


Demographics of Astrophysical, Planetary & Space Sciences: 30 Year Perspective

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We've come
a long way,
but.....

Women In Physics & Astronomy

Moving beyond "the woman problem"

“how to help these poor women”

↓

“how to train/hire/retain the talent we need to do the job”

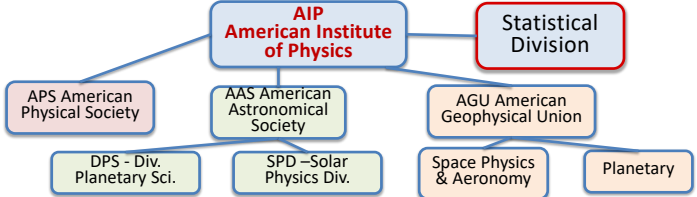
Fran Bagenal
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Think Globally - Act Locally

Outline

- First, the numbers.....
 - International
 - National
- Where are the worst leaks?
- How to fix them?
 - Think globally, Act locally

The acronym soup
of professional
organizations



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graph TD
    AIP[AIP American Institute of Physics] --- SD[Statistical Division]
    AIP --- APS[APS American Physical Society]
    AIP --- AAS[AAS American Astronomical Society]
    AIP --- AGU[AGU American Geophysical Union]
    APS --- DPS[DPS - Div. Planetary Sci.]
    AAS --- SPD[SPD - Solar Physics Div.]
    AGU --- SPA[Space Physics & Aeronomy]
    AGU --- P[Planetary]
    
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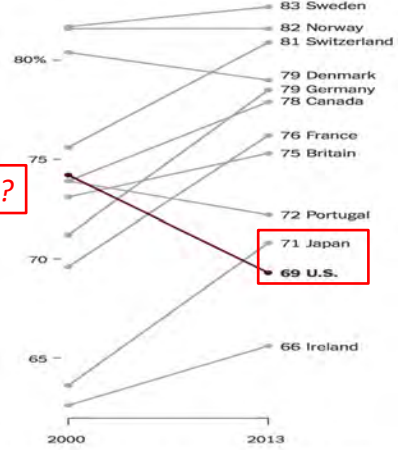
Statistics - buyer beware!

Percentage of women
ages 25-54 who are employed

- *First, there's the numbers*
- *Then, there's the interpretation*

What's going on here?

- *Statistics can often reveal interesting sociology... or politics... or....?*
- *or maybe it's just a change in the way they are gathering the numbers.....*



Country	2000 (%)	2013 (%)
Sweden	83	83
Norway	82	82
Switzerland	81	81
Denmark	79	79
Germany	79	79
Canada	78	78
France	76	76
Britain	75	75
Portugal	72	72
Japan	71	71
U.S.	75	69
Ireland	65	66

Source: Organization for Economic Cooperation and Development

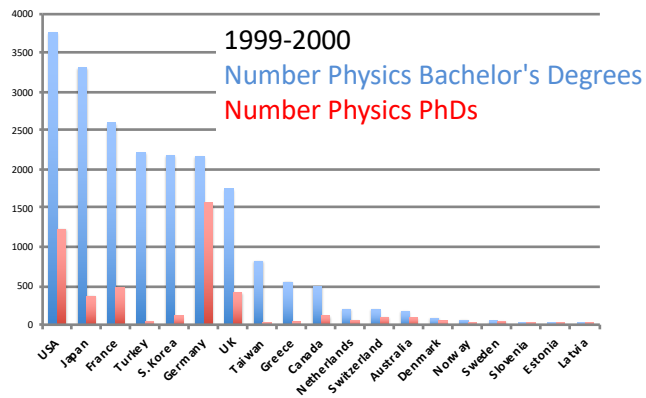
Reflections

- Why does it require an effort to bring more women into scientific careers?
- ... and for them to thrive there
- Women are "the canaries in the mine" – generally, addressing gender issues improves things for all

International View

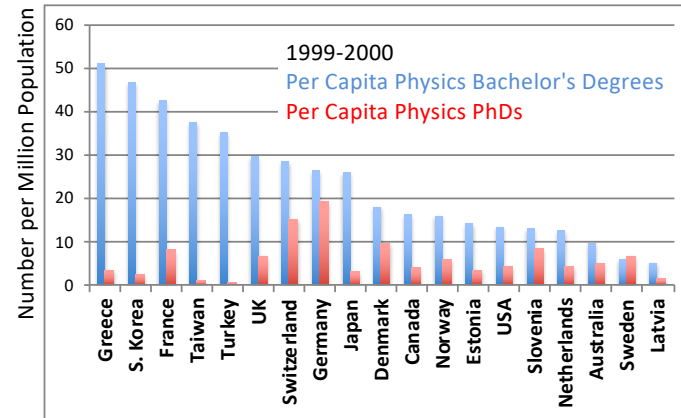
International

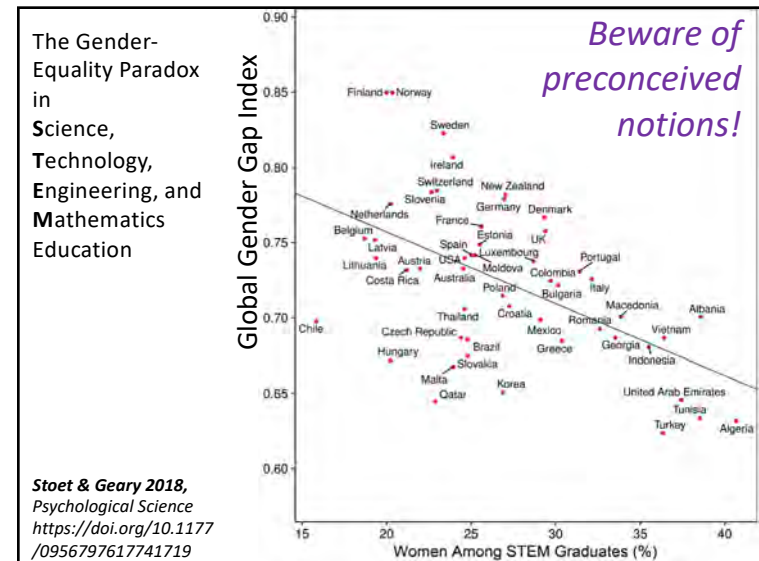
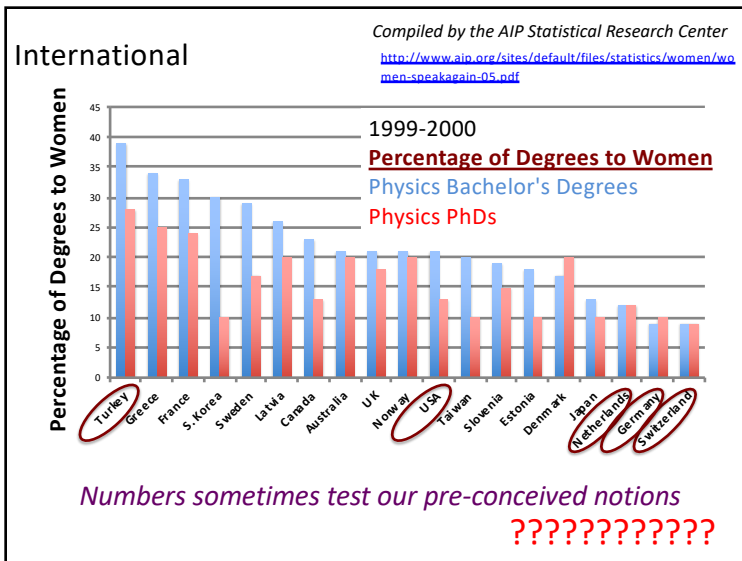
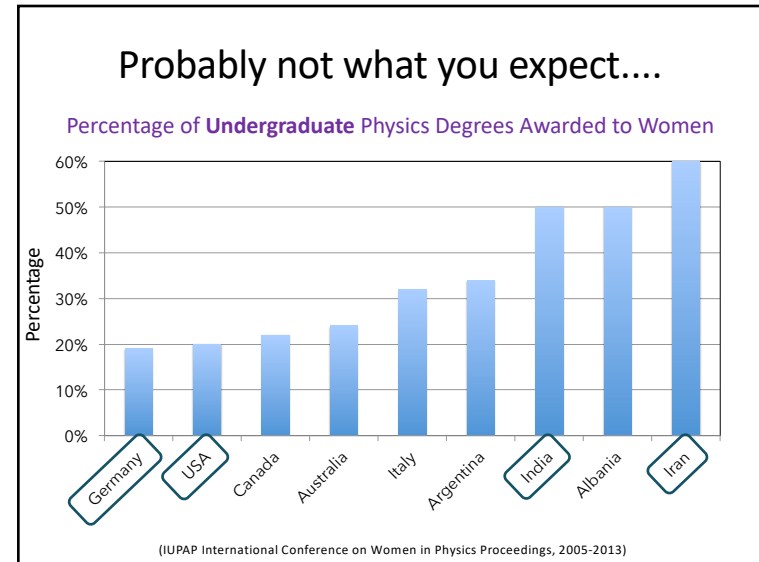
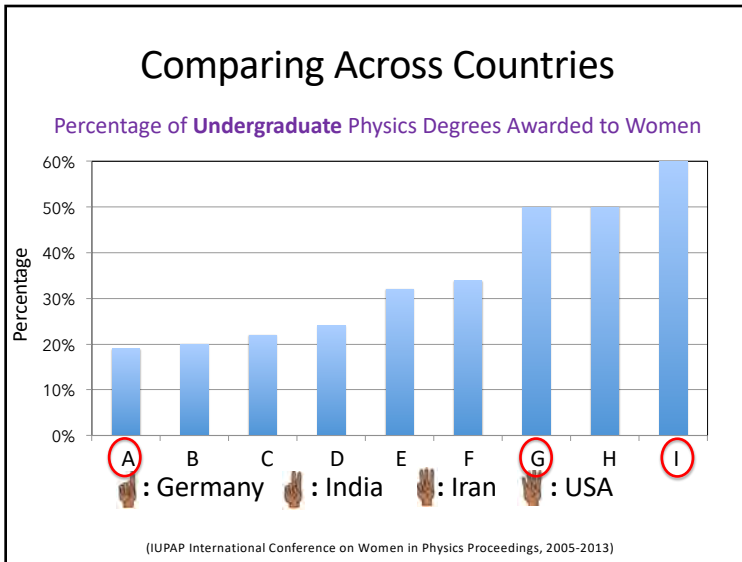
Compiled by the AIP Statistical Research Center

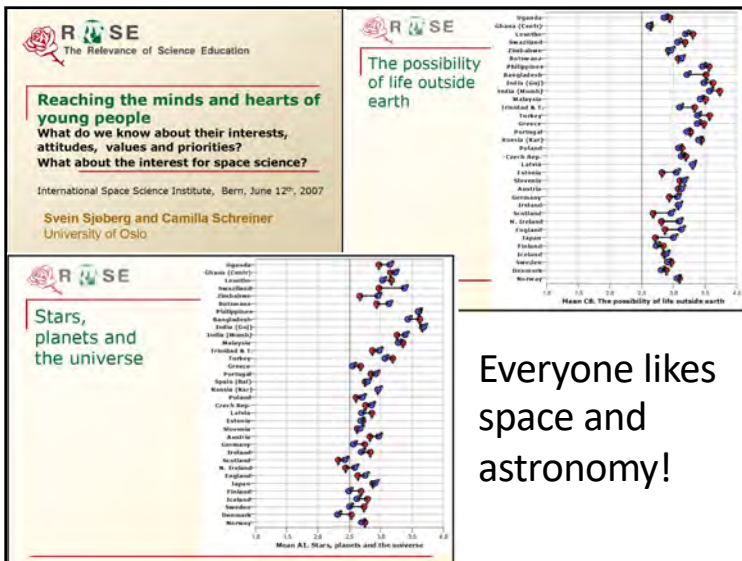
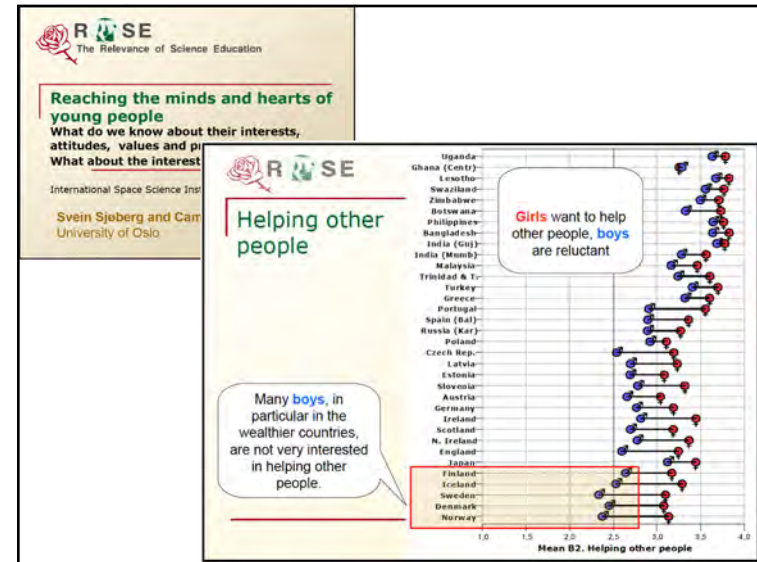
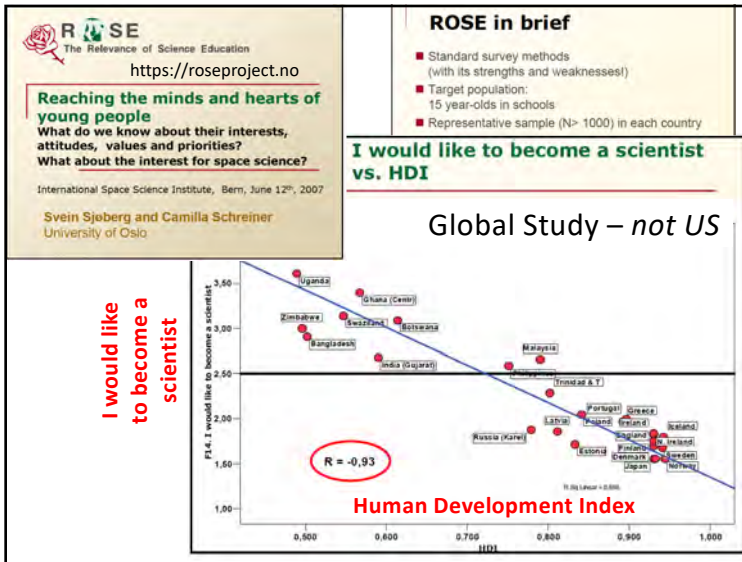


Many countries missing – India? China?

International







National Surveys:

Astronomy
Planetary Science
Space Physics

National Surveys

Astrophysics: 2013 AAS Survey by AIP
63% response = 1583 Respondants
→ 2040 PhD astrophysicists in US

Solar & Space Physics: 2013 NRC Decadal Survey
AGU-SPA, AAS-SPD, Space Weather Week
51% response = 1305 Respondants
→ 2300 PhD solar, space & upper atmos. in US

Planetary: 2011 AIP Survey
62% Response = 2622 Respondants
→ 1200 PhD planetary scientists in US

Not all PhDs

Attendees/Members of Planetary Conference/Section				
	LPSC	AGU	DPS	All Three
LPSC	1280	345	90	
AGU		264	124	
DPS			358	
All Three				161

PhDs/year in US

Astro ~250
Solar & Space Physics ~62
Planetary ~65

Astro Decadal Survey

Solar & Space Physics

Solar & Space Physics

Total = 475

US National Surveys

1. Half PhDs leave academia
2. Few faculty jobs per PhD
3. PhDs get great jobs
4. **More non-academic career advice needed!**

Astronomy: Jobs for PhDs

Planetary - Jobs for PhDs

62 PhDs / year

1 faculty per 5-20 PhDs ??

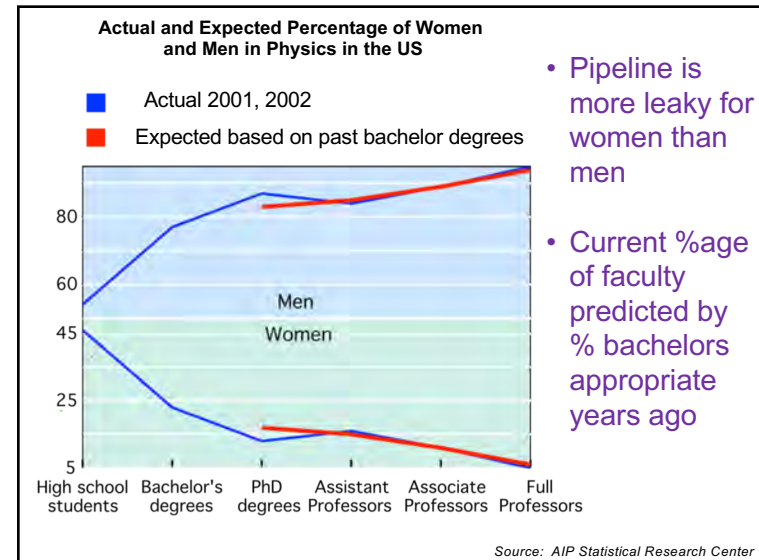
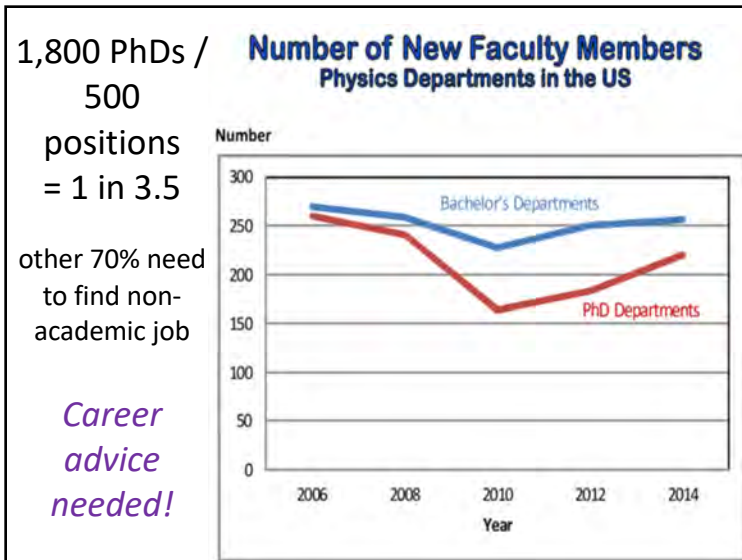
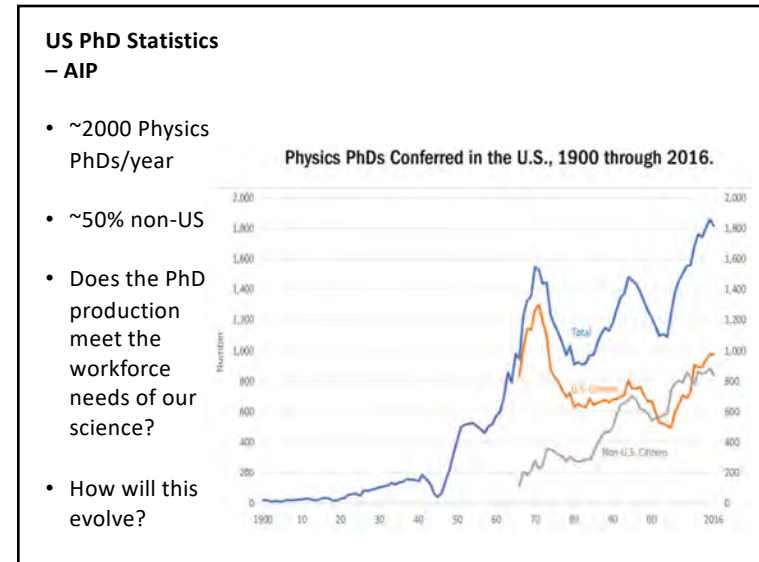
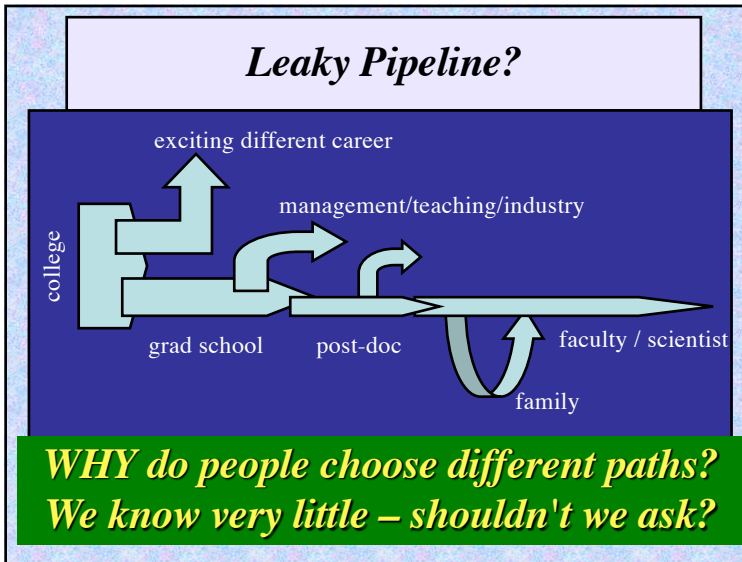
Recent years??

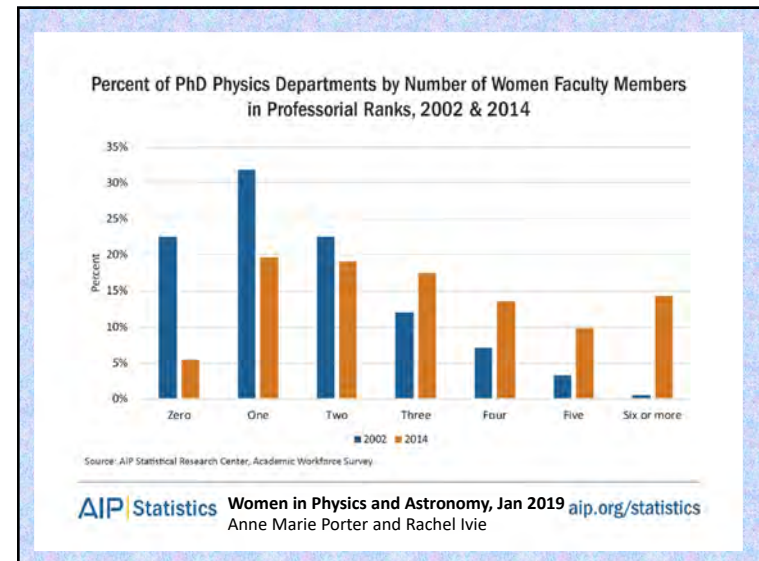
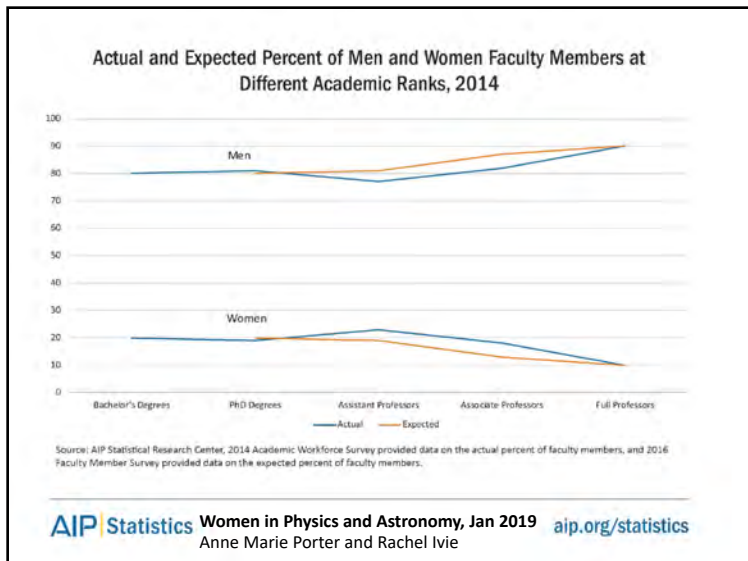
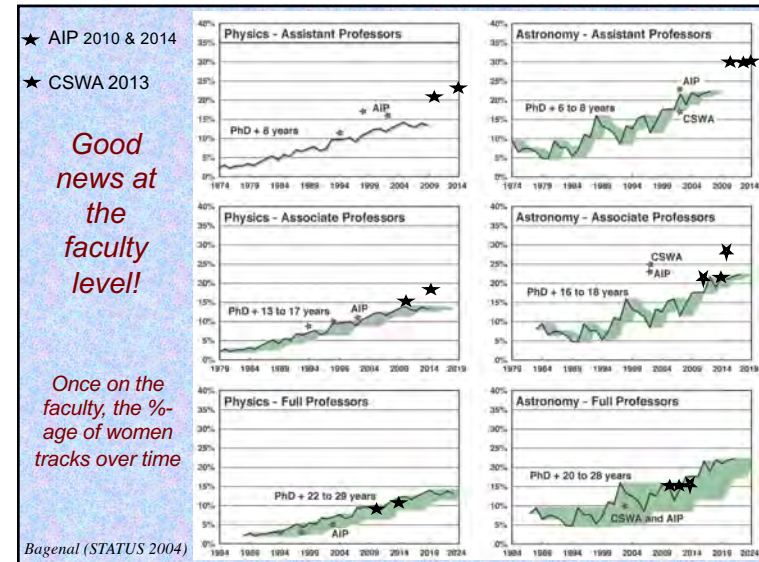
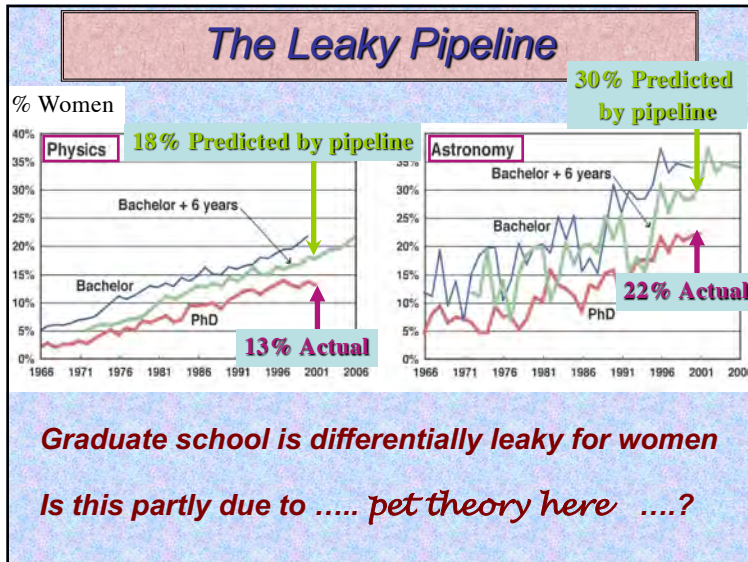
More varied? Less academic?

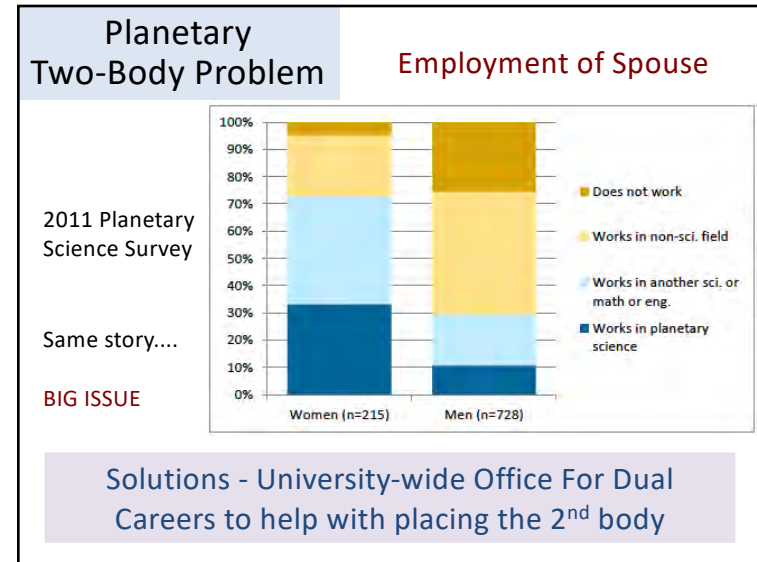
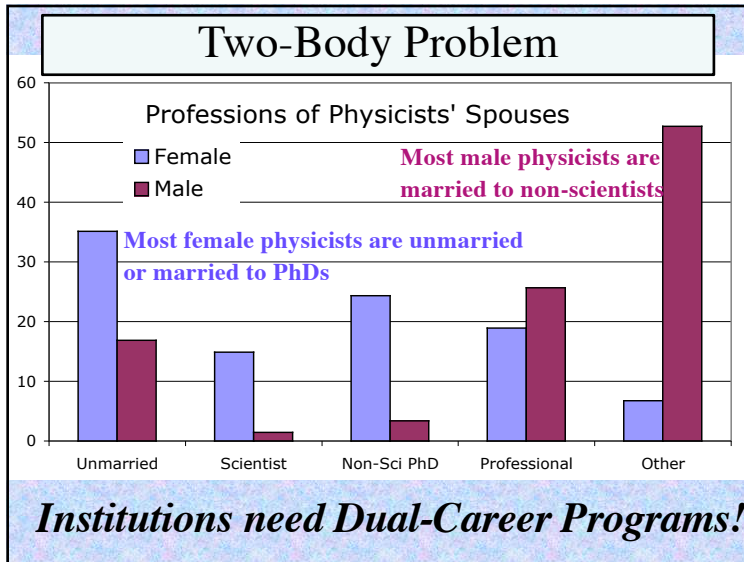
Solar & Space Physics - Jobs for PhDs

The Leaky Pipeline

..... What's up with those canaries?







Gender Differences in Career Opportunities, Advancement, and Resources

Career Opportunities and Resources	Survey Source	Gender Differences
Number of promotions	PhD Plus 10 Survey, 2011	No significant difference
Number of publications	PhD Plus 10 Survey, 2011	No significant difference
Gave a talk as an invited speaker	Global Survey of Physicists, 2010	Men were 45% more likely
Acted as a manager	Global Survey of Physicists, 2010	Men were 33% more likely
Acted as a journal editor	Global Survey of Physicists, 2010	Men were 27% more likely
Supervised undergraduate students	Global Survey of Physicists, 2010	No significant difference
Supervised graduate students	Global Survey of Physicists, 2010	Men were 32% more likely
Had enough funding	Global Survey of Physicists, 2010	Men were 53% more likely
Had enough equipment	Global Survey of Physicists, 2010	Men were 36% more likely
Had enough office space	Global Survey of Physicists, 2010	No significant difference
Had enough lab space	Global Survey of Physicists, 2010	Men were 15% more likely
Had enough employees	Global Survey of Physicists, 2010	Men were 36% more likely

"PhD + 10 years" survey

Which factors are most important for pay?? for promotion??

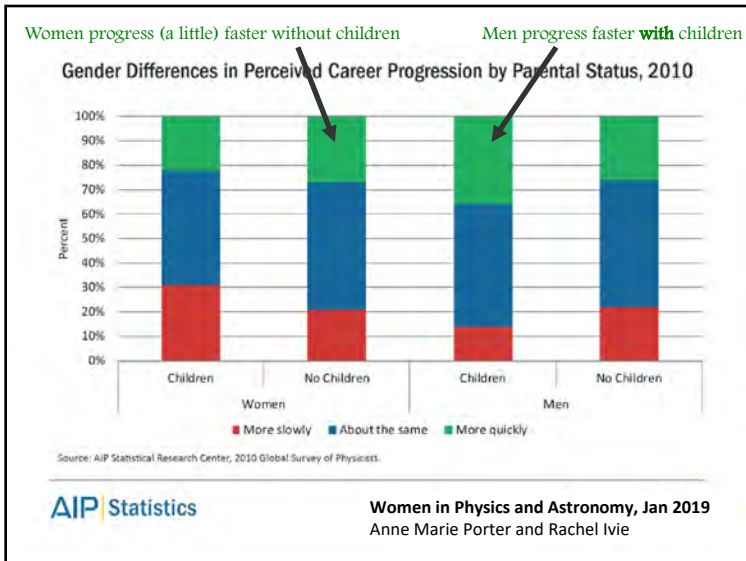
Men had 10% higher salary

AIP Statistics Women in Physics and Astronomy, Jan 2019
Anne Marie Porter and Rachel Ivie

Gender Differences in Career Compromises for Family Reasons

Career Compromises	Survey Source	Gender Difference
Relocated for a spouse	Longitudinal Study of Astronomy Graduate Students, 2007-2016	Women were 204% more likely
Declined job for a spouse	PhD Plus 10 Survey, 2011	Women were 346% more likely
Had a career break for family reasons	Global Survey of Physicists, 2010	Women were 400% more likely
Became a stay-at-home parent	Global Survey of Physicists, 2010	Women were 463% more likely
Chose a less demanding or more flexible schedule	Global Survey of Physicists, 2010	Women were 111% more likely
Changed employers or field of employment	Global Survey of Physicists, 2010	Women were 40% more likely
Spent less time at work	Global Survey of Physicists, 2010	Women were 104% more likely

AIP Statistics Women in Physics and Astronomy, Jan 2019
Anne Marie Porter and Rachel Ivie

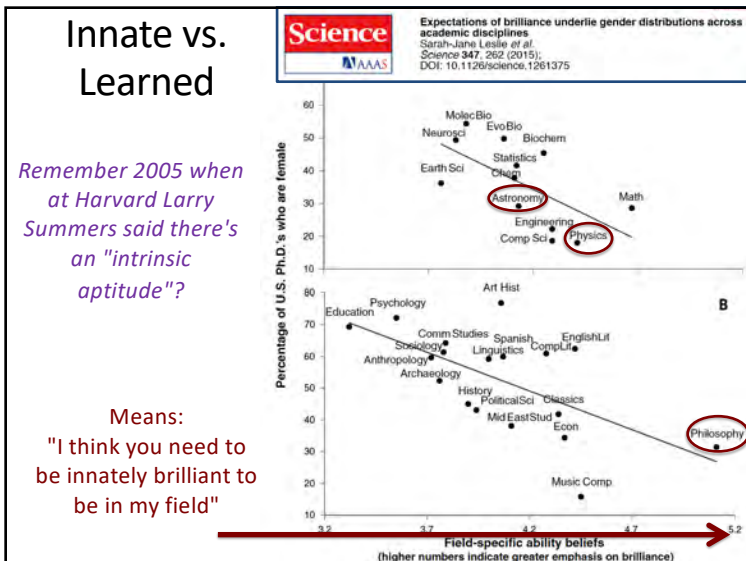


Reasons for Disparities?

*Meg Urry, Yale Physics Dept.
AAS Past-President*

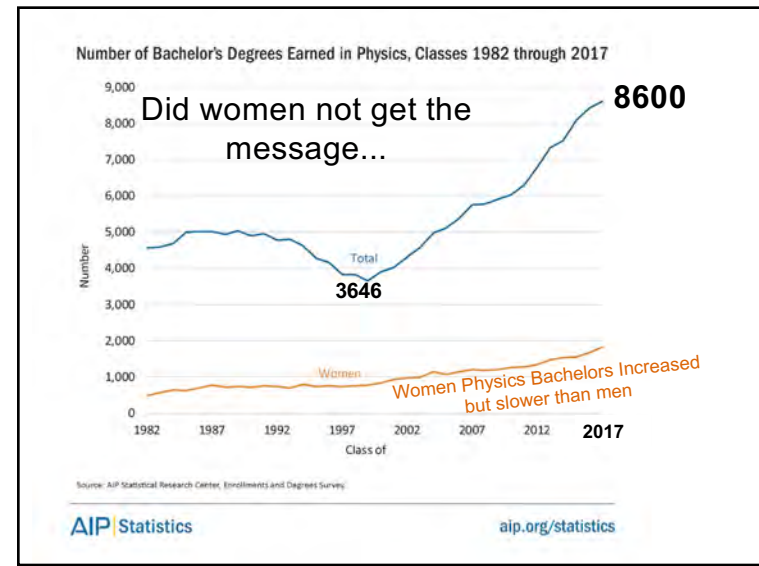
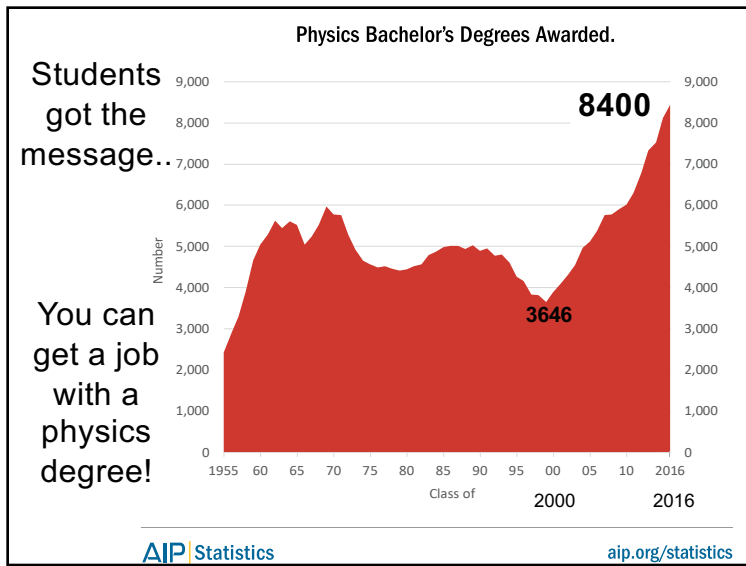
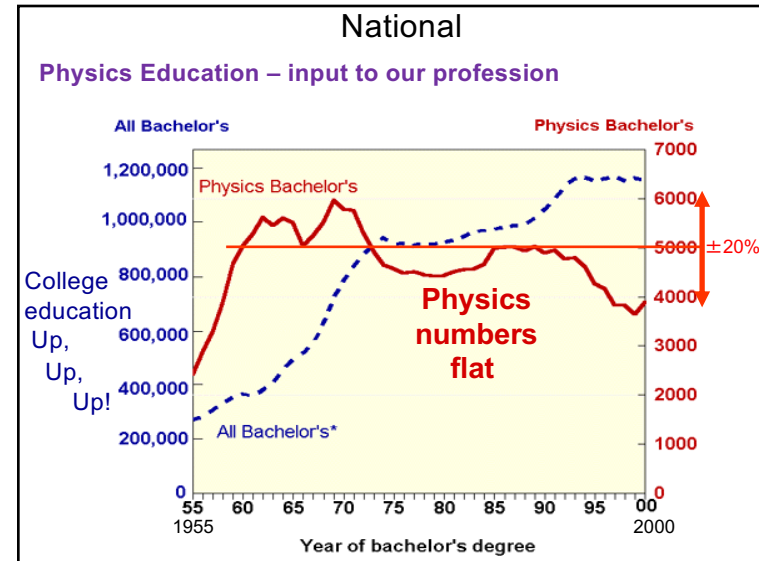
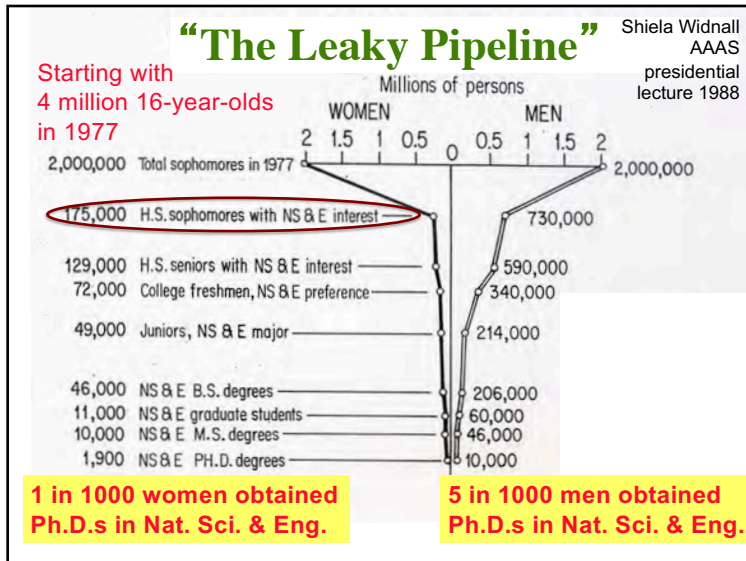
- **Not family**
 - Women w/o children not more successful
 - Many women in other demanding fields
 - Countries w/ strong support systems (e.g., Scandinavia) have few women in physics
 - Academic careers flexible: *become a professor, have a family!*
- **Culture?**
- **Earlier in Pipeline?**

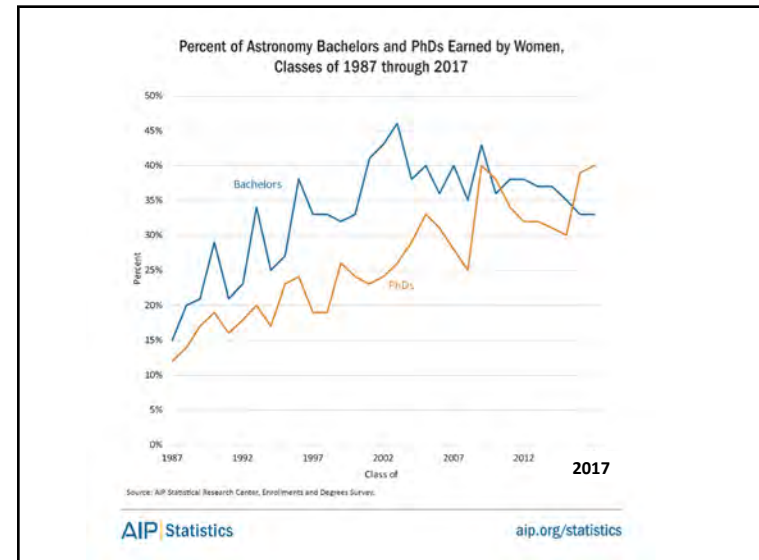
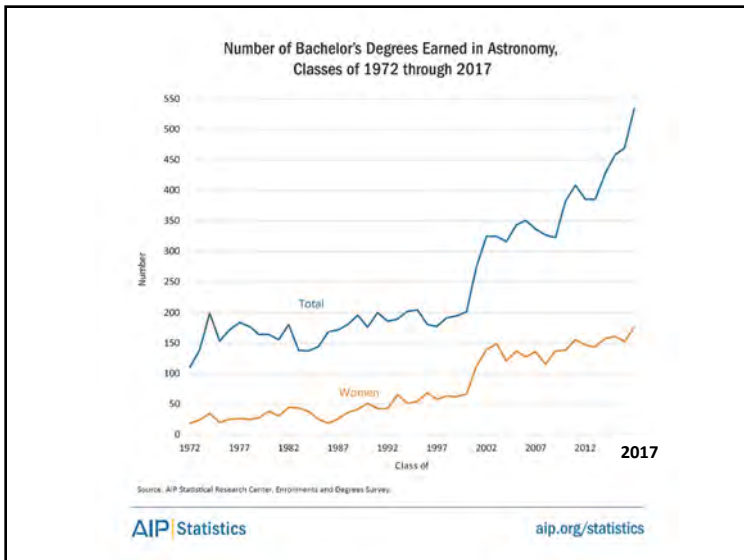
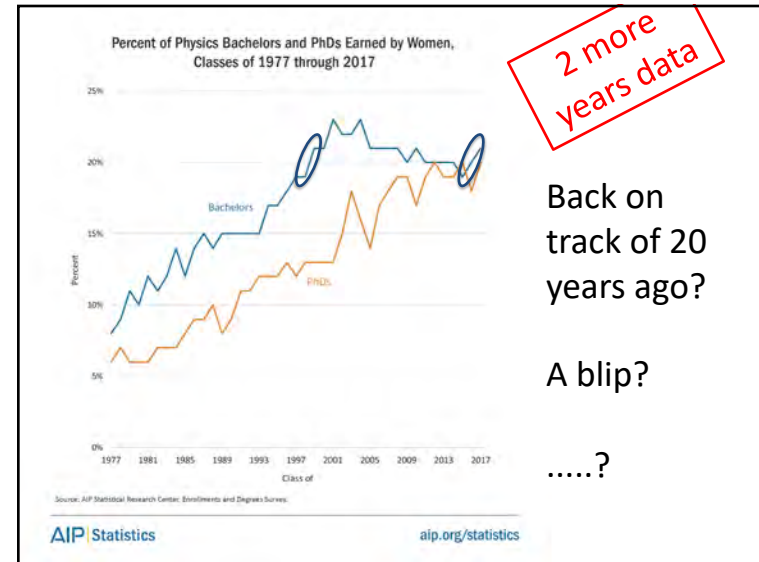
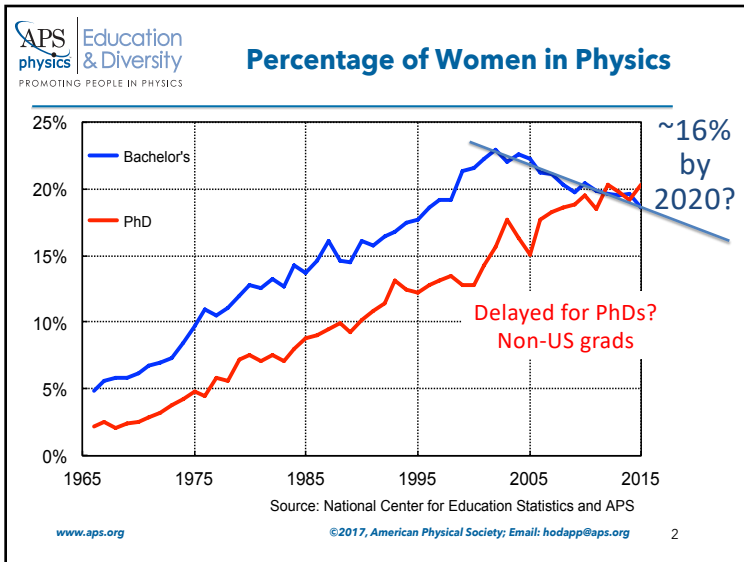
*Fran says:
"Work, family, life
- at any 1 time pick 2"*

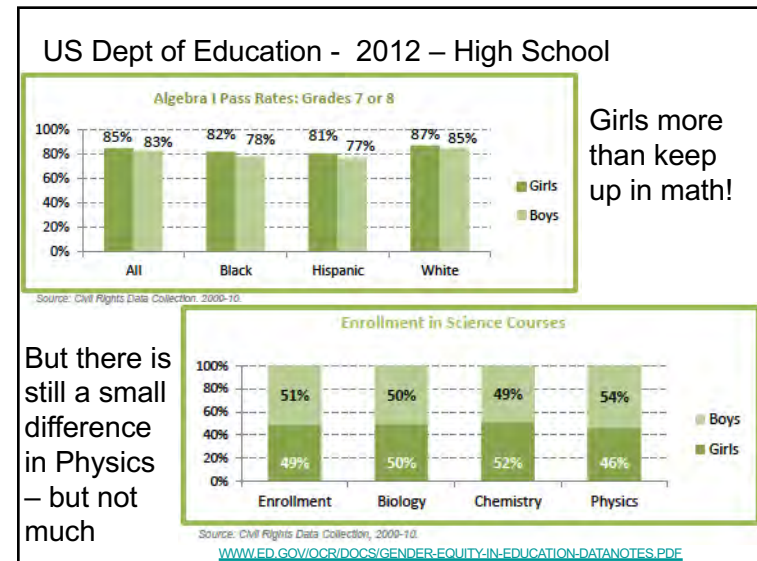
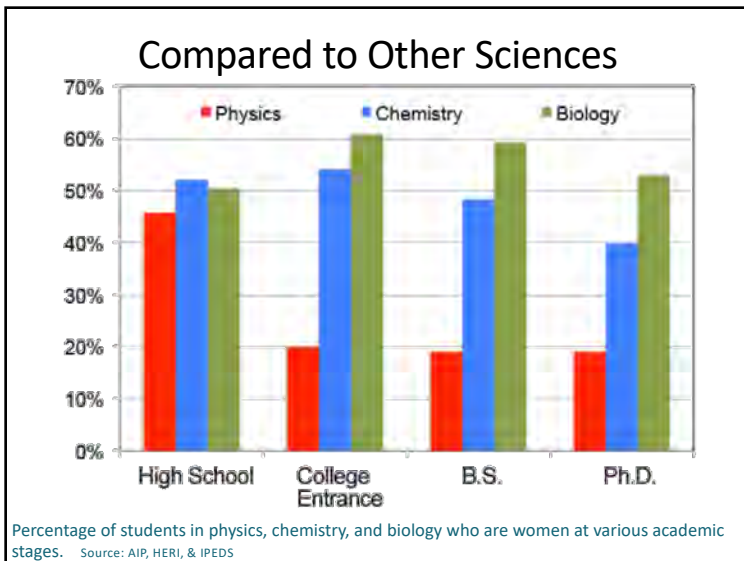
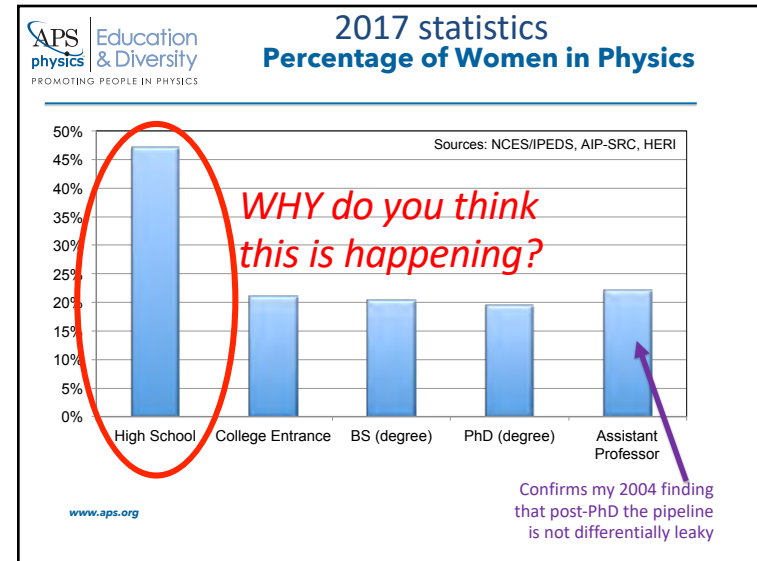
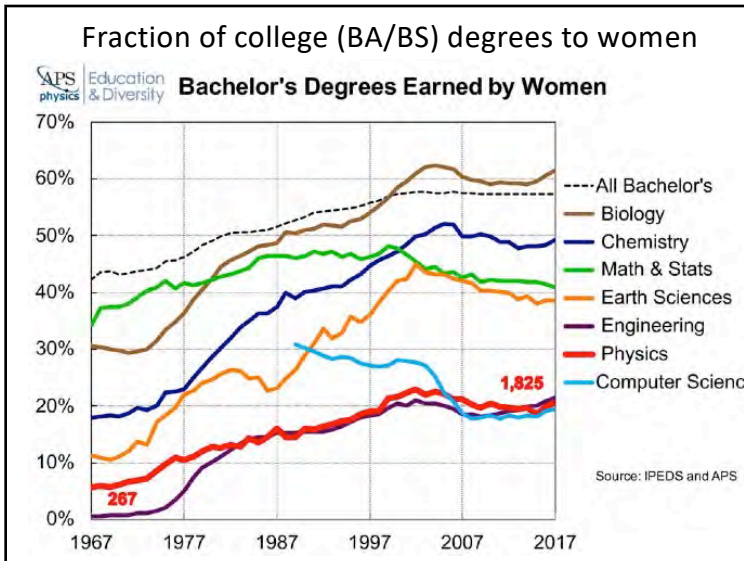


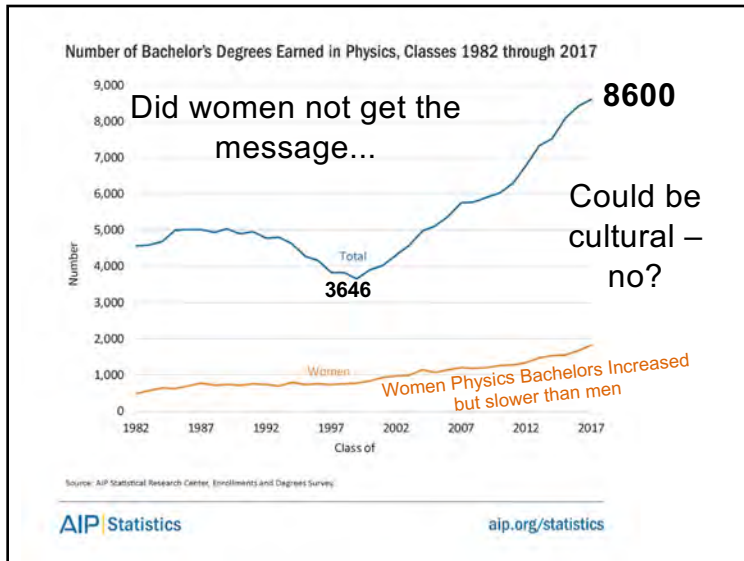
US Physics Undergraduate Education:

Workforce Supply
Total Numbers
Gender Issues
Other Minority Issues









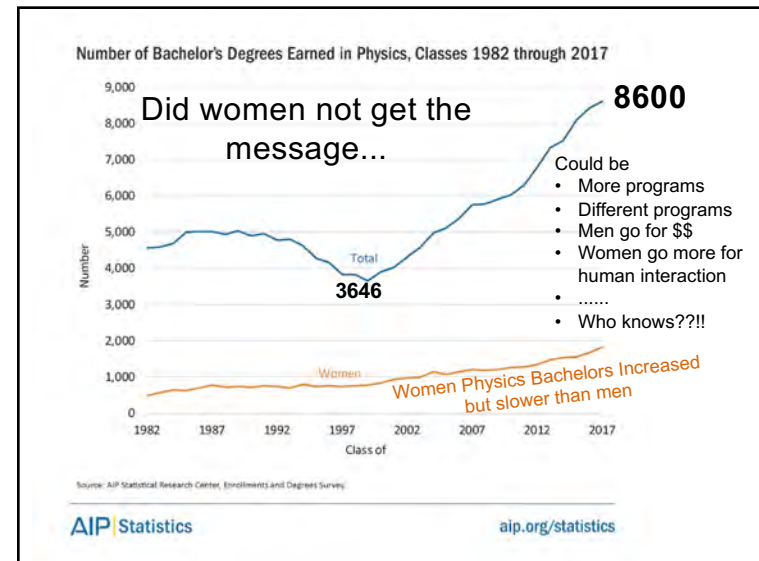
What does a physicist look like?

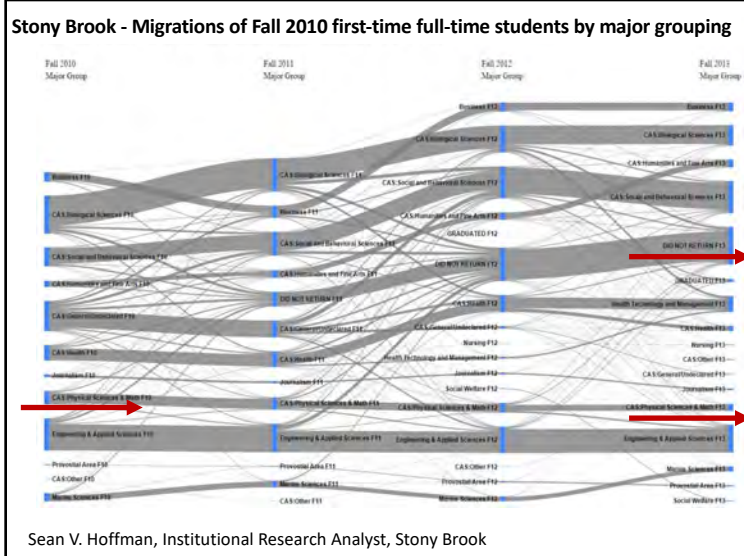
Ask Google Images: 6 out of 140 women

Hmm.... not much we can easily do about this

Yes, there's *Hidden Figures* but there's also *Big Bang Theory*, Bill Nye, etc., etc., etc.,

Anybody can be a physicist





Where majors start-end

- What does this look like separated by years?
- When do students move? Why?
- Gender? Minorities?
- **What does this look like at your institution?**

Let's do the research

CHARTING A PATH

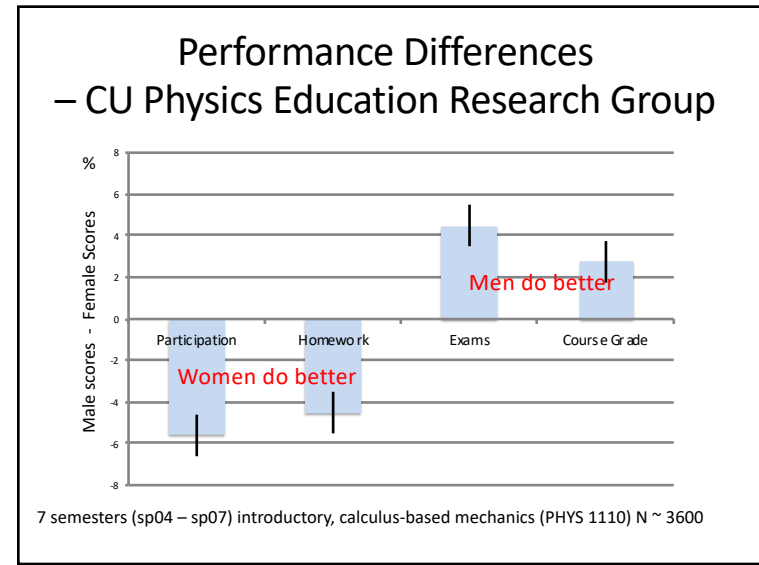
Visualizing students' educational journeys has informed recruitment and retention efforts at the University of California Davis (UCD). The tool was developed by the IAMSTEM HUB in Undergraduate Education.

It's not just about grades....

- women and men equally likely to change their major in response to poor grades
- Women more likely to switch out of male-dominated STEM majors in response to poor performance compared to men

still
Is this true at your institution?
 ^
Got the stats?

NATIONAL BUREAU OF ECONOMIC RESEARCH
 Kugler et al. 2017 <http://www.nber.org/papers/w23735>



Women lack math ability ...

- STEREOTYPE THREAT: performing below ability because of expectations
- Example: Given math test told "this will be hard"
 - Men: 25/100
 - Women: 10/100
 - Gender gap in math?
- "This test has been designed to be gender neutral"
 - Women: 20/100
 - Men: 20/100
- Important for minority students?

Costs Nothing!!

Credit: Scott Baxter
Florida State U.

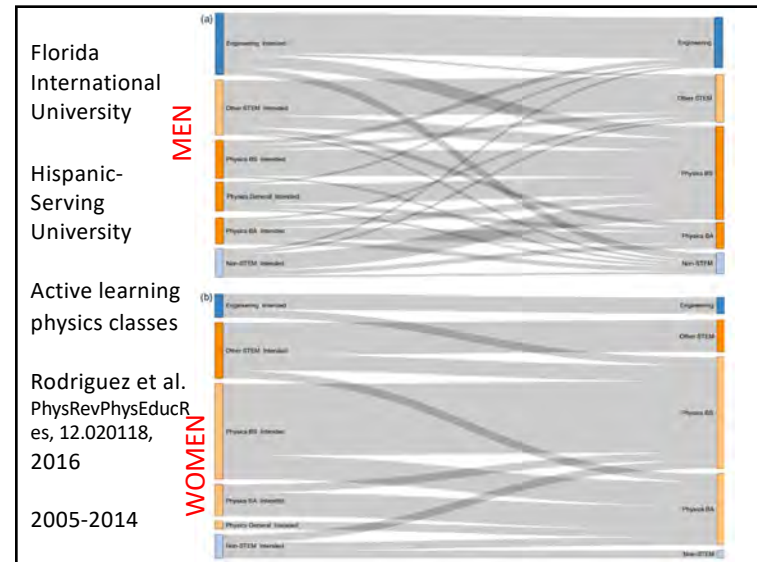
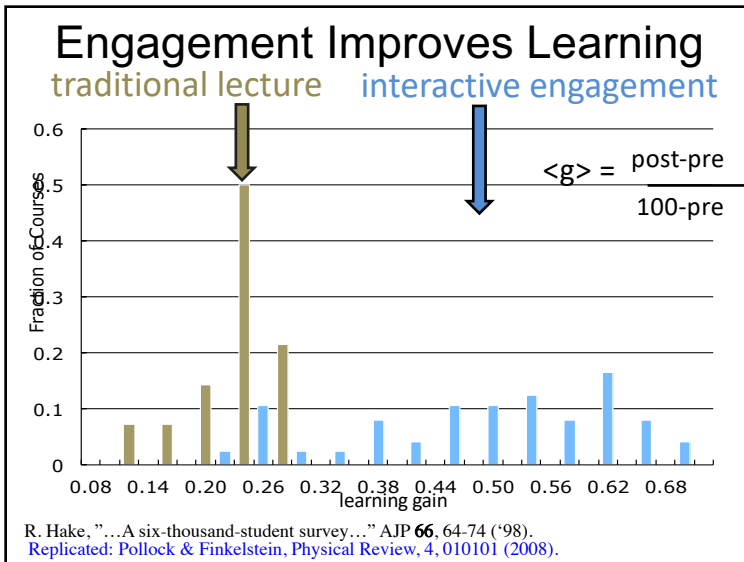


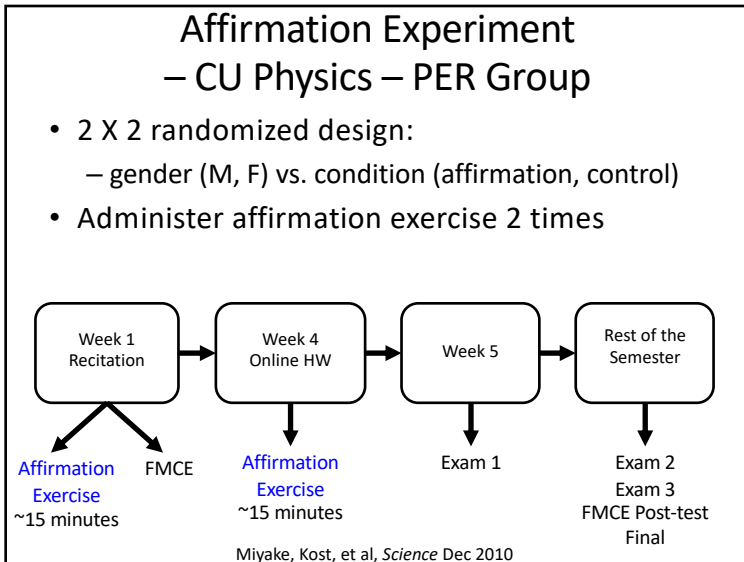
Virginia Tech

Group Learning

- more interaction
- practical questions
- more social

Physics professor Erin De Pree (standing) works with a group of students at St. Mary's College of Maryland. Credit: Michelle Miller



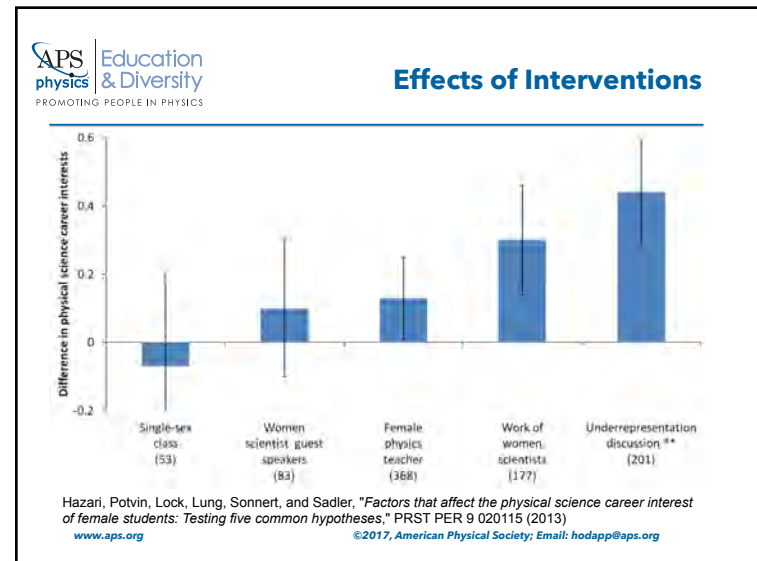
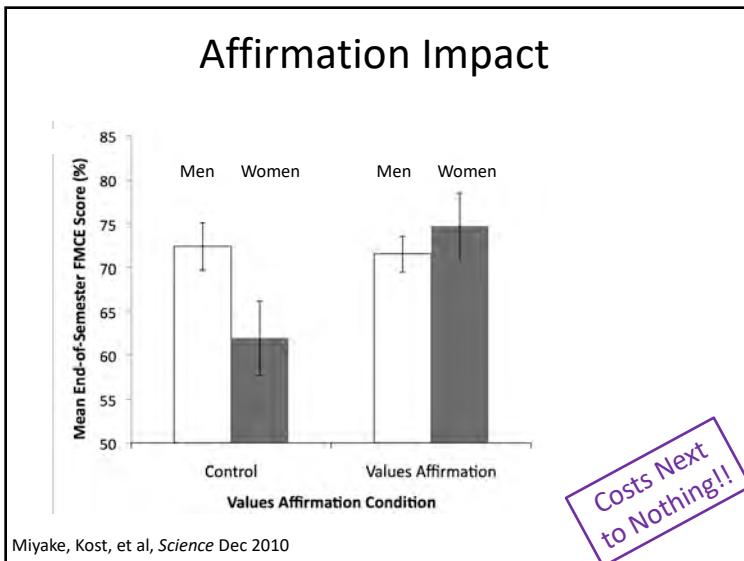
Affirmation Experiment – CU Physics *just 15 mins*

The first page listed 12 values:

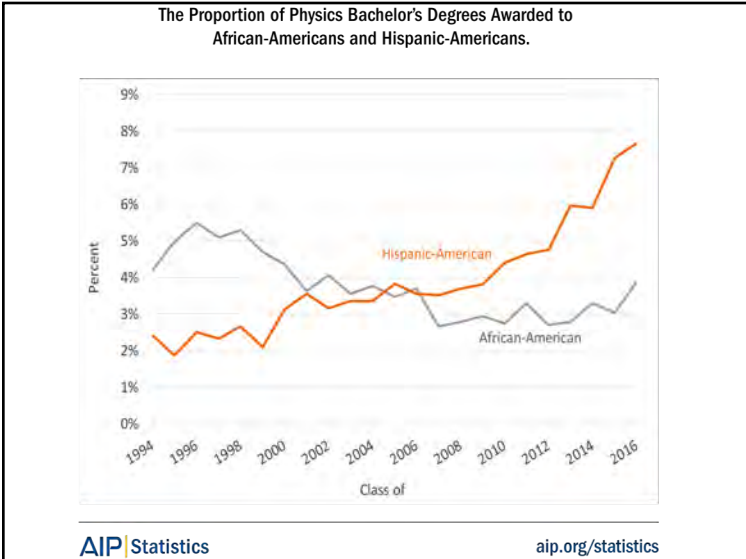
- being good at art;
- creativity;
- relationships with family and friends;
- government or politics;
- independence;
- learning and gaining knowledge;
- athletic ability;
- belonging to a social group (such as your community, racial group, or school club);
- music;
- career;
- spiritual or religious values;
- sense of humor.

- 1 – Pick two or three values
 - most important to them (affirmation condition)
 - least important to them (control condition)
- 2 - Through a series of structured prompts, students instructed to describe in a few sentences either why the selected values were important
 - to them (affirmation condition)
 - to someone else (control condition)
- 3 - Asked to list the top two reasons why these values were
 - important to them (affirmation condition)
 - might be picked as important by someone else (control condition)

Miyake, Kost, et al, *Science* Dec 2010



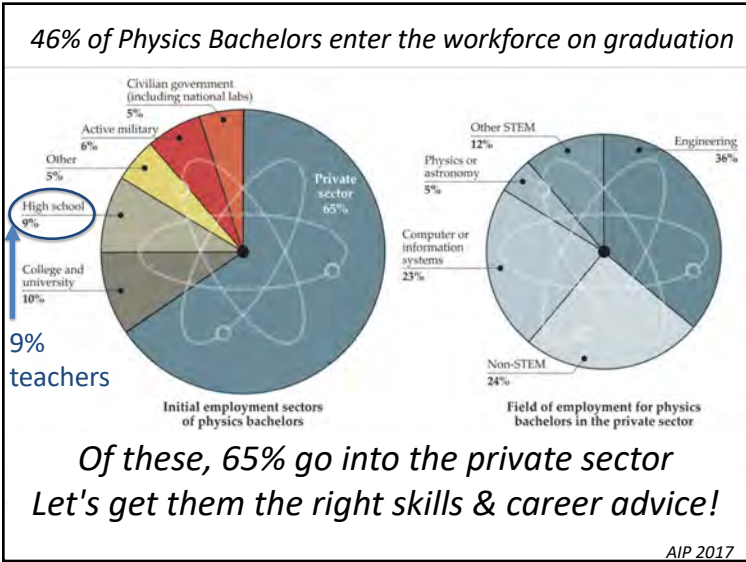
Under-Represented Minorities



Top 10 Majors by Concentration of African-American Bachelor's Degrees

	Percent White	Percent African-American	Percent Hispanic	Percent Asian	Percent Other Races & Ethnicities
School Student Counseling	56	38	<0.5	6	<0.5
Human Services and Community Organization	65	21	11	1	2
Counseling Psychology	72	20	3	5	1
Health and Medical Administrative Services	71	18	6	5	1
Public Administration	67	18	10	4	2
Social Work	71	16	9	3	1
Miscellaneous Social Sciences	77	16	3	4	<0.5
General Medical and Health Services	71	15	7	6	1
Public Policy	72	15	6	7	1
Community and Public Health	73	14	4	7	1

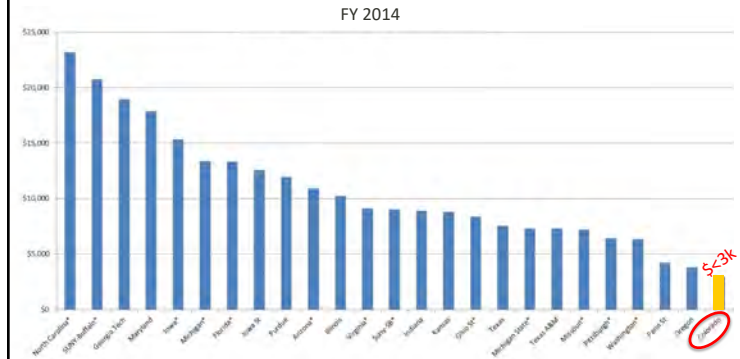
Doing good things for society...
not the best paid



Thought Experiment:
 What would it take to put a teacher with a physics bachelor in every high school in the US?

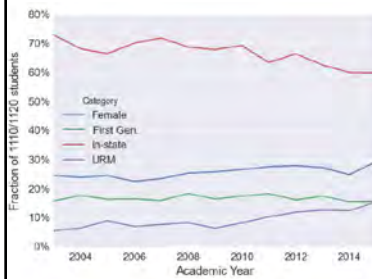
- 45,000 high schools
 15 years "Typical career length" – survival span (optimistic)
 = 3000 Physics bachelors per year going into teaching
- Currently 9% of 8000 = 720
- Crank up production another factor 4
- Incentivize? Pay better?
- Change "Physics" to "Natural Sciences"?
- Placement at local schools?

State Funding per Resident Student



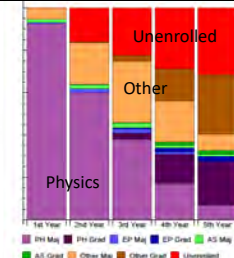
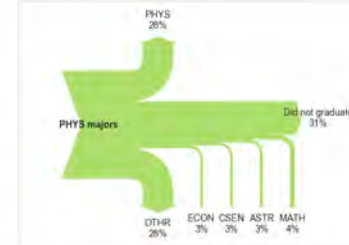
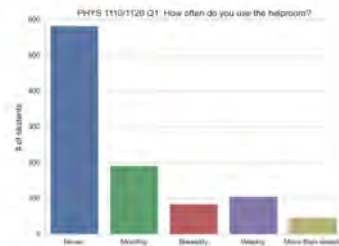
Kelly Fox, CFO CU Boulder

Report of the physics 2014-15 DAT on diversity, recruitment and retention in the undergraduate physics programs
 Meredith Betterton, Joel Corbo, Kathleen Hinko, Loren Hough, Ethan T. Neil, Daniel Reinholz, Charles Rogers Department of Physics, University of Colorado



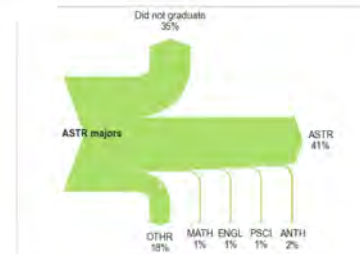
69-page report with >200 plots 2016

- Women are twice as likely as men to drop physics 1110 the first time they take it,
- general student population 13% vs. 6%
 - undeclared students 23% vs. 13%



Attrition of enrolled students out of physics & astronomy majors is significant for all students, and is higher for women and minorities.

Report of the physics 2014-15 DAT on diversity, recruitment and retention in the undergraduate physics programs
 Meredith Betterton, Joel Corbo, Kathleen Hinko, Loren Hough, Ethan T. Neil, Daniel Reinholz, Charles Rogers Department of Physics, University of Colorado



**Think Globally
Act Locally**

Solutions - 1 – Keep the UGs going

- A – More interactive classes – less "chalk&talk"
- B – Affirmation exercises (they're cheap!)
- C – The Sophomore Roadbump
 - provide undergraduate "study buddies"
 - don't put most traditional teachers in E&M 1!
- D – Socialize (safe) study spaces – university wide
- E – Invite Physics Education Researchers to give a Dept. Seminar
- F – Dept/AGU/AAS/APS needs to provide more advice on non-academic careers **REAL WORLD!**

Got Stats?

Let's do the research

US Physics Graduate Education

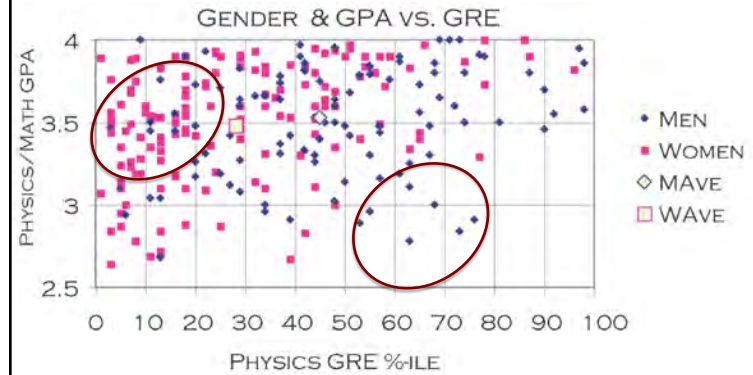
US PhD Statistics - AIP

- ~2000 Physics PhDs/year
- ~20% women

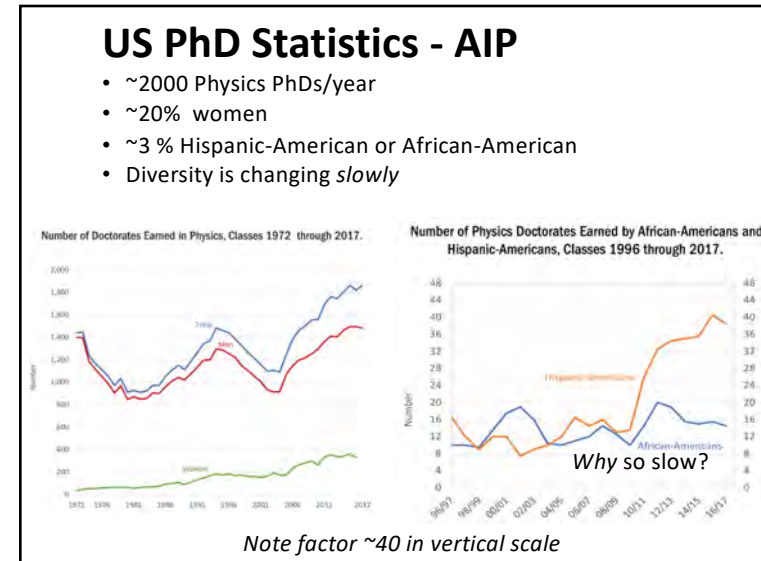
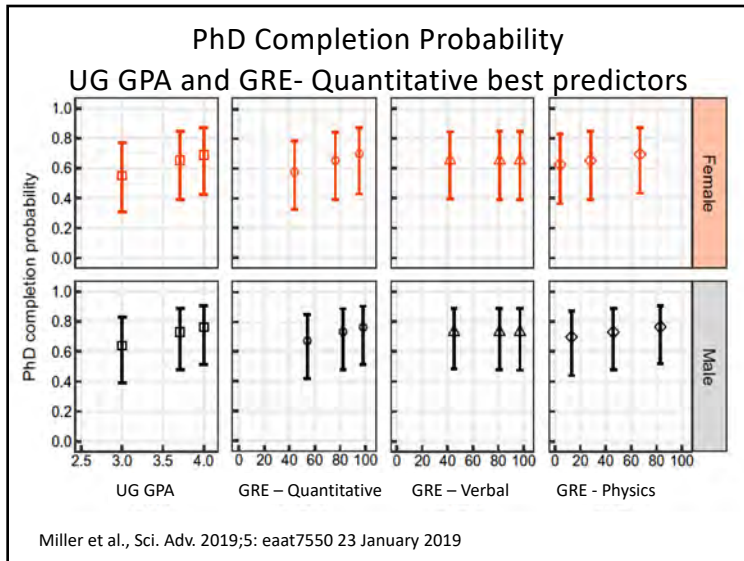
Number of Doctorates Earned in Physics, Classes 1972 through 2017.



300+ Applicants to CU Astronomy Program 2003+4



Each of us can think of reasons why this happens – **but** do we really know whether GRE or GPA or WHAT are good predictors of success for grad school? *We need to look at the numbers.*



Think Globally
Act Locally

Solutions – 2 Grad School

Recruitment:

- what are the realistic predictors of success in grad school?
- cast a broad net – makes a better environment

Program

- set fair, consistent, expectations
- design a program that supports and encourages a broad spectrum
- evaluate and articulate progress in a fair, consistent manner – so students know where they are early & often **REAL WORLD!**

Non-academic career advice
– get people from the real world out there to come give advice on real-world careers

Think Globally
Act Locally

Solutions – 3 - Family

- A society that puts generous resources into educating women - and should make a major effort to benefit from the investment on the long term
- Institutions need to develop policies and resources – Dual Careers Recruitment Office, Family Support, "stop the tenure clock", etc; – be flexible, adapt to specific cases/needs
- Think long-term – 2 years of supporting "re-entry stipend" pays off over 25-30 year career (e.g. to pay for post-doc to keep research going)

**Think Globally
Act Locally**

Solutions – 4 - Culture

- Don't blame the women.
Telling women to become more like men is not the solution.
- Change the institutional environment
BUT don't just ask women faculty/researchers to "fix" the problem
- Hire more women faculty/researchers - it's non-linear
- But it is as much CULTURE that drives women away
 - Women are less content with their work environment
 - 2-body problems, family issues
 - But also hostile environment - many subtle obstacles
- **Leadership - from the very top - is critical**

Solutions – 5 - National

- Sponsor AIP to do the demographic surveys – SMD-wide – in time for next Decadal Surveys
 - How are numbers changing?
 - What fraction of researchers are non-US to meet needs of the field?
 - How is the field changing?
 - What workforce is needed for next decade?
- Urge APS/AGU/AAS to provide career advice
- **Make physical science education a priority – high school, college, graduate**
– surely we can do better than 8600 physics majors out of 300 million people!



Thank You!



"Reserve your right to think,
for even to think wrongly is better than not to think at all."
Hypatia of Alexandria (370-415 BC)