

# The Current Model of STEM Graduate Education and Postdocs

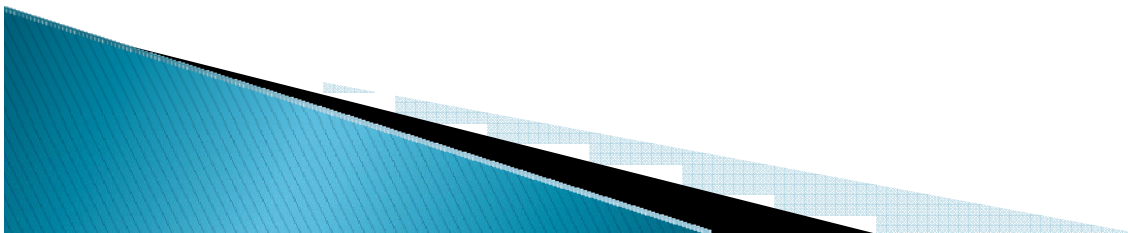
*Is it **evolving** to meet needs of the nation  
and its participants?*

Michael S. Teitelbaum  
Vice President

Alfred P. Sloan Foundation  
OSTP, November 5–6, 2007

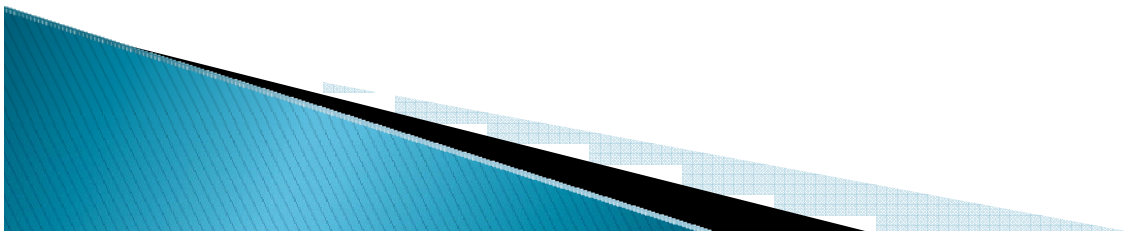
# How well aligned is the current model with national needs?

- ▶ Summary: not very well
- ▶ Persistent “shortage” claims by employers
- ▶ Growth in PhDs and postdocs...
- ▶ ...yet poor prospects for recent PhDs/postdocs
- ▶ Federal \$ focus on PhD, designed for academe
- ▶ But career growth potential outside academe
- ▶ CHALLENGE: how **evolve** w/ minimal damage?



# “Shortages” and “shortfalls”: Washington perennials

- ▶ Long, embarrassing history
- ▶ Late 1980s: “looming shortfall” forecasts
  - Strong criticism from inside NSF---ignored
  - Few years later: Congressional investigation
- ▶ Late 1990s: IT firms’ “shortages” lobbying
  - Dubious data on “unfilled IT jobs” (ITAA)
  - Success: H-1B visas tripled beginning 2001
  - Timing exquisitely poor--IT bust began 2001...
- ▶ 2005-07: employers, National Academies



# TAPPING AMERICA'S POTENTIAL

The Education for Innovation Initiative

AeA

Business Roundtable

Business-Higher Education Forum

Computer Systems Policy Project

Council on Competitiveness

Information Technology  
Association of America

Information Technology Industry  
Council

Minority Business RoundTable

National Association of  
Manufacturers

National Defense Industrial  
Association

Semiconductor Industry  
Association

Software and Information  
Industry Association

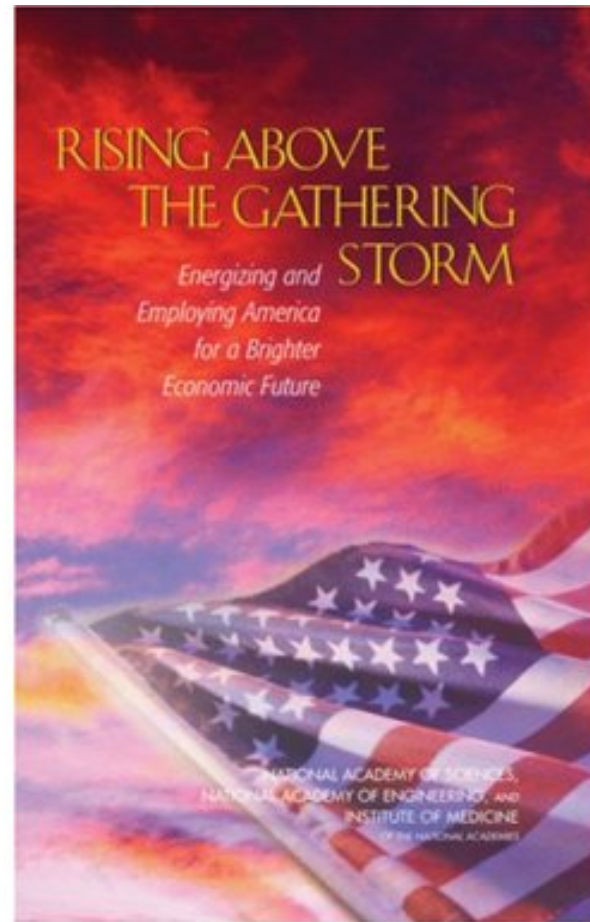
TechNet

Telecommunications Industry  
Association

U.S. Chamber of Commerce

**GOAL:**

*Double the number of science, technology,  
engineering and mathematics graduates by 2015*



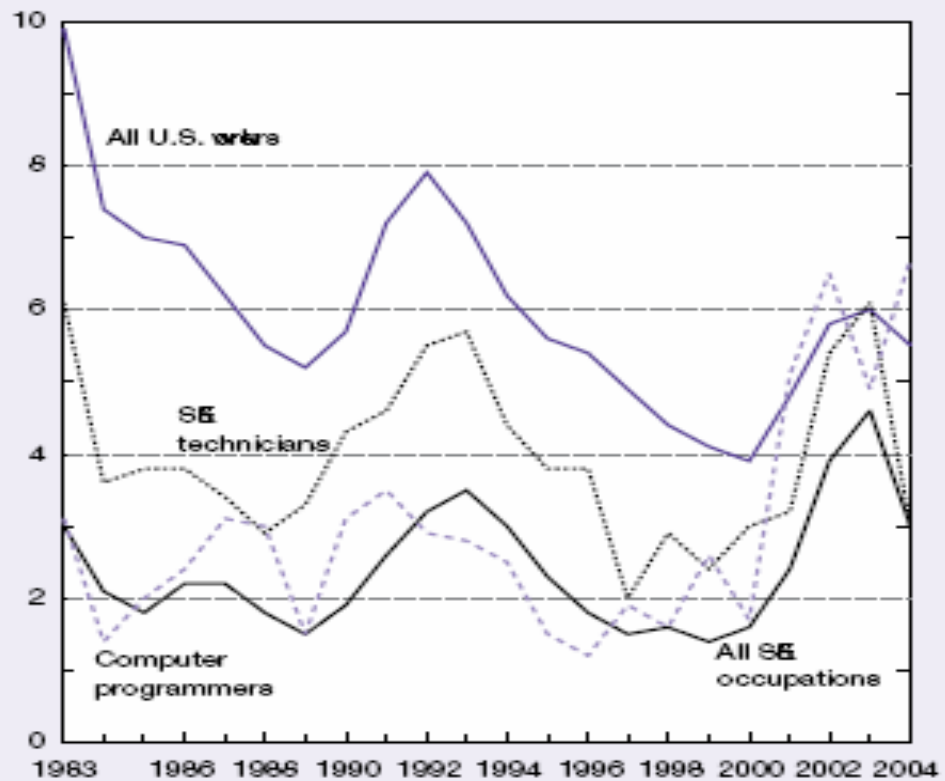
# The evidence?: labor markets slack...

- ▶ No general shortages discernable in data
- ▶ Remuneration flat, career paths unstable
- ▶ Lots of variation over time, and by field
  - “Hot” fields can coexist with slack general markets
- ▶ If anything, data point more to surpluses...
- ▶ ...even during ‘90s high-tech boom? (RAND)  
*...rising S&E unemployment that “while the overall economy is doing well, is a strong indicator of developing surpluses of workers, not shortages.”*
- ▶ Since: IT, telecom, biotech bubbles burst



Figure 3-12  
**Unemployment rate, by occupation: 1983–2004**

Percent

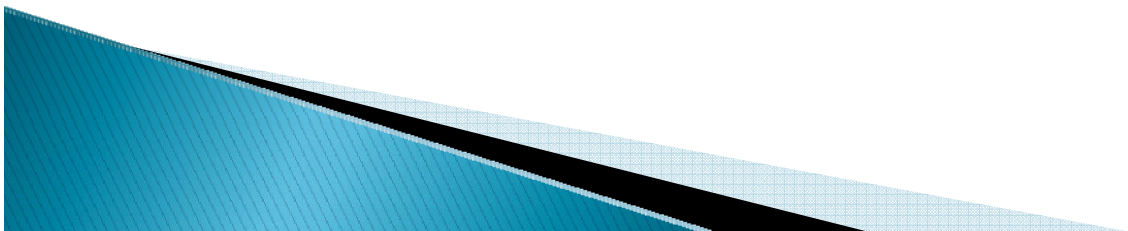


SOURCE: National Bureau of Economic Research, *Merged Outgoing Rotation Group Files*, from U.S. Department of Labor, Bureau of Labor Statistics, Current Population Survey. See appendices 3–8.

*Science and Engineering Indicators 2006*

# Yet “shortage” claims continue – why?

- ▶ Interest groups making their case
  - Employers
  - Universities
  - Government funders
  - Immigration lawyers
- ▶ Intend no harm; just promoting interests
- ▶ But politicians, journalists often believe
- ▶ & Federal agencies often fail to analyze





## Supply Without Demand

If there is one domain of science policy in which bad estimates have become routine, it is the one we used to call “scientific manpower.” Time after time we have been warned of impending shortages which, with evergreen consistency, are subsequently transformed into gluts, to the dismay of those most affected: the future practitioners of our disciplines. Somehow, the predictors seem to forget that calls to increase future supply should bear some relationship to the present balance between supply and demand.

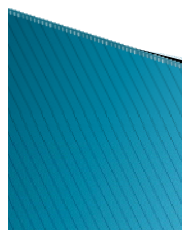
This is an old problem in the United States, where the ill-advised prognostications of the National Science Foundation in the early 1990s were followed by intense congressional criticism and widespread outrage among graduate students and postdocs. The National Science Board has apparently not profited from that harsh lesson. Now, expressing concern that few native-born citizens are entering scientific careers, it calls for an intensified national effort to expand domestic production. Meanwhile, unemployment rates for scientists are going up; according to the American Chemical Society, they have doubled among chemists over the past 2 years.

The habit is apparently contagious. On the other side of the Atlantic, the European Union has set targets for increases in R&D spending that, it predicts, will require 700,000 new scientists in the coming years. To meet this anticipated demand, the European Commission (EC) is implementing a series of new programs, as Philippe Busquin reported on this page last month (*Science* 9 January 2004, p. 145). But repatriation and mobility won't solve the problem. At an EC meeting at Rockefeller University in December 2003, angry expatriate Italian scientists pointed out that even if they want to go home, as many do, there are no jobs for them.

What is going on here? Why do we keep wishing to expand the supply of scientists even though there is no evidence of imminent shortages, and most jobs are in the private sector, where they are immune to management by policy fiat? First, there is a widespread belief that economic progress depends on science and technology; why shouldn't we have more of such a good thing? Second, policies are set mainly by elders, who, like the institutions that employ them, have little incentive to downsize their operations. Instead, academic reward structures and government funding priorities tend to perpetuate the “train more scientists” status quo.

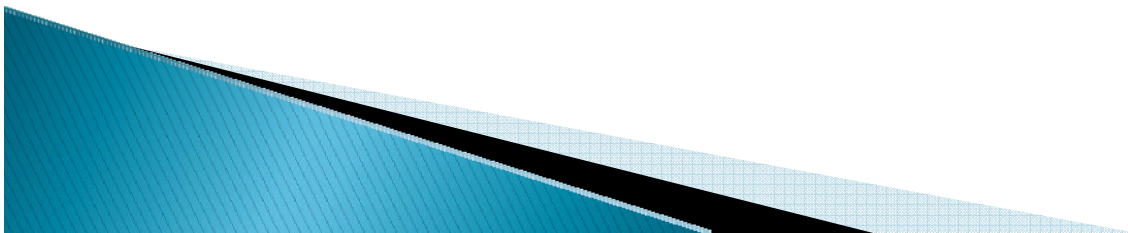
There's one more, uncomfortable, explanation for calls to increase the supply of scientists. The present situation provides real advantages for the science and technology sector and the academic and corporate institutions that depend on it. We've arranged to produce more knowledge workers than we can employ, creating a labor-excess economy that keeps labor costs down and productivity high. Maybe we keep doing this because in our heart of hearts, we really prefer it this way.

The consequences of this are troubling. To be sure, the best graduates of the most prestigious programs may eventually find good jobs, but only after they are well past the age at which their predecessors were productively established. The rest—scientists of considerable potential who didn't



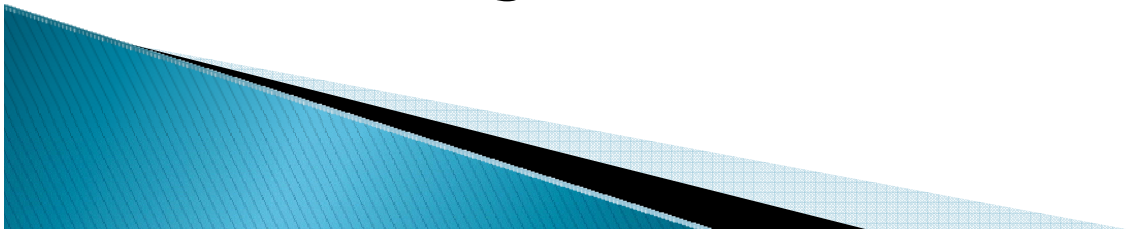
# Supply without demand?

- ▶ Demand side often ignored – surprising!
- ▶ S&Es need employment, labs
  - Few can hang out shingle...
- ▶ Education requires large personal investment
- ▶ S&E careers falling behind others



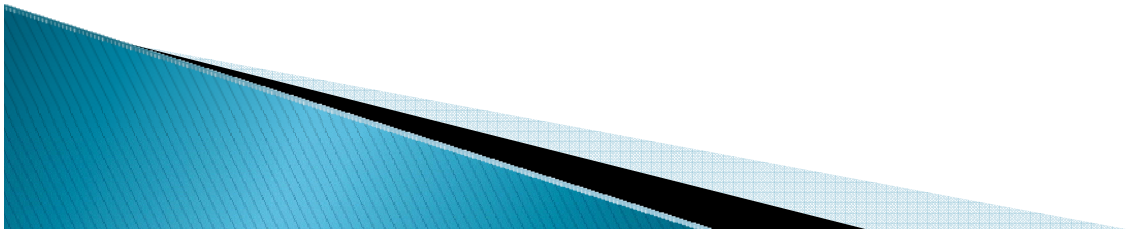
# Are shortages “looming”?

- ▶ Career demand is critical
- ▶ But hard to forecast accurately
- ▶ Many shocks, long lags
  - Government S&E budgets: unpredictable
  - Military procurement: erratic, unpredictable
  - Private markets: speculative booms & busts
    - IT, aerospace, biotech, telecom
- ▶ Most forecasts have failed (*“Accurate forecasts have not been produced”*– NRC, 2000)
- ▶ Getting even harder (offshore outsourcing)



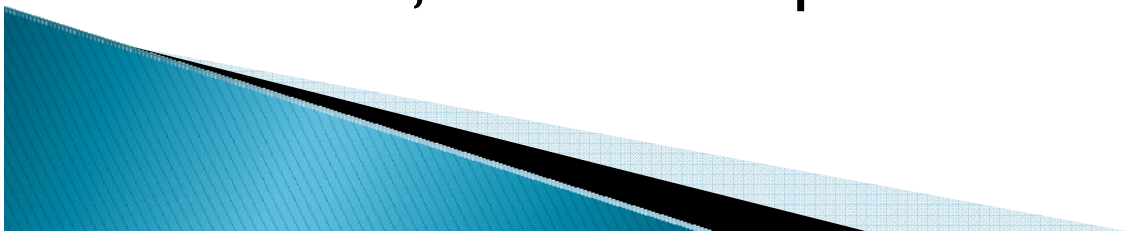
# So, how **evolve** constructively?

- ▶ Pumping up supply w/o demand is:
  - unwise & wasteful
  - ultimately ineffectual
- ▶ Assess first: how attractive are careers?
- ▶ Assess: do temporary visas and & offshoring reduce domestic interest?
- ▶ Needed: *honest* “systems” perspective
- ▶ Needed: focus on quality, not quantity
- ▶ Needed: connect degrees with demand



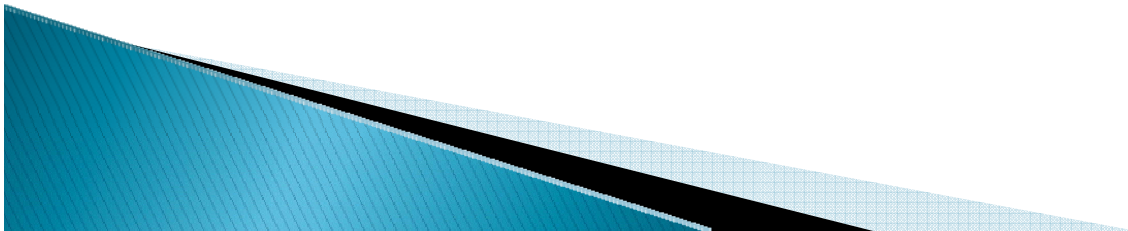
# Evolving domestic supply

- ▶ Increasing domestic supply feasible
- ▶ Lots of interest among college entrants
- ▶ Most leverage?: retention/completion
  - 1 / 3 entering undergraduates intend S&E degree
  - But < 1 / 2 intending freshmen complete S&E degree
    - 1 / 3 shift to other fields
    - ~1 / 5 drop out
      - Source: HERI, UCLA surveys, recent years
- ▶ So, raise completion from < 50% to 60–70%?



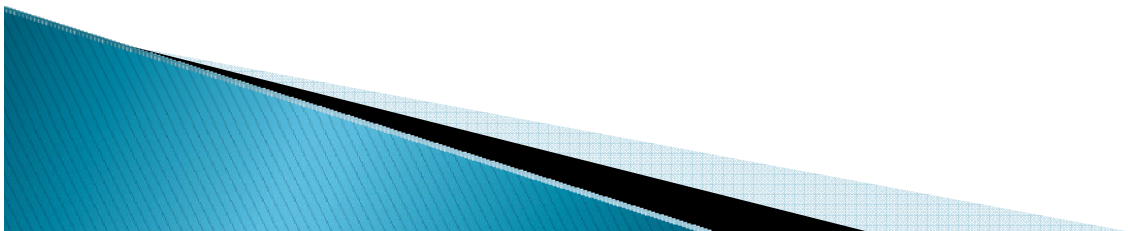
# BUT: What not to do...

- ▶ “Supply-side” actions only
- ▶ Encourage more students...
- ▶ ...without parallel career demand
- ▶ Self-defeating over medium-term
  - Students are smart, have other options
  - Computer Science: responses to market



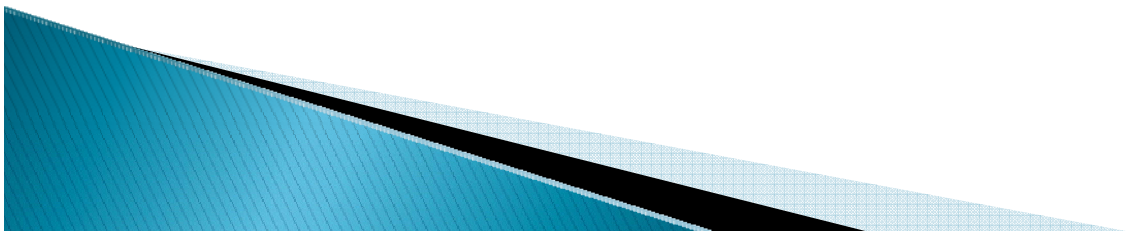
# Basic research is important

- ▶ Contributions to human welfare
  - Health, food, energy, environment...
  - Companies: can't profit from investment
    - Declines at e.g. Bell Labs, IBM Research
- ▶ Basic research is a “public good”
- ▶ SO, a good role for government support



# But: basic research=prosperity?

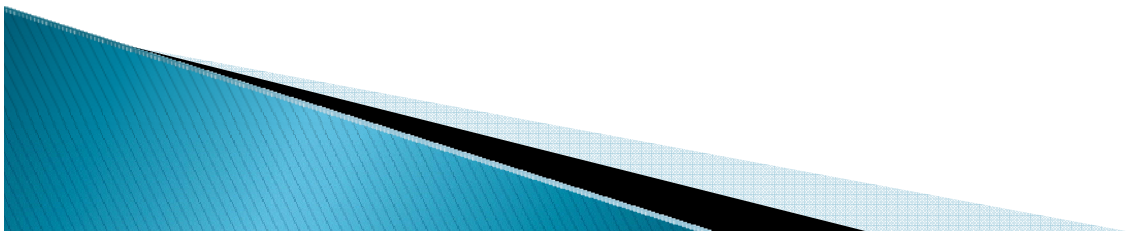
- ▶ Benefit to nation NOT automatic
- ▶ Results are “public goods”
  - Findings published, exploitable by all
  - Benefits are significant, but global
- ▶ Companies and universities: globalizing
- ▶ Challenge: how maximize return to taxpayers who pay for basic research?





# Evolving Federal funding structure

- ▶ Nasty “hard landing” underway at NIH
- ▶ NIH research budget: +100% 1998–2003...
- ▶ ...from \$13.6 to \$27.3 billion
- ▶ Lower if inflation–adjusted, but still large
- ▶ Goals included:
  - Higher grant success rates
  - Better outcomes for younger applicants
- ▶ See: Stephan presentation, Harvard, Feb 2007  
<http://nber15.nber.org/sewp/Early%20Careers%20for%20Biomedical%20Scientists.pdf>

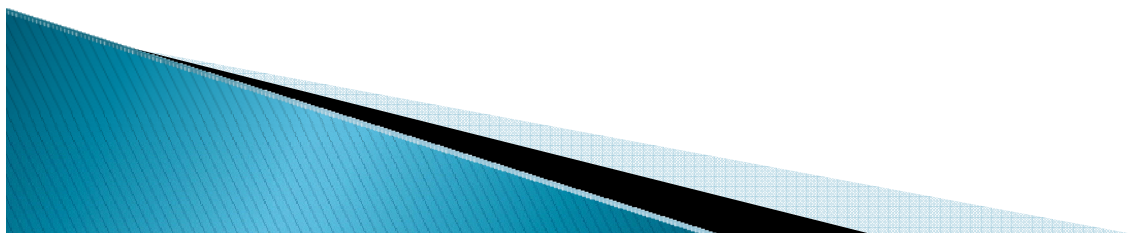
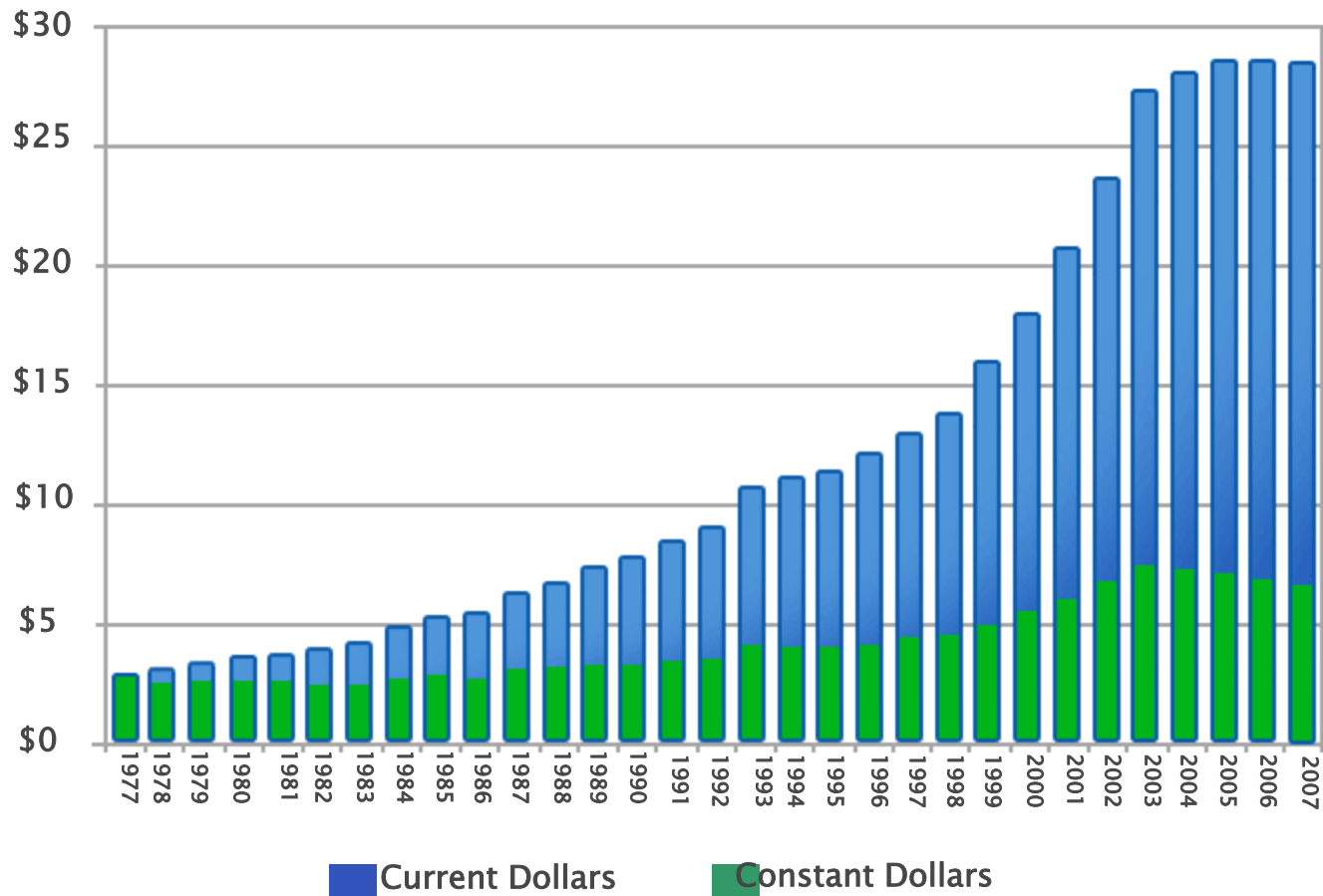


# NIH Budget Authority FY 1977 - FY 2007

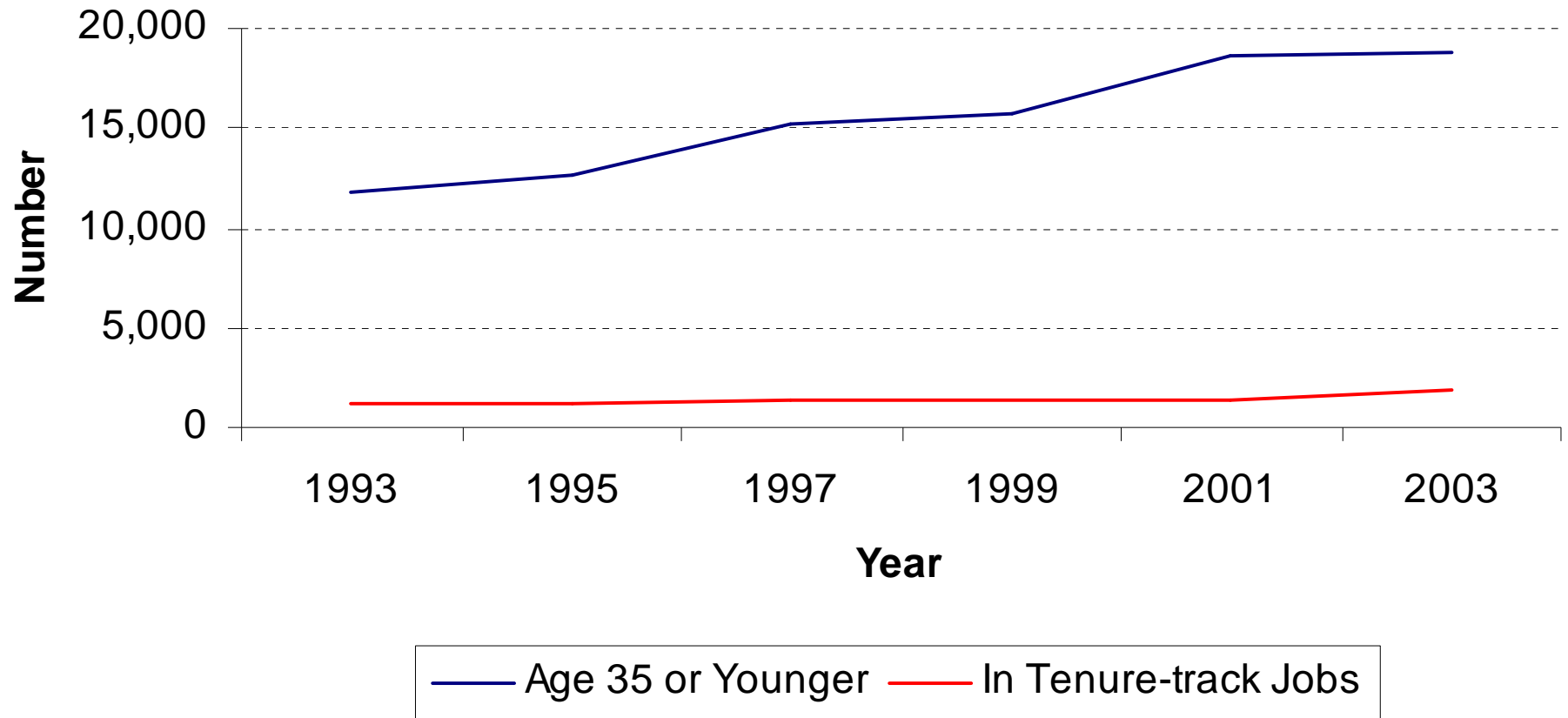
Current dollars and constant 1977 Dollars [using BRDPI as inflation factor]

(Dollars in Billions)

Source: NIH



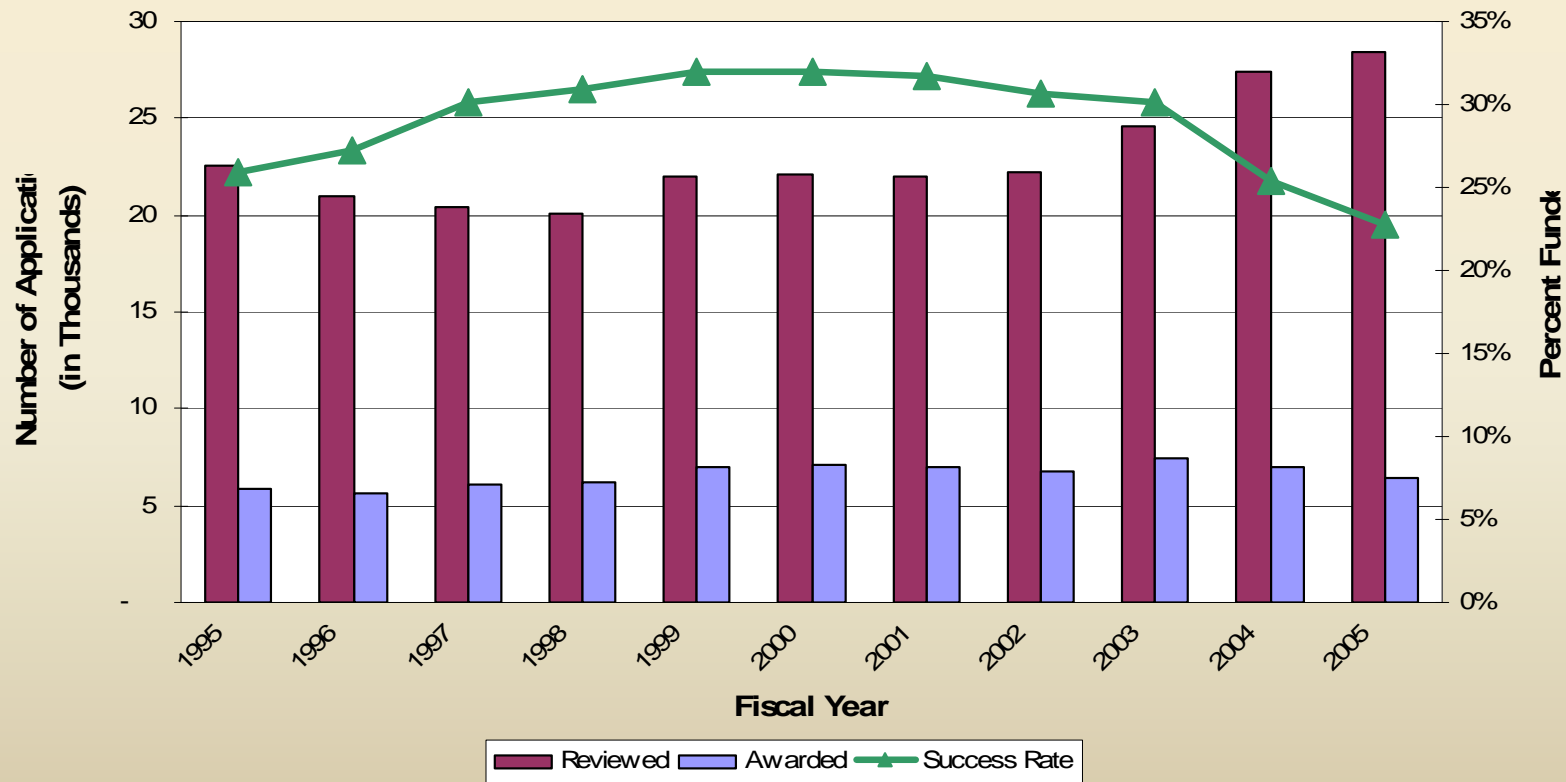
## Number PhDs 35-or-younger increased far more than those in tenure-track jobs



Source: Survey of Doctorate Recipients, NSF. The use of NSF data does not imply NSF endorsement of the research methods or conclusions contained in this report.

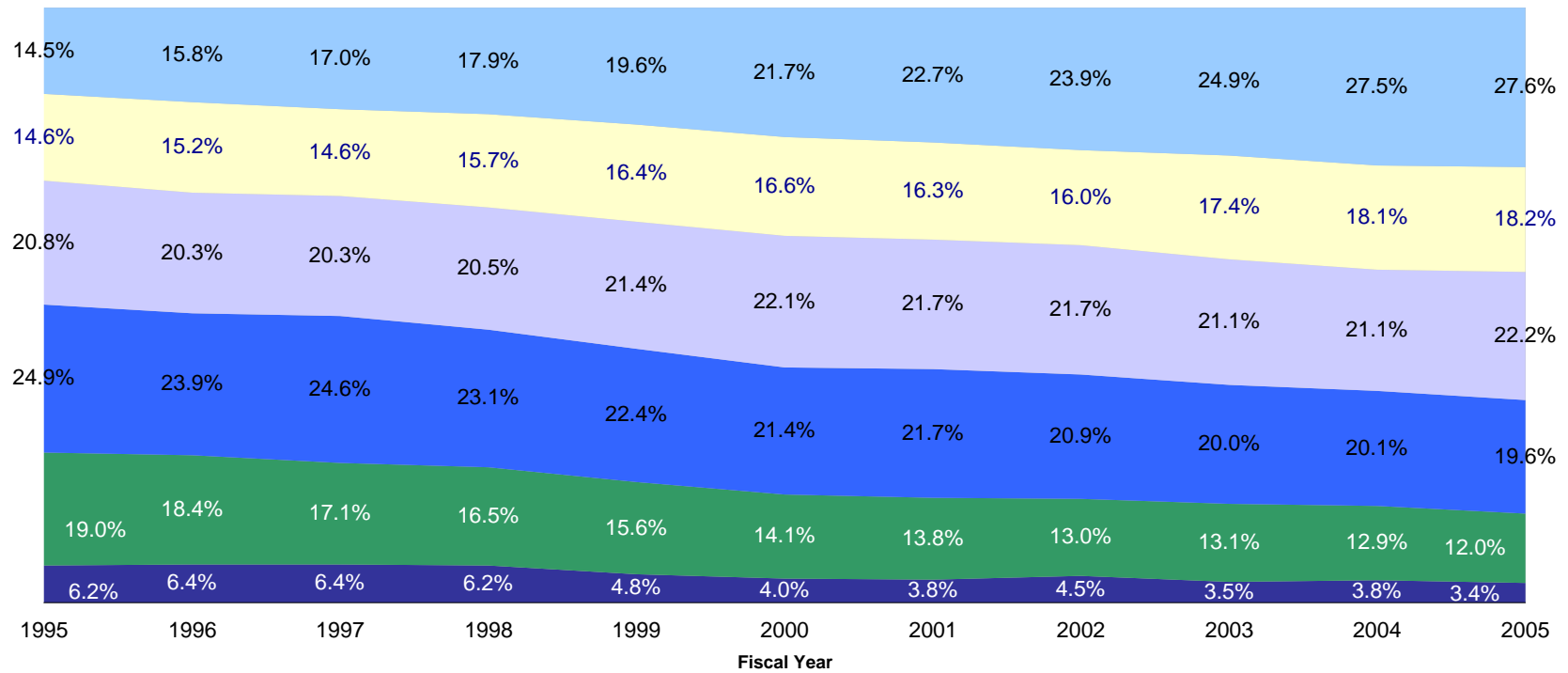
# Grant success rates first rose, then declined to lower than pre-doubling

## Number of NIH Competing R01 Equivalent\* Applications, Awards and Percent Funded (Success Rate)

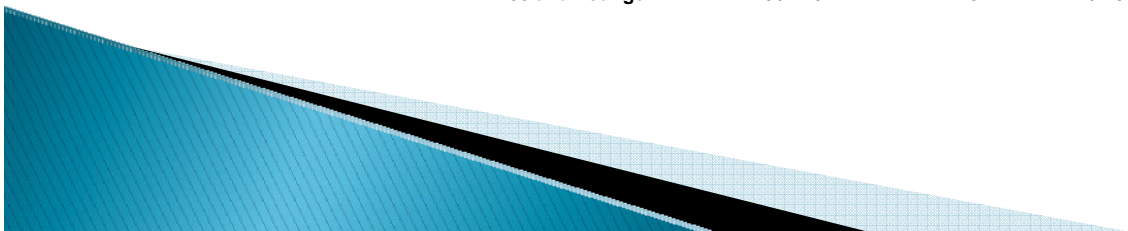


# Success rates down for younger

NIH Competing R01 Equivalent Awardees

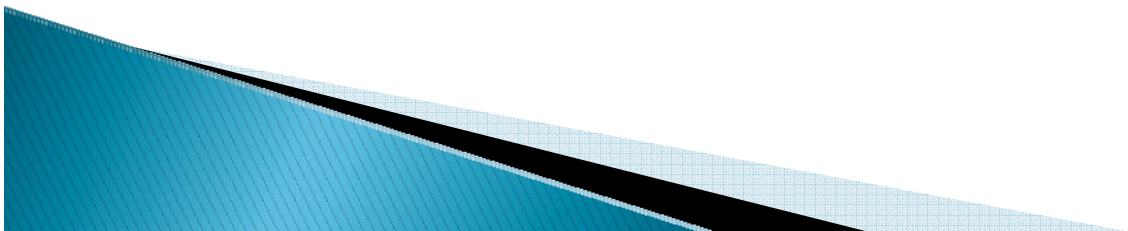


■ 35 and Younger   
 ■ 36 - 40   
 ■ 41 - 45   
 ■ 46 - 50   
 ■ 51 - 55   
 ■ Over 55



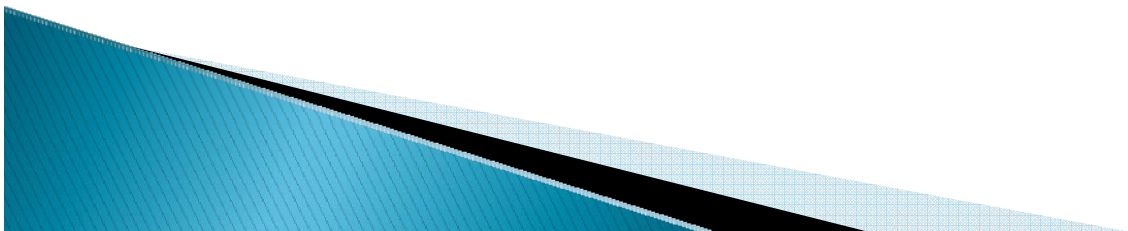
# The problems are structural

- ▶ Positive feedback loops => unstable equilibria
- ▶ Magnifies booms, magnifies busts
- ▶ PhDs & postdocs funded by research grants
  - Increase research \$ = more PhDs and postdocs
- ▶ Lag (multi-year)
- ▶ Then more seeking NIH research \$  
=> declining grants success rate
- ▶ Especially difficult for younger scientists



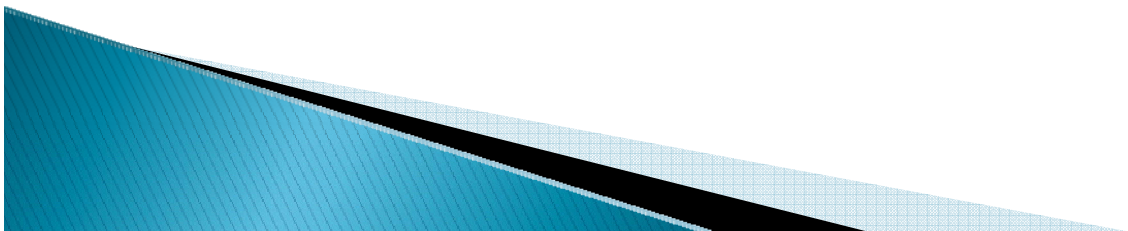
# A valuable heads-up

- ▶ America COMPETES Act
- ▶ NSF research doubling 2008–2015...
  - Depends on Appropriations, of course, but...
- ▶ Think now: how **evolve** graduate support to avoid hard landing in 2016?
  - Reduce feedback of research \$ to PhD/postdocs
  - Re-balance % Fellowships vs. RA's
- ▶ COMPETES focus: economic competitiveness
  - So pay attention to non-academic science careers



# Evolving better “fit” with demand

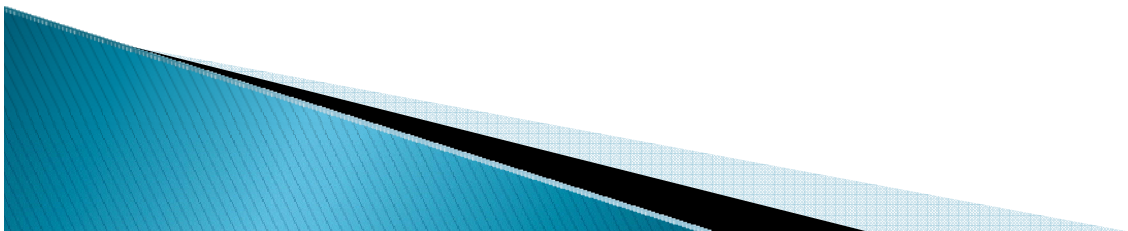
- ▶ PSM: science professionals for non-academe
- ▶ Employers want: strong graduate science, PLUS skills in:
  - basic business
  - project management
  - interdisciplinary/teamwork
  - communication
  - computation





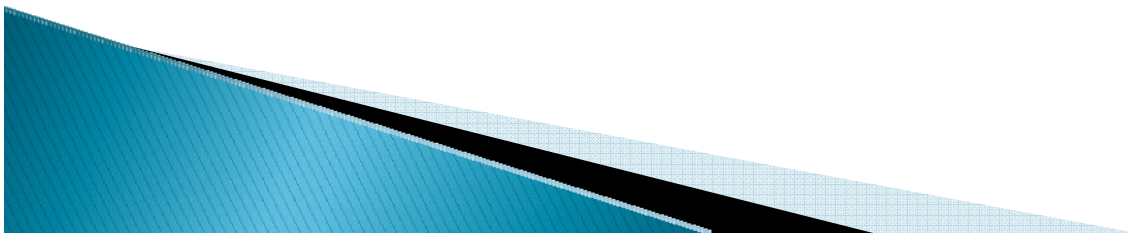
# Status report

- ▶ Proof of concept
  - ~105 programs, 55+ universities, 25 states
  - 1300–1500 current students
  - ~2000 alumni
  - Initial job experiences good
- ▶ Real progress, but still small and fragile
- ▶ Goal: “normal” part of US graduate education



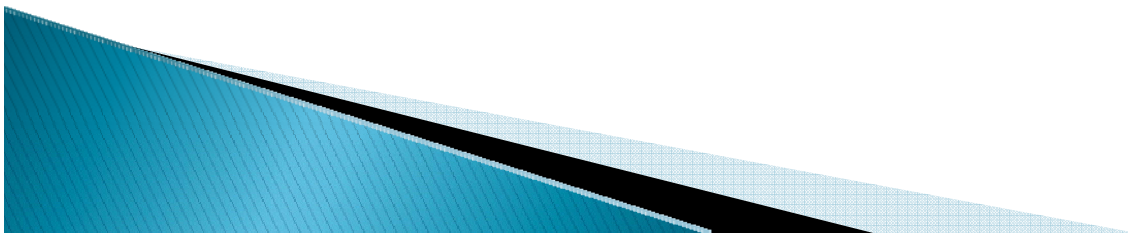
# So far: little Federal support

- ▶ COMPETES Act: PSM authorization for NSF
- ▶ Plus buoyant NSF basic research budgets
  - Funding competition fierce when budgets flat
- ▶ Hope: opportunity to **evolve** NSF funding structure for graduate science education



# To summarize:

- ▶ Current: weak alignment w/national needs
- ▶ “Shortage” claims persist, but lack credibility
- ▶ Growth in PhD/postdoc numbers...
- ▶ ...yet poor prospects for recent PhDs/postdocs
- ▶ Federal \$ focus on PhD, designed for academe
- ▶ ...but career growth potential outside academe
- ▶ CHALLENGE: how **evolve** w/ minimal damage?



# Some useful links

- ▶ [RAND | Issue Papers | Is There a Shortage of Scientists and Engineers? How Would We Know?](#)
- ▶ [http://www.rand.org/pubs/conf\\_proceedings/2005/CF194.pdf](http://www.rand.org/pubs/conf_proceedings/2005/CF194.pdf)
- ▶ [Bill Gates: U.S. Senate Committee Hearing on Strengthening American Competitiveness](#)
- ▶ [Into the Eye of the Storm: Assessing the Evidence on Science and Engineering Education, Quality, and Workforce Demand](#)

# Thank you!

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