

Michigan Engineering Commencement

Introduction

Engineering Commencement

Congratulations

It is my honor to convey to you congratulations
on behalf of the Officers of the University
Congratulations to the Class of 1988E...
And to your families and friends who have
gathered with us this evening to
celebrate your achievements
Actually, this is also a great personal pleasure,
since your class is very special.

The Class of 1988

1. In a sense, I view you as half mine!
Some of you who are able to remember far
back into the dim past of your freshman and
sophomore years may also remember that
I was once your Dean way back in those
prehistoric times...
2. It was your class that led the charge to
the North Campus...and while the move
during your years at Michigan may have
sometimes been inconvenient and
frustrating, I suspect that you will also
look back on this as a time of great
excitement for Michigan Engineering
3. Your Class is special for yet another reason...
because of the time at which you are graduating
--at the dawn of what is sometimes called the
Information Age

Actually, something even more profound is

happening at just the time when you are graduating
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 Reason, the Age
of Discovery, the Industrial Revolution

You are graduating at a time when our
civilization is going through yet another
such change...

A change in which we are evolving from a
resource-intensive to a knowledge-
intensive society...

A transition in which..

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

It is not just the impact of science technology...
although, to be sure, this is playing a critical --
indeed, perhaps a driving, role.

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

New forms of thought such as
Feminism and Pluralism
Liberation Theology

Obscure, yet profound, new ways to
approach knowledge such as
Deconstructionism

Knowledge Engineering
Even new fundamental philosophies
of life, such as the new philosophy

of "literalism", first stated in last week's Bloom County by Opus...

"You're born...
You live...
You go on a few diets...
You die."

Think about it...
Some real words of wisdom, there...

In a very real sense, the Class of 1988 is graduating during the birth of an entirely new age...
"An Age of Knowledge"...
In which people and their ideas will be the most precious commodity of all.

In one sense you are probably the best

prepared of Michigan's graduates today to respond to this new age, since your combination of a rigorous education in science and engineering, pursued within the more general context of a liberal education, has prepared you to create and apply new knowledge across the full span of disciplines
In contrast to the majority of our society, you are literate both in our traditions of culture...and in the new forms of knowledge that will determine our future...

Yet, with this knowledge comes not only opportunity but responsibility as well.

Remember the haunting passage from T. S. Eliot:

"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?"

While you might view your education at Michigan

as one aimed at extracting knowledge from the vast information characterizing our society, let me suggest that our real goal was something far beyond that.

Our goal, indeed, the goal of any liberal education,

was to help you learn how to extract wisdom from knowledge -- and through that wisdom, prepare you to learn the art of life itself...

We hope that while at Michigan you have

learned how to find the wisdom in knowledge...
and hence to find the life that is in living"

Congratulations!

Godspeed!!!

And may the force be with you...

The force of the maize and blue!!!

How to Give a Commencement Address

But not to worry. Because I have learned that it is far easier to prepare a commencement speech that it is to listen to one!

Because you see, there is really only one commencement address...

And although it has been given thousands of times...
in thousands of different ways...

The basic message is still the same...

First you tell the graduates that their education has prepared them to go forth into a world in which they, and they alone, will have the power to control their own destiny.

Then you throw in some advice on how to

go about doing this...
although, of course, it is traditional for graduates to
totally ignore this advice...
The only real challenge is to figure out how to
say this once again...in yet another way...
and to keep it all under 15 minutes!!!
So here goes (*glancing at my watch*)

Some Personal Memories

I should note that this task generates a certain nostalgia since it was exactly a quarter-century ago that I graduated.

In fact, last week I experienced the trauma of my 25th Year College Reunion back at Yale...

When I think back, I remember a time of great optimism in America... the glow of Camelot of the Kennedy administration... still lingered with us.

There were great causes to take up such as
...world peace...
...the conquest of space
...the Civil Rights movement

My Class of '64 graduated with feeling of boundless confidence in ourselves and our country.

But there were already clouds gathering on the horizon even during my senior year that suggested that things would be not quite so simple, that dramatic changes were coming...

John F. Kennedy was assassinated during the fall of my senior year...

The Cold War had begun to heat up with the Cuban Missile Crisis

A few people were talking about a distant war in a place called Viet Nam

The Free Speech Movement at Berkeley was revealing a new spirit of student anger and activism on the campuses.

But even with these warning signs, we were not prepared for the dramatic crises and confrontations, the great changes that Americans and their institutions would face in the years immediately following our graduation...

- the war in Vietnam that so profoundly affected all of our lives...
...both those who served and those who protested...
- the eruption of assassination and terrorism which robbed us of our heroes
- the racial turmoil that tore apart our cities
- the emergence of the drug culture...
as more people turned on and tuned out...
- Watergate, and the crisis in confidence in our leaders

In a sense, during the decade following my graduation America lost its innocence...

In many ways, my class may have represented the last generation of Americans to be truly optimistic about the future... to welcome its challenges and to feel equal to them.

I can't say whether my own choice of a career would have been different if I could have foreseen the future... but it seems appropriate this morning to engage in some futuring...to speculate a bit about the world you will be entering...

Possible Futures

The French poet Paul Valery once said that

"The trouble with our times is that the future is not what it used to be."

If my experience is any guide, your future will be a time of greater change and transformation than any experienced before in our nation's history.

You are graduating at a truly extraordinary time...

Think about it for a moment...

You were born and educated in the 20th Century, indeed, most of you are children of the 60s generation...
...**my** generation (and that's a frightening thought!)

Yet you will be spending the majority of your life in the next century...in the 21st Century.

And while it is always risky to speculate about the future, three themes of the next century seem clear...

1. Demographic Change: The New Majority

America is changing rapidly...

When we hear references to the demographic changes occurring in our nation, our first thought probably focuses on the aging of our population.

It is indeed true that the baby boomers are now entering middle age, and their generation has been followed by a baby bust... in which the number of young adults will be declining over the remainder of this century by roughly 20%.

Indeed, today there are more people over 65 than teenagers in this country, and this situation will continue for many decades.

Further, the growth rate in both our population and workforce is declining to the lowest level in our nation's history.

America will simply not be a nation of youth again in your lifetimes.

Yet, there is a far more profound change occurring in the population of our nation.

America is rapidly becoming the most pluralistic, multicultural nation on earth.

Women, minorities, and immigrants now account for about 90% of the growth in the labor force.

By the year 2000, they'll represent 60% of all of our nation's workers!!!

Those groups we refer to today as minorities will become the majority population of our nation in the century ahead...just as they are today throughout the world.

And women have already become not only the predominant gender in our nation and our institutions, but they are rapidly assuming their rightful role as leaders of our society.

In this future, the full participation of currently underrepresented minorities and women will be of increasing concern as we strive to realize our commitment to equity and social justice.

But, in addition, this objective will be the key to the future strength and prosperity of America, since our nation cannot afford to waste the human talent represented by those currently underrepresented in our society, this human potential, cultural richness, and social leadership.

If we do not create a nation that mobilizes the talents of all our citizens, we are destined for a diminished role in the global community, increased social turbulence, and most tragically, we will have failed to fulfill the promise of democracy upon which this nation was founded.

But there are other important challenges associated with such demographic change.

In particular, it is important to realize here that 21st Century America will NOT be a melting pot in which all cultures are homogenized into a uniform blend -- at least not during our lifetimes.

Rather, it will be pluralistic...composed of peoples of vastly different backgrounds, cultures, and beliefs...peoples seeking to retain their cultural roots...to maintain their differences and identities.

Our challenge will be to find the common bonds and values that unit us, even as we learn to respect and value our differences.

The growing pluralism of our society is perhaps our greatest challenge as a nation...yet it is also among our most important opportunities, since it gives us an extraordinary vitality

and energy as a people.

2. The Internationalization of America

The second theme is triggered by an event that happened from almost exactly two decades ago...when Apollo 11 set down on the Sea of Tranquility to put man on the moon.

The image I have in mind is that extraordinary photo of the earth taken by Lunar Orbiter as it circled the moon...
...an image that dramatically revealed how nations and peoples are passengers together on spaceship Earth.

It was a portent of today, a time in which all aspects of American life are becoming increasingly "internationalized", in which our nation has become a member of a truly global community.

Whether through travel and communication, the arts and culture, the internationalization of commerce, capital, and labor, we are becoming increasingly dependent on other nations and other peoples.

The world and our place in it have changed.

The fact is that a truly domestic US economy has ceased to exist.
...It is no longer relevant to speak of the California economy or the American economy...or the competitiveness of California industry or American industry.

Our economy...our companies...are truly international, spanning the globe...and intensely interdependent on other nations and other peoples.

In slightly more than 5 years, US trade deficit has taken us from the world's largest creditor to its largest debtor nation.

We are no longer self-sufficient or self-sustaining. We are not immune to the shocks of the world society.

As the recent events in China and the Soviet Union make all too clear.

But beyond commerce and national security, there is an even more important reason to pay attention to the trends of internationalization...

The US has become the destination of about half the world's immigrants
Probably 10 million this decade alone...

With falling fertility rates, immigration will soon become the main determinant of the variability in our population.

As we have been throughout our history, we continue to be nourished and revitalized by wave after wave of immigrants, coming to our shores with unbounded energy, hope, and faith in the American dream.

Yet today, in a very real sense,
America is evolving into the first true "world nation", with not simply economic and political but also ethnic ties to all parts of the globe...

From this perspective, it becomes clear that understanding cultures other than our own has become necessary not only for personal enrichment and good citizenship, but indeed, necessary for our very survival as a nation.

3. 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.

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.

In a sense, we are entering a new age, an age of knowledge, in which the key strategic resource necessary for our prosperity, security, and social well-being has become knowledge--educated people and their ideas.

Themes of Change...

The America of the 20th Century that I have known...

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

But that is an America of the past.

You will inherit a far different nation...

a highly pluralistic, knowledge-intensive, world nation that will be the America of the 21th century

These themes of your future,

the changing nature of the American population...

our increasing interdependence with other nations and other peoples...

and the shift to a knowledge-intensive, post-industrial society.

Are actually not themes of the future...but rather themes of today...

...in a sense, I have simply been reading the handwriting on the wall...

(In fact, the brave new world I have been describing as

America of the 21st Century is California of the 1990s!!!)

But, whether these are themes of the present or of the future,

it is clear that they are also themes of change...

...themes that will both reflect and stimulate even more fundamental structural changes in the nature of our society and our civilization.

The Challenge of Change

Indeed, change itself might be regarded as the fourth theme characterizing your future that I can predict with some certainty.

It is clear that the future will never again be what it used to be!!!

New ideas and concepts are exploding forth

at ever increasing rates...

Indeed, in many fields, the knowledge base is doubling every

few years... the knowledge you have mastered as undergraduates is becoming obsolete even as you are graduating!

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

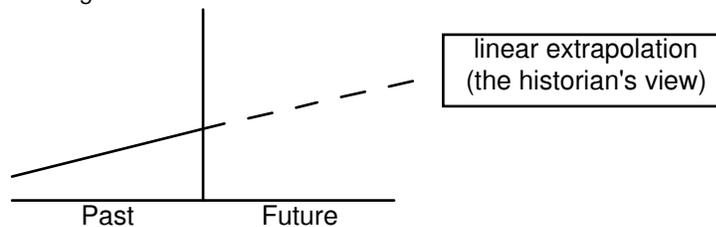
continual change...

and the capacity to relish, stimulate, and manage

change will be one of the most critical abilities of all.

Models of Change

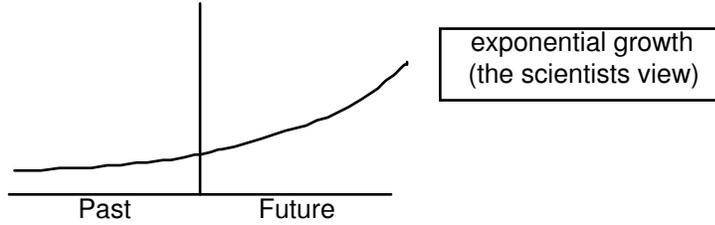
Linear growth



Here we face a particular challenge, since most of us have been trained to think in terms of change from a historical perspective...

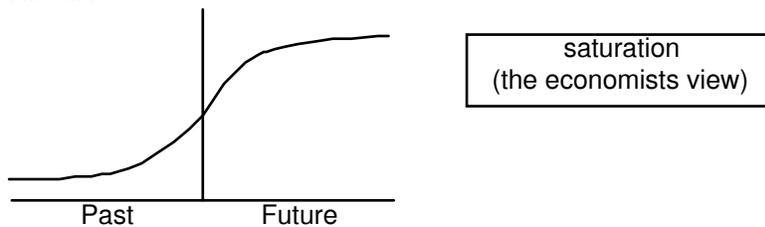
...as a linear, causal, and rational process.
We have been taught that by looking back to the past,
we can simply linearly extrapolate to predict the future.

Exponential growth



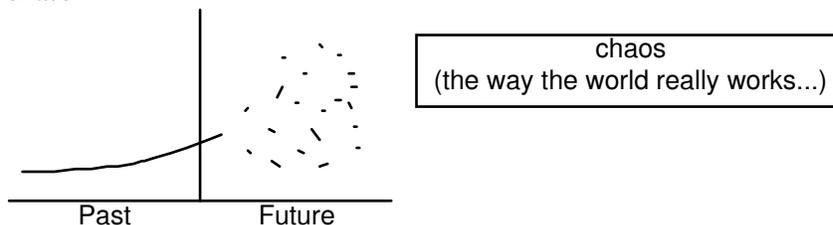
Of course, the scientist has a much different view of change...
...a view that is much more disturbing.
The scientist notes that most change in our natural world does not occur linearly with time, but rather exponentially, at every increasing rates.
From this view, the challenges that face us, challenges such as the growth in the world's population or the consumption of our natural resources or the pollution of our planet are growing ever more serious at exponential rates.

Saturation



Enter the economist, who says "not to worry"...
Sooner or later every exponential phenomenon eventually reaches a limit, a saturation, as a Parkinson's law of diminishing returns sets in.
Sooner or later, we run out of the necessary resources to sustain exponential growth, and the process of change slows to a halt.
The bacterial colony on the petri dish runs out of nutrient.
World population will run out of land surface... perhaps when, in the year 2500, there are 40 trillion people on Earth with only one square yard per person!

Chaos



Ah, but we have learned in recent years that the world really doesn't work like this either!
Instead, we have learned that even the simplest systems in nature tend to behave in a far more complex and unpredictable fashion...
They follow a change process known in today's popular lexicon as "chaos".
While the early stages of change are linear, exponential,

and perhaps even saturating, at later stages, change frequently occurs in far more dramatic and unpredictable ways.

In this view of the world, systems become unstable and undergo dramatic and often chaotic change to create new levels of order and complexity.

Ex: Witness the complex evolution of clouds in the sky, or the complexity of flowing water, or the extraordinary complexity and diversity of living creatures.

There are several particular features of this modern view of change... that have major implications for the world in which we live:

- i) First, from this modern view, change is not simple and gradual and linear. Rather it is characterized by nonlinearities that lead to complex behavior frequently to dramatic rather than gradual change... to revolution rather than evolution.
- ii) But that's not all. Change is also not predictable and deterministic but rather random and stochastic in nature. The real world works in sharp contrast to the deterministic views of classical science of Newton or such modern determinists as Freud or Marx or Skinner.

That's the bad news. Now for the good news!

- iii) Chaotic change depends far more sensitively on small disturbances than we had ever thought possible.

To mathematicians, chaotic systems are "ill-posed"...

But the popular press has a more picturesque term...

known as the "butterfly effect"...which arises from the suggestion that the even the disturbance in the air caused by a butterfly's wings could cause major changes in weather halfway around the globe because of the chaotic nature of weather patterns.

Translated into more human terms, dramatic change is frequently triggered by a few extraordinary people with extraordinary ideas--or by the young or newly initiated--people who haven't had the time yet to become trapped in the same ruts as the more experienced of us...

More specifically, change is frequently triggered by people exactly like you here before me today!

To put it more bluntly, if this modern view of change is right,

each of you will have a truly remarkable chance to change the world!!!

But you will also be faced with some unusual challenges.

Implications for You as Graduates

If indeed, your future will be one characterized by rapid, unpredictable, and dramatic change, then it becomes apparent that your capacity for continual renewal and personal development will become increasingly important.

Has your education here at Caltech helped you to value, welcome and control change?

I hope so.

While most of you have probably looked at your college education as preparation for a career...

as scientists or engineers...

or doctors, lawyers, or teachers...

or even investment bankers...

I suspect that was not the real purpose of your education at Caltech.

The eminent philosopher Alfred North Whitehead once stated that the purpose of a college education was "to learn the art of life".

Well, in a very real sense, that is what you should have been learning at Caltech.

You should have sought...and must continue to seek...

a spirit of liberal learning...a spirit that will
enrich your lives and through you, the lives of your
families, friends, and colleagues.

But I suspect that it may be dawning on many of you this
morning that perhaps you did not learn as much of
"the art of life" as Caltech as you might have wished...
(I certainly didn't when I was an undergraduate!!!)

Not to worry...

Your college education was intended only as a
the stepping stone to a process of lifelong education...

Indeed, most college graduates of your generation will
find themselves changing careers several times during
their lives.

Hence you will find yourselves continuing to learn--and relearn--
and relearn yet again through self study and returning to
school on occasion, as you attempt to adapt to a world of change.

Just look at my example! Who could have predicted that
a Caltech graduate would end up a president of a
university that won both the Rose Bowl and the NCAA
national basketball championship in the same year!!!

A Future of Hope

The modern view of change suggests that the future
is indeed not what it used to be...
...or at least as it has traditionally been portrayed, as a time
of gradual, predictable change, rigidly moored to the past.

Rather, my crystal ball suggests a future characterized
by rapid, unpredictable, and frequently dramatic change...
...in the nature of our people...
...in our bonds to other societies...
...in what we do...

It will be a future of great challenge and responsibility...
Indeed, as you stand today on the threshold of a new century,
it seems clear that your generation will face problems and
challenges of a magnitude that would have been incomprehensible
in earlier times...

Further, your years following graduation will be a time of less security, less
stability, and more unpredictability than mine.

But you will also face a future of extraordinary opportunity and
excitement.

For, as the philosopher Whitehead has noted,
"The great ages have been unstable ages!"

Concluding Remarks

Emerson once noted that the wisest council of all to the young was to
"always do what you are afraid to do."

The truth is that adapting to change and challenge is what keeps our species evolving.
We should relish change. Welcome it. Seek it out.
Not for its own sake but for the challenge it brings and the possibility for progress.

We should approach life as a true adventure of opportunity and risk.

We are made for risk. We thrive on it.

I guess I tend to be an incurable optimist.

I believe that we can be masters of our fate.

That we can seize control of forces around us--most of all ourselves--
and bring progress to the world.

In fact, I even think that each individual has the possibility to change the world--
just remember the "butterfly effect"--you can change the world with
the beat of your own wings...

As Caltech graduates, you are uniquely qualified to work in the
exponential region of the knowledge curve!

There is an old saying that...

"The best way to predict the future is to invent it!"..

That is the real challenge before you!

To go out into that exciting world full of challenge and opportunity...

...and to invent the future!

Indeed, it is your challenge to make certain that
the future will not be what it used to be!

Congratulations...

...God-speed...

...and go get 'em

...and Go Blue!!!