

Santa Fe Institute 1.0 (11/1/90)

Welcome

Welcome to our guests from Santa Fe
and greetings to Michigan colleagues.

I am delighted to be here today.

This colloquium is of the highest interest and importance.
to our University and to the advancement of scholarship.
Several months ago, in a good demonstration of his political
skill, John Holland asked me to make a few remarks
at one of our sessions.

Of course, I knew the real purpose was to get me
involved in this dialog between SFI and UM...
...and since it gave me an excuse to get out of the office
for a couple of hours, I agreed.

The only problem is that I didn't have the foggiest idea of
what to say to such a group of distinguished scientists.
To be sure, I deal with "complex adaptive systems" every
minute of the day...from simple systems such as
state or federal government to many body problems
such as faculty governance...to the most complex
adaptive systems of all...creative and determined
faculty such as John Holland.

Further, the University itself is a "complex adaptive system"
...more complex than most people realize
...are far less adaptive than we would like

Actually, what I would like to do is to simply make
a few observations about
i) some of the particular intellectual challenges

faced by comprehensive research universities
such as Michigan

- ii) how unusual organizations such as the Santa Fe Institute can respond to these challenges by augmenting the intellectual activities of the University
- iii) and then conclude with an assorted of random, --and I am afraid not very profound or original-- questions about the nature of such institutes and their relationships to universities

The University as a Complex Adaptive System

Of course, the University of Michigan in many ways is the prototype of the comprehensive research university so unique to American society.

Parameters:

Enrollment: 35,000 (Ann Arbor) (47,000 total)

Faculty: 2,600 (14,000 employees)

Budget: \$1.5 billion

Academic Units

17 Schools and Colleges

Hundreds of research centers, institutes,
and other types of interdisciplinary
programs

Mission:

- i) Provides instruction, research, service
- ii) Spans all intellectual disciplines and professional areas
- iii) Attempts to conduct programs that rank

among the nation's best in all areas
(and succeeds...)

We also run the largest health care system in
the Midwest, treating over 750,000 patients each year...

We conduct events in the performing arts which rival
New York and London...

whether it be Leonard Bernstein performing his 70th
birthday concert with the Vienna Philharmonic
or, God-forbid, the Grateful Dead....

And, speaking of entertainment, we also have the
Mo and Steve show...the Michigan Wolverines...
playing in the fall to 105,000 every Saturday afternoon

On this campus, we provide one of the most
incredible intellectual smorgasbords in
the world--a fascinating cornucopia of
ideas supported by some of the finest
facilities in the world -- one of the nation's
great libraries, museums, laboratories,
computers, concert halls,
athletic facilities -- and even more
important, one of the world's great
faculties.

Michigan's **Heritage** of Leadership

Although Michigan was not the first of the state universities, it was the
first to free itself of sectarian control and become a true
public institution, governed by the people of the state.

So too, the organic act establishing the Michigan in 1837 was regarded
as

"the most advanced and effective plan for a state university, a model for all the state institutions of higher learning which were established subsequently."

From its founding, Michigan was identified with the most progressive forces in American higher education...

First to blend the classical curriculum with the German approach stressing faculty involvement in research and dedicated to the preparation of future scholars.

First university in the West to pioneer in professional education, starting the Medical School in 1850, the Law School in 1859, and engineering courses in 1854

Among the first to introduce instruction in zoology and botany, modern languages, modern history, American literature, pharmacy, dentistry, speech, journalism, teacher education, forestry, bacteriology, naval architecture, aeronautical engineering, computer engineering...and even in my own field, nuclear engineering (with the associated Michigan Memorial Phoenix Project)

Reputation as the flagship of public higher education

A large, comprehensive, public, research university

A serious commitment to scholarship

Unusual breadth, rich diversity of academic disciplines, professional schools, social and cultural activities...

...our intellectual pluralism...

Unusual degree of participation of faculty and students in

University decisions

Indeed, throughout its history, Michigan has been known for a spirit of democracy and tolerance among its students and faculty.

Harper's Weekly (1860):

"The most striking feature of the University is the broad and liberal spirit in which it does its work."

After all, in a very real sense, it was our University that developed the paradigm of the public university capable of responding to the needs of a rapidly changing America of the 19th century...
as American expanded to the frontier...
as it evolved through the industrial revolution...
as it absorbed wave after wave of immigrants
a paradigm that still dominates higher education today.
In a sense, we have been throughout our history the flagship of public higher education in America.

Reinventing the University

The winds of change are blowing...
stirring the cauldron of higher education
to create a new model of the university
for the future.

Few realize the the ever-accelerating
pace of change in our nation...and in the world!

Our students will inherit a much different America
than you and I have known...

i) It will be future in which our nation becomes a truly
multicultural society, with a cultural, racial, and
ethnic diversity that will be extraordinary in our history

In which those groups we refer to today as minorities will become the majority population of our nation in the century ahead...

In which women take their rightful place as leaders of America...

ii) It will be a future in which America will become "internationalized"...

in which every one of our activities must be viewed within the broader context of participation in the global community...

Whether through travel and communication, the arts and culture, the internationalization of commerce, capital, and labor, we will become increasingly interdependent on other nations and other peoples.

Further, as the destination of roughly half the world's immigrants, the United States is rapidly becoming a "world nation" with not simply economic and political but strong ethnic ties to all parts of the globe.

iii) The Age of Knowledge

But there are even more profound changes underway...

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.

Hence, is it not appropriate to question whether our present concept of the research university, developed largely to serve a homogeneous, domestic, industrial society...must also evolve rapidly if we are to serve the highly pluralistic, knowledge-intensive, world nation that will be America of the 21st Century.

Of course, this has been one of my themes for the past two years.

I have suggested that we should look at the decade ahead as a period during which we should accept the challenge of creating this new paradigm of the university to meet the needs of a new century--to respond to a changing nation and a changing world.

Indeed, I have suggested that perhaps it is time for Michigan to "re-invent" the University.

Now it is time for us as a faculty to focus our attention on our primary endeavors of teaching and scholarship and attempt to define the fundamental academic

mission of the University in light of the changes occurring
in our internal and external worlds.

We will not be alone in our deliberations.

From Harvard to Stanford, Cornell to Texas,
our peers are also taking up the challenge of reflection and renewal.

And we should remind ourselves that

As institutions, universities are always changing--
probably never more so than in the past fifty years
as the modern public comprehensive research university
that we know today took shape.

Challenges

Interdisciplinary Research

As Provost I have been frequently caught between

Those who believe that the most exciting
work today is occurring not within the disciplines,
but at the interfaces between them where there
is a collision of ideas that leads to new knowledge.

Some would even contend that this deification of
the disciplines may be leading the academy toward
intellectual stagnation, trapped in the sterile
pursuits of increasingly specialized studies.

But there are also those who believe that there is a certain
faddish nature to interdisciplinary work...
and that efforts to stimulate this activity
are, in reality, just causing people to staple
together unrelated projects into proposals so
that they smell more interdisciplinary...

It is certainly true that the academic disciplines today

tend to dominate the modern university...whether in the areas of curriculum, resource flow, administration, or rewards.

Further, it also seems clear that increasing specialization has led many of our colleagues to focus their loyalties more on their disciplines than the institution, thereby losing that sense of a community of scholars so important to a University.

As we attempt to build stronger and stronger programs in the traditional disciplines, we also tend to create strong centrifugal forces which tend to push the various components of the University to the periphery.

On the other hand, we can also diminish the intellectual core of the institution by forcing interdisciplinary activity where it is not really appropriate, thereby perhaps diverting badly needed resources from the disciplines and starving the core of the University.

Achieving the appropriate balance between the disciplines and interdisciplinary teaching and scholarship is one of the major challenges before institutions such as ours...just as it is before the nation's research establishment.

The Role of SFI

Fortunately, this University has a very natural mechanism to stimulate and sustain interdisciplinary activities without the bureaucracy frequently associated with major centers and institutes...

It is Rackham.

Rackham plays a uniquely unifying
role by serving to draw us together
in a common effort as a community of scholars.

Score one for Rackham.

Venturesome Research

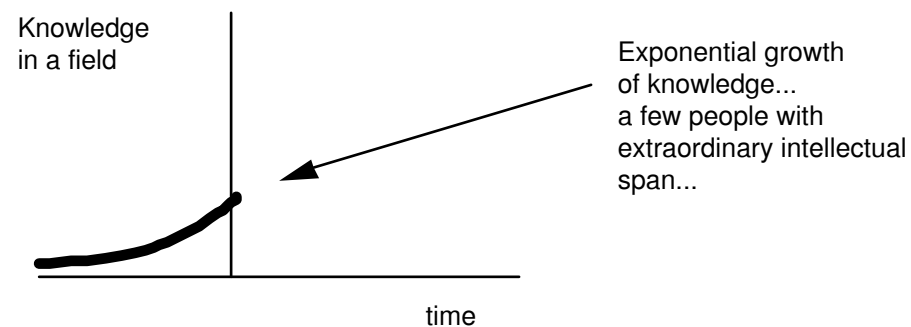
University must be responsive to changing
intellectual currents.

Intellectual leadership...

demands pushing to the forefront of discovery

This term comes from a discussion I had with
a Caltech faculty member, Carver Mead,
a number of years ago in which he characterized
the growth of knowledge in a field over time as
a familiar S-shaped 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...



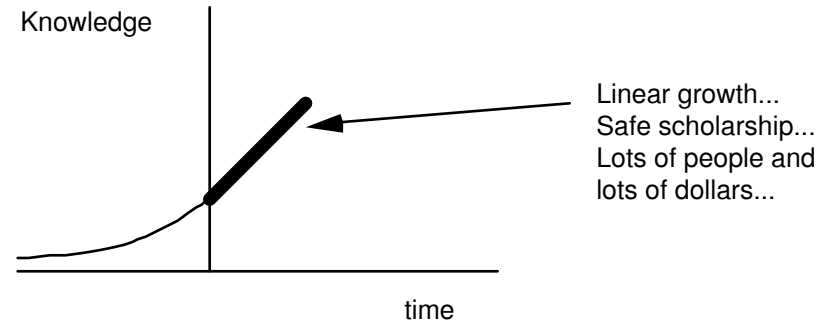
At this early stage, a few individuals of
exceptional ability and great intellectual span can
have truly extraordinary impact, essentially
stimulating and defining entirely new fields

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....

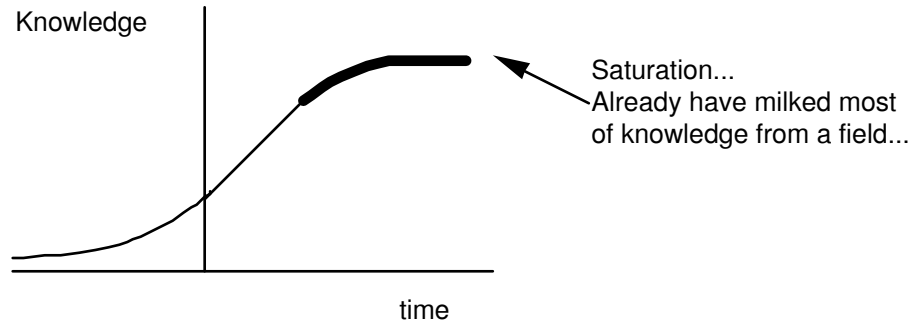


In this stage, the more resources you throw at an area...the more people or dollars...the more you learn...

(I usually refer to this as the Michigan region of the knowledge curve...you might prefer to call it the MIT region instead...)

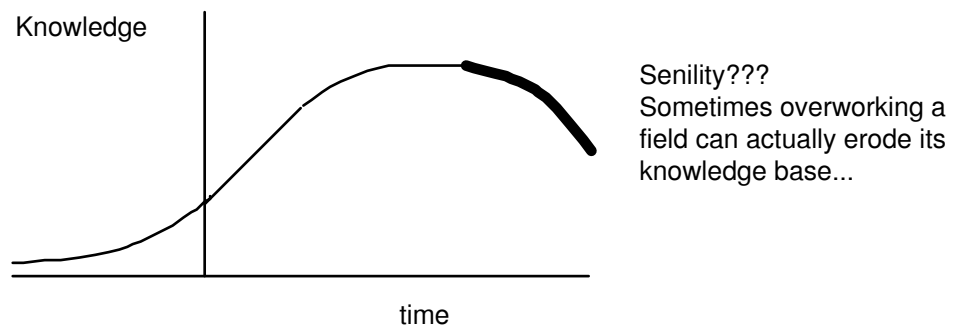
This is where it is "safest" to work... easiest to get grants and to achieve tenure...

As the field matures still further, the growth in knowledge tails off...it saturates...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.



(Actually, there have been times recently when I've begun to wonder if my old field, nuclear fusion, has entered this final phase of intellectual evolution of late...)

All too often people...and institutions... tend to regard their role more as the keepers and transmitters of existing knowledge than as the creators of new knowledge...and chose to work only on the safe problems.

Role of SFI:

Once again, Rackham comes to the rescue...

1. As a home for highly venturesome scholarship
2. As a source of stimulation, encouragement,
and support of high-risk activities

Change and Renewal

The Challenge

I believe that it was Burke who said that:

"A state without the means of change is without the
means for its preservation"

The capacity for intellectual change and renewal
has become increasingly important to
academic institutions.

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

In many fields, the knowledge base is doubling every
few years...

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...

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.

Role of SFI:

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.

And, once again, Rackham rides to the rescue...

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, Rackham can encourage the fluctuations in our scholarship...becoming, in effect the Rackham School of Chaotic Studies

Questions

1. Crass and mundane question

How does one sustain the financial support of such separate entities?

Comprehensive universities, by their very nature, are characterized by broad resource portfolios...

...tuition dollars

...state support

...federal research support

...private giving

...endowment

...auxiliary activities

(hospitals and football teams)

National labs like LASL always have one big sugar daddy...DOE, DOD, or whatever

But what about novel organizations such as SFI?

...federal

...private

Worry about long term stability...and the amount of your energy which has to be spent in keeping the wolf from the door.

2. Can such a “think tank” structure focused on a single intellectual area such as “complex adaptive systems” be sustained for the long haul?

i) Worry that this may be another example of a solution in search of a problem...

Having dabbled in an earlier existence in similar areas...

...nonequilibrium statistical mechanics

...the many body problem

I know all too well the seduction of elegant formalisms

Must always ask “Where is the beef?”

Or in a more crass way, what is your product, your deliverable?

ii) Other models: RAND, MITRE, SRI...

...all were forced to become quite comprehensive
to survive

3. Are there alternative forms of intellectual structures better
suited to meeting the challenges of the university

i) collaboration technology

ii) colabs

iii) information technology

4. Is it really appropriate...or, in a sense, “intellectual healthy”, to
build such an intellectual entity in physical isolation from the campus.

To be sure, Santa Fe is lovely

...Great weather

...Great skiing

I've been there...in fact, I've even done time “On the Hill”

But the great character of the modern research university
is due, in part, to its rich diversity...

...its array of academic and professional disciplines

...its broad mix of resources, from libraries to laboratories,

computers and networks,

theatres and museums,

hospitals and football stadiums,...

...its multiple missions...teaching, research, service,

health care, economic development, social development,

entertainment, political activism,

social and cultural change

...its rich mix of students at the undergraduate, graduate,
and professional level
...its increasingly multicultural nature...
characterized by great diversity and pluralism
of people from every race, religion, nationality, belief,
socioeconomic background, and political persuasion
...its extraordinary array of intellectual, cultural, social,
and political activities and issues

It has always struck me that such structures as SFI, set up apart
from the campus, run the risk of becoming somewhat sterile,
detached as they are from the rich diversity of the university.
(Incidentally, I have always felt the same about the national laboratories
...and tended to discourage my students from conducting their
PhD research off campus for that reason).

Concluding Remarks

As Murray Gell-Mann points out in his paper on the Institute,
Santa Fe offers universities a needed challenge by example
and it gives some of our most productive scholars
a challenging arena for interaction and collaboration.

I agree completely with this proposition.

The work of the Institute and our Michigan group
is generating new understanding,
both theoretical and applied, across fields as seemingly diverse as
the global economy, theoretical immunology, psychology and ecology.

SFI reponds to what is largely missing today
boldness and daring,
the willingness to take risks,
to dream dreams,

to step beyond narrow questions
or specialized disciplinary boundaries.

to seek and welcome vast and seemingly overwhelming intellectual
challenges.

And this is where SFI is playing such a critical role

It is not just the research itself but as a catalyst for change
for broadening our intellectual horizons.

Thus for me, the greatest contribution of your work is to give us inspiration.

Out of the perhaps too ordered world of disciplinary scholarship

you have brought us “chaos”

and very welcome it is, too,

as it opens us to a whole new world of scholarly creation.

I look forward to following your progress

both in this Colloquium and in the years to come.

We have definitely got a win-win relationship going.

And its ultimate contributions will spread benefits far beyond
the research community.

thank you.