Think Global, Act Local
Demographics of Space Sciences

Fran Bagenal
University of Colorado
Boulder

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

1

~2001 I started thinking about why there were so few women.....

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"

Women are "the canaries in the mine" – generally, addressing gender issues improves things for all....

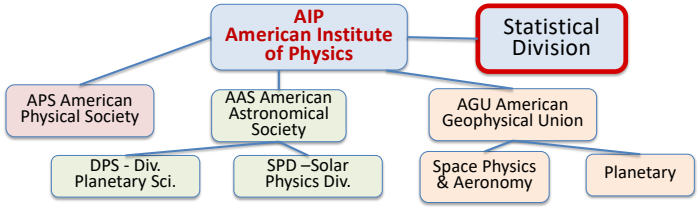
2020 .....but not necessarily ALL

3

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



4

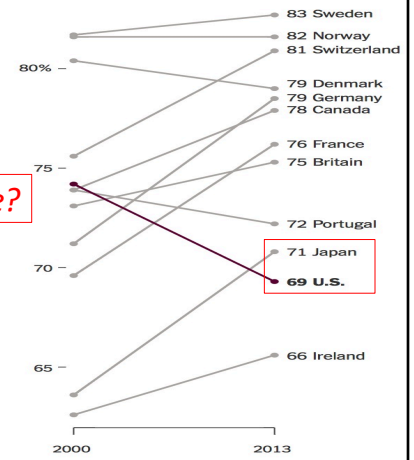
Statistics - buyer beware!

- *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.....

Percentage of women ages 25-54 who are employed



Source: Organization for Economic Cooperation and Development

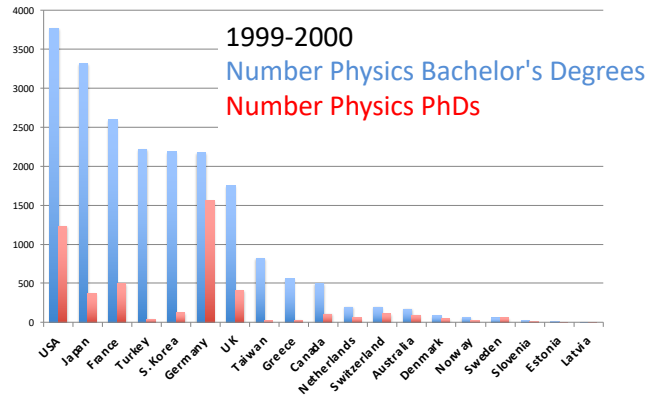
5

International View

6

Compiled by the AIP Statistical Research Center

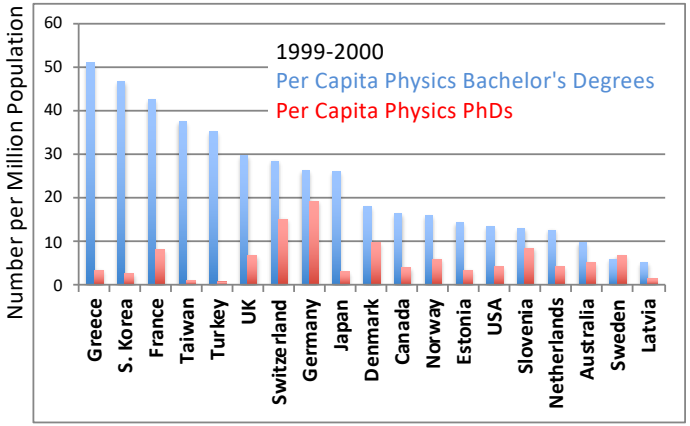
International



Many countries missing – India? China?

7

International



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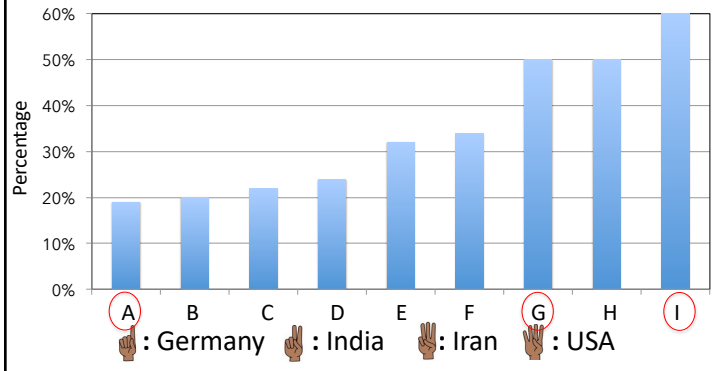
Comparing Across Countries

Percentage of **Undergraduate** Physics Degrees Awarded to Women

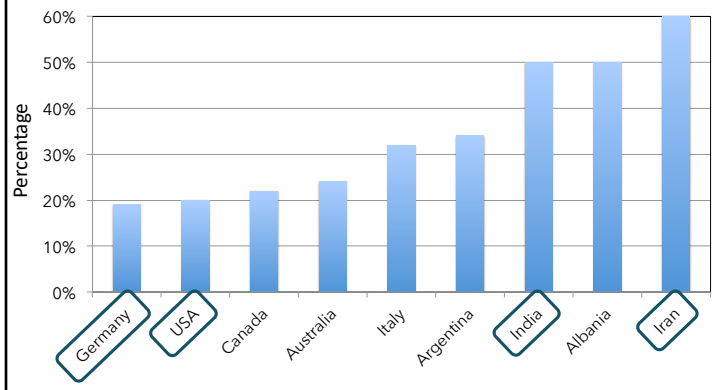


(IUPAP International Conference on Women in Physics Proceedings, 2005-2013)

9

Probably not what you expect....

Percentage of **Undergraduate** Physics Degrees Awarded to Women



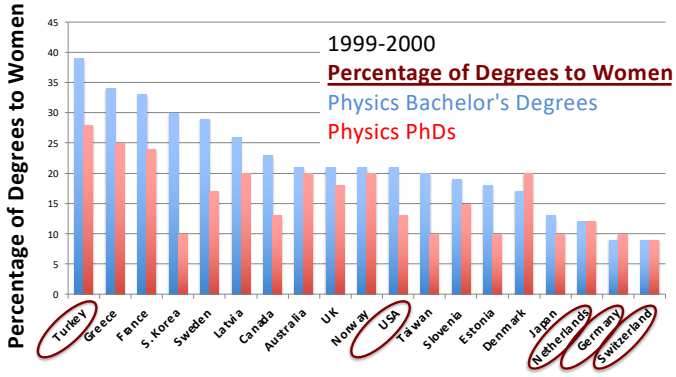
(IUPAP International Conference on Women in Physics Proceedings, 2005-2013)

10

International

Compiled by the AIP Statistical Research Center

http://www.aip.org/sites/default/files/statistics/women/women-speakagain-05.pdf

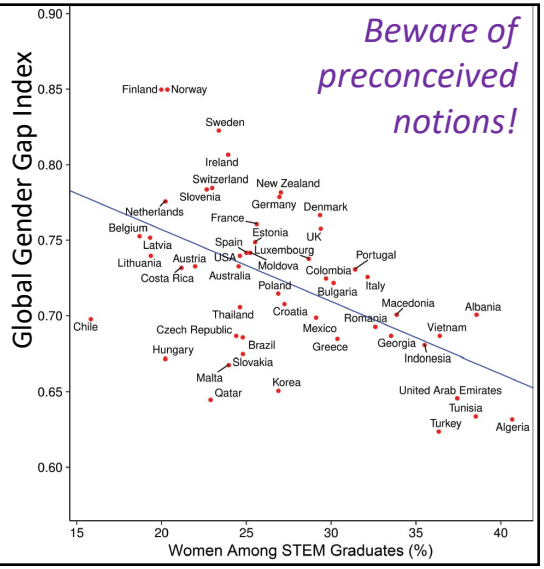


Numbers sometimes test our pre-conceived notions

11

The Gender-Equality Paradox in **S**cience, **T**echnology, **E**ngineering, and **M**athematics Education

Beware of preconceived notions!

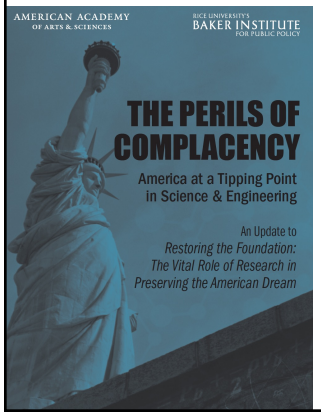


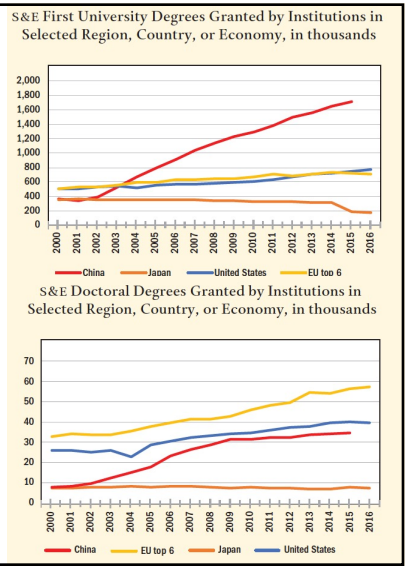
Stoet & Geary 2018,
Psychological Science
https://doi.org/10.1177/0956797617741719

12

2020: Perils of Complacency

Norm Augustine & Neal Lane

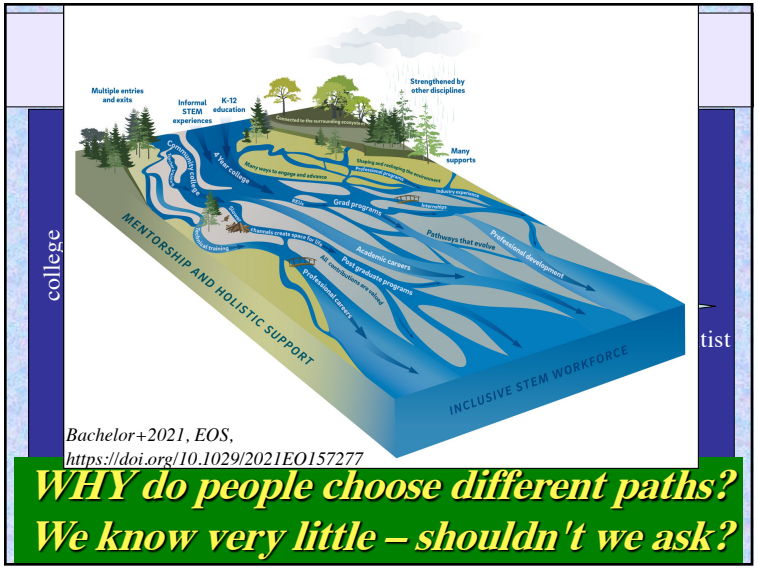




13

STEM in the US
"The Leaky Pipeline"

14



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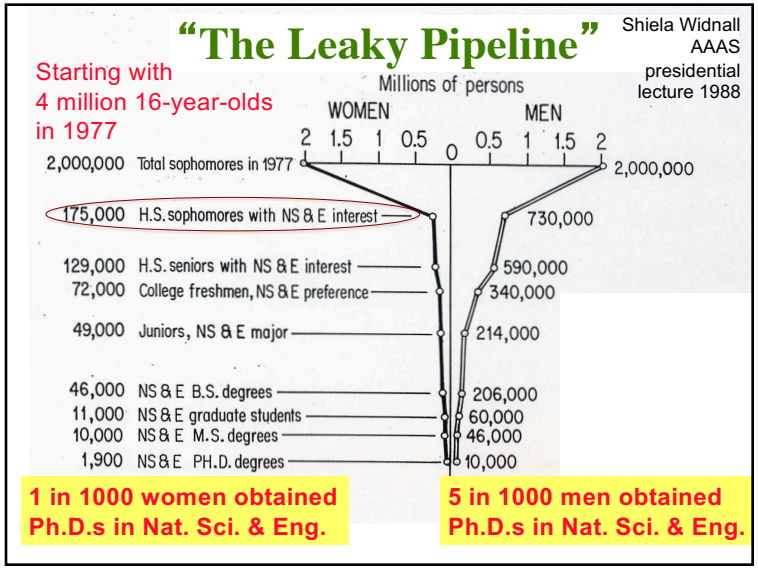
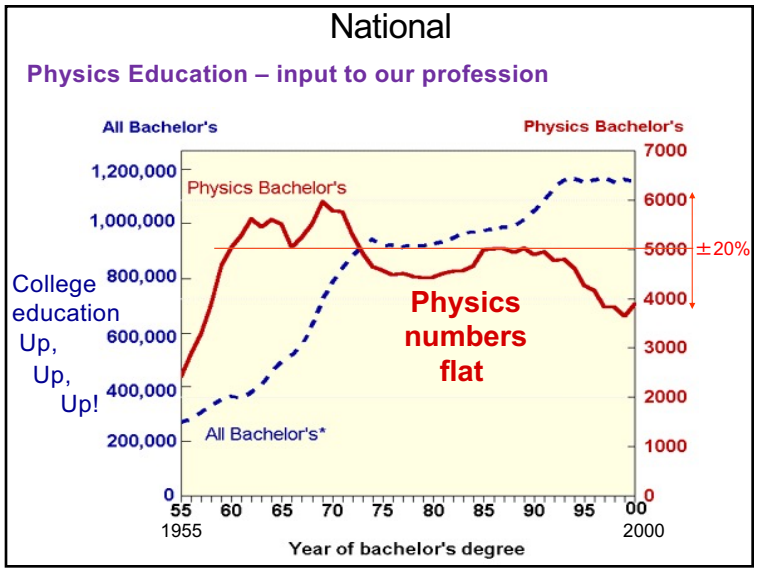


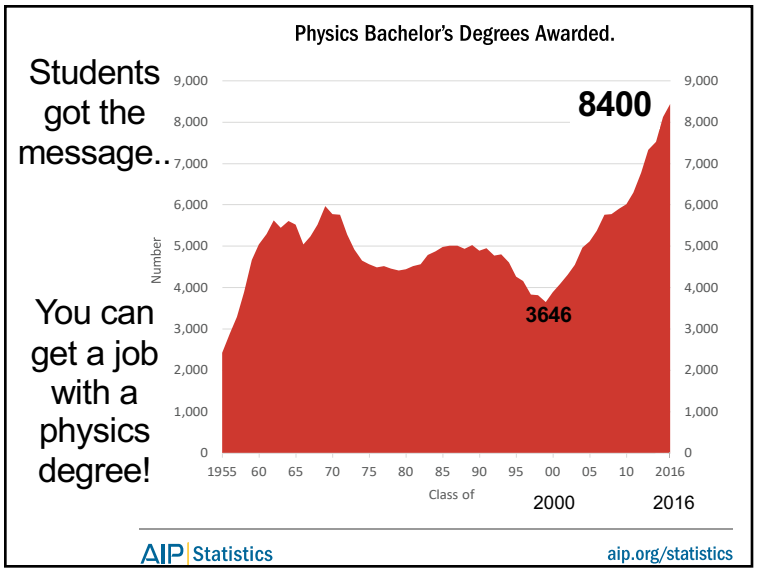
16

US Physics
Undergraduate Education

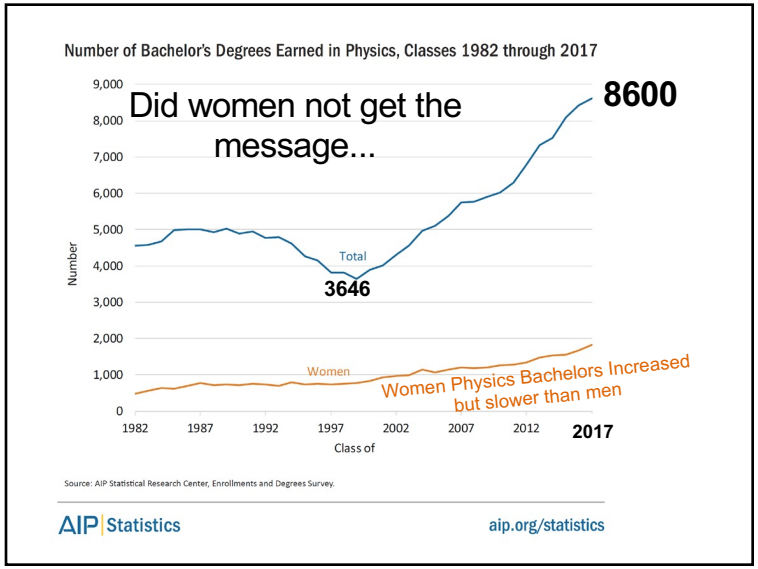
17


National
Physics Education – input to our profession
All Bachelor's
Physics Bachelor's
Physics Bachelor's
All Bachelor's*
College education Up, Up, Up!
Physics numbers flat
±20%
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
7000
6000
5000
4000
3000
2000
1000
0
55 60 65 70 75 80 85 90 95 00
1955
2000
Year of bachelor's degree

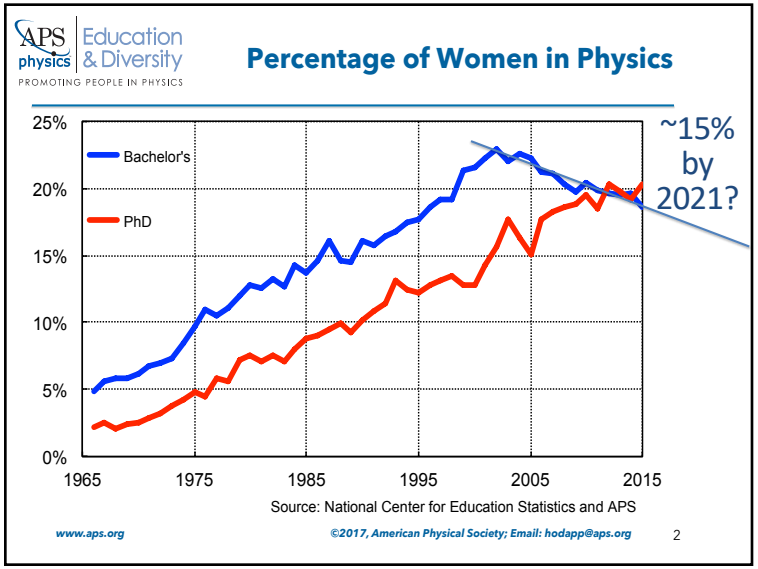
18


Physics Bachelor's Degrees Awarded.
Students got the message..
You can get a job with a physics degree!
8400
3646
Number
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1955 60 65 70 75 80 85 90 95 00 05 10 2016
Class of
2000
2016
AIP Statistics
aip.org/statistics

19

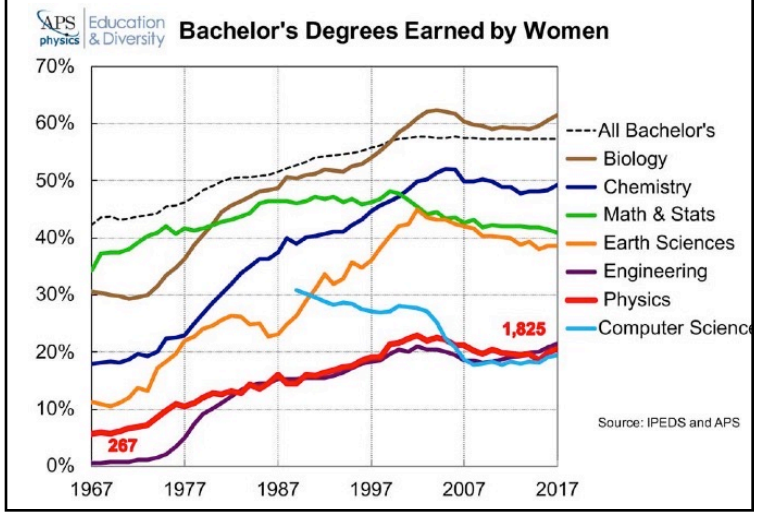

Number of Bachelor's Degrees Earned in Physics, Classes 1982 through 2017
Did women not get the message...
8600
Total
3646
Women
Women Physics Bachelors Increased but slower than men
2017
Number
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1982 1987 1992 1997 2002 2007 2012
Class of
Source: AIP Statistical Research Center, Enrollments and Degrees Survey.
AIP Statistics
aip.org/statistics

20


APS physics
Education & Diversity
PROMOTING PEOPLE IN PHYSICS
Percentage of Women in Physics
Bachelor's
PhD
~15% by 2021?
25%
20%
15%
10%
5%
0%
1965 1975 1985 1995 2005 2015
Source: National Center for Education Statistics and APS
www.aps.org
©2017, American Physical Society; Email: hodapp@aps.org
2

21

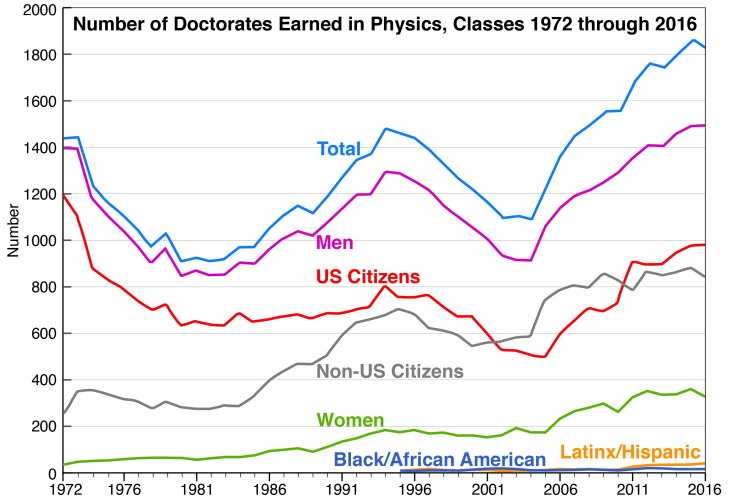
Fraction of college (BA/BS) degrees to women



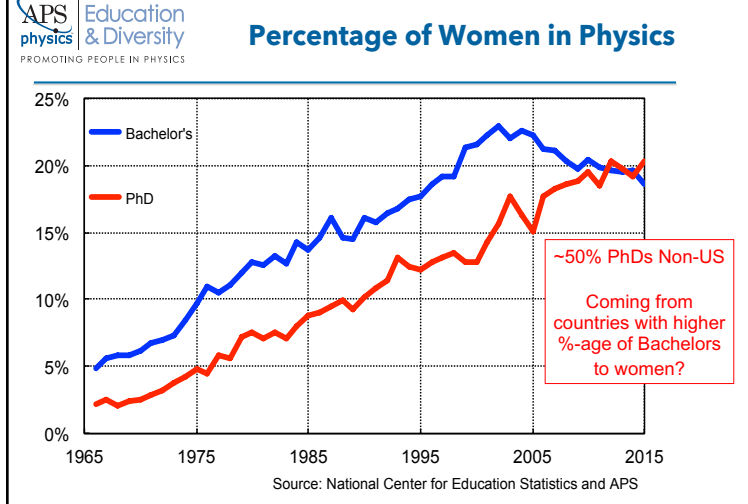
24

US Physics
Graduate Education

25



26



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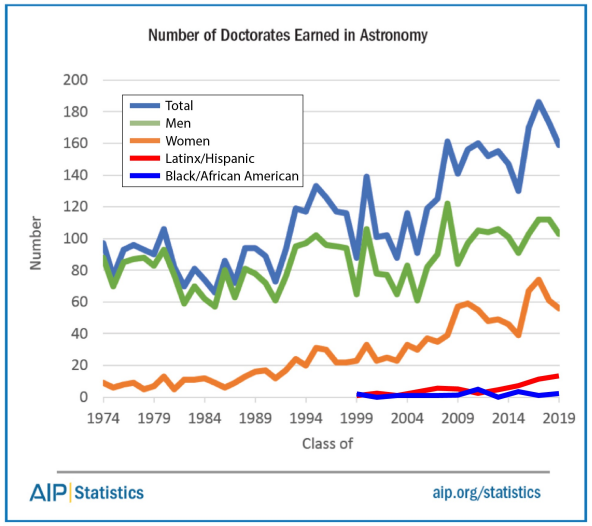

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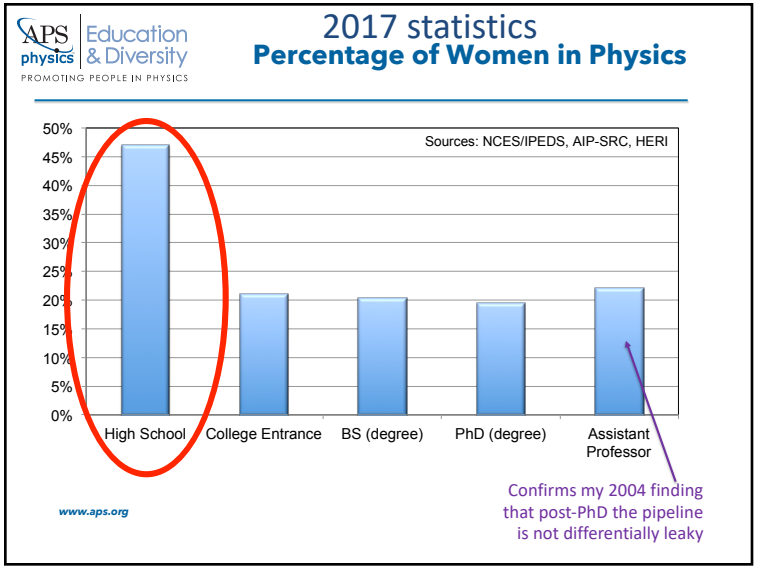

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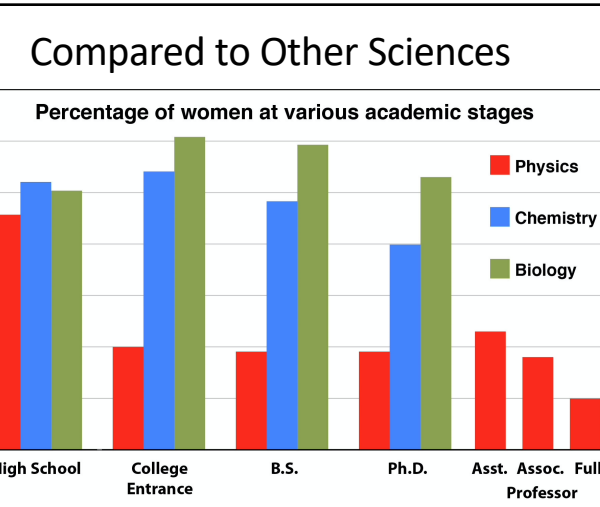
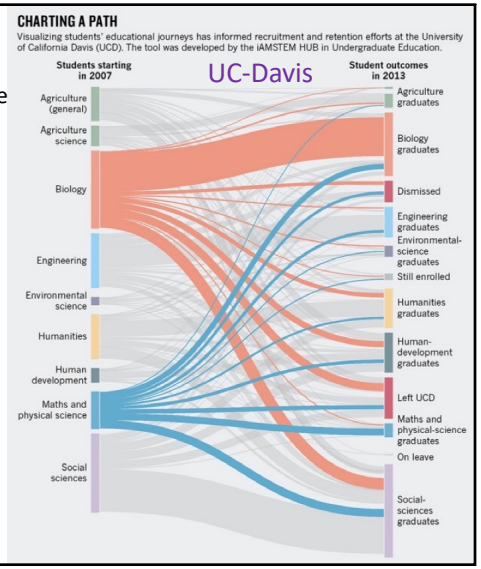


30

Where majors start-end

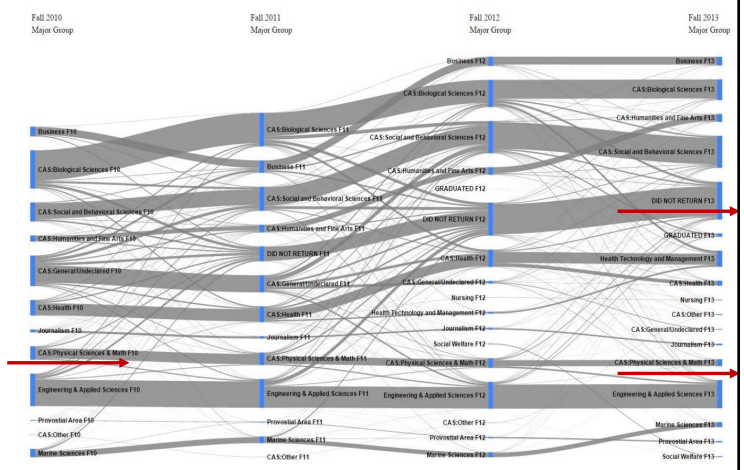
- What does this look like separated by years?
- When do students move? Why?
- Gender? Minorities?
- **What does this look like at your institution?**

Let's do the research



31

Stony Brook - Migrations of Fall 2010 first-time full-time students by major grouping



Sean V. Hoffman, Institutional Research Analyst, Stony Brook

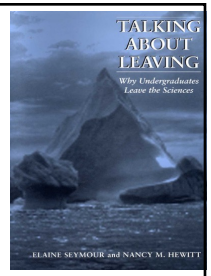
32

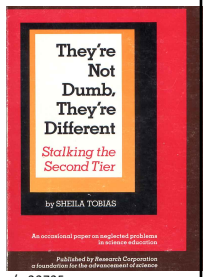
1990s Studies

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
- Poor teaching, attitudes, culture.
- Other subjects more appealing

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





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

33

2021

Talking about Leaving Revisited:
Dysfunction of the STEM weed-out system

"Better to bail than fail"

Example:

- Weed-out course experiences cited by 43% of all switchers 18% of persisters
- 69% of women switchers left with GPAs of 3.5 or higher, half of these women of color

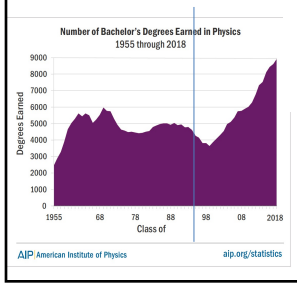
34

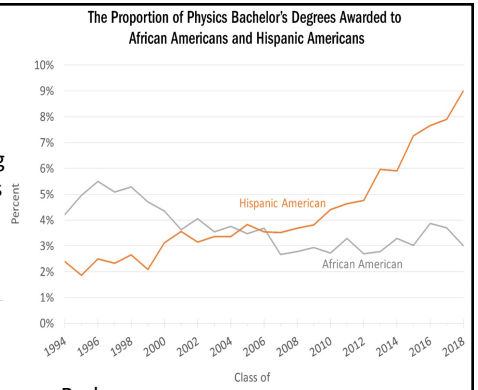
Under-Represented Minorities

35

Good news:

- Proportions of Physics Bachelors to Hispanic Americans is increasing
- 2% -> 9% over 24 years
- Still below US population

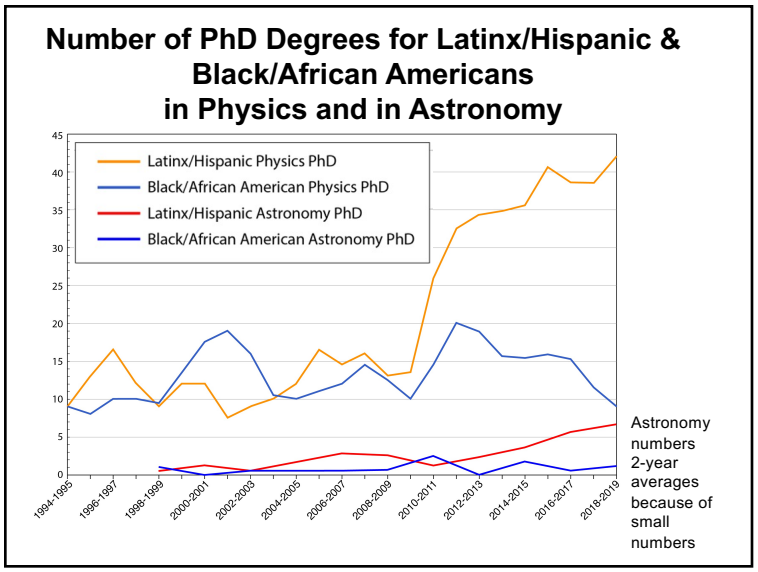




Bad news:

- Proportions of Physics Bachelors to African Americans is dropping
- ~5% -> 3%

36



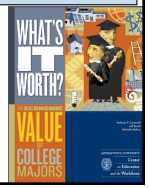
Astronomy numbers 2-year averages because of small numbers

37

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

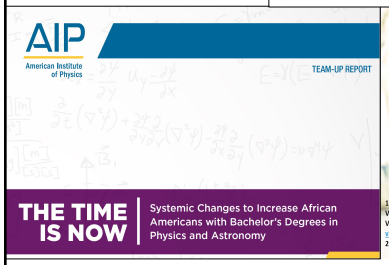
Doing good things for society...
not the best paid



38

Increasing Participation of Historically Minoritized Communities in STEM

Past year– organizations are making statements, delivering webinars, doing studies, publishing reports, ...



What's EFFECTIVE?
National and/or local initiatives?

39

Some Experiments and Ideas for the Classroom.....

40

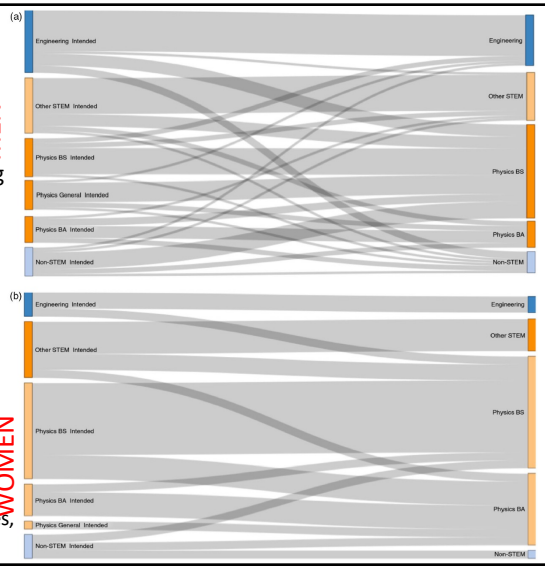
Florida International University

Hispanic- Serving University

Active learning physics classes 2005-2014

Impressive retention!!

Rodriguez et al. PhysRevPhysEducRes, 12.020118, 2016



45

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

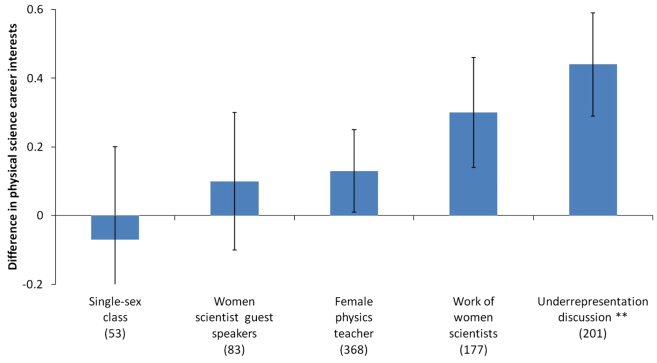
Group Learning

- more interaction
- practical questions
- more social

43

APS physics Education & Diversity
PROMOTING PEOPLE IN PHYSICS

Effects of Interventions



Hazari, Potvin, Lock, Lung, Sonnert, and Sadler, "*Factors that affect the physical science career interest of female students: Testing five common hypotheses*," PRST PER 9 020115 (2013)

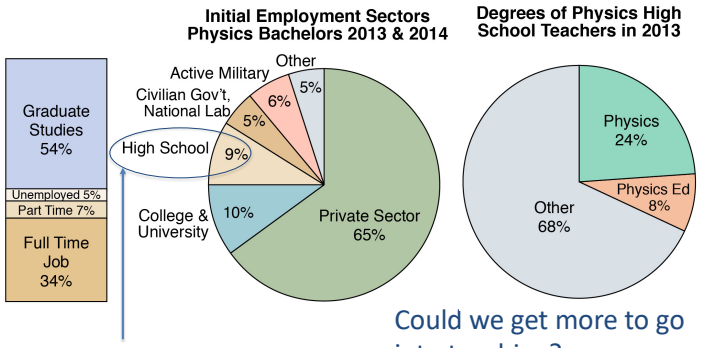
49

Physics Education Careers

(Teaching – rather than research)

50

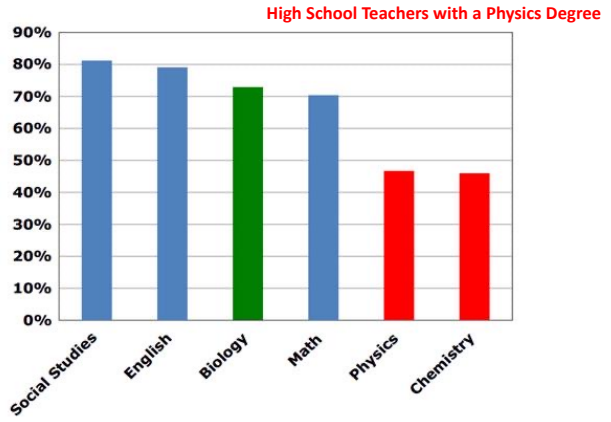
46% of Physics Bachelors enter the workforce on graduation
Let's get them the right skills & career advice!



9% become teachers

Could we get more to go into teaching?
More Phys. Ed. degrees?
Better pay?!

52



Only 47% of physics classes are taught by a teacher with a degree in the subject, compared with 73% of biology classes and about 80% of humanities classes.

Source: Jason G. Hill and Kerry J. Gruber, Education and Certification Qualifications of Departmentalized Public High School-Level Teachers of Core Subjects: Evidence from the 2007-08 Schools and Staffing Survey, Statistical Analysis Report [NCES 2011-317] (National Center For Education Statistics, U.S. Department of Education, Washington, D.C., 2011). Available at: http://nces.ed.gov/pubs2011/2011317.pdf.

53

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"? to "Phun"?!
- Placement at local schools?

54

Think Globally Act Locally

Solutions - 1 – Keep the UGs going

0 – Get the numbers when students drop out & why

1 – More interactive classes, less "chalk&talk"

2 – Affirmation exercises (they're cheap!)

3 – The Sophomore Roadbump
- – provide undergraduate "study buddies"
- – don't put most traditional teachers in E&M 1!

4 – Socialize (safe) study spaces – university wide

5 – Involve students in research

Got Stats?

Let's do the research

What works?

55

Think Globally Act Locally

Solutions - 2 – Keep the UGs going

6 – Invite Physics Education Researchers to give a Dept. Seminar

7 – Expand Physics Education degrees & careers
- – Direct pathway to high school teaching
- – Masters students TAs in service classes as training for community college teaching

8 – More joint degrees with biology, environmental science, communication, journalism, computing....

9 – Dept/AGU/AAS/APS needs to provide more non-academic career advice

56

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

Get people from the <u>real world</u> out there to come give advice on real-world careers

57

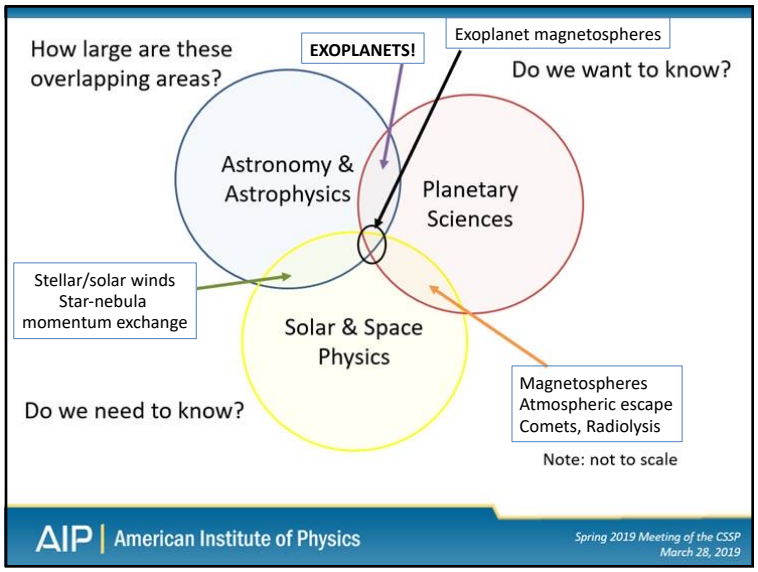
National Surveys:

Astronomy
Planetary Science
Solar & Space Physics

Usually motivated by a Decadal Survey

None for space-related Earth Science workforce

58



59

Planetary and Astrobiology Decadal 2023-2032

Statement of Task

#9 - The report should provide a clear exposition of the following:

The state of the profession including issues of diversity, inclusion, equity, and accessibility, the creation of safe workspaces, and recommended policies and practices to improve the state of the profession. Where possible, provide specific, actionable and practical recommendations to the agencies and community to address these areas.

The National Academies of SCIENCES ENGINEERING MEDICINE

60

AIP Planetary Workforce Surveys – 2011 & 2020

Funded by NASA

2011

Attendees/Members of Planetary Conference/Section

	LPSC	AGU	DPS	All Three
LPSC	1280	345	90	
AGU		264	124	
DPS			358	
All Three				161

- LPSC, DPS, AGU
- US only
- w/PhD
- 62% response
- 71% identify as planetary scientist
- 56% in research

Funded by DPS of AAS

2020

	LPSC	GSA	DPS	All Three
LPSC	1372	122	139	
GSA		113	7	
DPS			587	
All Three				23

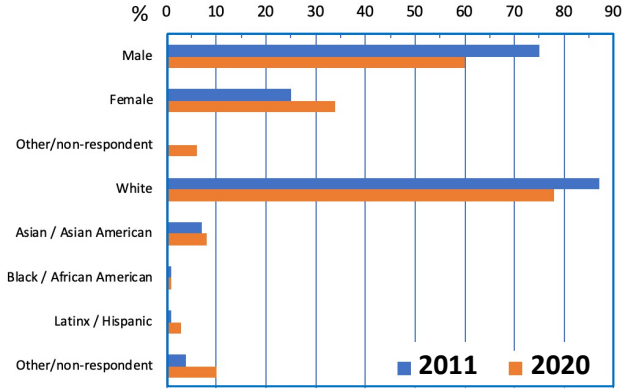
- LPSC, DPS, GSA
- 48% response
- Includes students, international

Missing: – Astrobiology
– American Meteoritical Society
– Exoplanets, space physics, ...

61

Planetary Science Demographics

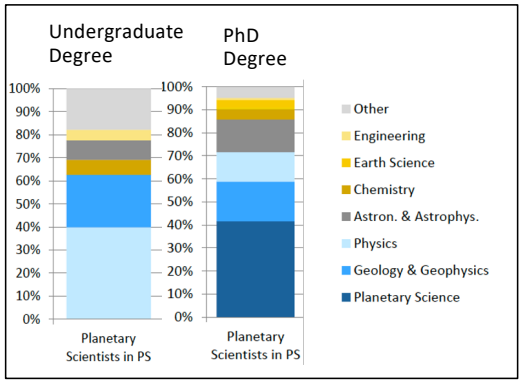
~1500-2000 have PhD & work in US*



*AIP survey For 2020: - limited to those with PhDs
- "in US" = eligible to apply for US funded grants – may exclude postdocs
- Disability reported by 1.4% PhD, in US

62

2011 Planetary Survey



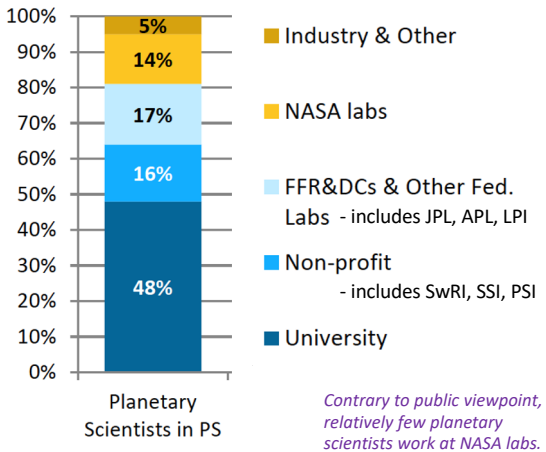
Respondents limited to having PhD & working in US & identify as planetary scientist

Planetary Science is very interdisciplinary

64

2011 Planetary Survey

Respondents limited to having PhD & working in US & identify as planetary scientist



Contrary to public viewpoint, relatively few planetary scientists work at NASA labs.

65

Planetary, Astrophysics, Space Physics

Astrophysics: 2018 AAS Survey by AIP
60% response = 2018 Respondants (including students)
-> 2040 PhD astrophysicists in US

Solar & Space Physics: 2011 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 – LPSC, DPS, AGU
62% Response = 2622 Respondants
-> 1140 PhD planetary scientists in US
2020 AIP Survey – LPSC, DPS, GSA
47% Response = 2400 Respondants
-> 1100 PhD planetary scientists in US

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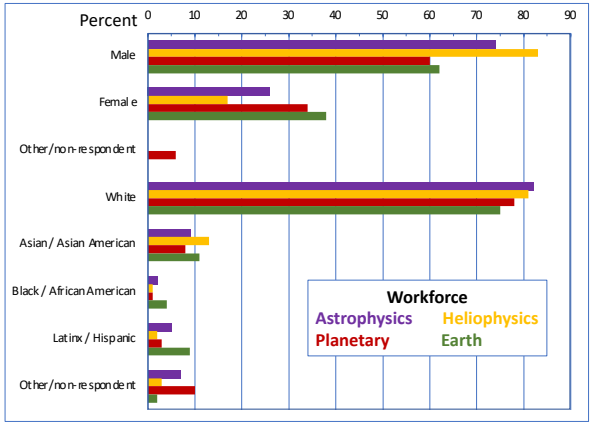

67

Academic Department Surveys 2011 & 2018

Planetary Science:
54 Departments >1 PS faculty
250 faculty
100 Undergraduates / year

PhDs: 50-65 / year
40-45% women
30% non-US
8% minority

Astronomy (AIP) For comparison:
93 Departments (40 Astro, 53 Astro+)
550 faculty
666 Undergrad degrees / year
159 PhDs / year

https://www.aip.org/statistics/reports/roster-astronomy-2019

- Planetary Science: Very interdisciplinary, dispersed, poorly defined
- Astrobiology & Exoplanets not included
- Only a dozen universities dominate field
- 7% growth in faculty over 7 years
- Fraction of women faculty increasing 14%->20%
- Untenured women -> 30%

Note: These surveys were ad hoc – initiated and carried out by a small group. Needs to be developed as a systematic evaluation of the production of planetary scientists and astrobiologists.

68

Planetary Science:
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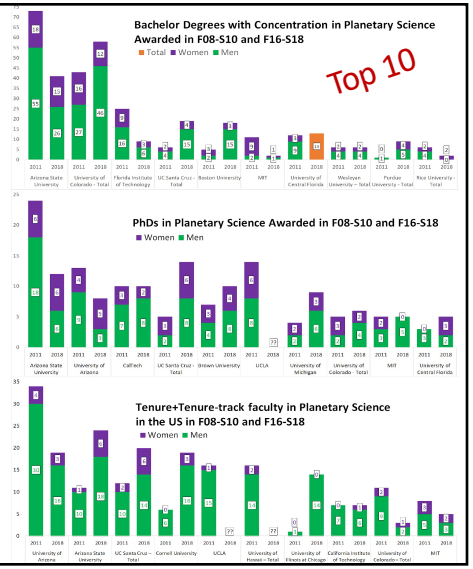


69

In parallel to the Decadal Survey I am co-chairing this NASEM committee that is happening right now – across all 4 divisions of NASA's Science Mission Directorate

The National Academies of SCIENCES ENGINEERING MEDICINE

Increasing Diversity and Inclusion in the Leadership of Competed Space Missions

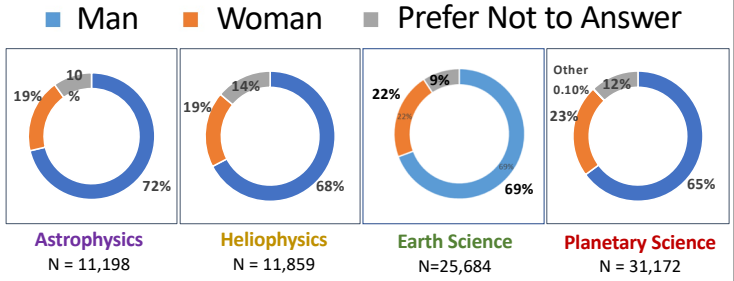
Co-chairs: **Fran Bagenal** and **Wanda E. Ward**

Agendas and links for open sessions are here:
https://www.nationalacademies.org/our-work/increasing-diversity-in-the-leadership-of-competed-space-missions
p.s. Orlando Figueroa is also on this committe – yea!

70

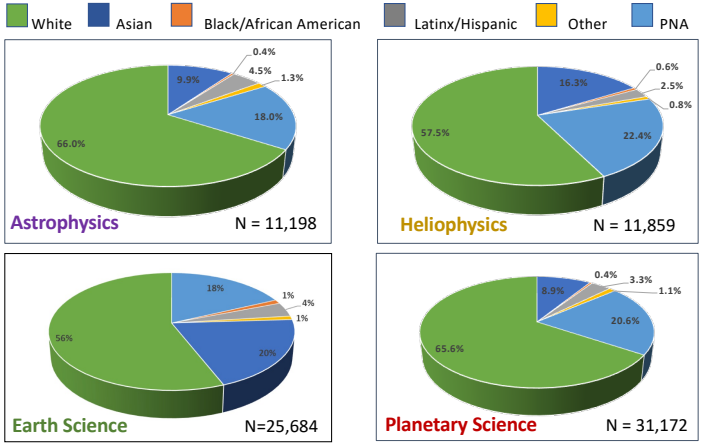
NASA Office of the Chief Scientist
– analysis of NSPIRES Personal Profile Data
Public Presentations by Louis Barbier

NSPIRES Gender Participation:
All PIs & Co-Is 2014 - 2020



71

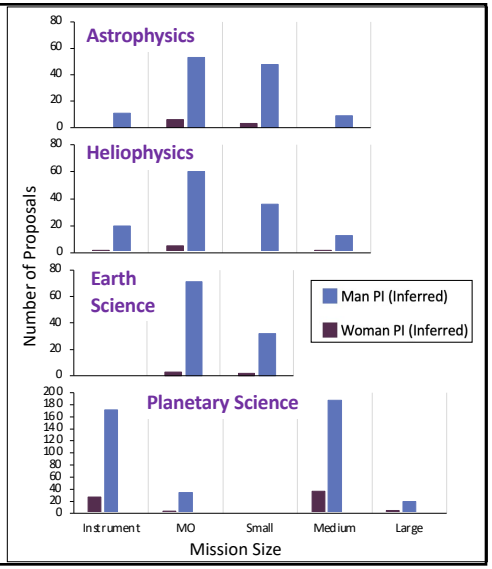
NSPIRES Race/Ethnicity Participation: All PIs & Co-Is 2014 - 2020



72

NASA HQ – Analysis of Competed Mission Proposals 2010-2019

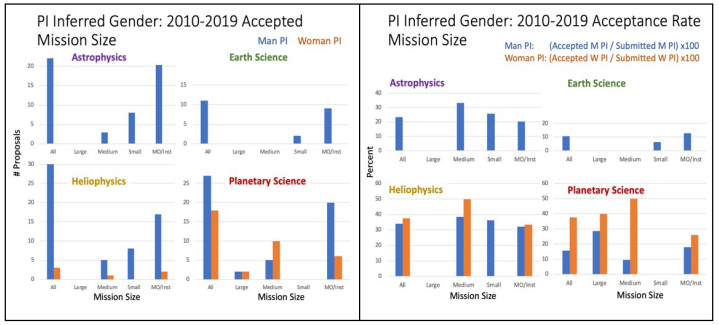
Public Presentations by Michael New



73

NASA HQ – Analysis of Competed Mission Proposals

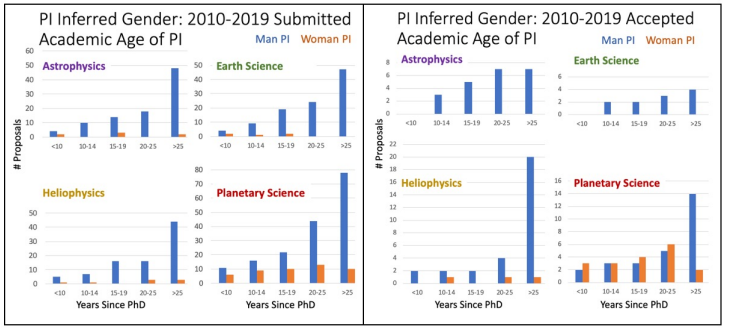
Public Presentations by Michael New



74

NASA HQ – Analysis of Competed Mission Proposals 2010-2019

Public Presentations by Michael New

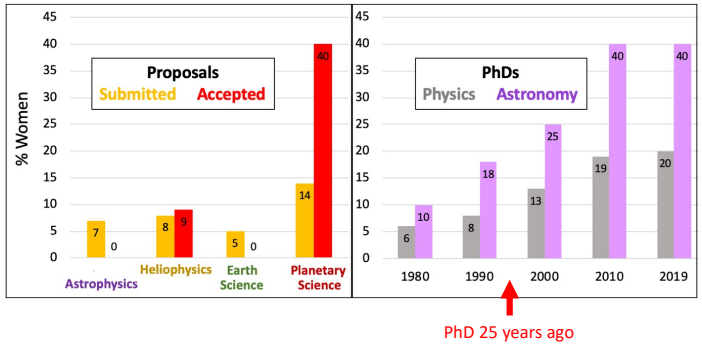


75

NASA HQ

– Analysis of Competed Mission Proposals 2010-2019

Public Presentations by Michael New



76

Solutions – 5 - National

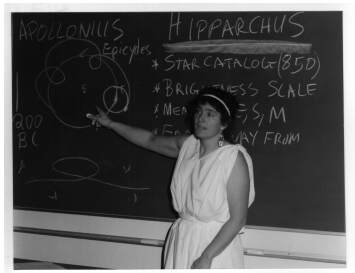
Sponsor AIP to do the demographic surveys, SMD-wide, every 3-5 years

- How are workforce numbers changing?
- How is the field changing?
- What fraction of researchers are non-US born?
- What workforce is needed for next decade?

Make physical science education a priority – high school, college, graduate

- Especially in historically minoritized communities
- Do the research – why do students drop out?
- ***Surely we can do better than 8600 physics majors out of 300 million people!***

77



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)

78

White Papers to Decadal Survey

Before the start of the Decadal Survey of Planetary Science and Astrobiology, the community was invited to submit White Papers on related topics.

Related to the State of the Profession there were a total of 36 White Papers submitted.

On the gender axis, 52.5% of white paper authors were women, 37.9% were men, and 9.6% were non-binary.

About 28% of papers did not offer substantial evidence or propose recommendations; these were mainly "views" and treated as such. 48% of white papers offered light evidence and did propose recommendations. About 23% of papers offered reliable and substantial evidence; most of these also offered recommendations. 50% of papers mentioned race, 41.7% focused on multiple groups and raised concerns of general interest, 30.6% discussed issues concerning gender, followed by 16.7% on aspects of ability (e.g., disability, neurodiversity), 13.9% on socioeconomic class, specifically the loss of talent from groups that today have little opportunity, and 13.9% on issues of sexual identity and orientation.

White paper contents were categorized into 17 broad topics. These topics concern the work produced by planetary scientists and astrobiologists (e.g., education, grants, tenure) as well as issues concerning quality of life that impact work (e.g., childrearing, service work, awareness of bias, workplace culture). Many of the most concerning issues are at the core of the profession (e.g., grants, collaboration, conferences).

79

White Papers to Decadal Survey - 1

Principal Author	White Paper Title	Link
Alessandra Aloisi	(Un)conscious Bias in the Astronomical Profession: Universal Recommendations to Improve Fairness, Inclusiveness, and Representation	https://baas.aas.org/pub/2021n4i408/release/1?readingCollection=7272e5bb
Elizabeth Frank	Normalizing non-academic career paths in planetary science	https://baas.aas.org/pub/2021n4i405/release/1?readingCollection=7272e5bb
Kathleen Vander Kaaden	Creating Inclusive, Supportive, and Safe Environments in Planetary Science for Members of the LGBTQ+ Community	https://baas.aas.org/pub/2021n4i411/release/1?readingCollection=7272e5bb
Matija Cuk	Pathways to Sustainable Planetary Science	https://baas.aas.org/pub/2021n4i440/release/1?readingCollection=7272e5bb
Zahra Khan	Military Work by Space Exploration Organizations: A Barrier to Inclusion and Safe Workspaces for Marginalized Communities	https://baas.aas.org/pub/2021n4i421/release/1?readingCollection=7272e5bb
Christopher Carr	Space Drones: An Opportunity to Include, Engage, Accelerate, and Advance	https://baas.aas.org/pub/2021n4i425/release/1?readingCollection=7272e5bb
Britney Schmidt	Diversity in action: Solutions for a more diverse and inclusive decade of planetary science and astrobiology	https://baas.aas.org/pub/2021n4i426/release/1?readingCollection=7272e5bb
Steven Vance	Addressing Mental Health in Planetary Science	https://baas.aas.org/pub/2021n4i429/release/1?readingCollection=7272e5bb
Julie Rathbun	Who is Missing in Planetary Science?: Strategic Recommendations to Improve the Diversity of the Field	https://baas.aas.org/pub/2021n4i395/release/1?readingCollection=7272e5bb
Moses Milazzo	The Growing Digital Divide and its Negative Impacts on NASA's Future Workforce	https://baas.aas.org/pub/2021n4i438/release/1?readingCollection=7272e5bb
Julie Rathbun	Enabling the Planetary Workforce to do the best science by funding work that is a service to the Profession	https://baas.aas.org/pub/2021n4i437/release/1?readingCollection=7272e5bb
Julie Rathbun	Ensuring Inclusivity in the 2023 Planetary Science and Astrobiology Decadal Survey	https://baas.aas.org/pub/2021n4i438/release/1?readingCollection=7272e5bb
Christina Richey	A Call to Planetary2023 Panels to Implement Actionable Recommendations from Recent National IDEA Studies	https://baas.aas.org/pub/2021n4i441/release/1?readingCollection=7272e5bb
Beck Strauss	Nonbinary Systems: Looking towards the future of gender equity in planetary science	https://baas.aas.org/pub/2021n4i442/release/1?readingCollection=7272e5bb
Edgard Rivera-Valentín	Who is missing in planetary Science?: A demographic study of the planetary science workforce	https://baas.aas.org/pub/2021n4i443/release/1?readingCollection=7272e5bb
Jennifer Piatek	Breaking Down Barriers: Accessibility in Planetary Science	https://baas.aas.org/pub/2021n4i444/release/1?readingCollection=7272e5bb
Christina Richey	Recommendations from the CSWA Survey on Workplace Climate	https://baas.aas.org/pub/2021n4i445/release/1?readingCollection=7272e5bb
Moses Milazzo	DEIA White Papers for Planetary 2023 supported by the Cross-AG EDI Working Group	https://baas.aas.org/pub/2021n4i446/release/1?readingCollection=7272e5bb

80

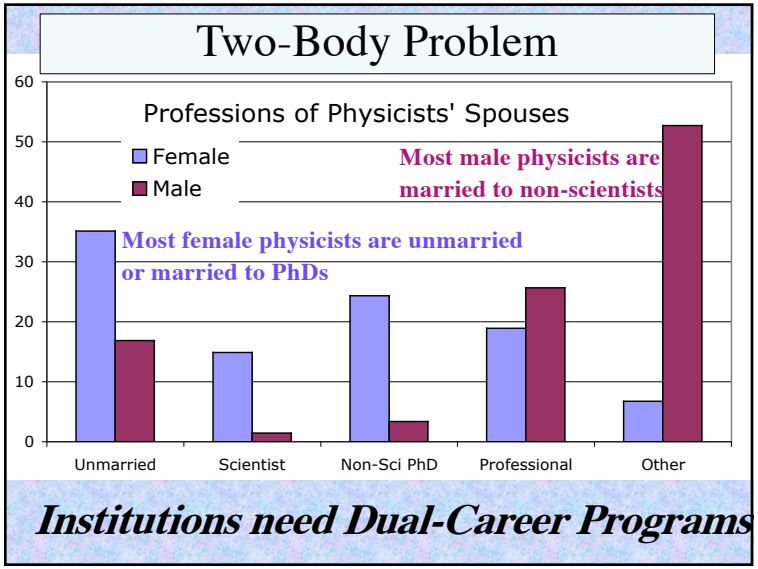
White Papers to Decadal Survey - 2

Principal Author	White Paper Title	Link
Jacob Richardson	Building Safer and More Inclusive Field Experiences in Support of Planetary Science	https://baas.aas.org/pub/2021n4i447/release/1?readingCollection=7272e5bb
Serina Diniega	Ensuring a safe and equitable workspace: The importance and feasibility of a Code of Conduct, along with clear policies regarding author, & team mem.	https://baas.aas.org/pub/2021n4i448/release/1?readingCollection=7272e5bb
Monica Vidaurri	Absolute Prioritization of Planetary Protection, Ethics, and Avoiding Imperialism in All Future Science Missions: A Policy Perspective	https://baas.aas.org/pub/2021n4i450/release/1?readingCollection=7272e5bb
Christina Richey	Lessons Learned on IDEA from the Astro2020 Decadal Survey	https://baas.aas.org/pub/2021n4i452/release/1?readingCollection=7272e5bb
Matthew Tiscareno	Planetary Nomenclature and Indigenous Communities	https://baas.aas.org/pub/2021n4i452/release/1?readingCollection=7272e5bb
Frank Tavares	Ethical Exploration and the Role of Planetary Protection in Disrupting Colonial Practices	https://baas.aas.org/pub/2021n4i461/release/1?readingCollection=7272e5bb
Matthew Tiscareno	Planetary Nomenclature and Indigenous Communities	https://baas.aas.org/pub/2021n4i462/release/1?readingCollection=7272e5bb
William Bottke	Tenets of an Effective and Efficient Research and Analysis Program for NASA	https://baas.aas.org/pub/2021n4i463/release/1?readingCollection=7272e5bb
Jani Radebaugh	The Value of a Dual Anonymous System for Reducing Bias in Reviews of Planetary Research and Analysis Proposals and Scientific Papers	https://baas.aas.org/pub/2021n4i464/release/1?readingCollection=7272e5bb
Ingrid Daubar	Extended Missions in Planetary Science: Impacts to Science and the Workforce	https://baas.aas.org/pub/2021n4i465/release/1?readingCollection=7272e5bb
Kathryn Gardner-Vandy	Relationships First and Always: A Guide to Collaborations with Indigenous Communities	https://baas.aas.org/pub/2021n4i471/release/1?readingCollection=7272e5bb
Ryan Watkins	Professional development in the next decade: Supporting opportunities in all career paths and life events	https://baas.aas.org/pub/2021n4i472/release/1?readingCollection=7272e5bb
Amanda Hendrix	Results of the 2020 Planetary Science Workforce Survey Conducted by the AAS-DPS	https://baas.aas.org/pub/2021n4i473/release/1?readingCollection=7272e5bb
Kristen Bennett	The Preventing Harassment in Science Workshop: Summary and Best Practices for Planetary Science and Astrobiology	https://baas.aas.org/pub/2021n4i474/release/1?readingCollection=7272e5bb
Daniella Scalice	Power and Responsibility	https://baas.aas.org/pub/2021n4i493/release/1?readingCollection=7272e5bb
Abbie Grace	Promoting the 'A' in SPACE: 'Arts' run the places STEM takes us	https://baas.aas.org/pub/2021n4i495/release/1?readingCollection=7272e5bb
Heather Kaluna	Creating Spaces for Indigenous Voices within Planetary Science - Part 1	https://baas.aas.org/pub/2021n4i502/release/1?readingCollection=7272e5bb
Brittany Kamai	Creating Spaces for Indigenous Voices within Planetary Science - Part 2	https://baas.aas.org/pub/2021n4i503/release/1?readingCollection=7272e5bb

81

Family & Career
The 2-Body Problem

82



83