new century...the 21st Century...

But, even beyond that, I believe that you will be starting
your careers at a most unusual moment...
...a time of great challenge, opportunity, and excitement...

Let me explain...

The Age of Knowledge

Looking back over history, one can identify certain
abrupt changes, discontinuities, in the nature,
the very fabric of our civilization...

The Renaissance, the Age
of Discovery, the Industrial Revolution

There are many who contend that our society is
once again undergoing such a dramatic shift in
fundamental perspective and structure.

As Erich Bloch, Director of the National Science Foundation
suggests, we are entering a new age, an "Age of
Knowledge"

The signs are all about us.

Today we are evolving rapidly to a new post-industrial,
knowledge-based society, just as a century ago our
agrarian society evolved through the Industrial Revolution.

Some examples:

1. Industrial production is steadily switching away from
material and labor intensive products and processes
to knowledge intensive processes:
In a car, 40% materials, 25% labor...
In a chip, 1% materials, 10% labor, 70% knowledge!!!
2. Our nation's future has probably never been less constrained
by the cost of natural resources. Future areas of
growth are likely to come from the application of technologies
that require few natural resources.
3. Increasing manufacturing production has come to mean
decreasing blue collar employment!
In the 1920s, 1 of 3 was a blue-collar worker
today 1 in 6 and dropping fast
probably to about 1 in 20 within a couple of decades...
Indeed, UM economic studies suggest that less than 5%
of General Motors' work force will be unskilled labor
by the year 2000.
4. Recent Office of Technology Assessment report:
40% of all new investment in plant and equipment goes
to purchase information technology
US and Japan already have become postindustrial societies;
with predominate sectors in service and high tech. By
1990, 75% of US labor force in services---not burger flipping,

but financial services, professional and design services, and human services. Core of postindustrial society is professional and technical services.

A fundamental transformation is underway in our economy that is reshaping virtually 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 gravity of the labor force.

A transition in which..

Intellectual capital--brainpower-- is replacing financial and physical capital as key to our strength, prosperity, and well-being

This is having a profound impact on our social structure, culture, and economy.

The Challenge of Change

Intellectual Change

Today we have entered a period of great intellectual change and ferment...

New ideas and concepts are exploding forth at ever increasing rates...

We have ceased to accept that there is any coherent or unique core of wisdom that serves as the basis for new knowledge...

We've seen simply too many instances in which a new concept has blown apart our traditional views of a field...

Einstein's theory of relativity
quantum mechanics
the molecular foundations of life...
superstring theory

We are increasingly surrounded by radical critiques of fundamental premises and scholarship...

Hence the capacity for intellectual change and renewal has become increasingly important to us as individuals...and to our institutions

As the pace of the creation of new knowledge accelerates, it seems apparent that we are entering a period in which permanence and stability become less valued than flexibility and creativity... in which the only certainty will be the presence of continual change... and the capacity to relish, stimulate, and manage change will be one of the most important abilities of all.

Traditional Approaches

Part of the problem is that most of us have been trained to think in terms of change as a linear, causal, and rational process. We have been taught that by looking at the past, we can extrapolate into the future.

Yet, perhaps because of my background as a physicist, I have become increasingly convinced that change in most complex systems, organizations, or fields of knowledge is:

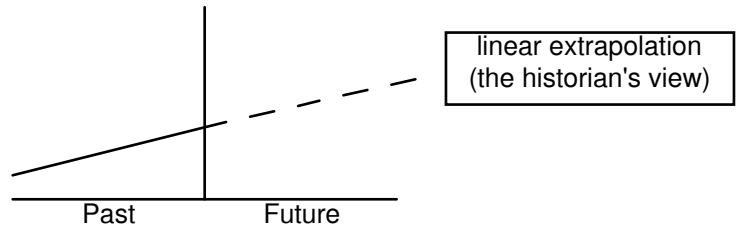
- i) highly nonlinear
- ii) frequently discontinuous
- iii) and usually stochastic...random in nature...

Let me expand on this theme for a moment...

Models of Change

Contrasting models of change...

Linear growth

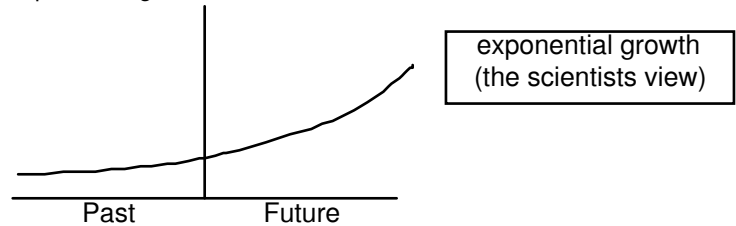


("here we go again...")

Most of us have been trained to think in terms of change as a linear, causal, and rational process.

We have been taught that by looking back to the past, we can simply extrapolate to predict the future.

Exponential growth



("doom and gloom...")

Growth in world's population...

Examples:

World population growth...5 B now, doubling 40 years
(will it peak or grow exponentially to unmanageable proportions)

Energy: fossil fuel consumption

Pollution Problems: Greenhouse, acid rain, ozone
AIDS

We live in an exponential world in which the scientific and technical problems that beset us are growing exponentially

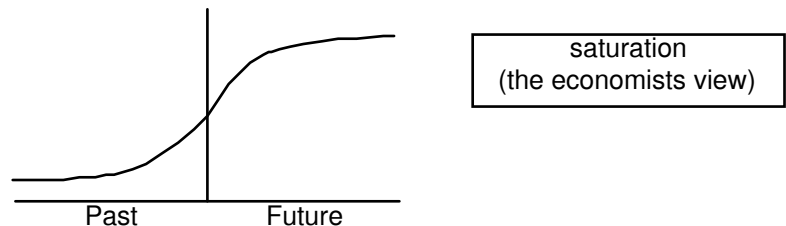
Growth in knowledge...

The rate of change in our reservoir of understanding and insight is proportional to the amount of understanding and insight we already have...the basic exponential condition.

However, we have never been in a better position to deal with serious problems, because knowledge is also increasing exponentially.

Since we are attempting to apply an exponentially growing knowledge base to exponentially growing problems, any imbalance could lead to catastrophe, since we would be overtaken before we learn how to cope with the problem.

Saturation



("not to worry...")

Sigmoid curve...

Parkinson's Law...

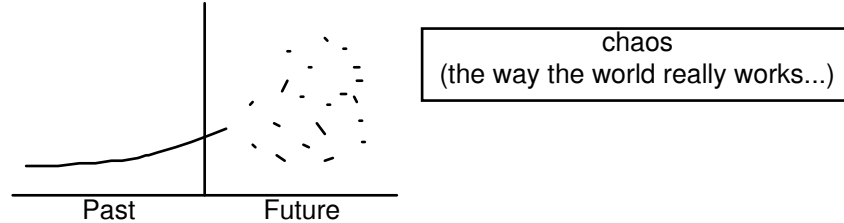
ii) Every exponential phenomenon eventually reaches a limit...

The bacterial colony on the petri dish runs out of nutrient.

World population will run out of land surface...indeed, in 500 years (the time since Columbus), there will be only one square yard per individual...

Sooner or later, we run out of the necessary resources...

Chaos



Note the difference between the logistic equation and the sigmoid equation. (The logistic equation is the one governing population growth.)

("surprise, surprise!!!")

Logistics equation

The real world...

highly nonlinear

frequently discontinuous

usually stochastic, random, chaotic...

A Modern View of Change

We now know that most complex systems that may first appear to be stable and unchanging are, in reality, comprised of components that are continually fluctuating or changing...

In these systems, a situation sometimes occurs in which a single fluctuation becomes so large, as a result of feedback and nonlinearities, that it shatters the stability of the system. At this singular point, called in the language of physics, a bifurcation point, it becomes quite impossible to predict in advance which direction change will take...

...whether the system will disintegrate into a highly disordered or chaotic state...

...or leap to a new higher level of order or organization...

Of course, such bifurcation instabilities cannot be triggered by just any old fluctuation, but only by those that are particularly "dangerous"--that is, those that can exploit to their advantage the nonlinear relations that can trigger the instability of the existing state.

The more complex a system is, the more numerous are the types of fluctuations that threaten its stability.

The Butterfly Effect

The basic idea of Western science is that you don't have to take into account the falling of a leaf on some planet in another galaxy when you're trying to account for the motion of a billiard ball on a pool table on earth. Very small influences can be neglected. There's a convergence in the way things work, and arbitrarily small influences don't blow up to have arbitrarily large effects."

Butterfly effect: sensitive dependence on initial conditions.

...the notion that a butterfly stirring the air today in Peking can transform storm systems next month in New York.

Revolutionary Change (a la Kuhn)

If we take the viewpoint that most organizations...or even most fields of knowledge...are examples of such complex systems, then this view of change is remarkably similar to that of Thomas

Kuhn's thesis concerning the way that knowledge changes in a field. In essence, it says that a single individual...or idea...can create dramatic change...a revolution, if you will, in the traditional way that we look at a field.

Kuhn's uses the term "paradigm" to refer to the body of knowledge...in essence, the way that one is accustomed to look at a field...accepted practices or perspectives.

In a sense, a paradigm is what the members of a community of scholars share, and conversely, a scholarly community consists of people who share a paradigm.

However, in contrast with the standard useage, a knowledge paradigm is not really a model designed for replication; rather it is an subject for further study and articulation.

Most research consists not of seeking major novelties, but rather polishing up existing paradigms...essentially mopping up -- or in the language of the familiar GM add, "sweating the details"...

In Kuhn's view, major progress does not occur through the gradual evolution of an existing paradigm, but rather through a revolutionary process in which an existing paradigm is replaced by a new paradigm.

The transformations of paradigms are revolutionary in nature, and the successive transition from one paradigm to another via revolution is the usual developmental pattern of mature field of knowledge.

Kuhn also observes that those who achieve the fundamental inventions of a new paradigm are usually either very young or very new to the field whose paradigm they change. These are the individuals who, being little committed by prior practice to the traditional rules of the field, are particularly likely to see that those rules no longer define a playable game and to conceive another set that can replace them.

They can make contributions of unusual importance since they haven't had the time yet to fall in the same old ruts that have trapped more experienced scholars.

An aside here: This may be one of the reasons why the perspectives of feminists, minorities, and third world scholars are of such importance to us...why they can lend a rich new vitality to our traditional forms of scholarship -- why they can launch new paradigms of learning...

Note that just as in my earlier discussion of the nonlinear evolution of complex systems, we again see a theme in which single fluctuations...individuals or ideas...can trigger dramatic...and possibly unpredictable...change.

Some Themes of Change

- i) linear to nonlinear world (e.g., world of gradual change to revolutionary change (Kuhn)
- ii) deterministic to stochastic (chaos)
- iii) "Ill-posed" --unstable dependent on initial conditions or perturbations
We should distinguish between states of the system in which all individual initiative is doomed to insignificance on othe one hand, and bifurcation regions in which an individual, an idea, or a new behavior can upset the global state.
- iv) unusual importance of young or newly initiated in triggering change.

Implications

For Our Institutions...

Responding to Intellectual Change

If our future is indeed one in which the capacity to stimulate and manage intellectual change becomes

important...

And in which change is also viewed as a highly nonlinear, occasionally dramatic, and usually unpredictable process triggered by extraordinary people and their ideas...

Then, this suggests that academic institutions may well wish to think carefully about how they go about their business of teaching and research...

In this future, renewal and change will become essential for both the achievement and sustaining of excellence.

It seems critical that academic institutions not just respond grudgingly to change;

A university must relish and stimulate and manage a process of continual change and renewal if it is to achieve excellence and leadership.

Here we must seek programs that accomplish the following:

1. To act as a "change agent" to stimulate intellectual change...to encourage paradigm shifts...bifurcations of the knowledge curve... knowledge revolutions...
2. And to provide the kind of fault-tolerant environment in which people are encouraged to take chances, to pursue bold and daring scholarship...without fear of failure.
3. In a sense, we must encourage the fluctuations in our scholarship...in a sense, encouraging "chaos"...and through this, evolving new forms of knowledge...

Venturesome Research

A university must be responsive to changing intellectual currents.

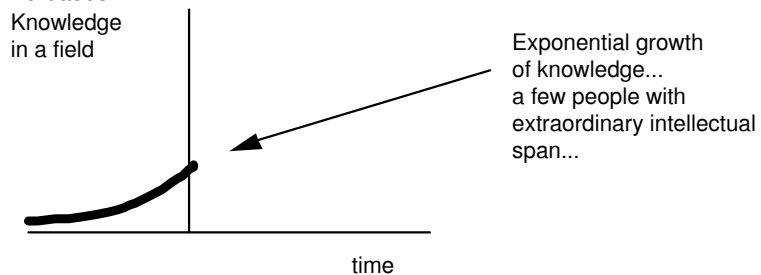
Intellectual leadership...

demands pushing to the forefront of discovery

All too often academic institutions tend to regard their role more as the keepers and transmitters of existing knowledge than as the creators of new knowledge.

Here I like to refer to the image of the growth of knowledge in a field as an S-shaped or sigmoid curve...

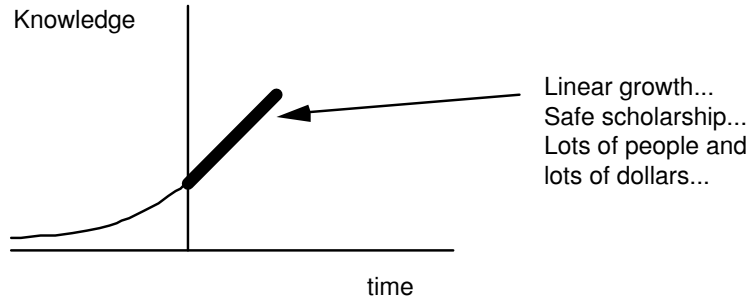
In the early stages, the growth of knowledge is exponential with time, since the more you learn, the more rapidly the rate of knowledge increases...



At this early stage, a few individuals of exceptional ability and great intellectual span can have truly extraordinary impact, essentially stimulating and defining entirely new fields of knowledge...

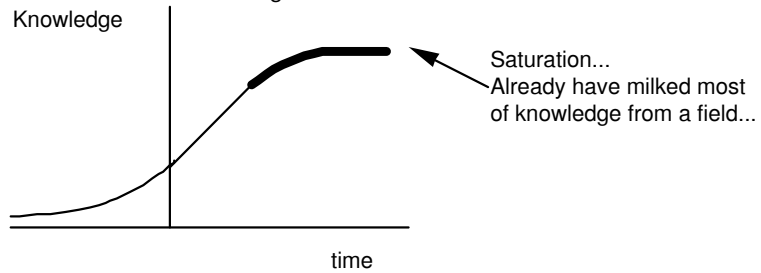
This is the "high risk" area...since it can frequently

take years (in addition to great talent) to achieve something...
 As a field matures, the growth in knowledge becomes linear with time....

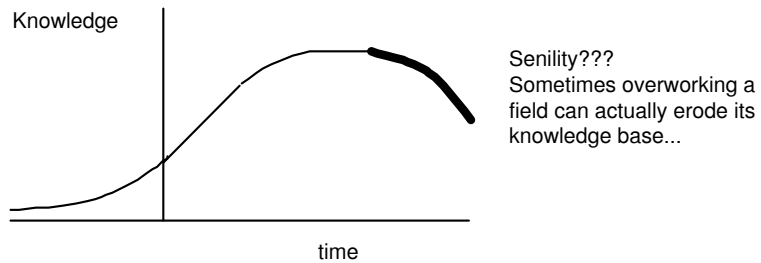


In this stage, the more resources you throw at an area...the more people or dollars...the more you learn...
 This is where it is "safest" to work...
 easiest to get grants and to achieve tenure...

As the field matures still further, the growth in knowledge tails off...a law of diminishing returns sets in as one mines most of the new knowledge out of a field.



All too often, many of us get trapped in this regime...essentially trapped in a rut.
 Some of my colleagues suggest there may be a fourth phase...they refer to it as senility...
 where continuing to work in a field actually is counterproductive and reduces its knowledge content.



One of the great challenges of research universities is how we can encourage more people to work down in the high-risk, exponential part of the knowledge curve... without unduly jeopardizing their academic careers... We must stimulate more of a risk-taking intellectual culture in which people are encouraged to take bold initiatives. From this perspective, it is important to jar as many people as

possible out of "conventional wisdom" by fostering experiments, recruiting restive people from outside the university and turning them loose--"causing trouble" by making conventional paths more trouble than unconventional ones--using PRs, speakers, etc. to build up a sense of institutional momentum.

The Changing Role of the University

Further, as our society becomes ever more knowledge-intensive, and hence ever more dependent upon educated people and their ideas...

It is clear that we will become ever more dependent upon our research universities as primary sources of new knowledge and those capable of applying it.

Hence our institutions will face a period of unusual responsibility, challenge, and opportunity in the years ahead.

But I believe we will also face a period of major change.

But in a very real sense, the university as we know it today was invented to serve an America of the past...

...a nation characterized by a rather homogeneous, domestic, industrialized society.

"The organizational characteristics of the university were invented after the Civil War: the academic department, the undergraduate college, the graduate school, the professional school training format, the semester credit hour. All of these developments coincided with the expansion of industrial America. (Indeed, the synchronous, serial approach to undergraduate education of universities is similar to early production lines, we find that these are the last institutions to retain the factory system. We are, in effect, one of the last artifacts of the industrial age.

It is becoming increasingly apparent that it is time to develop a new model of higher education--- to re-invent the university, if you will--so that it is capable of responding to the needs of the highly pluralistic, knowledge-intensive, world nation that will be the America of the 21st Century.

Of course, there have been many in recent years who have suggested that the traditional paradigm of the public university must evolve to respond to the challenges that will confront our society in the years ahead...

But will a gradual evolution of our traditional paradigm be sufficient...or, will the challenges ahead force a more dramatic, indeed, revolutionary, shift in the paradigm of the contemporary research university...

For Our Society...

The third wave...

Source of strength lies in change...

ability to transform their products and organizations in response to changes

Contrast: industrial age companies
stress stability

Bureaucratic planning depends on assumed continuity and tends to plan in linear projections, always constrained by rationality.

Entrepreneurial planning assumes discontinuity and anticipates change, although it makes no pretense of predicting it.

The bureaucrat assumes that change can be kept at the periphery of the enterprise and will not affect core purposes, while the entrepreneur assumes that change is part of the

enterprise itself.

A linear model of the innovation process has been used to justify an increasingly unrealistic view of basic science and product development and production as sequential, loosely coupled processes.

Innovation consists of a discontinuity in the concept of production. The heart of the innovation is novelty in solving the problem, not necessarily economy compared to current practise. The innovator wants to get off of one learning curve, and on to another, even if the initial cost penalty of the jump is severe and the risk high. His eye is on the future; he wants nature on his side.

Toffler's Wave concept:

First wave:

agricultural phase
built for growth...

Second wave

industrial age
built for stability
lack flexibility, creativity, innovation
stress management by consent
in business of getting bigger
defend what is theirs
people motivated by promotion, salary

Third wave

built to adapt to change
love to reorganize
"Organizations shouldn't have
permanence"
designed for management by dissent
stress networking rather than heirarchy
interested in finding a better way
goal: to make yourself and your own
products obsolete
people motivated by commitment to
an ideology, a change to change the
world, a change to growth as a person
more risk-taking

The importance of human capital...

Needless to say, these same challenges of pluralism, of globalization, and of this age of knowledge that is our future will pose great challenges and demand similar changes in our state.

Indeed, I am personally convinced that our nation faces a very unusual period of challenge in the decade ahead...a watershed, in a sense, from which we can either emerge as a world leader...or as an also run...an economic backwater

My central theme is that education, broadly defined, will be the pivotal issue in determining which of these two alternative futures will be America's.

Indeed, I am absolutely convinced that the dominant issue of the 1990s will be the development of our human resources.

People must be the major focus...

People -- not equipment or buildings -- are the source of creativity.

They generate the knowledge that makes the technological innovation possible. They are the workforce that makes society run.

They are our researchers and teachers, our leaders, managers, and decisions makers in modern technological society.

Previous economic transformations were closely associated

with major public investment in infrastructure such as
railroads, canals, electric networks, and highways.
In the coming economic transition, an equivalent
infrastructure will be an educated population.

But here we face very serious challenges...

For Students...

In many fields, the knowledge base is doubling every
few years...indeed, in some fields the knowledge
taught undergraduates becomes obsolete even
before they graduate!

The typical college graduate of today will
likely change careers several times during a
lifetime...

Hence a college education will only serve as
the stepping stone to a process of lifelong education...
and the ability to adapt to...indeed, to manage
change...will become the most valuable skill of all.

Educational Change

The problem is that we really aren't prepare people
for a world in which they'll change careers four or
five times in a lifetime. In this type of world,
the most successful people will be those who
can deal with ideas, who can look at things from
many perspectives.

Yet, in education, we continue to move to more and
more specialization. Further, we are approaching
the point of information overload, and it will take
discerning individuals to figure out what is important,
what they should use, and how they can understand
it. Yet the majority of people coming out of
universities today have weak communication skills
and a limited view of the world.

Young people are too quickly encouraged into job-
related specialization when they really should be
challenging the ideas of the past, discovering the
wisdom of others, exploring knowledge, and stretching
the intellectual breadth of their minds.

In the 21st century, people will finally think in terms of
lifelong education; college will be only one intermediate
step in one's education.

The Importance of Fundamental Values

While change and renewal will be important themes of
our future, they can only occur upon a foundation
of fundamental institutional values.

Of course, academic institutions usually focus first on
intellectual values...values of the mind....

The seeking of wisdom
Freedom of inquiry
Intellectual integrity
Discipline of the mind
Respect for reasoned conclusions

While these are of course essential in any university,
there are also other sets of values which we must
not ignore:

Values of moral character:

Honesty
Integrity
Courage
Tolerance and mutual respect

So too, we must bear in mind those all-important
values which characterize civilized societies:

Caring and concern and compassion
Cooperation and communication and civility
These are the values that pull us together as
a community.

In a future characterized by rapid and unpredictable
change, a future dominated by the themes of
pluralism, internationalization, and knowledge,
it seems clear that our institutions will increasingly
become the crucibles in which the new ideas and
social structures capable of responding to this
future are created.

Here we must take care that the ferment and
controversy that always surround the birth of
new ideas does not tear apart our communities.

We must recognize that in this future of change,
these values of community will provide the bonds
that must unite us...

The Need for a Liberal Education

These challenges suggest that the principal
focus of an undergraduate education appropriate
for the 21st Century will be the goal of liberal learning...
that is, a liberal education as the preparation for
a lifetime of learning.

Alfred North Whitehead, in
his "Aims of Education", puts it best:

"Though knowledge is one chief aim of intellectual
education, there is another ingredient, vaguer but
greater and more dominating in its importance.
It is wisdom. You cannot be wise without some
basis of knowledge, but you may easily acquire
knowledge and remain bare of wisdom.

Wisdom is the way in which knowledge is held. It concerns
the handling of knowledge, its selection for the
determination of relevant issues, its employment to
add value to our own immediate experience. This
mastery of knowledge which is wisdom is the most
intimate freedom obtainable.

The only avenue toward wisdom
is by freedom in the presence of knowledge, the
only avenue towards knowledge is by discipline in
the acquirement of ordered facts."

To stress this point, I usually take the opportunity
at University rites of passage such as Freshman
Convocation or Commencement to recall that
haunting passage from:

T.S. Eliot ("The Rock", 1934)

All our knowledge brings us nearer to our ignorance.
All our ignorance brings us nearer to death.
But nearness to death no nearer to God.
Where is the Life we have lost in living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?
The cycles of Heaven in twenty centuries.
Bring us farther from God and nearer to the Dust.

We must not view an education
as simply aimed at extracting knowledge from the vast
information characterizing our society.

Instead, our goal, indeed, the goal of any liberal education,
must be to help our students learn how to extract wisdom from
knowledge -- and through that wisdom, prepare them
to learn the art of life itself...

