Training, trainees, and trainers in science | **Hannah Gelman**
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What is scientific training?
Your scientific training experience (If you haven't experienced one of these stages of education, feel free to reflect on your impression of that stage from the outside)

	K-12	**Undergrad**	**Grad**	**Post-doc**	**Professional**
What did you learn at this stage of your training? (be either specific or general)					
How did you learn at this stage of your training? (e.g. classes, experience, mentorship, other)					
What was your goal in this stage of your training? Did you meet it?					

Who set your goals at each stage of training? Did this change as you progressed?

Who set your training plan at each stage of training? Did this change as you progressed?

How did you receive feedback on your progress at each stage of training? Did this change as you progressed?

Why do we train scientists anyways?

1) *Science as a tradition*: a set of theories, perspectives, and understandings that scientists build on
2) *Science as a set of technical skills*: a set of technical (mathematical, mechanical, computational) skills that scientists can deploy
3) *Scientists as workers*: scientists are a labor pool that can meet the needs of industry or society
4) *Scientists as independent thinkers*: scientists should have the skills, background, and perspective to lead an independent research program

How does the emphasis on these goals change throughout the course of scientific training?

Have you observed other perspectives on the goals of training scientists throughout your career?

Are any of these goals mutually exclusive? If so, how?

Who is invested in the training of scientists?
Society, funders, institutitions, supervisors/PIs, and trainees themselves are all stakeholders in the process of scientific training.

How does the relative weight of each of these stakeholders change throughout the course of scientific training?

What happens if stakeholder goals don't align?

Viewpoints on scientific training:
Each viewpoint is a semi-themed collection of text, charts, data, or images about some aspect of training in science. For your group's viewpoint, try to answer:

1) Which goal(s) of scientific training are **consistent** with the production of this artifact? i.e. what values surround scientific training do these objects espouse or respond to?
2) Which goal(s) (if any) of scientific training are **inconsistent** with the production of this artifact?
3) Which stakeholder(s) in scientific training might find this information particularly **compelling** or **irrelevant** to the evaluation of scientific training programs?

How do we evaluate the success of a scientific training model?

It is widely discussed that the current model of biomedical training (and to a lesser extent, other scientific training) has long-lasting consequences for both trainees and for science as a whole. For example:

- While the average total length of training in biomedical fields has remained 12 years (grad school + postdoc), the percentage of biomedical PhDs working in tenure track positions has dropped by ~33% since 1997. Postdocs who eventually take jobs out of TT academia pay a long-term price in yearly earnings and a career-long price in total earnings (Kahn and Ginther, 2017).

- The average age of recipients and the age of first award of NIH R01 grants has risen significantly since 1980 (Biomedical Workforce Working Group Report, 2012)

- Women and minorities are underrepresented in the scientific workforce and among scientific doctorate holders, with some attributing part of the "leaky pipeline" to low wages and lack of support during the long training period (Gibbs, *et al*. 2014), as well as more acute disparities in exposure to harassment and abuse during training (Clancy, *et al* 2014, 2017).

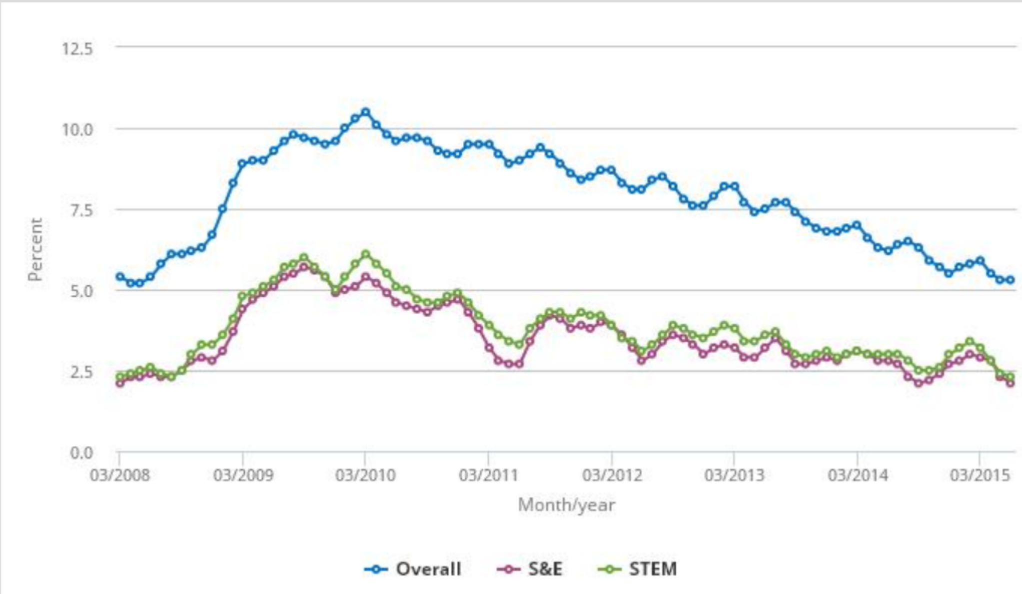
- The extreme competitiveness of the training- and grant-writing pathway takes away time and effort from productive scientific work, and is a disincentive for pursuing risky projects and foundational discoveries (Alberts, *et al*. 2014)

To what extent do these (and other similar statements) address the fundamental question of whether or not the current training paradigm is successful or not?

How does your perspective on the underlying goals of scientific training affect this answer?

Viewpoint 1: The Science and Technology Workforce

Unemployment rates for S&E, STEM, and the overall labor force: March 2008–June 2015



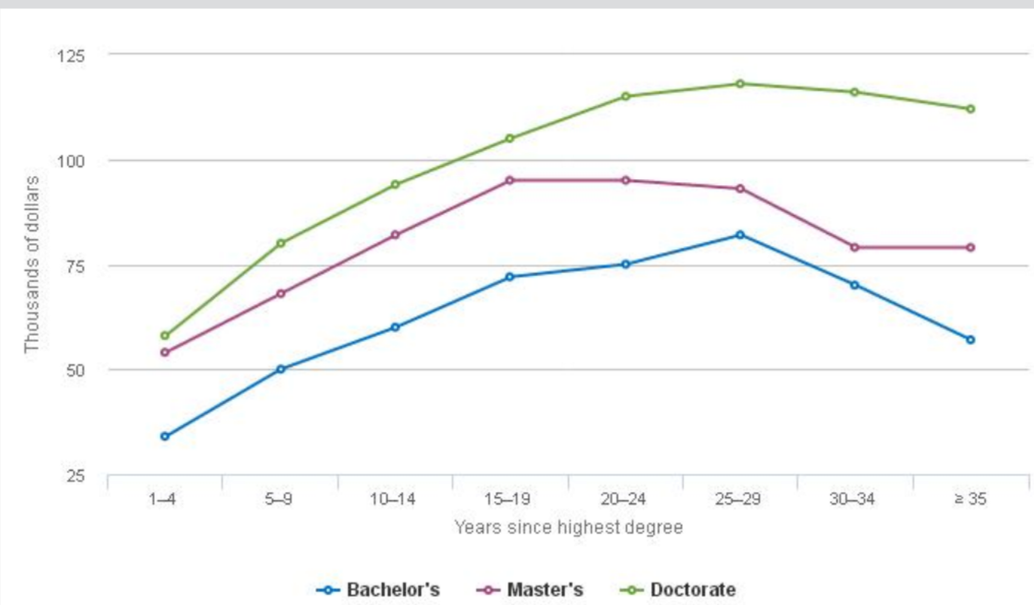
STEM = science, technology, engineering, and mathematics.

NOTES: Data for S&E, STEM, and the total labor force include people at all education levels. Estimates are not seasonally adjusted. Estimates are made by combining 3 months of microrecords of the Current Population Survey (CPS) in order to reduce the problem of small sample sizes and therefore will not match official CPS estimates based on a single month.

SOURCE: Bureau of Labor Statistics, CPS, Public Use Microdata Sample (PUMS), January 2008–June 2015.

Science and Engineering Indicators 2016

Median salaries for S&E highest degree holders, by level of and years since highest degree: 2013

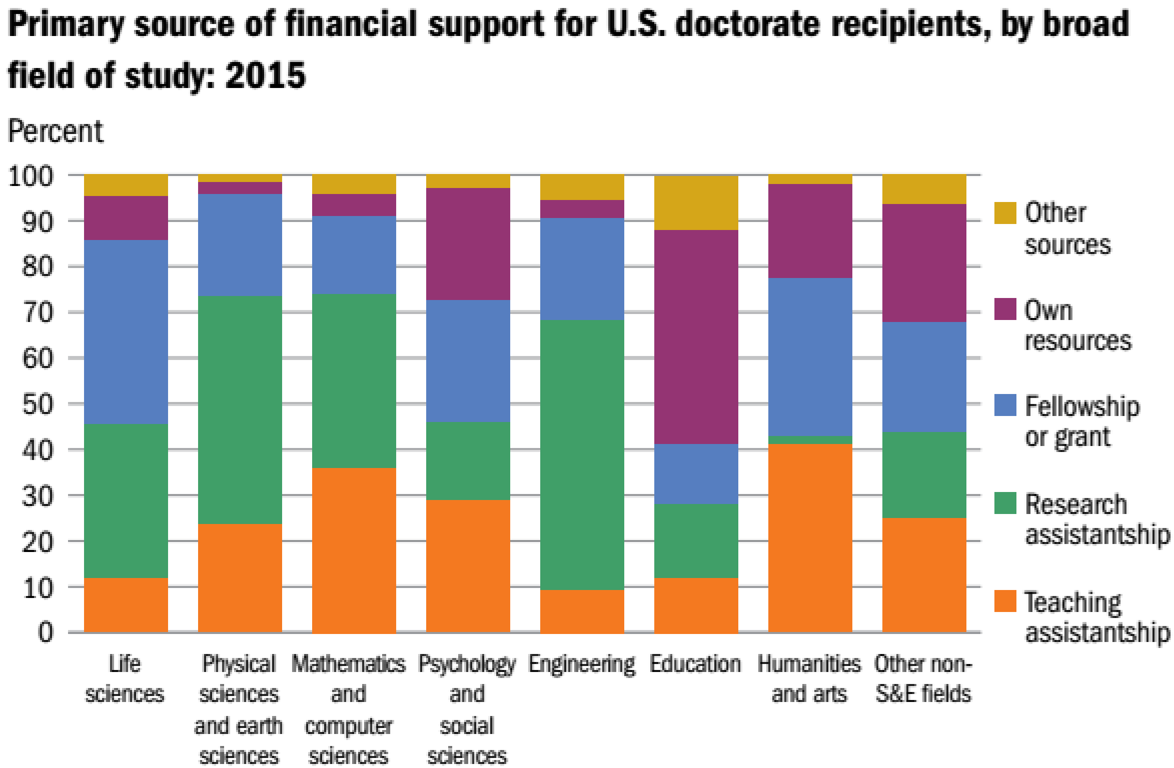


SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT) (2013), http://sestat.nsf.gov.

Science and Engineering Indicators 2016

National Science Board. 2016. *Science and Engineering Indicators*

Viewpoint 2: Funding sources for scientific trainees



National Science Foundation. 2015. *Survey of Earned Doctorates.*

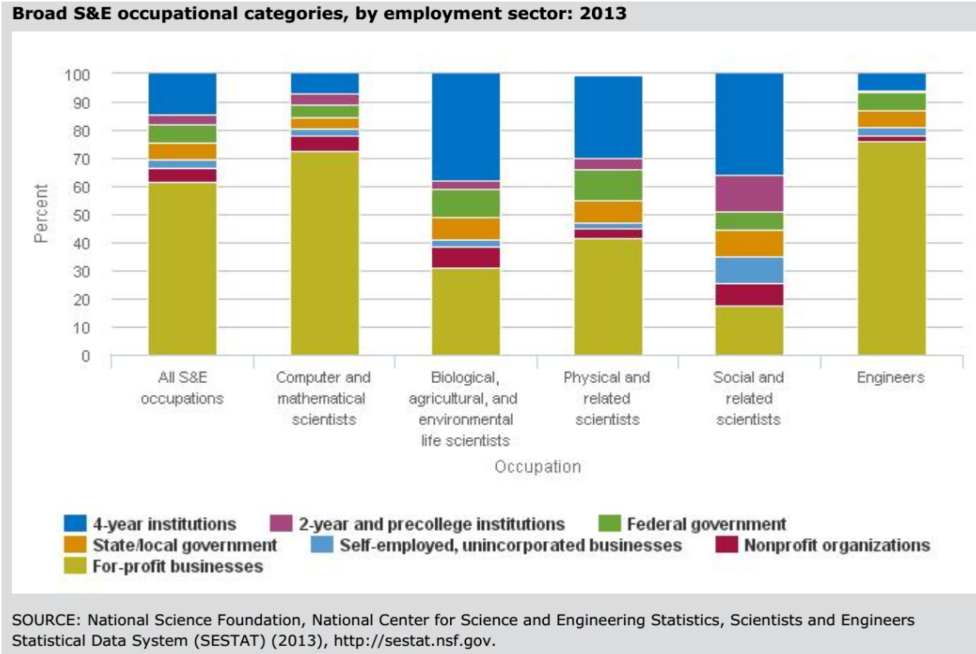
“***Educating graduate students.*** For the last several decades, the numbers of graduate students pursuing careers in biomedical science have grown unchecked because trainees are overwhelmingly supported on research grants (2). In contrast, the number of students who rely on training grants and individual fellowships has remained constant for a long time.

To give federal agencies more control over the number of trainees and the quality of their training, we propose moving gradually to a system in which graduate students are supported with training grants and fellowships and not with research grants. Fellowships have the virtue of providing peer review of the student applicants, and training programs set high standards for selection of students and for the education they receive.

If this recommendation is adopted, it will be essential to change policies that now prohibit the funding of non-US citizens on training grants. Foreign students have contributed enormously to the vibrancy and success of US science, and their continuing contributions are critical to the future of science in the United States.”

- Alberts, *et al*. 2014. Rescuing US biomedical research from its fatal flaws. *PNAS* 111(16): 5773-5777.

Viewpoint 3: Trainee career outcomes



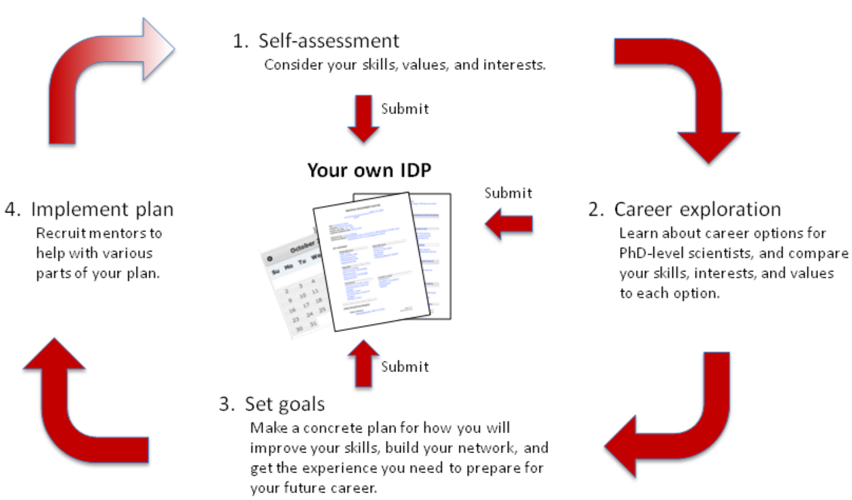
National Science Board. 2016. *Science and Engineering Indicators*

“You have put a lot of time and effort into pursuing your PhD degree. Now it's time to focus on how to leverage your expertise into a satisfying and productive career. An individual development plan (IDP) helps you explore career possibilities and set goals to follow the career path that fits you best.”

An Individual Development Plan (IDP) is a structured planning tool designed to help you:

- identify **long-term career goals** that fit with your unique skills, interests, and values,
- make a plan for **improving your skills**,
- set goals for the coming year to **improve efficiency and productivity**, and
- structure productive **conversations with your mentor**(s) about your career plans and development.

This module will guide you through the process of creating an IDP:



Science Careers, *MyIDP.*

Viewpoint 4: Training for non-research careers

ABOUT

AAAS Science & Technology Policy Fellowships (STPF) provide opportunities to outstanding scientists and engineers to learn first-hand about policymaking and contribute their knowledge and analytical skills in the policy realm. Fellows serve yearlong assignments in the federal government and represent a broad range of backgrounds, disciplines, and career stages. Each year, STPF adds to a growing corps over 3,000 strong of policy-savvy leaders working across academia, government, nonprofits, and industry to serve the nation and citizens around the world.

Insight in a nutshell:

1. 7 week, full-time, postdoctoral data science training fellowship.
2. Full tuition scholarship for all Fellows.
3. Self-directed, project-based learning (*no classes!*) under the guidance of top industry data scientists.
4. A group of smart people who are excited about working on interesting problems while having a positive impact.
5. Interview at top companies immediately following the program.

BU Chemistry

Postdoctoral Faculty Fellowship Program

This innovative program provides a two-year, full time appointment in the Department of Chemistry for recent Ph.D. graduates who plan to pursue academic careers at 4-year liberal arts colleges.

The program provides Postdoctoral Faculty Fellows (PFFs) first-hand experience in teaching chemistry, while enabling them to conduct research.

Viewpoint 5: Trainee attitudes towards training

Table 7. Ratings of Behaviors of Primary Advisor (For Those Students with One Advisor[7]), by Gender (N=2299[a])

Behavior of advisor	Percentage indicating that each behavior is descriptive of advisor to a "considerable" or "very great" extent.		
	All Students	Men	Women
Gives the appropriate level of credit to me for my research contributions	77.6	78.9	76.3
Encourages me to take on challenging opportunities	73.6	77.0	70.1
Encourages me to attain my goals	72.3	74.6	69.9
Asks me to write the first drafts of scientific manuscripts	72.2	73.8	70.6
Gives regular feedback on my research	68.1	70.7	65.3
Models good professional relationships	67.0	67.9	66.1
Advocates for me	66.0	68.1	63.8
Encourages me to present our research at scientific conferences	65.8	68.4	62.9
Creates an environment where all group members are treated fairly	63.4	65.8	60.9
Supports my career path of choice	59.4	61.4	57.3
Takes time to learn about my background, interests, and/or personal relationships	47.9	49.0	46.7
Gives regular feedback on my progress towards degree completion	44.8	46.7	42.8
Helps me to develop professional relationships	43.3	45.7	40.8
Provides information about academic career paths	38.8	40.5	37.0
Engages me in writing grant proposals	33.0	35.6	30.3
Provides information about nonacademic career paths	25.8	26.9	24.7

Note: See Appendix Table E7a for significance notations.
[a] Men: n=1179; Women: n=1112

ACS Graduate Student Survey, 2013.

"So, does this time frame [7-10 years of total training] make any sense? Hm? Think about it. OK, that's enough time. The answer is no! Why? If the answer was yes, then there would have to be strong indications that this training period was structured appropriately to require this amount of time (yes, I know it isn't, but humor me here). There would have to be some sort of master plan, a blueprint for 'Training to be a Scientist'. Graduate and postdoc training would be integrated with definitive milestones and outcomes. Different stages of training would be assigned sequentially, and transition to the next level would require assessment that the appropriate milestone had been successfully reached. Mentors involved in different stages would also have to receive some training to make sure that they were aware of what the student had accomplished and what was expected in the next period of training and how that would be assessed. The student would know where they were in their training, what was expected in the next stage, how much more they had to learn and that there was a definitive outcome, a product - 'the Trained Scientist'."

- How long does it take to train a scientist? 2002. *Journal of Cell Science*. 115: pp. 2253-2254.