

## Flat Panel Display Conference

### Buzzwords

“strategic research”

“technology policy”

“industrial policy”

### Some Signs of the Times

There are many reasons for concern today...

The crash of big science...

The myopic Hubble Space Telescope

The Mars Observer (poof...)

The collapse of the SSC project

The controversy over LIGO, Gemini

Science and Indicators

Compared to other nations, the US still maintains  
the largest investment in total R&D and industrial R&D.

However other countries are either closing the gap or  
even lead the US by some measures.

The real rate of growth in US industrial R&D has been  
declining since the late 1970s and early 1980s.

Our national investment in nondefense R&D continues  
to lag behind that of other nations.

While academic continues to increase its share of  
national R&D, federal funding as a fraction of  
this has been declining since 1980, with  
contributions from the universities themselves  
increasing.

International comparisons between the highest achieving  
nations and the US continue to show lagging US  
performance, even when comparing our best  
school districts.

The absolute number of UG degrees in engineering,

mathematics, and computer science continues to decline.

#### Mission Agencies

NASA is rapidly reducing fundamental space science in favor of mission projects  
E.g., priorities are indicated as Mission to Planet Earth, Space Station,...and any science will only be conducted in support of these missions

The Department of Energy seems to be focusing more on correcting the sins of the past  
...radioactive waste  
...dismantling nuclear weapons  
...human experiments with radioactivity  
than looking toward the future.

And, of course, the Department of Defense is downsizing rapidly--so-called "defense conversion"--and basic research (6.1 projects) is the first casualty.

#### The stresses on universities

During the course of the past year, I have been involved in an effort sponsored by the National Science Board to understand better the stresses on the academy as seen from the perspectives both of the faculty and university administrations.

It is clear from a number of forums we have hosted on university campuses

across the nation that there is a growing gulf between those characteristics faculty value--such as an emphasis on basic research, a highly disciplinary focus, and strong, long-term support for individual investigators--and the terms dictated by federal and industrial sponsors,

e.g., more applied investigations of a highly interdisciplinary nature

involving large research teams.

Put another way, the faculty believes they are deprived of the opportunity

to do what they do best--thinking, dreaming, talking, teaching, and writing--by the pressures of the day which force them to hustle contract research, manage research projects, and deal with government and university bureaucrats, all of which takes them out of not only the classroom but the laboratory as well.□

While the stress on the faculty today has many symptoms, it has fundamentally one major cause: the stress associated by the reaction to change--change occurring far more rapidly in universities than most of us are comfortable with.

Indeed, one member of our study group remarked that university faculties

appear to be the last groups remaining in our society who believe that

"the status quo is still an option"!□

### **What is Going On**

From guns to butter...

For almost half a century, the driving force behind many of the major investments in our national infrastructure has been the concern for national security in the era of the Cold War.

The evolution of the research university, the national laboratories,

the interstate highway system, our telecommunications systems and airports, the space program, all were stimulated by concerns about the arms race and competing with the Communist Bloc.

So too, much of the technology that we take for granted,

from semiconductors to jet aircraft, from computers to composite materials, all were spin-offs of the defense industry.

Yet in the wake of the extraordinary events of the last five years --the disintegration of the Soviet Union and Eastern Europe, the reunification of Germany, and the major steps toward peace in the Middle East --the driving force of national security has disappeared, and along with it, much of the motivation for major public investment. Far from a "peace dividend" providing new resources in a post-Cold War world for investment in key areas such as education and research, instead the nation is drifting in search of new driving imperatives.

While there are numerous societal concerns such as economic competitiveness, national health care, crime, and K-12 education, none of these has yet assumed an urgency sufficient to set new priorities for public investments.

Further, much of the existing intellectual infrastructure, developed to underpin national defense, is now at risk.

The national laboratories are facing massive downsizing and necessarily searching for new missions.

The burdens of the massive debts incurred in the buyout-merger mania of the late 1980s have forced corporate America to downsize R&D activities, including the shift of many of America's leading corporate research laboratories such as the Bell Laboratories and the IBM Research Laboratories from long-term research to short-term product development.

Equally serious are signs that the nation is no longer willing to invest in research performed by universities, at least at the same level and with a similar willingness

to support curiosity-driven basic research. Congress has made it clear that it will insist that universities focus increasingly on applied research, more directly related to national priorities (although many industrial leaders have tried in vain to explain that without "basic" research, there is nothing to "apply").

The federal government has yet to develop an successor to the government-university research partnership which served so well during the Cold War years.

“So the whole issue of having to interact with the outside world and having to understand some of the needs is really very important.

We are entering an era in which the boundaries between basic and applied research erode.

Today's more powerful link between scientific leadership economic security, and quality of life will provide the new impetus and rationale for the support of science in the post-Vannevar Bush Era, just as the valuable military contributions of science gave Bush and his colleagues the standing to launch the current era of federal support of science.

There is also a generational effect facing the scientific community today.

Before the creation of the National Science Foundation after the second World War, and during many of the subsequent years,

we did not have to spend time justifying our R&D efforts.

The nation seemed grateful for the contributions of our scientists.

Today we have many people in positions of power who weren't around at that time. And the general public may not consider the legacy to be that we won the war, but rather that we have

to consider the environmental consequences of nuclear explosions,  
or that we have living among us people who unknowingly participated in radiation experiments.

#### The Post-Vannevar Bush Era

Reports:

NSB

PCAST

FCCNET

GUIRR

COSEPUP

Science policy is very high on the domestic and international agendas

of many nations...not to remain on the scientific frontier, but from an increased anxiety to put in place public policies that will maximize a nation's continuing capacity to develop and deploy economically competitive technologies in the new international marketplace.

- i) Driven by the rapid convergence of incomes, productivity, and the ability to develop and effectively implement new technologies
- ii) A more open world economy
- ii) the increasing technological intensity of an ever-wider spectrum of products
- iv) the continued escalation of the pace of discovery
- v) the rapid development of world-wide "information nets" that allow the quicker dispersion of new knowledge and know-how.

#### The view from Washington

US Science Policy has become a mosaic of policies that is now rather poorly coordinated. It has become increasingly

dominated by the manner different, largely mission-orientated congressional initiatives. While most accept the view that basic research was an important component of any self-sustaining innovation system, the objectives of US science policy has always been motivated by very practical and rather well-defined pragmatic objectives.

Most observers would agree that despite a high level of federal support for R&D, the current federal investment in R&D is no longer based on any coherent overall policy or strategy.

And what is the current sentiment in Washington?

In general, there is a lot of apprehension about the commitment of the Clinton Administration to basic research.

You may have also heard the buzz that research universities, or perhaps more accurately higher education, has become just another special interest group, fighting for a piece of the federal budget each year.

Much of the problem is the institutional structure of Congress where most committees and therefore budget decisions are organized around specific mission-orientated agencies (e.g., defense, energy, health...)

### **Some Work on Language**

Basic Research: research that leads to new understanding of how nature works and of how its many facets are interconnected.

Applied Research: research aimed at making some thing work.

But now we can see why these definitions blur, since an often useful strategy of making something work is to understand some aspect of Nature's working.

Conversely, many scientists who achieve new understanding from their basic research are highly motivated to turn that understanding into some new device or process, some new, made thing.

From this vantage point it is easy to be clear by basic research is important to a country or a company and NOT a luxury. The importance of basic research stems first from the fact that it from time to time discovers or creates unexpectedly vast new possibilities for achieving society's goals.

Strategic Research: Research than can reasonably be expected to contribute to goals, including understanding-driven basic research.

Strategic research is not synonymous with applied research.

It is a categorization which is important primarily to the supporters, not the doers of research. It is research in scientific areas which are good bets to be helpful in reaching agreed-upon goals. It can be basic or applied; indeed, in the strategic areas, it is the task of those who support research to support the complete spectrum of research, from the most basic and fundamental to engineering and applied research.

There is no inherent conflict between strategic research and research done by individuals driven by a desire to understand nature. The strategic goal for which research is supported and the motivations of individual researchers are different things, and they are measured if along different dimensions.

### **What Are the Real Dangers?**

The eroding American research triad

The American research enterprise is a triad:

research universities

national laboratories

industrial R&D labs

The latter two are rapidly being forced to downsize fundamental research, while the first is under great stress.



- i) the continuation of the downsizing of industrial R&D  
(noting the Schmitt-Bement task force report)
- ii) the downsizing of basic research in key federal mission agencies  
(e.g., space science in NASA, 6.1 research in DOD, basic research in DOE with the demise of the SSC)
- iii) the downsizing and loss of mission of the national labs
- iv) the great stresses on the American research university  
(e.g., GUIRR study)

Our nation faces a great risk if it allows the current downsizing of basic research to continue.

Clearly it is possible to pick out areas of basic research which are a good bet

to help in achieving society's goals. But it does not follow that we know

what areas of science are NOT relevant.

A further reason why it is prudent to keep many of the discipline-only-driven fields healthy and vigorous is that they contribute strongly to the health of the whole of science, and in particular to the health of the so-called strategic areas, including basic research in the strategic areas.

#### Changing attitudes in Washington

Federal policy makers seem to be in hot haste to curtail exploratory basic

research at universities. The short term benefits of such a more are

questionable. The longer term consequences could be disastrous.

Congress wants federally-supported research to be highly focused on

specific national goals.

Unfortunately, at the same time exploratory basic research is also being

curtailed at major companies and at national labs.

The need for change in the American University

I'm certain that many of you have had a chance to take a look at the Fall 1993 issues of *Daedalus*, an issue devoted entirely to the American research university.

In an article Kenneth Prewitt of the Rockefeller Foundation titled, "America's Research Universities Under Public Scrutiny,"

Prewitt states that the general public has taken to asking research universities,

"What have you done for us lately?"

And, "Is the product worth the price?"

Prewitt added, "Public skepticism toward institutional sectors has become a fact of American political life.

No one would be foolish enough to suggest that universities are exempt from this public skepticism.

If the funds now supplied to NSF were diverted from the support of academic exploratory research, they would add comparatively little to a huge activity.

As a result of the diversion, the universities would be injured, and our world leadership in understanding nature would be injured.

### **What Can We Do About It?**

Where might we go from here with respect to protecting the basic research capability of our nation? How could we proceed to improve the situation? We must show the benefits of our work. Although there will be some of our colleagues who would prefer not to have to do so, we must make our case---learning to become better at politics, if you will--for the support of basic research.

Make the case for the importance of basic research!

What do the following advances in technology have in common?

modern agricultural products  
biotechnology  
designer drugs  
MRI systems  
penicillin and other antibiotics  
industrial catalysts  
CNC machine tools  
digital signal processing  
the modern computer  
frequency modulation  
masers and lasers  
ion implantation  
computer work stations  
plasma etching  
RISC computers  
artificial intelligence and neural networks  
compilers  
word processing  
image processing  
instrument landing systems, loran, inertial guidance  
nuclear energy

This is an incomplete sample of technological breakthroughs  
based on fundamental science and engineering...  
and universities played an important role in their  
conception, development, demonstration, and implementation.

Many were serendipitous consequences of fundamental research  
in that the investigator did not anticipate the commercial  
application.

This sample list is the 20th C prologue to a 21st C paradigm  
in which new knowledge will be the currency of

successful industry--an age of knowledge.

Each nation has to find its own route to economic success.

For the US, and possibly for a few other advanced nations as well,

it may be that their comparative advantage will be leadership in research and training in fundamental science and engineering.

Also have to put things in context.

Industry invests over \$55 B in R&D (and generates \$2 G in sales)

Industrial Research Institute notes:

“Since industry allocates only a small fraction of its R&D effort

to basic research, the success of our industrial R&D effort depends heavily on America’s universities for new knowledge

and highly trained scientists and engineers.

COSEPUP

Unpredictability of research:

Quantum mechanics --> electrons in solids

--> transistor --> computers

Premises:

i) The US should be among the world leaders in every major fields of science.

Hence if something does happen, you can

rapidly jump in--e.g., superconductivity in Switzerland.

This also gives a stable level of effort.

(Note: This accepts the fact that some science may turn out to be important.)

ii) The US should maintain clear leadership in some major areas of science.

(Note: This accepts the fact that some science

will almost certainly be important.)

Example: SSC

Should the US be alone at the top in fundamental particle physics? (No...)

If no, do we need the SSC to be among the leaders? (No...)

Q: Is this likely to have any impact in the present political climate?

White House leadership

In first days in office:

“Scientific advances are the wellspring of the technical innovations whose benefits are seen in economic growth, improved health care, and many other areas.”

However, to assure the highest possible return on the public investment in science and engineering, there are new pressures for a stronger focus on research areas of known relevance and on greater accountability.

A coherent national science and technology policy, a stronger industrial research mission, and a refocused mission for federal laboratories are essential components of this strategy.

White House Activities

A new National Science and Technology Council  
chaired by President

Establishment of 9 subcommittees, including  
a Fundamental Science and Engineering Research  
Committee  
(cochaired by Lane and Varmus and staffed by MRC  
Greenwood)

What is its focus?

...How to allocate the \$76 billion the nation spends on R&D  
each year...

...To determine whether it should be spending more...or less.

White House forum in two weeks

...Homer Neal and JJD

NSF role: protect basic research (after all, only 10% of federal R&D is fundamental research).

Believe that the key will be position NSF to play a key role in working with other agencies with more applied missions.

Much of mission of NSF is to maintain scientific capability, not just to find new hot spots.

Other Ideas

Hans Bethe article:

We need to make better use of the nation labs for the applied, strategic R&D necessary to respond to national goals such as competitiveness,

And keep the universities (and the NSF) focused on the basic research necessary to provide the knowledge necessary to sustain these applied efforts.

Getting our own house in order...

The Office of the Vice President for Research at Michigan is already planning to organize a follow-up conference to bring together representatives from the major research institutions and others from the scientific community to discuss exactly what such a group can and should do to make the case for supporting basic research.

What are some of the questions research universities must ask themselves now, in order to best continue our obligations to society?

Jonathan Cole, Provost at Columbia University, has listed the following

in his piece on the dilemmas of choice facing research universities:

- What role should the research universities play in modifying or replacing the Vannevar Bush paradigm with a new framework that maintains American preeminence in science and preserves the research university's role as the principal incubator of scientific ideas and talent?
- How can research universities retain commitments from the federal government while simultaneously developing new sources of research support?
- Can and should university scientists redefine their scientific goals and reorient themselves toward new types of scientific and technological problems that have the potential for short-term practical results?
- Can research universities adapt successfully to changing research conditions by increasing the number of inter-university collaborations and consortia research efforts?
- Can research universities increasingly collaborate with international partners without undermining national economic interests and American support for their research. How can research universities develop new research relationships with the industrial and corporate world without entering into

a Faustian bargain?arch efforts?

NSB effort

NSB Statement

As the 20th C draws to a close, the US is reaping the benefits of a half-century of extraordinary scientific and technological progress. The development of drugs and vaccines allows us to treat or prevent many once devastating diseases; agriculture has been made unimaginably productive; entire industries, such as semiconductor manufacturing, have arisen; work and leisure have been remade; and vast quantities of information now flow freely around the globe.

Each of these transforming advances has its origin in a wide array of

discoveries made by scientists, engineers, and mathematicians

pursuing a deeper understanding of the world we live in.

Using

fundamental methods of scientific inquiry, these men and women have

reshaped our world. This endeavor is basic research.

NSB Commission noted that research can be undertaken both to achieve strategic ends and to increase the base of knowledge.

Basic research is the foundation and essence of both, assuring

a deep reservoir of knowledge and providing choices and flexibility

for addressing future needs. Moreover, in the age of knowledge,

the problem solving approach of basic research helps prepare minds for work in all walks of life.



Basic research is one of many forces that contribute to the nation's

economic development.

Its benefits will be achieved only in connection with other parts of the nation's scientific and technological enterprise, including applied research, education, technology transfer, and

development, innovation, and manufacturing.

Basic research is not intended--nor should it be expected--to advance

short term goals. Rather it is an investment that, like education,

takes time to mature but has tremendous practical payoffs in the

long run.

Assuring the knowledge base appropriate for economic growth, long

term job creation, and social well being requires a conscious commitment to strong and consistent long term support for basic

research and education. Providing requisite support for this process is a matter of strategic national importance.