Technological Innovation
In the 21st Century

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President, National Academy of Engineering

Committee on Science, Engineering, and Public Policy
The National Academies
Washington, DC
September 4, 2009
Technological Innovation

1. Why is everyone in a hurry?

2. Where are we?

3. What do we see?

4. Where have we been?

5. Where do we need to go?

6. How are we going to get there?
Technological Innovation*

1. *Why is everyone in a hurry?*

2. *Where are we?*

3. *What do we see?*

4. *Where have we been?*

5. *Where do we need to go?*

6. *How are we going to get there?*

*Well, it’s not just Technological.
Why is everyone in a hurry?

Sound bites

Poetry

Facts
“Innovate or Abdicate”

-Sam Palmisano, CEO, IBM
It doesn’t matter whether you’re a lion or a gazelle- when the sun comes up, you’d better be running.

-Richard Hodgetts
Why Everyone is in a Hurry.

A bar chart showing the years for innovative products to reach 25% of the U.S. Population.

- World Wide Web: 10 years
- Cell Phone: 15 years
- Personal Computer: 20 years
- Radio: 25 years
- Telephone: 35 years
- Automobile: 55 years

The chart indicates that the automobile took the longest to reach 25% of the U.S. population, while the World Wide Web took the shortest time.
Where are we?

Four Facts
Three Consequences
One Principle
And an Irony
Four Facts

• People everywhere are smart and capable.
• Science and Technology advance relentlessly.
• Globalization is a dominating reality.
• The Internet and World Wide Web are democratizing forces.
Three Consequences

- Individuals must innovate.
- Companies must innovate.
- Nations and regions must innovate.
One Principle

Competition drives Excellence and Innovation

• Competition among universities
  – For the best students, faculty, research, and scholarship
  – Merit-based awarding of research grants

• Competition among companies
  – To create new markets
  – To get to market first
  – To gain market share
An Irony

In the 21st century Cooperation and Competition reinforce each other.
What do we see?

Research

People

R&D Funding
R&D is increasingly performed in “Pasteur’s Quadrant”

Research is inspired by:

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- Pure Basic Research (Bohr)
- Pure Applied Research (Edison)

Adapted from *Pasteur’s Quadrant: Basic Science and Technological Innovation*, Donald E. Stokes 1997
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First Engineering Degrees
(China Rises.)

Source: Science and Engineering Indicators 2006, National Science Foundation, Washington, DC
S&E UG Degrees

Source: NSF Science and Engineering Indicators 2008
Global R&D Investments
R&D Expenditures and Share of World Total

Data for 2002
World total = $813

NOTES: R&D estimates from 91 countries in billions of purchasing power parity dollars. Percentages may not add to 100 because of rounding.

Source: Science and Engineering Indicators, NSF 2008
Where have we been?

America’s Innovation System from 1945-2005

A Brief history
The Vannevar Bush Report, 1945

Primary Recommendations

• Universities should be the primary national Basic Research Infrastructure.

• Federal dollars do double duty:
  – Procure research results
  – Educate the next generation

• Award research grants based on competitive merit.

• Establish a National Science Foundation.
The Bush Report’s Economic Development Assumptions

- **Linear**
  
  Basic Research $\rightarrow$ Applied Research $\rightarrow$
  Product Development $\rightarrow$ Market Products and Services

- **Laissez-faire**
  
  Do basic research in universities and leave its commercialization to chance and market forces.
From 1945 - 1985

• American research universities grew to excel.

• American companies dominated.

• Large corporations dominated.

• Corporations developed massive central research laboratories
  – Attracted outstanding university graduates
  – Conducted outstanding pure and applied research
  – Contributed to the S&T Commons
Two Tectonic Shifts in the 1980s and 1990s

- Japanese companies suddenly dominated manufacturing.

- American entrepreneurship expanded explosively.
The Japanese Total Quality Movement was the Major Innovation of the 1980s.

It changed everything.
Evolution of U.S. Corporate Innovation and R&D

• 1970s: Central Corporate Research Labs

• 1980s: R&D Absorbed and Transformed into Product Development

• 1990s: Purchase High-Tech Startups to acquire Innovation

• 2000s: Open Innovation Systems
Evolution of U.S. University Research

- 1970s: The Engineering Science Revolution
- 1980s: Design, Manufacturing, Computer Science, Joint Management/Engineering
- 1990s: Life Science, Interdisciplinary, More “Use-Inspired”
- 2000s: These trends accelerating; more global cooperation
Where do we need to go?

• Henry Chesbrough
• Clayton Christensen
• Michael Piore and Richard Lester
• John Hagel and John Seeley-Brown
• Judy Estrin
• Charles Weiss and William Bonvillian
How are we going to get there?
Life Sciences and Information Technology

21st century Innovation
Disruptive Technologies
For Grand Challenges

21st century
Innovation
Macro Systems especially Energy

21st century Innovation
A new Enabling Technology?

21st century Innovation
Future of Venture Capital?

21st century Innovation
Globalization of R&D Education Workforce

21st century Innovation
Life Sciences and Information Technology

Macro Systems especially Energy

Globalization of R&D Education Workforce

A new Enabling Technology?

Disruptive Technologies For Grand Challenges

Future of Venture Capital?
Evolution of current Innovation System

Inducement Prizes

Virtual Communities

Discovery Innovation Institutes

New Universities

New Educational Organizations

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Aalto University
Olin College
Singapore
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21st century Innovation

Singularity University
Evolution of current Innovation System

Inducement Prizes

Discovery Innovation Institutes

New Universities

New Educational Organizations

Virtual Communities

21st century Innovation

Wikipedia
Roseta@Home.Org
IBM Innovation Jam
Social Networking
Extensive conformational sampling with Rosetta@Home

source: Prof. David Baker, University of Washington
Evolution of current Innovation System

Inducement Prizes

Discovery Innovation Institutes

Virtual Communities

X Prizes

DOE Grand Challenges

New Universities

New Educational Organizations

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- Discovery Innovation Institutes
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In closing …
Relentless Change
Grand Challenges
Distributed Intelligence
S&T Acceleration
Globalization
Internet Democracy
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21st century Innovation

To Be Determined by
A New Generation
Thank you.