

The Economics of the Postdoctoral Position

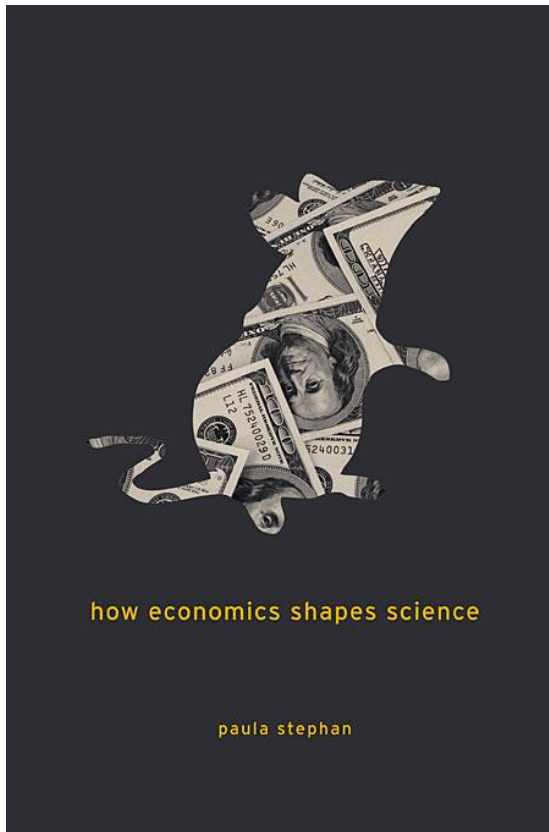
Paula Stephan, Georgia State University
and NBER

National Science Foundation

April 2014

Drawn from

Recent book



Comment in *Nature*



Perverse Incentives

Data Sources

- Survey of Doctorate Recipients
- Survey of Earned Doctorates
- GSS: Survey of Graduate Students and Postdoctorates in Science and Engineering
- BLS data

Caveat

- Speaking for myself
- Not on behalf of National Academies' committee "The Postdoctoral Experience Revisited" of which I am a member

Prologue

- Before looking at underlying economic issues
- Summarize postdoctoral trends over time
- Differentiate between
 - long term trends
 - trends related to business cycle—especially recent events occurring in 2008

Postdoctorates by Citizenship US, Science and Engineering

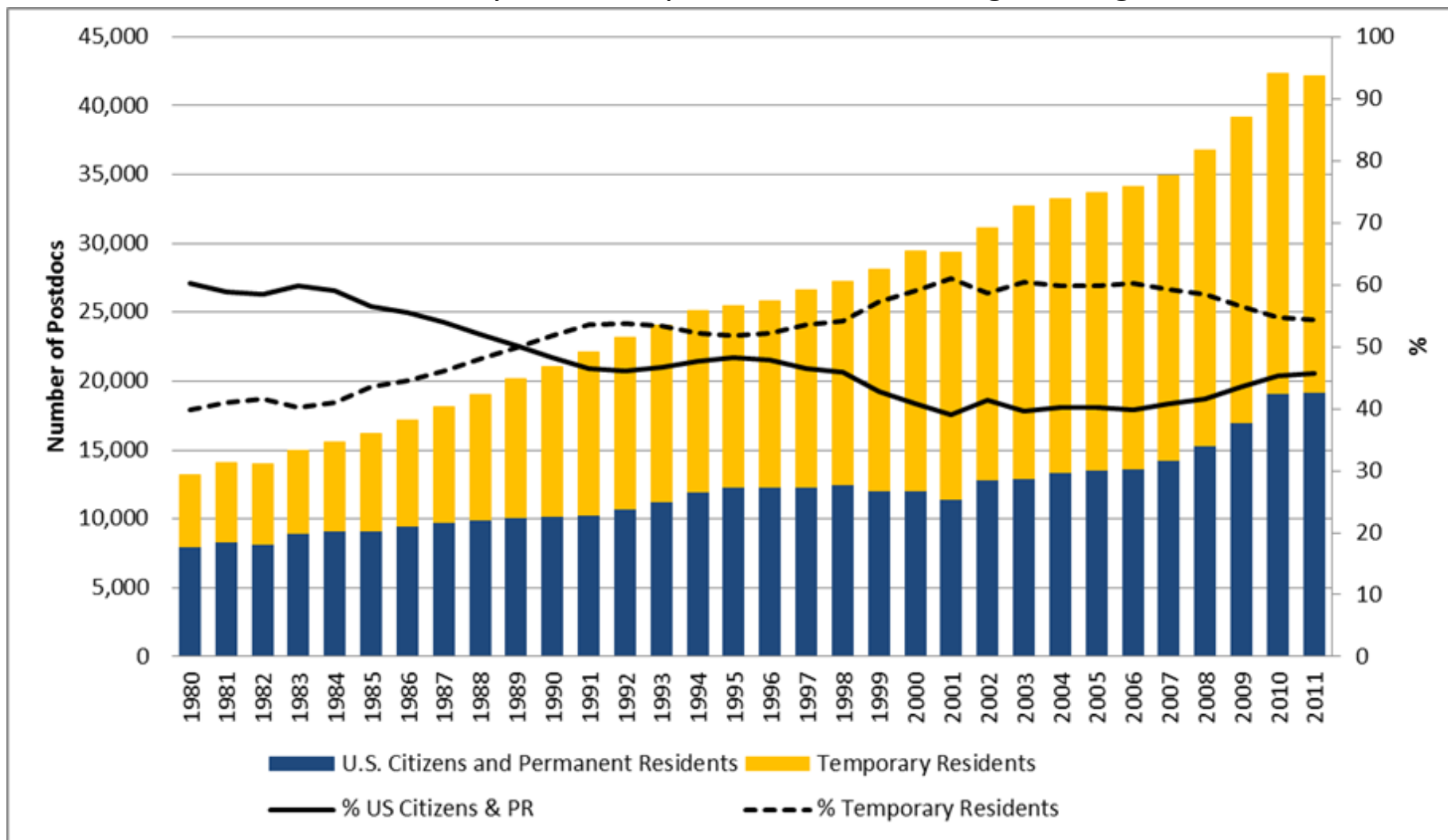
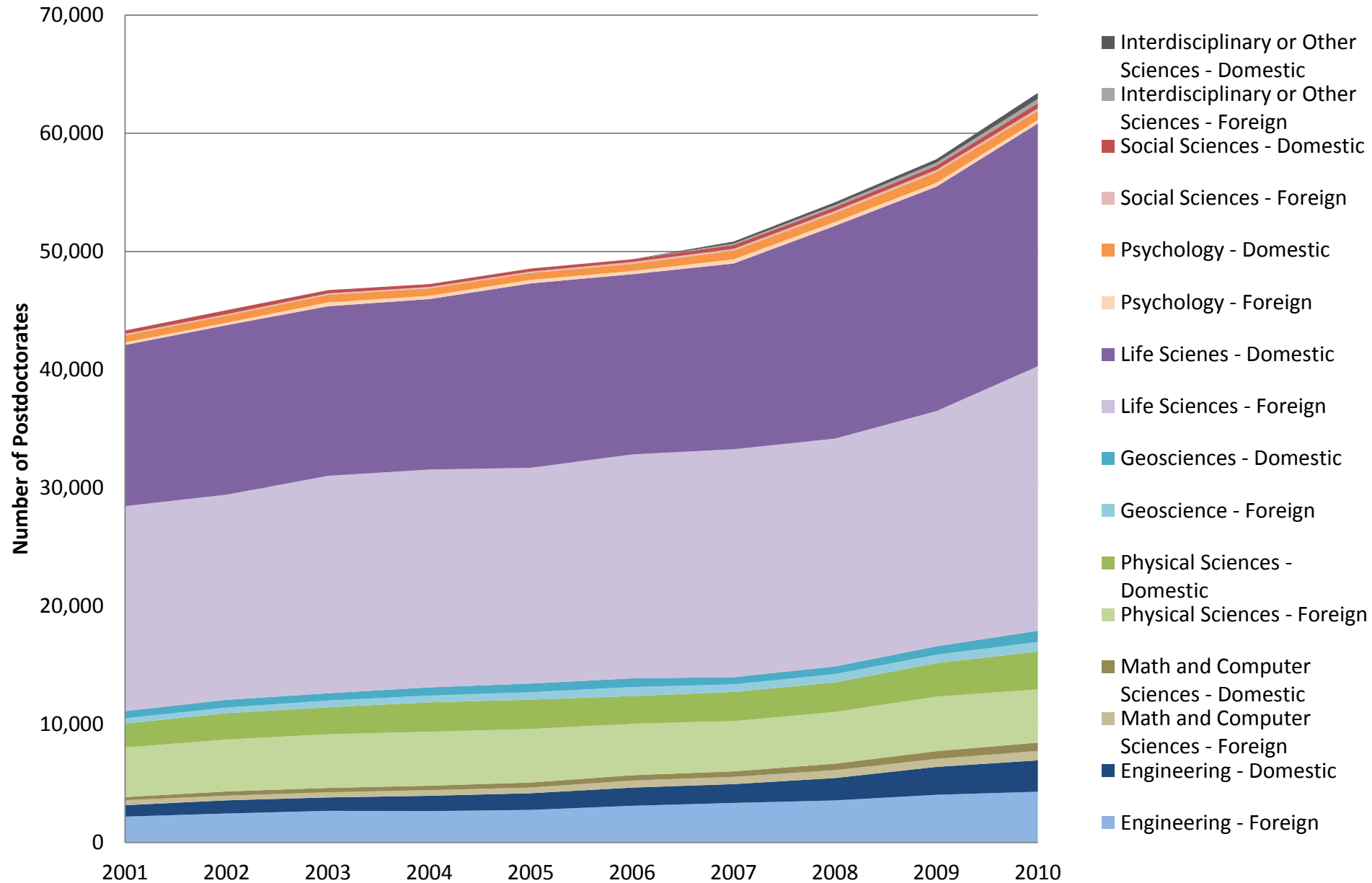


Figure excludes social sciences and psychology, as well as medical sciences, where many of the positions labeled as “postdoctorate” in NSF’s Survey of Graduate Students and Postdoctorates in Science and Engineering (GSS) are held by physicians rather than PhDs. Paula Stephan, GSU & NBER

Undercount

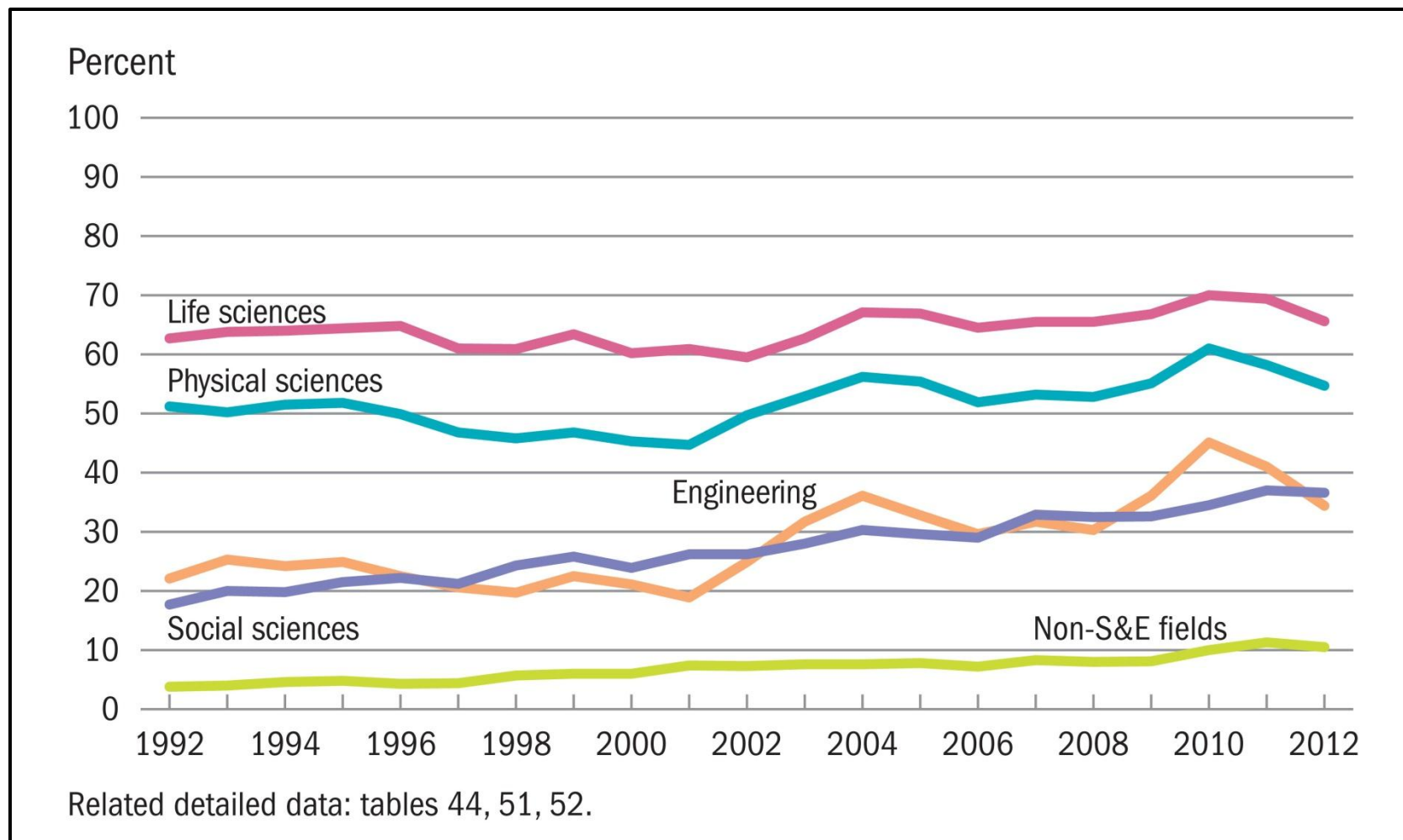
- Does not include those working in industry or at certain government labs
- Misses individuals in academe with “creative titles”

Number of Foreign and Domestic Postdoctorates by Broad Field



The Life sciences are the largest contributor to the number of postdocs, foreign or domestic

Postdoc rate, by field of study, new PhDs: 1992–2012



Survey of Earned Doctorates

Summary

- Postdoctoral taking rate increased from low in 2001 to high in 2010
 - In physical sciences by 31%
 - In life sciences by 17%
 - In engineering by 125%
 - In social sciences by 50%

Physics PhDs 1 Year Later

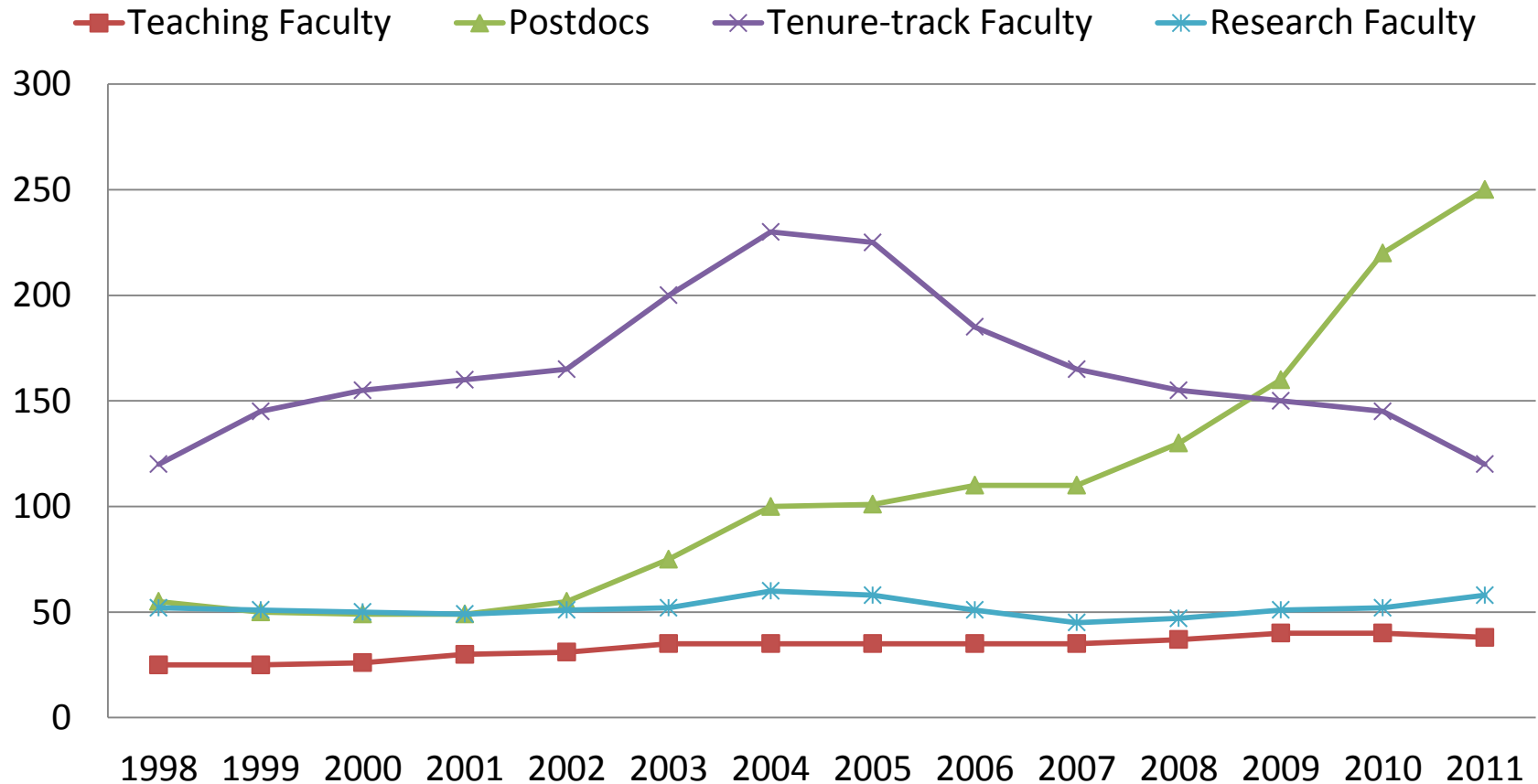
Classes of 2009 & 2010 Combined

1550 Physics Doctorate	84% remained in The US (1300 Physics Doctorate)	59% Postdoc Position University (560), Government incl. labs (170), Other (40)
		29% Potentially Permanent Positions Private Sector (215), Academe (80), Government incl. labs (60), Other (20)
		7% Other Temporary Positions Academe (75), Other (20)
		4% Unemployed the winter after receiving their degrees
		1% Out of labor force (not seeking)
	16% Left US	

Physics continued

- Physics
 - 13% of those who took postdoc position did so because they could not find permanent work, compared with 7% from classes of 2007 and 2008 (AIP)

Hiring of Computer Science Ph.D.'s in academia as in a three year-rolling average 1998-2011



Source: Anita Jones, "The Explosive Growth of Postdocs in Computer Science"
Viewpoint, Vol. 56., No.2., February 2013., pg. 37-39.

Trends

- Increase in postdoctoral-taking rate over time in all fields through 2010
- Number of postdoctoral scholars on temporary visas grew more quickly than that of citizens and permanent residents until recently
 - Grew especially quickly during doubling of NIH budget

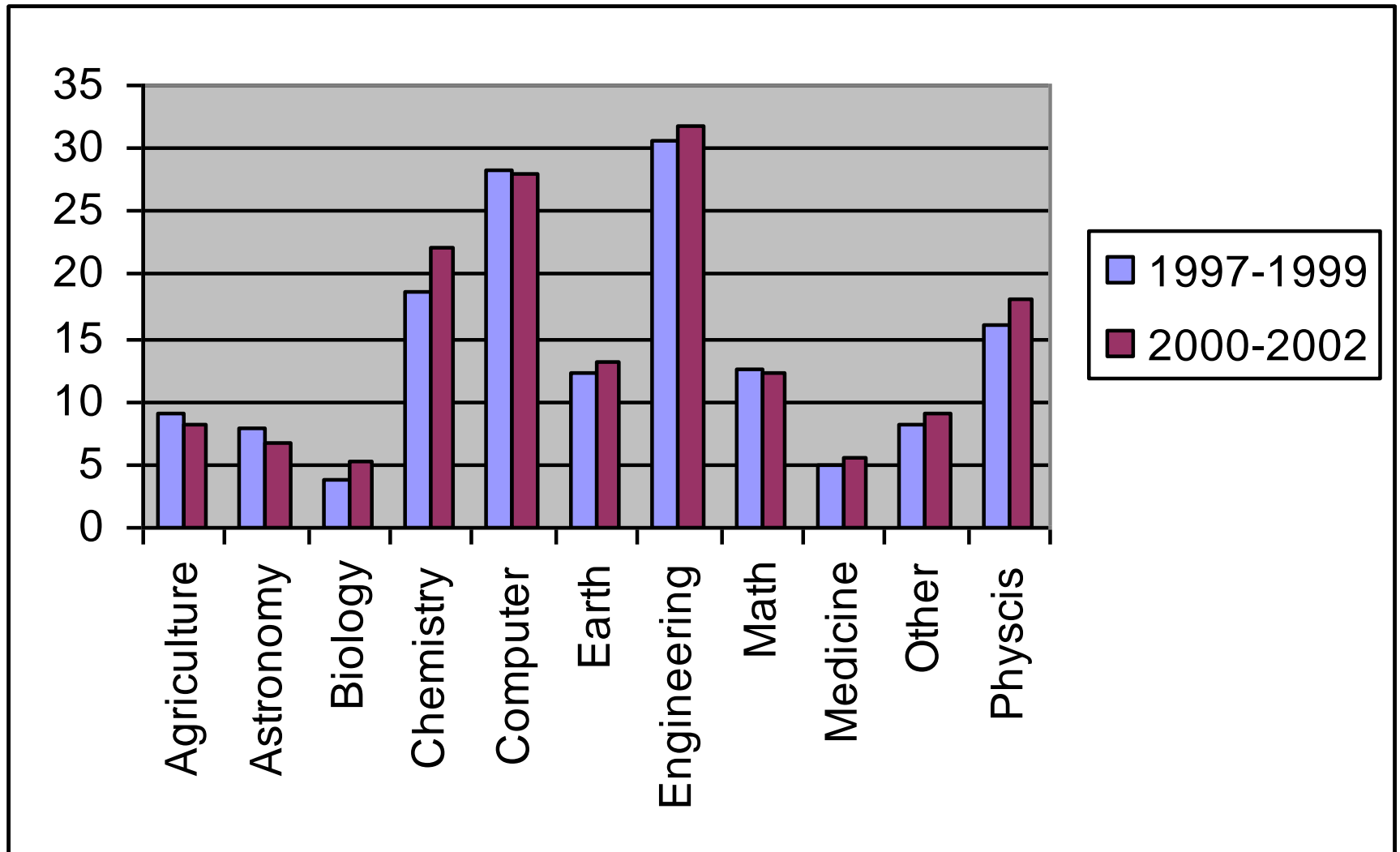
Differentiating Trends

- Some relate to long term problems in the labor market for new PhDs
 - Life sciences—
 - As early as 1977 clear indications that there were problems for new PhDs in this market
 - NRC report evaluating training grants concluded at that time that a “slower rate of growth in labor force in these fields was advisable” [biomedical sciences] (National Research Council, 1994, p. 98).
 - In 1998 problems again noted (*Trends in the Early Careers*) recommended “restraint of growth of the number of graduate students in the life sciences.”
 - NIH Workforce Committee of 2011 formed because of concerns
- Some reflect structural changes in demand
 - Example: chemistry

Trends Continued

- Percent taking postdoctoral positions also relates to state of the economy
 - Empirical work shows negative relationship between the probability that a new PhD takes a postdoc position and change in current fund revenue—a measure of demand in academe (Stephan and Ma)
 - Large increase in engineering postdocs after 2008
 - Decline in postdoc rate in the late 1990s when job market in pharma and other sectors of industry was strong
 - Increase in number of citizens and permanent residents taking postdoctoral positions after 2008 recession

Percent of PhDs Going to Industry



ARRA

- ARRA funding appears to have created a temporary surge in number of postdocs
- Distinct fall off after ARRA funds depleted

Economics of the Postdoctoral Position

Economics Is about Incentives and Costs

- Incentives and costs have significant impact on number of postdoctoral scholars employed in the United States

Incentives from PI's Perspective

- Increased importance of
 - Specialization in research
 - Funding for research
 - Publications as a necessary condition for funding

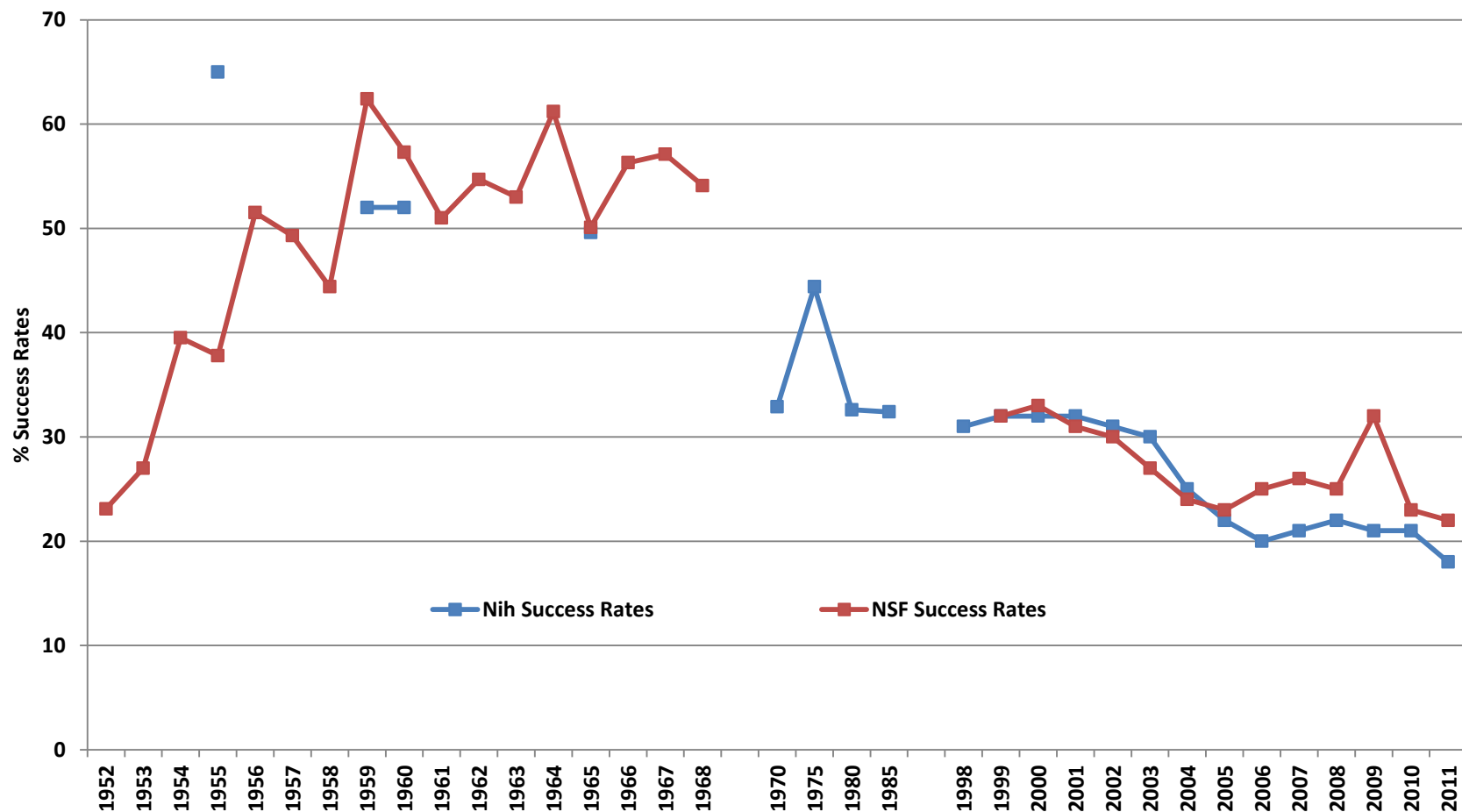
Specialization

- Sole author is a dinosaur when it comes to research—fewer than 15% of papers are now sole authored
 - Between 1955 and 2000 average number of authors in science almost doubled from 1.9 to 3.5
- Specialization means faculty increasingly look for individuals to work with them on research and to staff their labs

Increased Importance of Funding

- Faculty increasingly under pressure from university to bring in funding for research
- Long been model in biomedical and physical sciences; increasingly model in social sciences and even in humanities
- Pressure to bring in funding particularly acute for faculty in soft money positions— “funding or famine” to quote Stephen Quake
- At same time, funding is in short supply and success rates are declining

NIH and NSF Success Rates Available Years



Paula Stephan, Georgia State and NBER

NSF rates for 1952-1968 are for the Division of Biological and Medical Sciences

Focus on Grant Seeking

- Raises importance of having other people to work in lab—PI's time is diverted to grant preparation
 - Estimate that PIs on Federal grants spend 42% of research time in grant-related administration (Kean)
- Also raises importance of publications given important role publications play in grant review and grant success

Staffing of Labs

- Forces of specialization, funding and publications lead PIs to seek clever individuals to staff labs and help in production of research
- Three groups to choose from:
 - graduate students
 - postdocs
 - staff scientists
- This is where costs begin to play a large role

Costs of a Graduate Student

- Stipend between \$16,000 to \$28,000
 - Can cost an additional \$16,000 or more once tuition is included, depending upon limits set by funding agency and policies of university
- Survey of Big Ten Institutions in 2004 found median full cost (exclusive of indirect) of a GRA to be \$29,000; high was \$48,000; low was \$17,000
- GRAs work approximately 1200 to 1500 hours per year on average over career
- Hourly rate is \$25.00 to \$40.00 with fringes on Big Ten campuses;
- Hourly rate as high as \$37.00 on some campuses before fringes

Cost of Postdoctoral Scholars

- NIH stipulated rate for FY 2014 is \$42,000 for NRSA first-year postdoctoral scholar; up from \$39,264
 - Many institutions follow this rate for other postdocs
 - Few follow the NSF rate for fellowships
- Average postdoc reported working 2650 hours a year in life and physical sciences; 2550 in engineering and 2500 in math and computer sciences (SDR calculations)
- Hourly rate before fringes was \$14.82 in biomedical sciences; at FY2014 rate it is \$15.84.

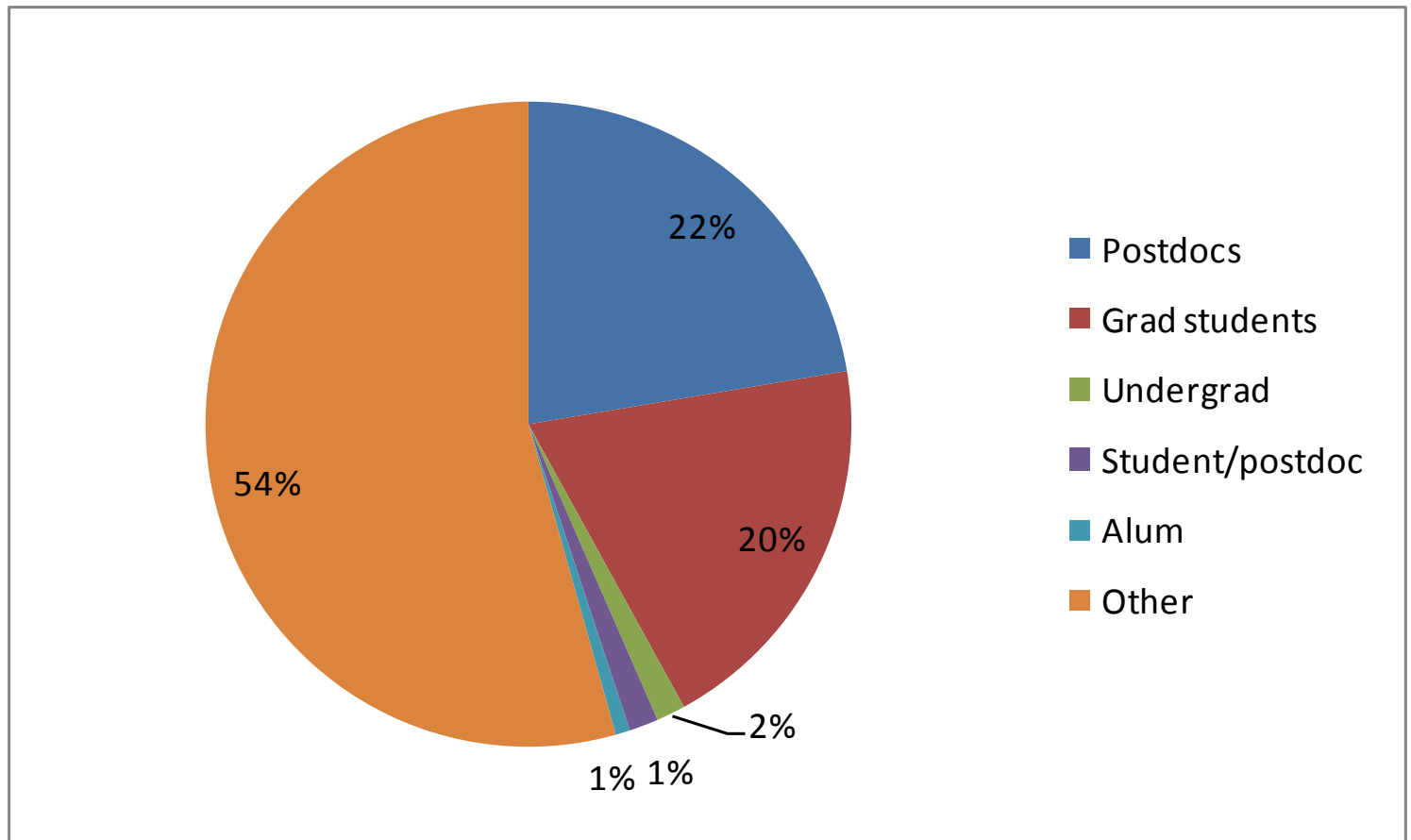
Cost of Staff Scientist

- Start at approximately \$55,000
- On many campuses considerably higher
- Fringe benefits are significantly higher than those for a postdoc because they are treated as employees by university
- Hourly rate of approximately \$25.00 before fringes at a minimum

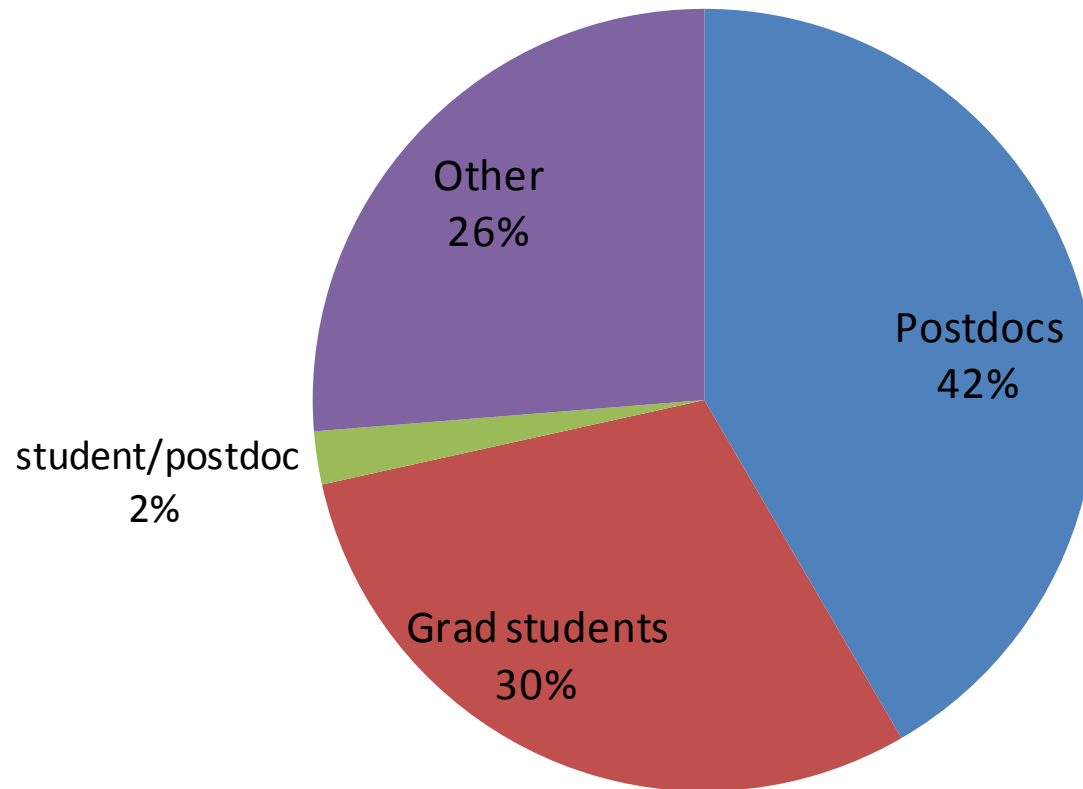
Cost Advantage Lies with Postdoctoral Scholar on Many Campuses

- Low salary and long hours of work mean postdoctoral scholars are half as expensive as graduate student or staff scientist on many campuses
- Higher level of skill than graduate student and “less risky”
- Possibly more motivated than staff scientist
- Some come with fellowships

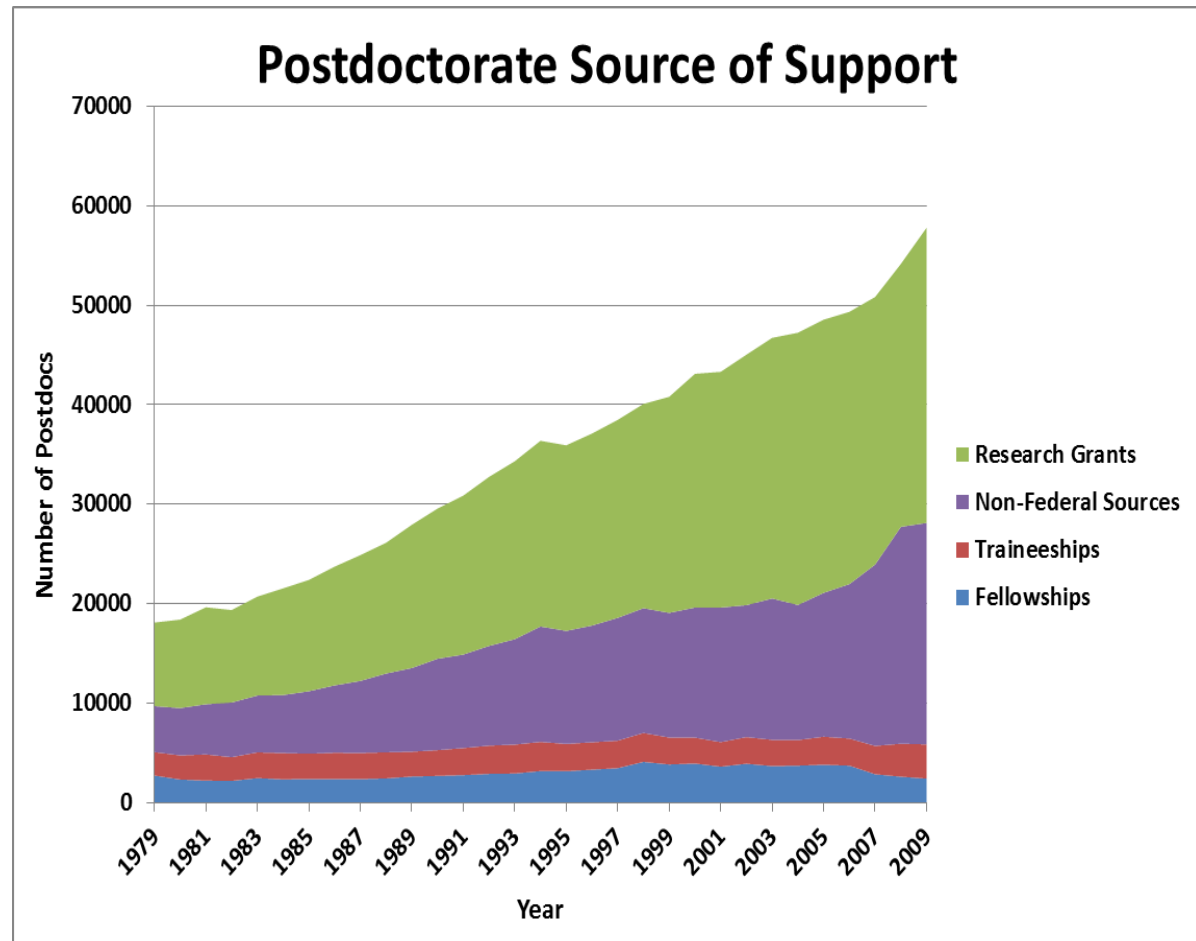
Authorship Patterns U.S. Articles with 10 or fewer authors in *Science*



First Authors: N=137



Funds Available from Grants



Variations in types of postdocs by sources of support.

SOURCE: NSF-NIH Survey of Graduate Students & Postdoctorates in Science and Engineering

FIGURE 3-16 NIH support of graduate students.

SOURCE: NSF. 2008. *Survey of Graduate Students and Postdoctorates in Science and Engineering*. Washington, DC: NSF.

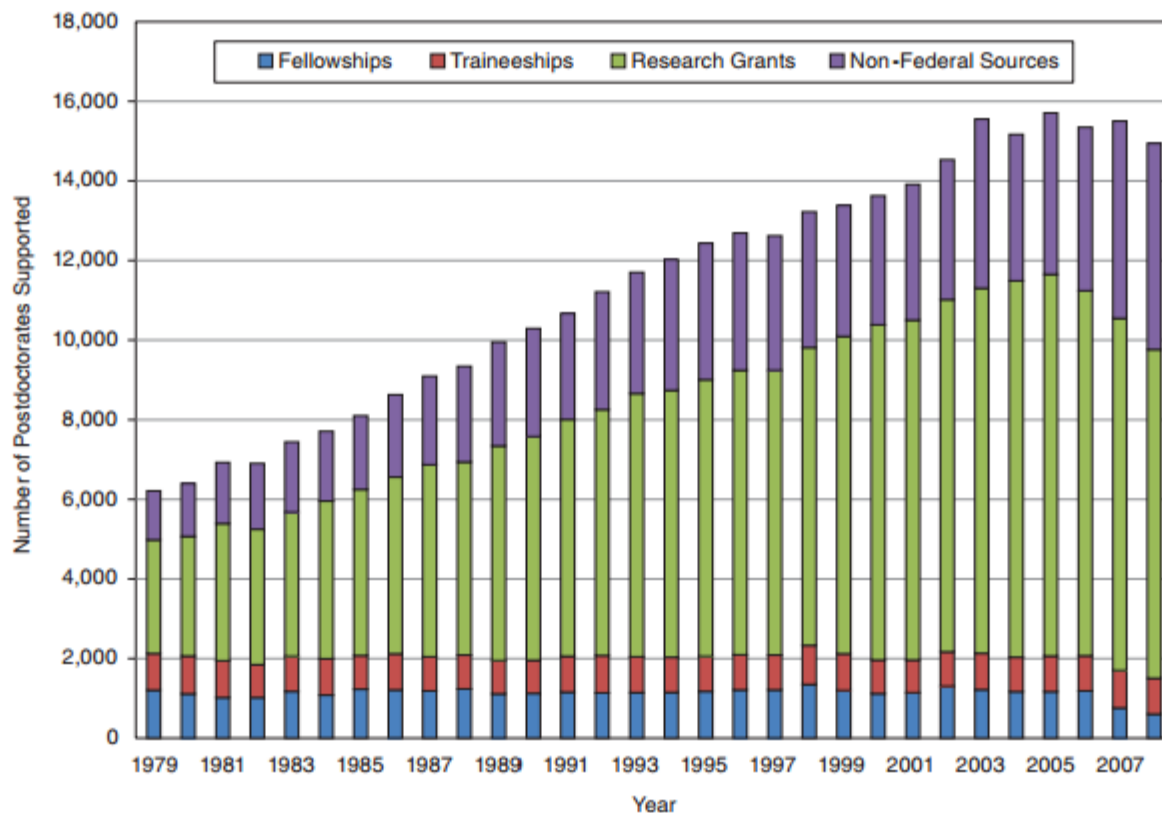


FIGURE 3-17 Postdoctoral support in the biomedical sciences.

SOURCE: NSF. 2008. *Survey of Graduate Students and Postdoctorates in Science and Engineering*. Washington, DC: NSF.

Federal Vs. Nonfederal

- In S&E approximately 60 percent of funds for support of postdocs comes from federal government
- In S&E fields, excluding field of “health,” two-thirds of support comes from research grants

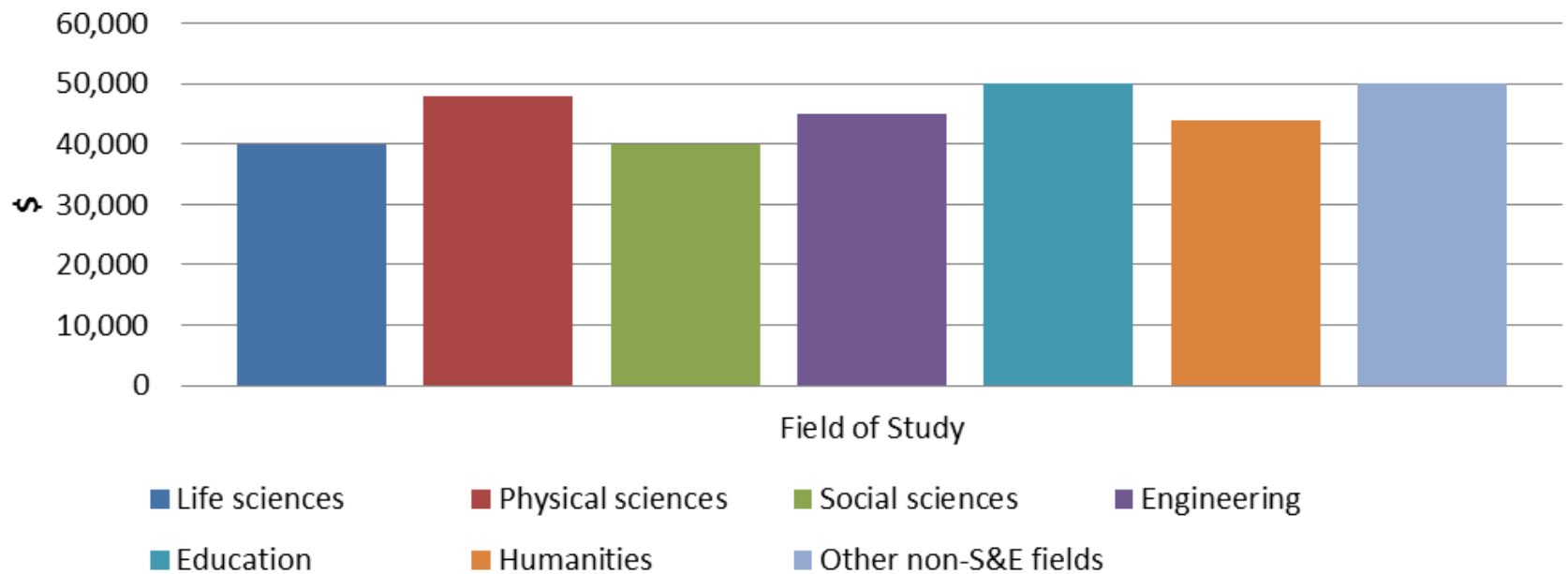
Vannevar Bush's Vision

- Federal government needed to train individuals to address the deficit in number of researchers
 - Train graduate students and postdocs through fellowships
 - Undergraduates through scholars
- *Sometime in 1960s transition was made from training students in order to get future research done to training students to get teaching and research done **today**; led to disconnect between PhD training and future demand*



“Cost Advantage” Suggests a Closer Look at Why Postdoctoral Wages Are Low

Median Salaries for Postdoc 2012

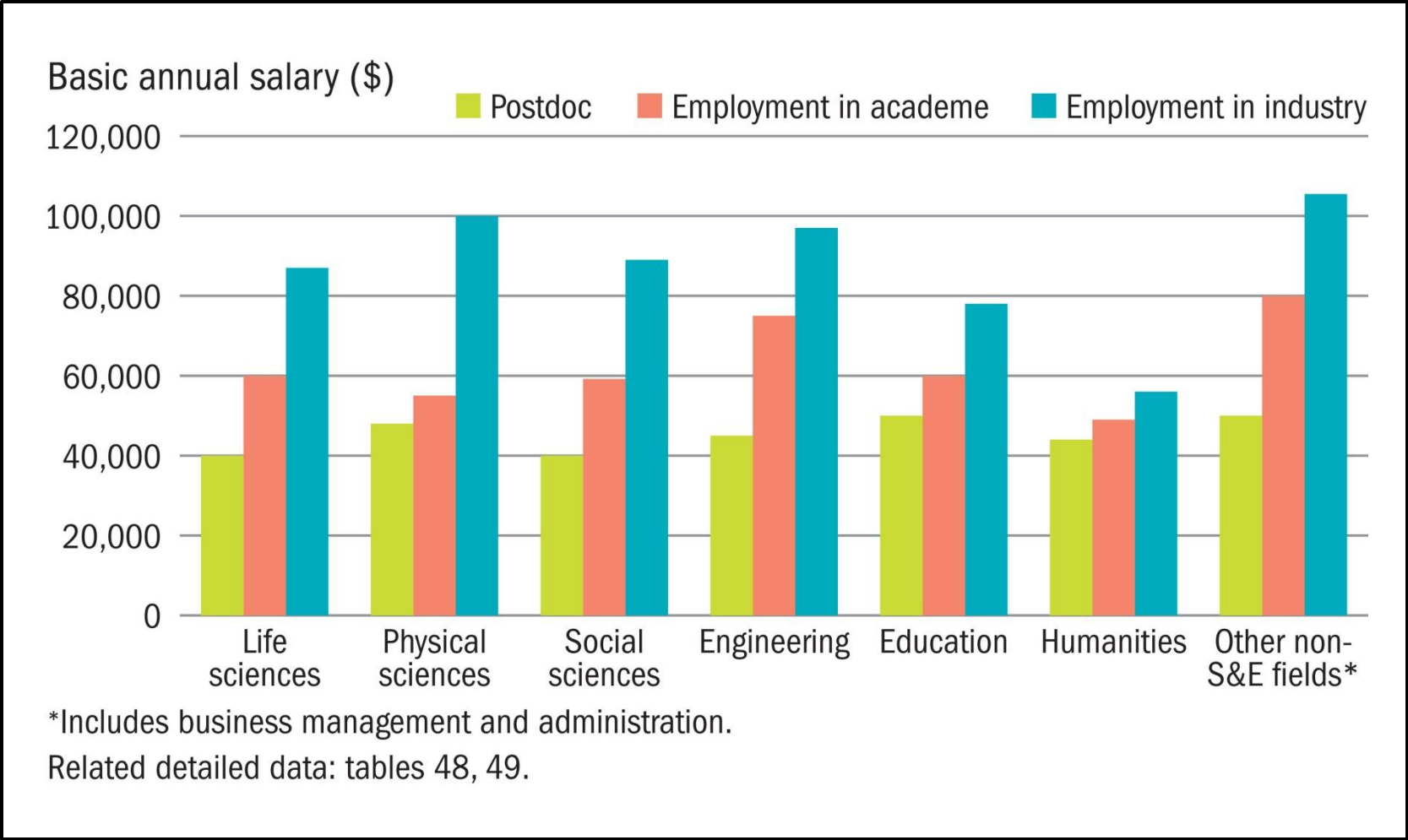


Source: Survey of Earned Doctorates

Salary Relative to Alternatives Is Low

- BA with 7 years of experience, no graduate school, earning about \$50,000 in 2012
- Average hourly wage for fulltime workers—regardless of level of education-- in United States is \$23.22—but they work 34 hours per week.
 - Means average U.S. worker takes home just about the same amount every week as a postdoc but works about 20 hours a week less.
- PhD in S&E starting in academe: \$55,000-\$75,000 depending on field
- PhD in S&E starting in industry: \$87,000 to \$100,000, depending on field

Median basic salary of doctorate recipients with definite commitments in the United States, by position type and field of study: 2012



Why So Low?

Training Argument

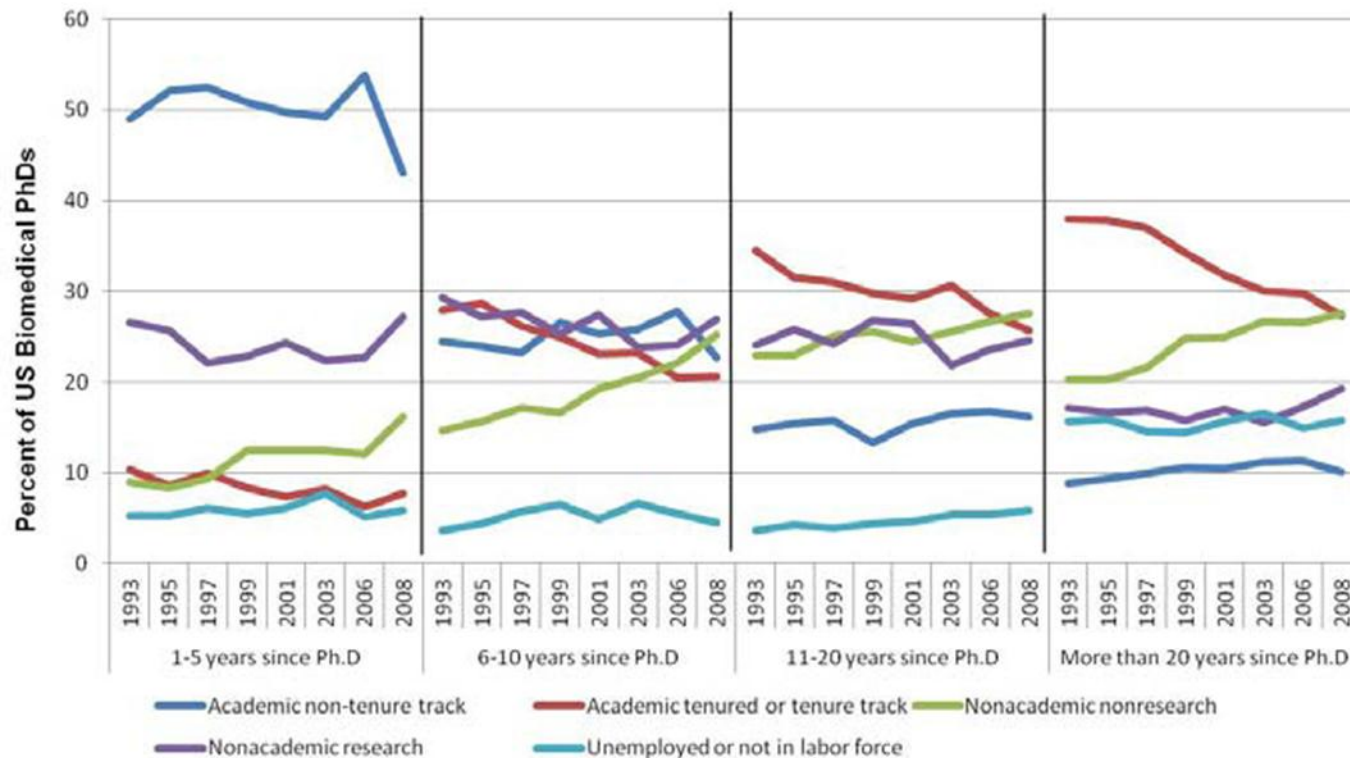
- Low pay to postdoctoral scholars is due to large training component of position
- Argument is that training received is portable to another position and thus should be paid for by the postdoctoral scholar in the form of reduced wages;
 - low wages are a down payment on a research career—Gary Becker's concept that general on-the-job training should be paid for by employee

Validity of Training Argument

- Definitely strong training component in many postdoctoral positions
 - But in some labs training component is minimal; postdoctoral scholars are relied on for routine procedures; little mentoring
 - In some labs postdoc is training others, including PI
- High cost of training
 - Classmates who did not get training beyond a BA are earning about \$49,911 in 2012, seven years after graduating; (Table 28 <http://www.census.gov/hhes/www/income/data/historical/people/>)
 - Approximately \$28.00 per hour
 - Compare this to \$16.00. A high cost of training!
 - Especially when many of the skills learned may not be transferable into a non-research position—a likely outcome for many—they are not “general” but instead “specific”

Employment Outcomes by Cohort

Biomedical Sciences



Alternative Explanation

Low Wages

- Not a real market
- Postdoc pay set by NIH in biomedical sciences; many campuses follow this for other fields
- Ample supply of domestically produced PhDs and large supply of PhDs educated abroad keep salaries low

Why Do Postdoctoral Scholars Take the Position?

Incentives from Their Point of View

- Interest in science
- Aspirations
- Information (lack of)
- Lack of alternatives

Interest/Aspirations

- Postdoctoral scholars get satisfaction from engaging in research
- They perceive their chances/ability as being better than that of others in their field
 - (Sauermann and Roach find majority of students rate themselves as being more able than their peers)
- Postdoctoral position is logical step for those who want to be a research scientist—acquire skills and build resumé—and for those who want to be an academic

Information

- Information is in short supply
- Many students receive minimal information about career options when they decide to go to graduate school or start their graduate training; PhDs are stressed over MA degrees
- Many doctoral programs offer few seminars or workshops that provide students with information on careers other than those in academia
- Postdoctoral position often first time information concerning jobs becomes available and is talked about
- PhD programs rarely post job outcomes on their Web pages
- Many faculty resist students seeking information regarding alternative careers; faculty are misinformed

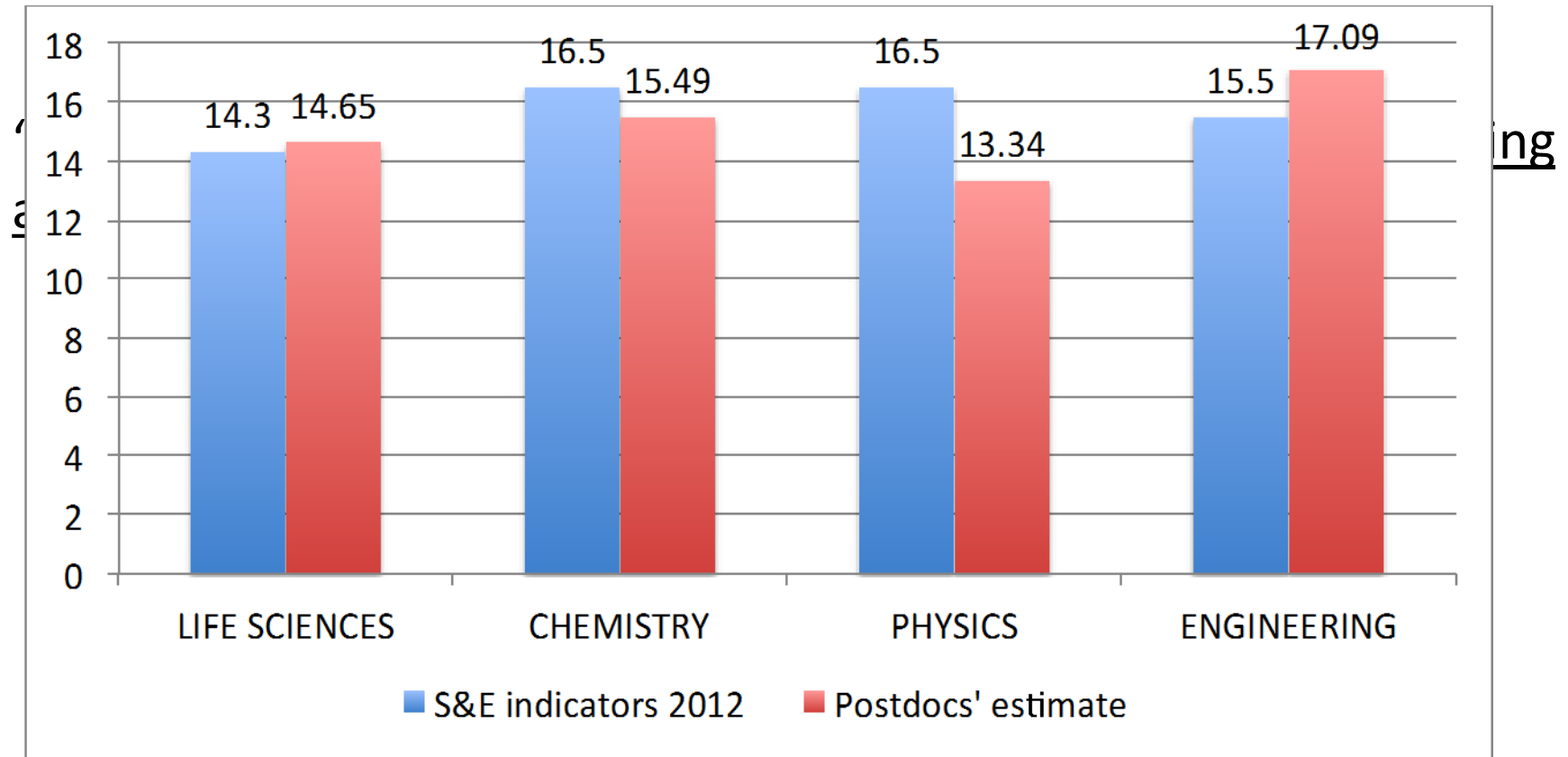
“When I left college and again when I left grad school, I felt as if I had been lied to - partly because PI's have their own agenda and partly because they genuinely do not know what is happening outside of the insulated doors of their colleges or universities.

I remember being taken on a trip to GSK in my undergrad (about 2007), so they could talk to us about careers in industry. One scientist informed us that M.S.-level chemists are more hireable than Ph.D.'s. My professors, then, spent the next month, reiterating that what we had learned at GSK was not true. Somehow, most of us, myself included, ended up believing our professors. That is only one of the many times I received poor career counseling from a professor.” Current postdoc in correspondence to Stephan, March 2014.

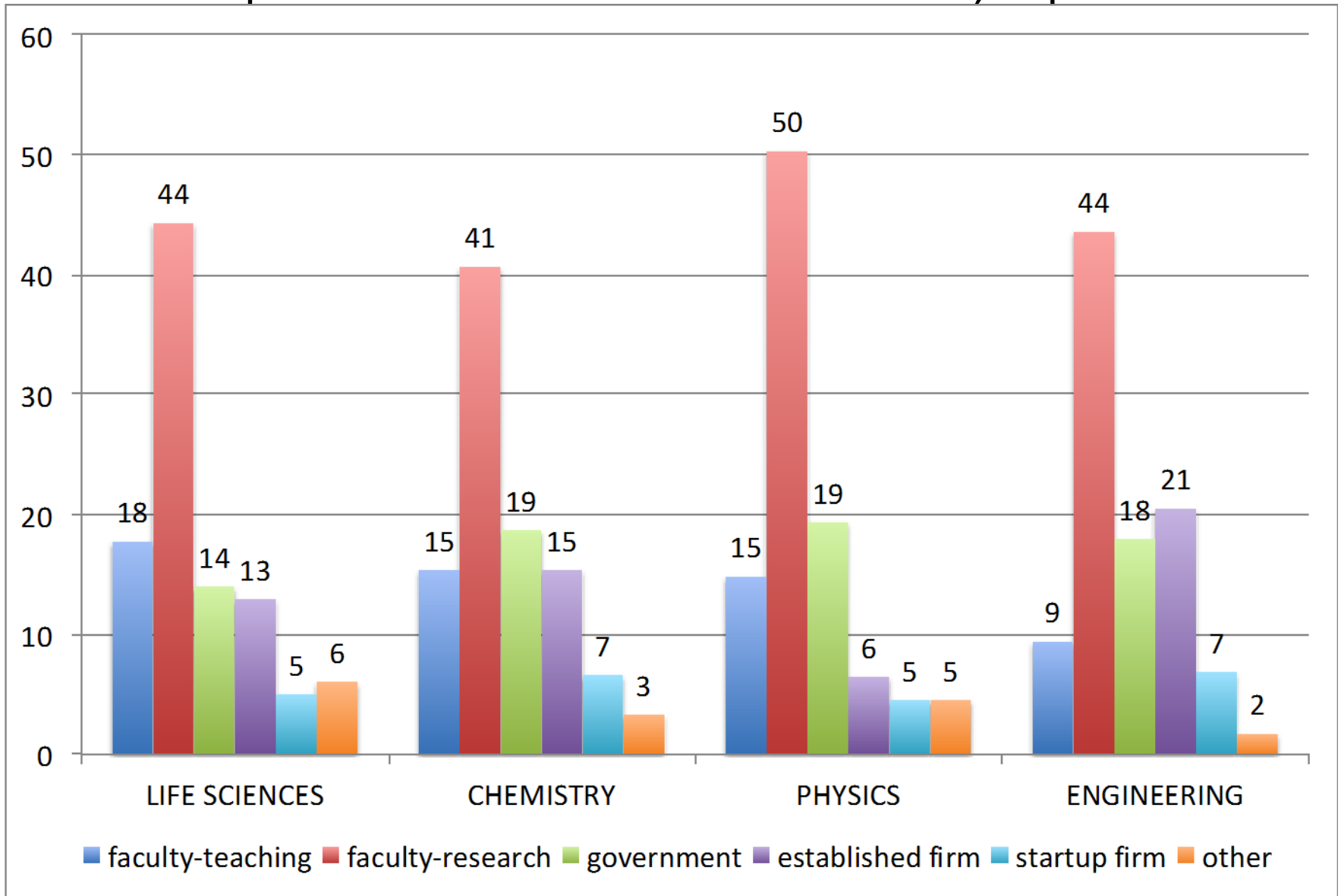
“Lack local” Information

- Important
- Students may know overall outcomes
- But perceive the outcomes of individuals from their programs as being better
- Supported by work of Sauermann and Roach

Are they aware of labor market conditions?

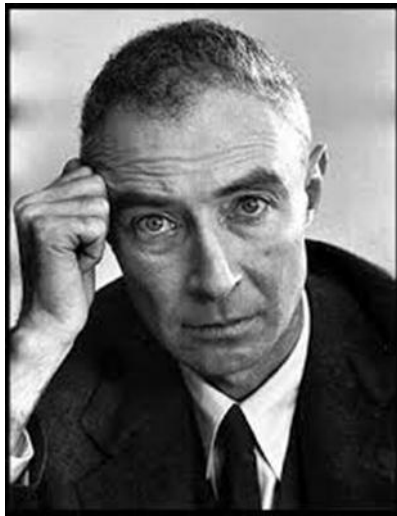


Most preferred career – current Postdocs, in percent



Survey of 45 Departments, Three Fields

- Only two reported on web page where students were placed
- By contrast, common in business schools and economics programs to report placements on web
- Note that NRC Committee “Trends in the Early Careers of Life Scientists” made recommendation that departments disseminate information regarding career outcomes—1998!



“The best way to send
information is to wrap it up
in a person”*
J. Robert Oppenheimer

*“The eternal apprentice,” Time
Magazine, vol. 52, p. 81

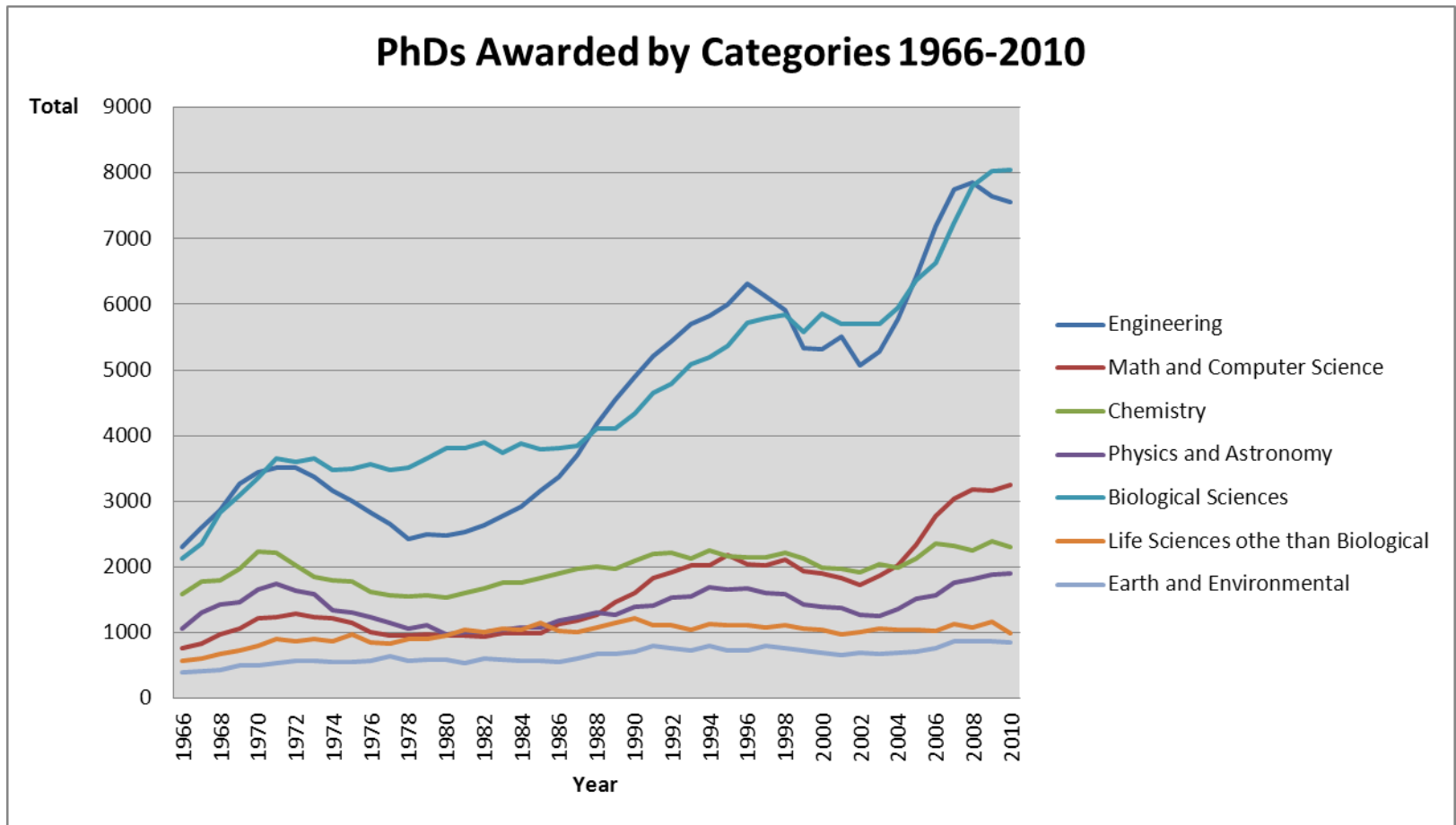
Not a Metric Universities Report

- Universities routinely report
 - Publications
 - Patents
 - Startup companies
 - Funding
- Do not report placements
- Incentives
 - Not a metric universities are typically ranked on

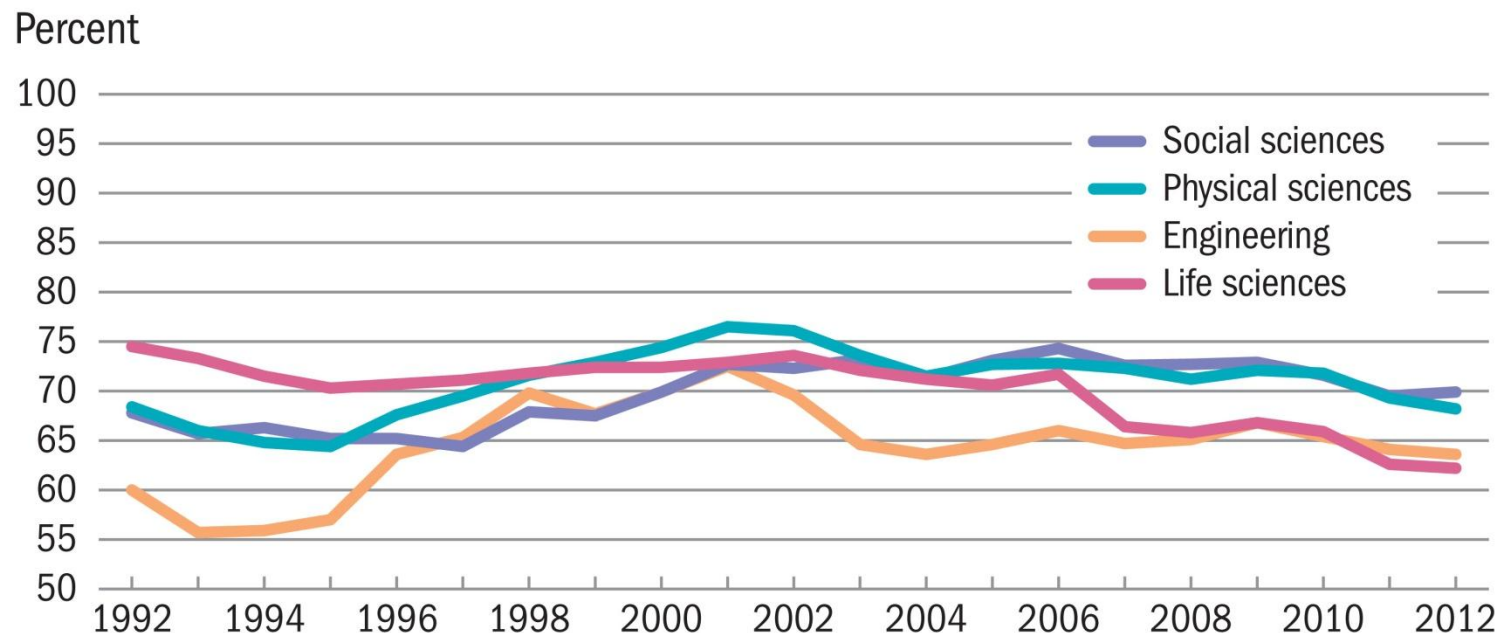
Alternative Jobs Are in Short Supply

- Supply has grown
 - Number of PhDs has increased
- Demand has slowed
 - Funding for research flat
 - State support declining
 - Restructuring of research in industry—example of pharma and large chemical research labs
- Probability of finding position has declined
- Probability of finding research position has declined

Production of PhDs



Definite commitments at doctorate award, by science and engineering fields of study: 1992–2012



NOTE: Definite commitment refers to a doctorate recipient who is either returning to pre-doctoral employment or has signed a contract (or otherwise made a definite commitment) for employment or a postdoc position in the coming year.

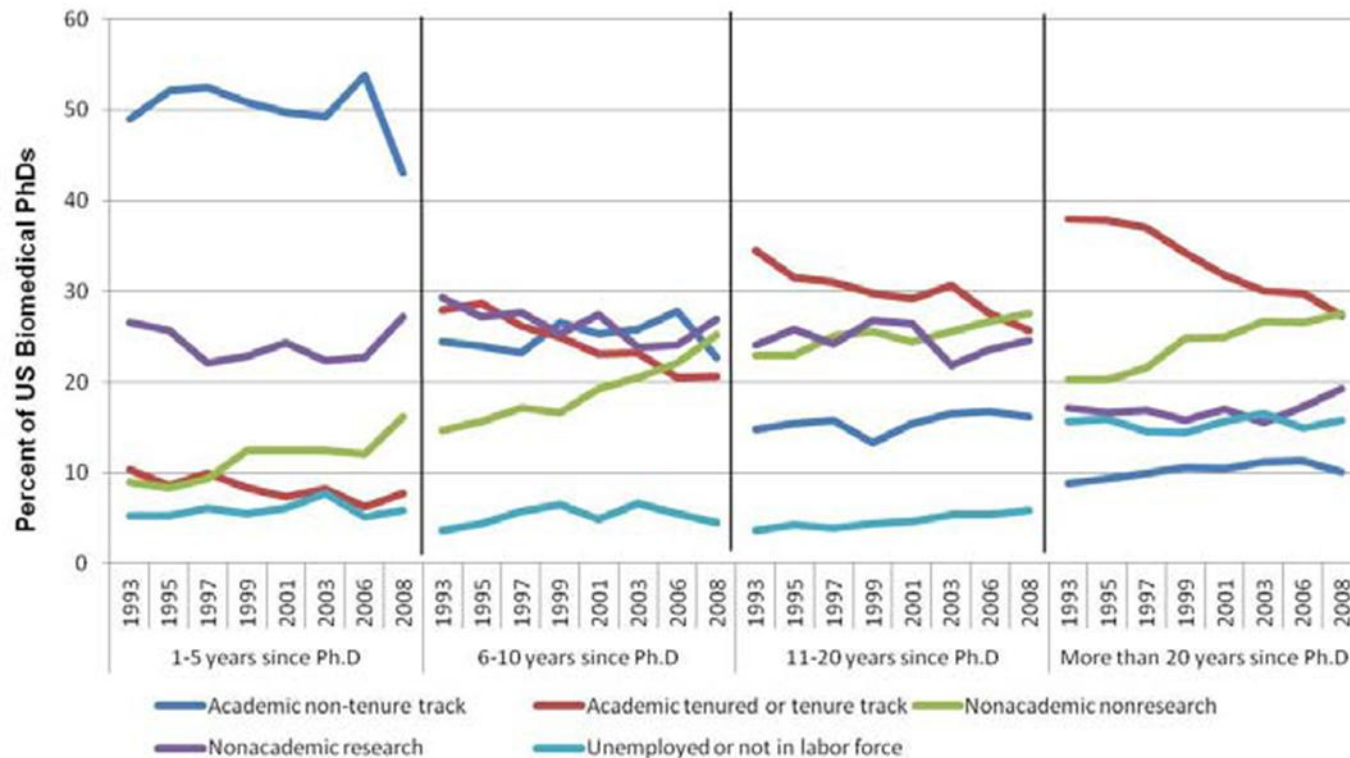
Related detailed data: tables 42, 43.

Summarize

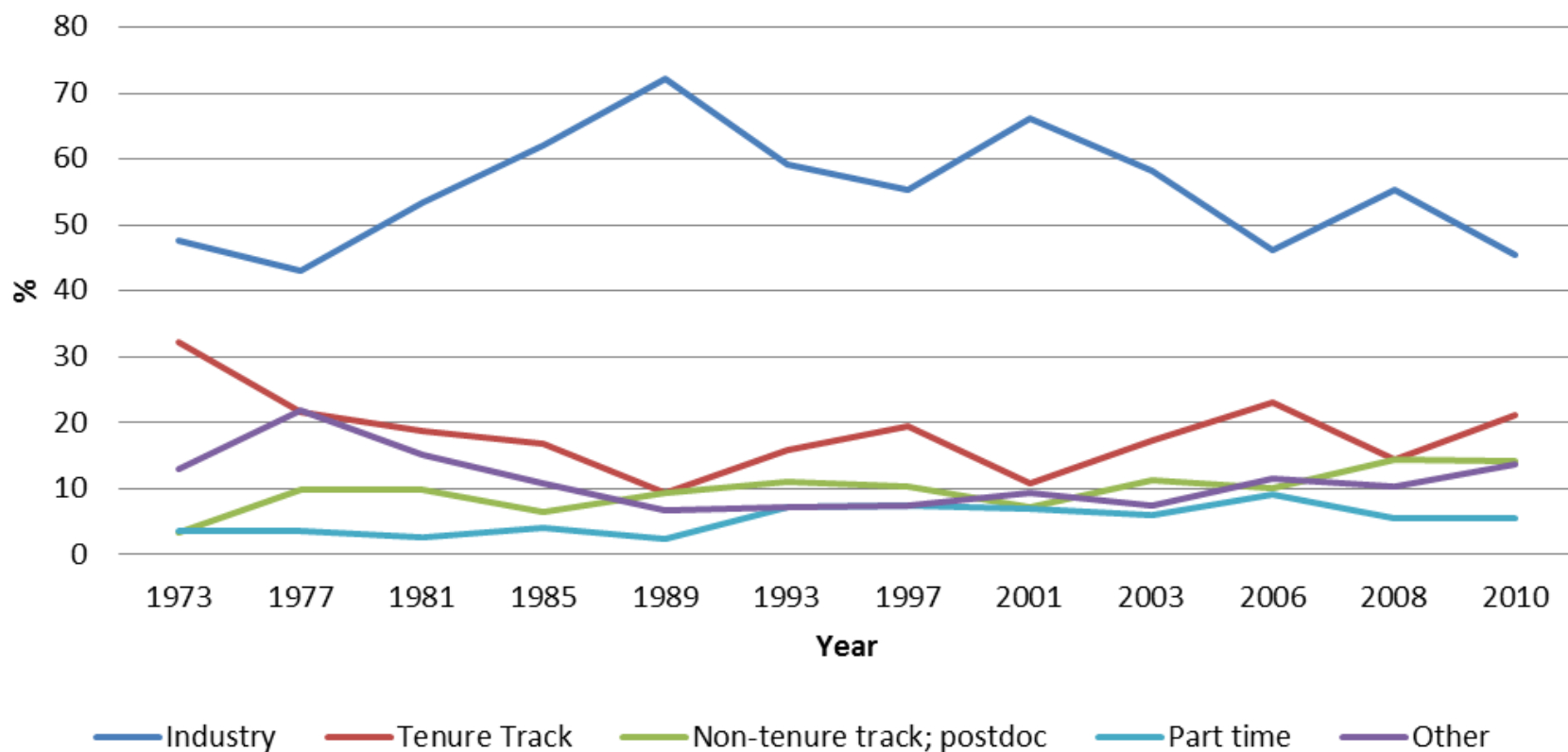
- Percent of new PhDs with definite commitments
 - Declined in the physical sciences by about 10% since 2001 peak;
 - Declined in engineering by about 14%
 - Declined in life sciences by about 14%

Employment Outcomes by Cohort

Biomedical Sciences



Job Position (Chemistry), 5-6 Year Cohort, 1973-2010



Data come from the Survey of Doctorate Recipients

Paula Stephan, Georgia State and NBER

Outcomes During Doubling of NIH

- David Levitt study of 400 NIGMS NRSA fellows 1992-1994 (2010)—the best and the brightest
- Careers launched during doubling—“best of times”
- Outcomes?
 - Slightly more than a quarter in tenure track position
 - 6 percent at a college
 - 30 percent in industry
 - 4 percent research leaders at institutes
 - 20 percent working as a researcher in someone else’s lab
 - 14 percent could not be located; had not published a paper since 1999

Moving Forward Possible Solutions

Fix What's Broken

Cut Back Demand for Postdocs

- Discourage overreliance on postdocs—make costs reflect social cost
 - Raise salary and benefits significantly
 - Consider placing a “training tax” on position that can be used to enhance quality of training programs
- Encourage institutions and provide incentives for institutions to create more staff scientists positions; common at NIH but less common in university community
- Limit amount of salary charged off grants, thereby diminishing demand for graduate students and postdocs



PERSPECTIVE

Rescuing US biomedical research from its
systemic flawsBruce Alberts^a, Marc W. Kirschner^b, Shirley Tilghman^{c,1}, and Harold Varmus^d^aDepartment of Biophysics and Biochemistry, University of California, San Francisco, CA 94158; ^bDepartment of Systems Biology, Harvard Medical School, Boston, MA 02115; ^cDepartment of Molecular Biology, Princeton University, Princeton, NJ 08540; and ^dNational Cancer Institute, Bethesda, MD 20892

Edited by Inder M. Verma, The Salk Institute for Biological Studies, La Jolla, CA, and approved March 18, 2014 (received for review March 7, 2014)

The long-held but erroneous assumption of never-ending rapid growth in biomedical science has created an unsustainable hypercompetitive system that is discouraging even the most outstanding prospective students from entering our profession—and making it difficult for seasoned investigators to produce their best work. This is a recipe for long-term decline, and the problems cannot be solved with simple approaches. Instead, it is time to confront the dangers at hand and rethink some fundamental features of the US biomedical research ecosystem.

graduate education | postdoctoral education | federal funding | peer review

By many measures, the biological and medical sciences are in a golden age. That fact, which we celebrate, makes it all the more difficult to acknowledge that the current system contains systemic flaws that are threatening its future. A central flaw is the long-held assumption that the enterprise will constantly expand. As a result, there is

DNA sequencing, sophisticated imaging, structural biology, designer chemistry, and computational biology—has led to impressive advances in medicine and fueled a vibrant pharmaceutical and biotechnology sector.

In the context of such progress, it is remarkable that even the most successful scientists and most promising trainees

doubling of the NIH budget ended demands for research dollars grew faster than the supply. The demand was fueled in large part by incentives to institutional expansion, by the rapid growth of the scientific workforce, and by rising costs of research. Further slowdowns in funding, caused by the Great Recession,

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Take Note

- No university has incentives to act alone and adopt such policies
- Would not be competitive if they did
- Policies such as these need to be implemented from above
 - NIH and NSF could play a large role here

Cut Back Supply of PhDs and Postdocs

- Provide information regarding different career paths early in graduate training experience; don't wait for career counseling until the postdoc!
- Provide information on alternative degrees, such as MA's
- Encourage internships during graduate school experience
- Require departments to post placement information on line
- Lessen coupling between research and training, thereby decreasing supply of PhDs: Effective training requires a research environment but effective research does not require a training environment
 - “Abstinence is, after all, the most effective form of birth control”

NIH Workforce Committee

- Made recommendations consistent with a number of these suggestions
- NIH recently implemented some of them
- However, two of the more radical proposals—limit amount of salary that could be written off a grant and shift funds from GRA and postdoc positions to training grants-- were not on the list.
- Disappointing!

Increase in Salary?

- Workforce Committee failed to recommend a significant increase in salary for postdoctoral scholars
- The most effective way to fix the system by helping PIs to realize that postdocs are not as cheap as they think

Take Note

- More funding would help but it does not address underlying issue of positive feedback in the system
 - Increased funding is accompanied by increased training which is accompanied by increased demand for funding and postdocs; unstable system
- Need to address incentives that have allowed system to evolve to current situation

Questions/Comments?

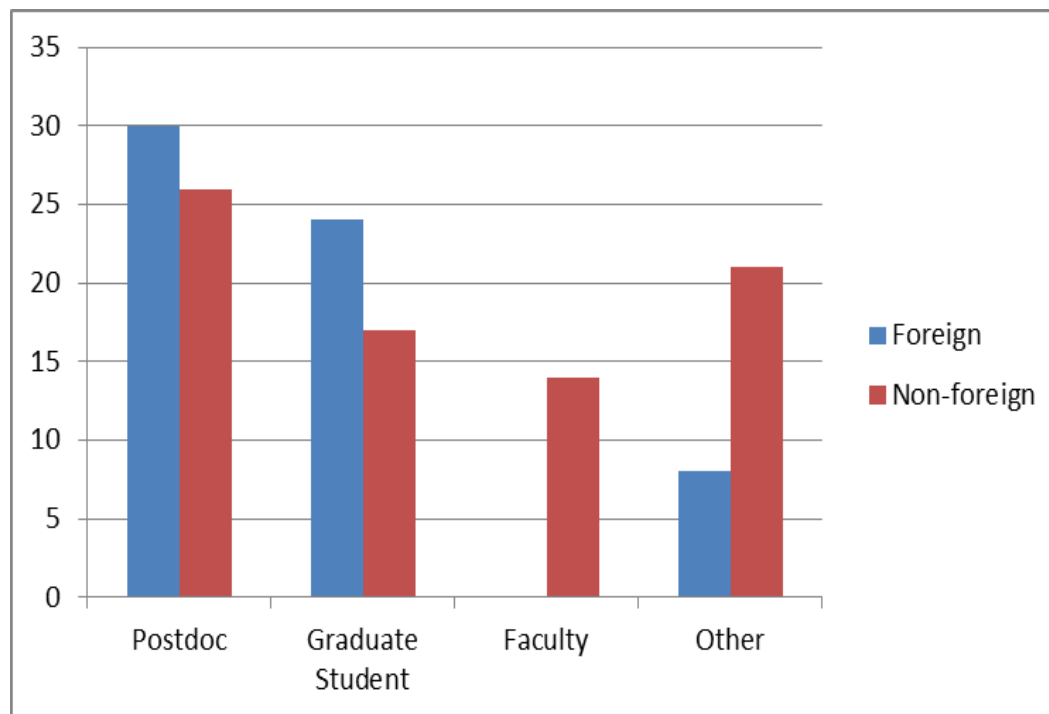
- pstephan@gsu.edu

Supplementary Material

Foreign Postdocs Highly Responsive to Availability of Funding

- 1 percent increase in federally supported research and development expenditures in the US associated with a .5 percent increase in the employment of foreign postdocs (Cantwell & Taylor, 2013).
- Foreign born postdocs grew during the doubling of NIH budget (Garrison, Stith and Gerbi, 2015).

First Authors, US Papers in *Science*



Black and Stephan, 2010