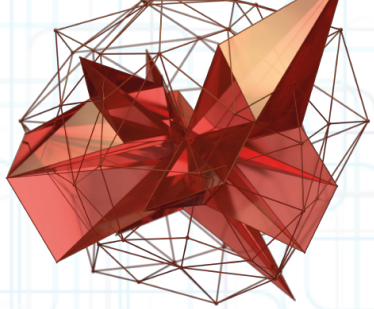

METASCIENCE 2019 SYMPOSIUM

The Emerging Field of Research on the Scientific Process.

Collaboration patterns in science: gender and funding

Marta Sales-Pardo
Universitat Rovira i Virgili
Tarragona

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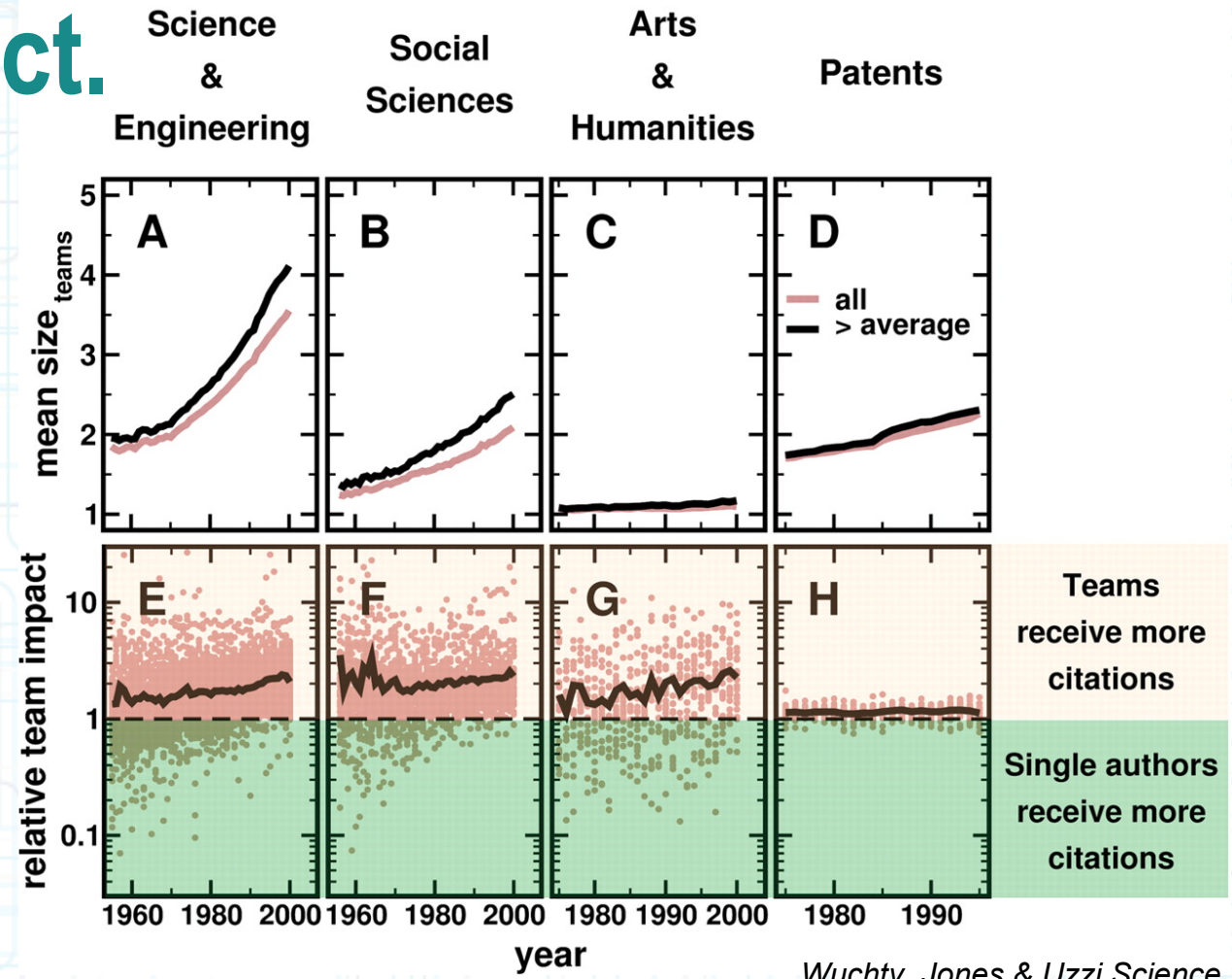
UNIVERSITAT ROVIRA i VIRGILI

"We like to bring together people from radically different fields and wait for the friction to produce heat, light and magic. Sometimes it takes a while."

Stanford, Sept 2019

In recent decades, scientists have increasingly worked in teams and this practice has resulted in higher impact.

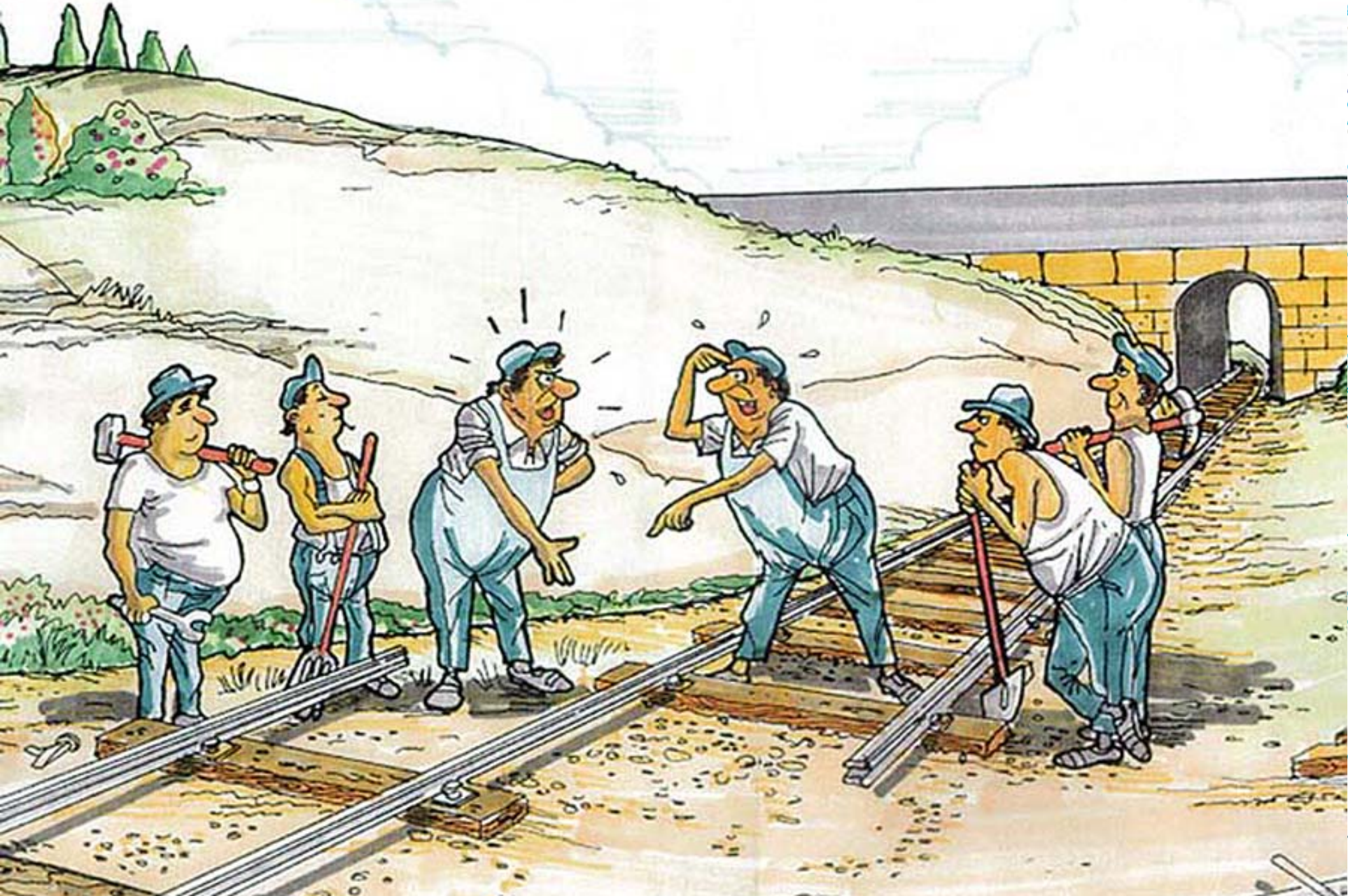


Wuchty, Jones & Uzzi Science 2007

However, not all teams are equally as good in terms of success

- Scientific team **composition in terms of member experience matters** - a mixture between newbies and repeating co-authors is best (Guimera et al Science 2005)
- **Diversity** (ethnicity, gender,background) in the composition of teams seems to be positively correlated with performance (Cooke & Hilton Eds. , NAS 2015)
- Large teams might be at a disadvantage in terms of producing disruptive science (Yu, Wang and Evans Nature 2019).

Team Work



Working in teams has many caveats:

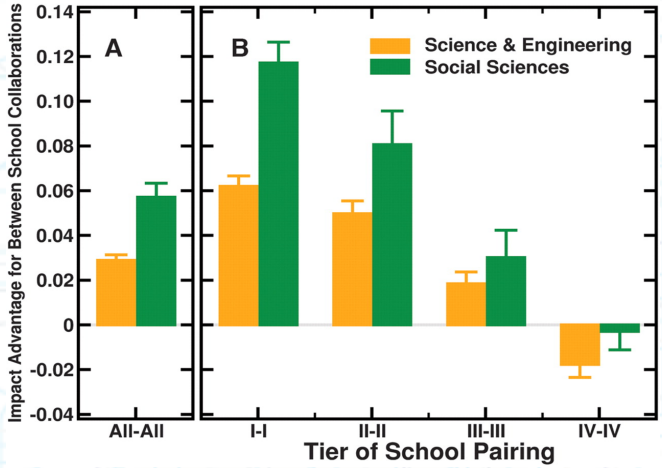
- Communication costs
- Language barrier in interdisciplinary teams
- Coordination costs in multi-institution collaborations
- ...

And yet, scientists want to engage in long distance collaborations

Multi-University Research Teams: Shifting Impact, Geography, and Stratification in Science

Benjamin F. Jones,[1,2]* Stefan Wuchty,[3]*† Brian Uzzi[1,3,4]*‡

This paper demonstrates that teamwork in science increasingly spans university boundaries, a dramatic shift in knowledge production that generalizes across virtually all fields of science, engineering, and social science. Moreover, elite universities play a dominant role in this shift. By examining 4.2 million papers published over three decades, we found that



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PLOS ONE

The Scientific Impact of Nations: Journal Placement and Citation Performance

Matthew J. Smith[1,5]*, Cody Weinberger[1], Emilio M. Bruna[2,3], Stefano Allesina[1,4,5]

1 Department of Ecology & Evolution, University of Chicago, Chicago, Illinois, United States of America, **2** Center for Latin American Studies, University of Florida, Gainesville, Florida, United States of America, **3** Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, Florida, United States of America, **4** Computation Institute, University of Chicago, Chicago, Illinois, United States of America, **5** Northern Plains Center for Human Potential, St. Paul, Minnesota, United States of America

Stanford, Sept 2019

And yet, scientists want to engage in long distance collaborations

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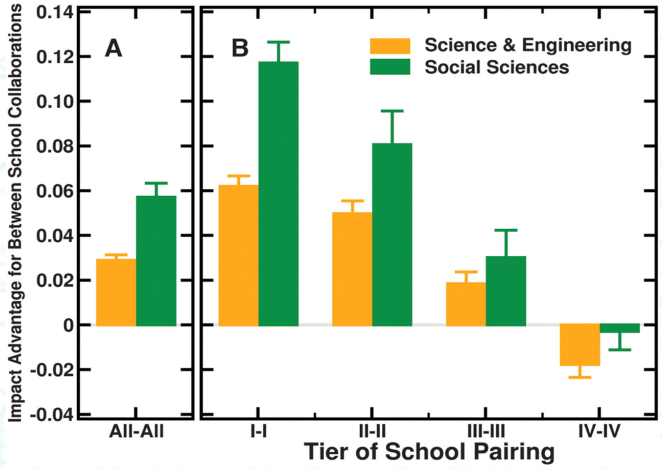

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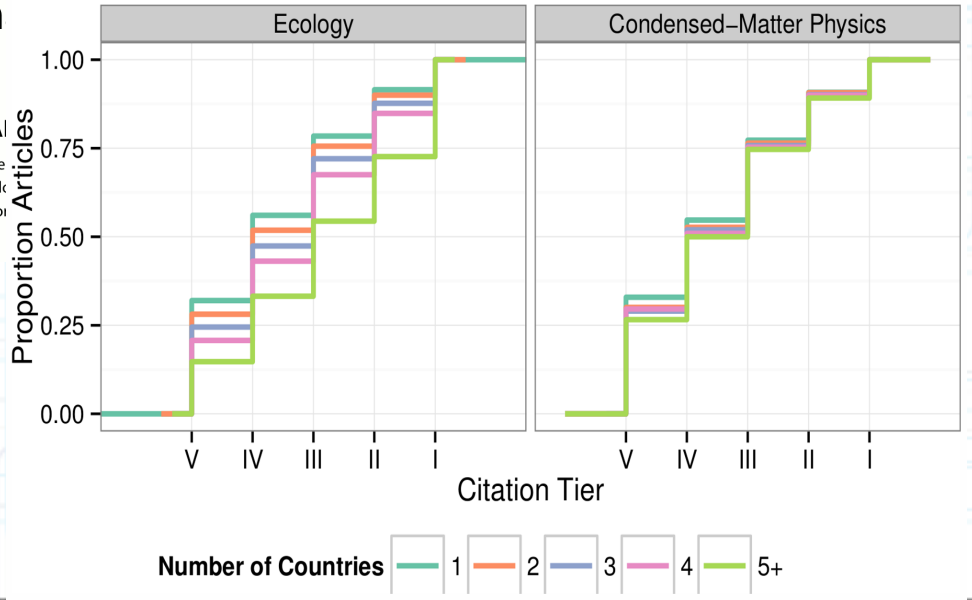


Stanford, Sept 2019

Question: How do scientists collaborate?

- What factors affect with whom and how we collaborate? Do women collaborate more/less/differently than men?

- How do factors such as resources/funding affect our pattern of collaboration?

Gender differences: Do women engage in collaborations that are different from that of men?

Having women within a team is in principle beneficial because it increases team diversity. In fact, the presence of women in a team significantly increases its collective intelligence or the ability of a team to perform a task.

Evidence for a Collective Intelligence Factor in the Performance of Human Groups

Anita Williams Woolley,[1]* Christopher F. Chabris,[2,3] Alex Pentland,[3,4] Nada Hashmi,[3,5] Thomas W. Malone[3,5]

Psychologists have repeatedly shown that a single statistical factor—often called "general intelligence"—emerges from the correlations among people's performance on a wide variety of cognitive tasks. But no one has systematically examined whether a similar kind of "collective intelligence" exists for

INTERDISCIPLINARY SCIENCE REVIEWS, Vol. 36 No. 2, June, 2011, 146–53

The Role of Gender in Team Collaboration and Performance

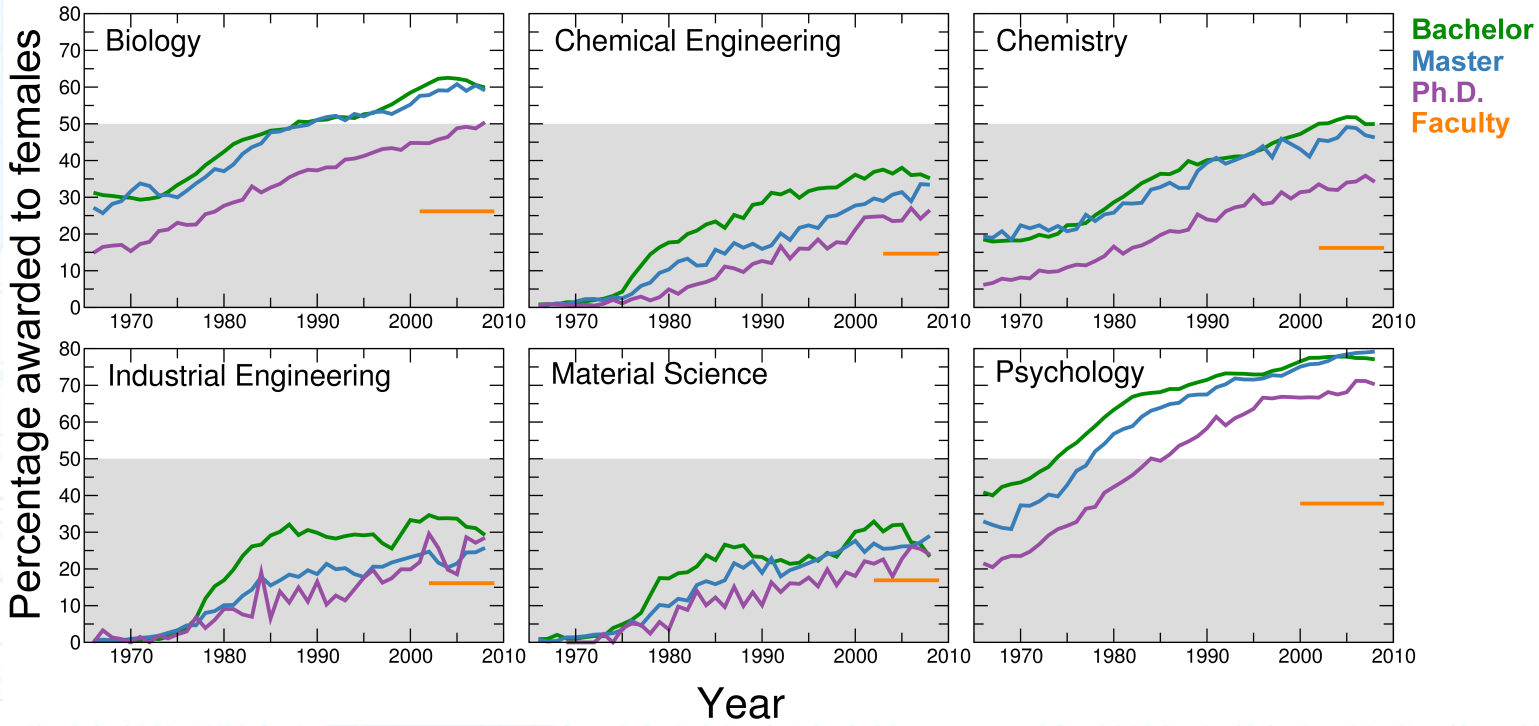
JULIA B BEAR
Technion — Israel Institute of Technology, Haifa, Israel

ANITA WILLIAMS WOOLLEY
Carnegie Mellon University, Pittsburgh, USA

Gender differences: Do women engage in collaborations that are different from that of men?

However in order to collaborate with women we need to have women in position of collaborating...

As, we know very few women survive the academic pipeline ('leaking effect')



Stanford, Sept 2019

Plos ONE 2012

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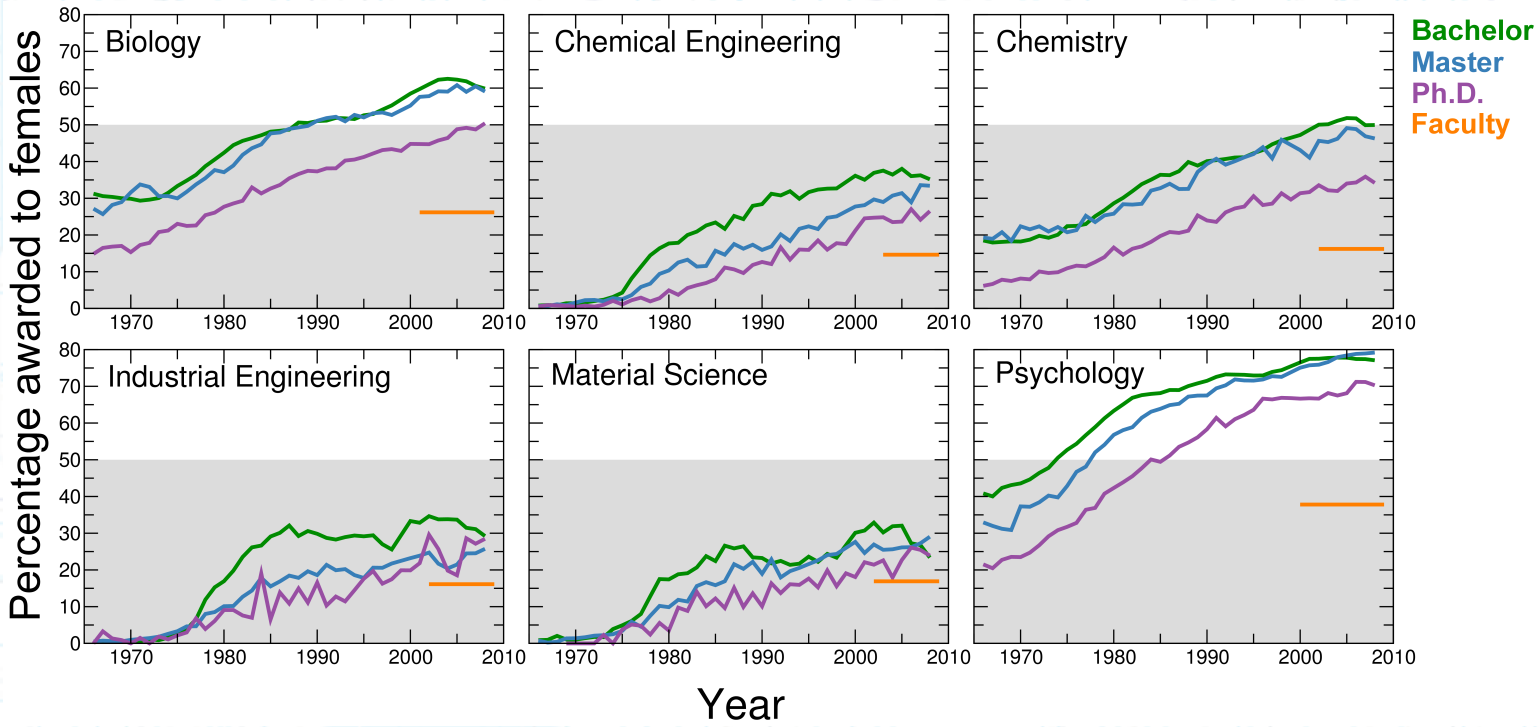

so we will have to look at the collaboration patterns of just a few 'successful women'.

Stanford, Sept 2019

Plos ONE 2012

Leadership science tells us that there are 'slight but consistent' differences in the way men and women lead

(Eagly & Johnson 2001)

- Male leaders tend to be more autocratic, task oriented, agentic and transactional

- Female leaders tend to be more democratic, interpersonal, communal and transformational

Leadership science tells us that there are 'slight but consistent' differences in the way men and women lead

(Eagly & Johnson 2001)

- Male leaders tend to be more autocratic, task oriented, agentic and transactional

- Female leaders tend to be more democratic, interpersonal, communal and transformational

Female leaders are more empowering and collaborative, so what does this tell us about how they collaborate?

We want to understand whether there are gender related differences in scientific practices and scientific production by discipline and career age

We collected data from faculty rosters of US Universities (and it took us a long time)

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EDUCATION

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B.S., West Virginia University, Morgantown, WV

Haslam Presidential Fellow, MIT

NIH Kirschstein NRSA Fellow, Chalmers University of Technology

Searle Leadership Award

RESEARCH INTERESTS

Synthetic biology, metabolic engineering, global health

What we do

Microbes must cope with harsh, rapidly changing environments to survive. To do this, microbes have developed sophisticated mechanisms to (a) sense the changes in the environment, and (b) respond quickly to these changes to protect itself from harm or capitalize on an opportunity. Our lab seeks to rewire these fundamental input/output relationships to program cells to do useful things for mankind in a paradigm called synthetic biology. Inputs: We study methods to modify existing

Stanford, Sept 2019

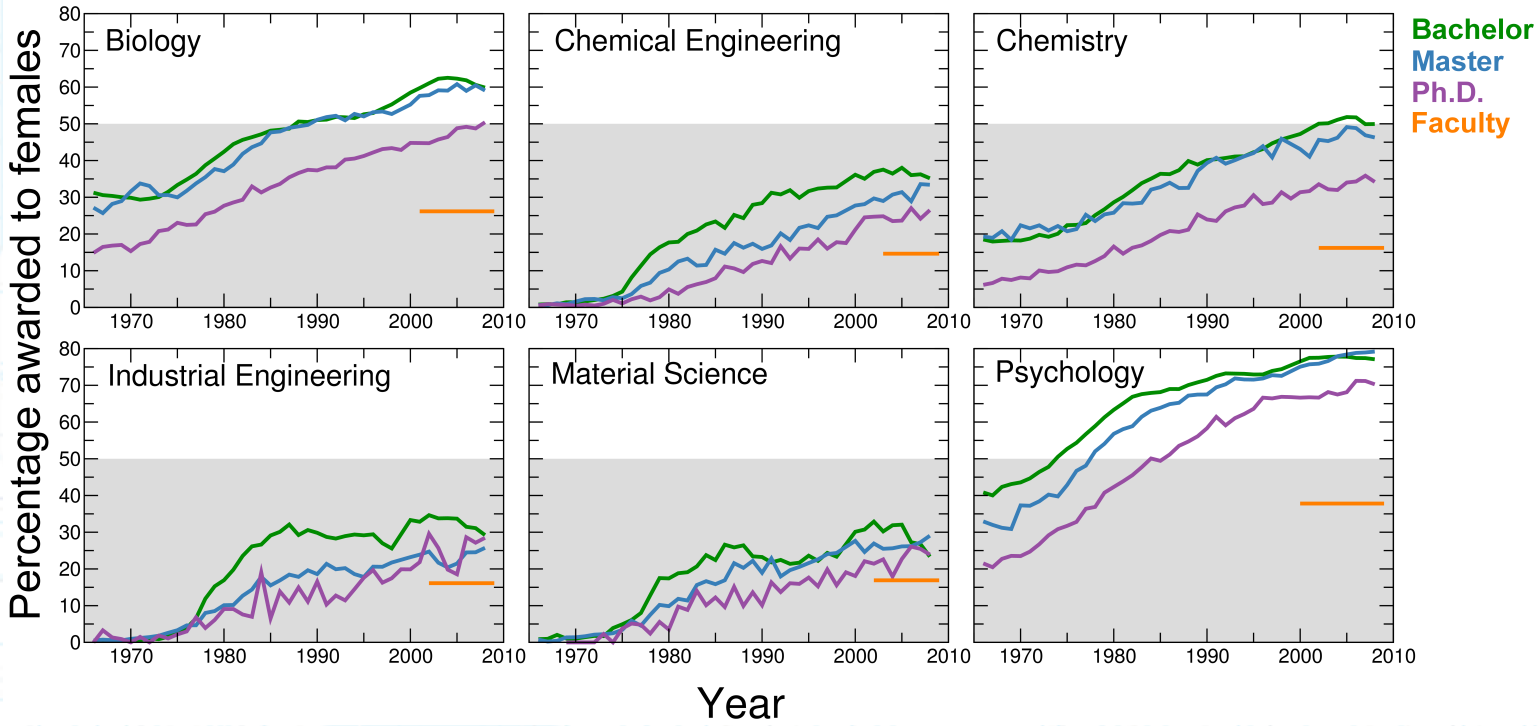
We collected data from faculty rosters of US Universities (and it took us a long time)

Discipline	Depts.	Faculty			Publications		
		Female	Male	Ratio	Female	Male	Ratio
Chemical Engineering	31	98	567	1:5.8	6,392	66,328	1:10.4
Chemistry	35	198	1,020	1:5.2	13,790	137,723	1:10.0
Ecology	15	106	328	1:3.1	3,976	22,425	1:5.6
Materials Science	26	98	473	1:4.8	9,538	75,373	1:7.9
Molecular Biology	11	168	474	1:2.8	9,882	51,234	1:5.2
Psychology	10	171	279	1:1.6	7,143	20,976	1:2.9
Total	129	839	3,141	1:3.7	50,721	374,059	1:7.4

doi:10.1371/journal.pbio.1002573.t001

Stanford, Sept 2019

Our data shows how the 'leaking effect' depends on the field



Stanford, Sept 2019

Plos ONE 2012

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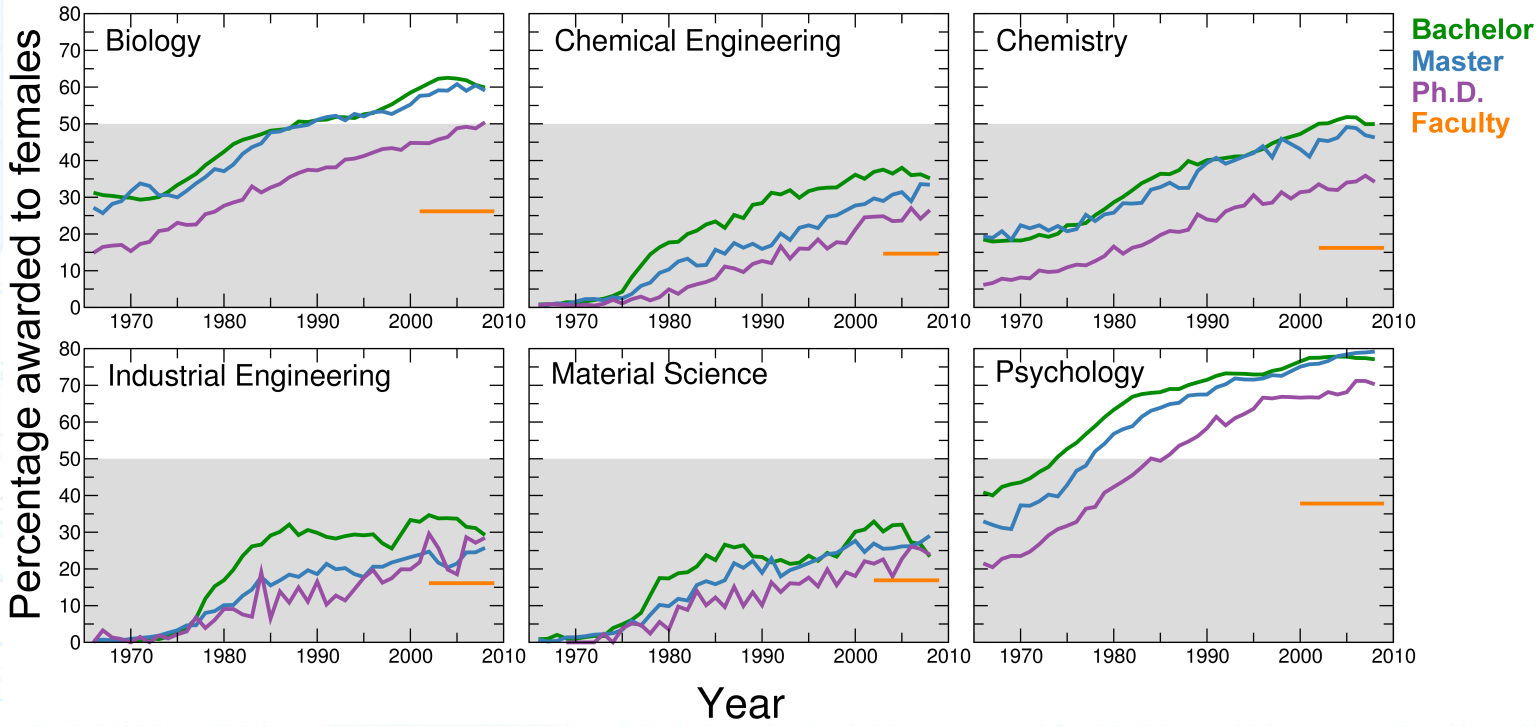
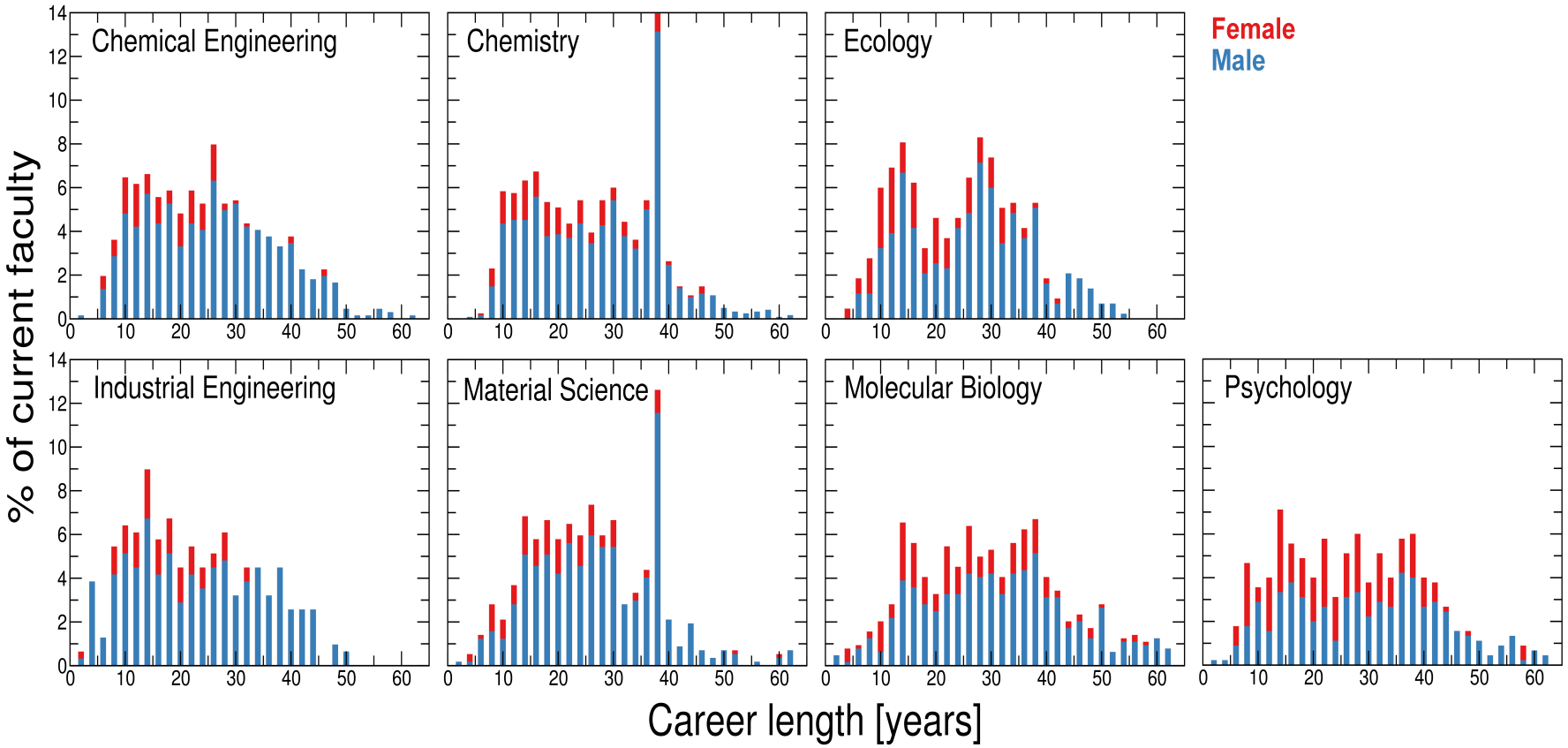


Stanford, Sept 2019

Plos ONE 2012

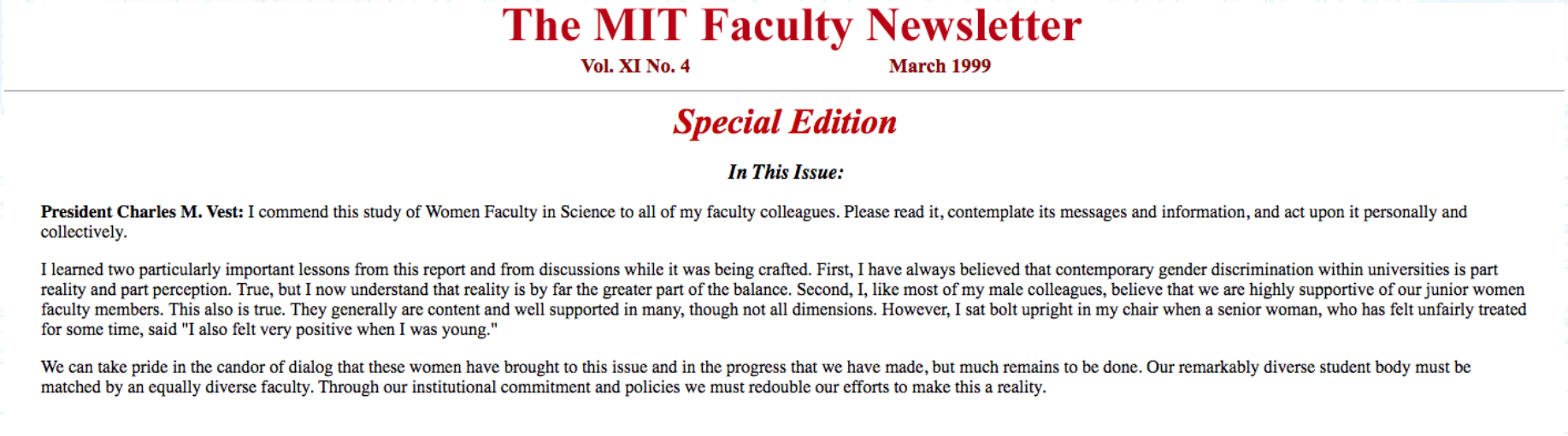
... and that there is no generalized increase in the fraction of female faculty in recent years



Stanford, Sept 2019

Plos ONE 2012

How do resources or career risk affect scientific practices of females in academia?



The MIT Faculty Newsletter

Vol. XI No. 4 March 1999

Special Edition

In This Issue:

President Charles M. Vest: I commend this study of Women Faculty in Science to all of my faculty colleagues. Please read it, contemplate its messages and information, and act upon it personally and collectively.

I learned two particularly important lessons from this report and from discussions while it was being crafted. First, I have always believed that contemporary gender discrimination within universities is part reality and part perception. True, but I now understand that reality is by far the greater part of the balance. Second, I, like most of my male colleagues, believe that we are highly supportive of our junior women faculty members. This also is true. They generally are content and well supported in many, though not all dimensions. However, I sat bolt upright in my chair when a senior woman, who has felt unfairly treated for some time, said "I also felt very positive when I was young."

We can take pride in the candor of dialog that these women have brought to this issue and in the progress that we have made, but much remains to be done. Our remarkably diverse student body must be matched by an equally diverse faculty. Through our institutional commitment and policies we must redouble our efforts to make this a reality.

Stanford, Sept 2019

How do resources and career risk affect females in academia?

The MIT

Vol. XI No. 4

President Charles M. Vest: I commend this study of Women Faculty in Science to all of my collectively.

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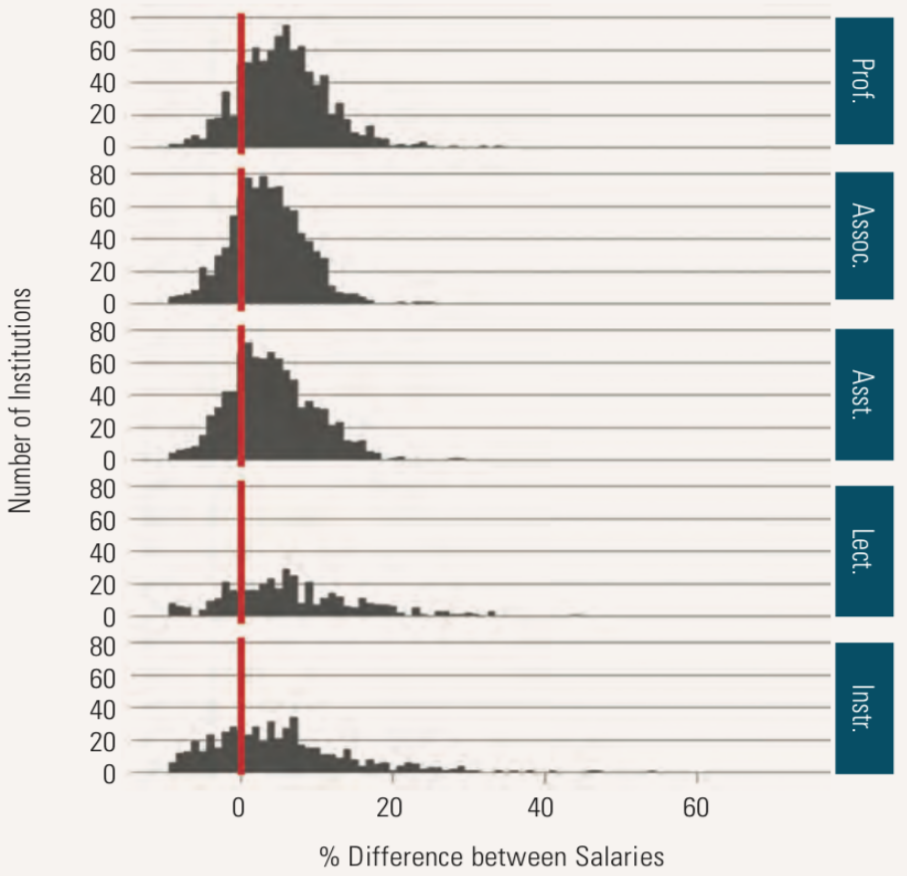
FIGURE 6

Distribution of Gender Inequity by Rank, 2017–18

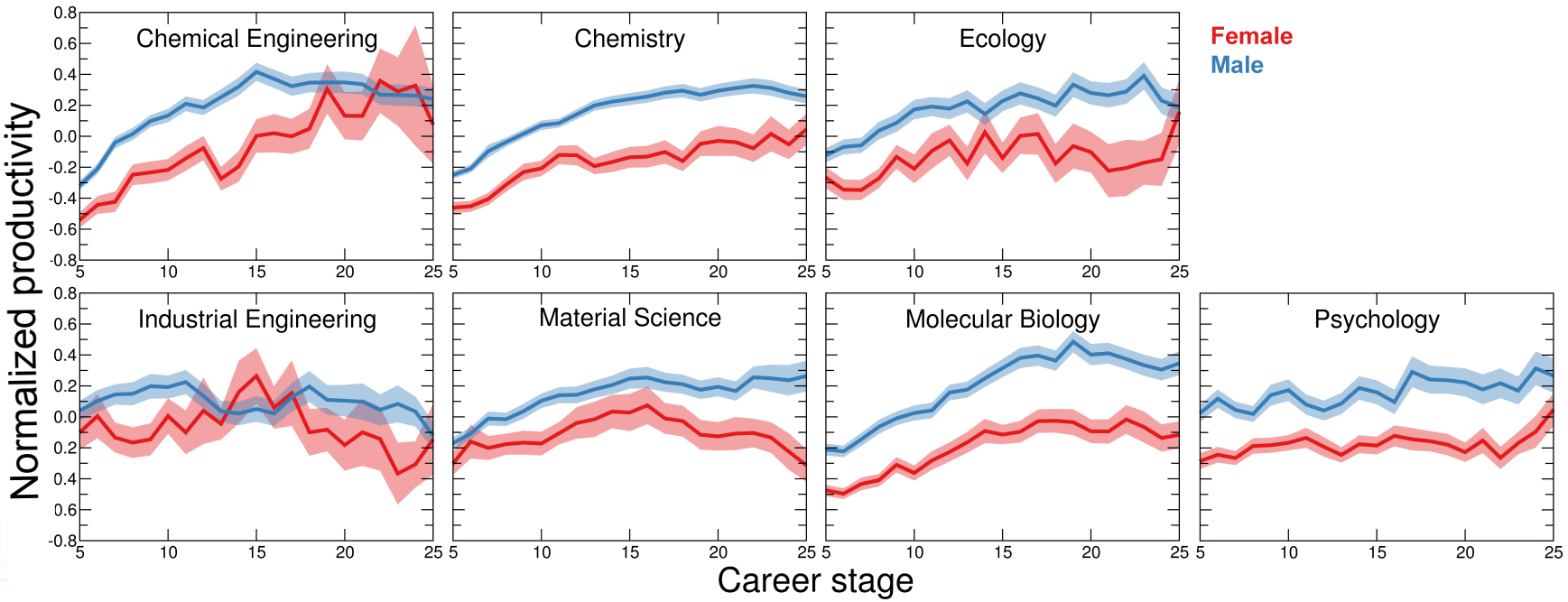


Note: Institutions to the right of the red line pay men more than women at the specified rank.

from AAUP

Observation 1 (resources): Resources are not equally distributed, therefore, the gap in productivity is higher in fields requiring lots of resources

In fields requiring more resources female faculty are less productive



Stanford, Sept 2019

PloS ONE 2012

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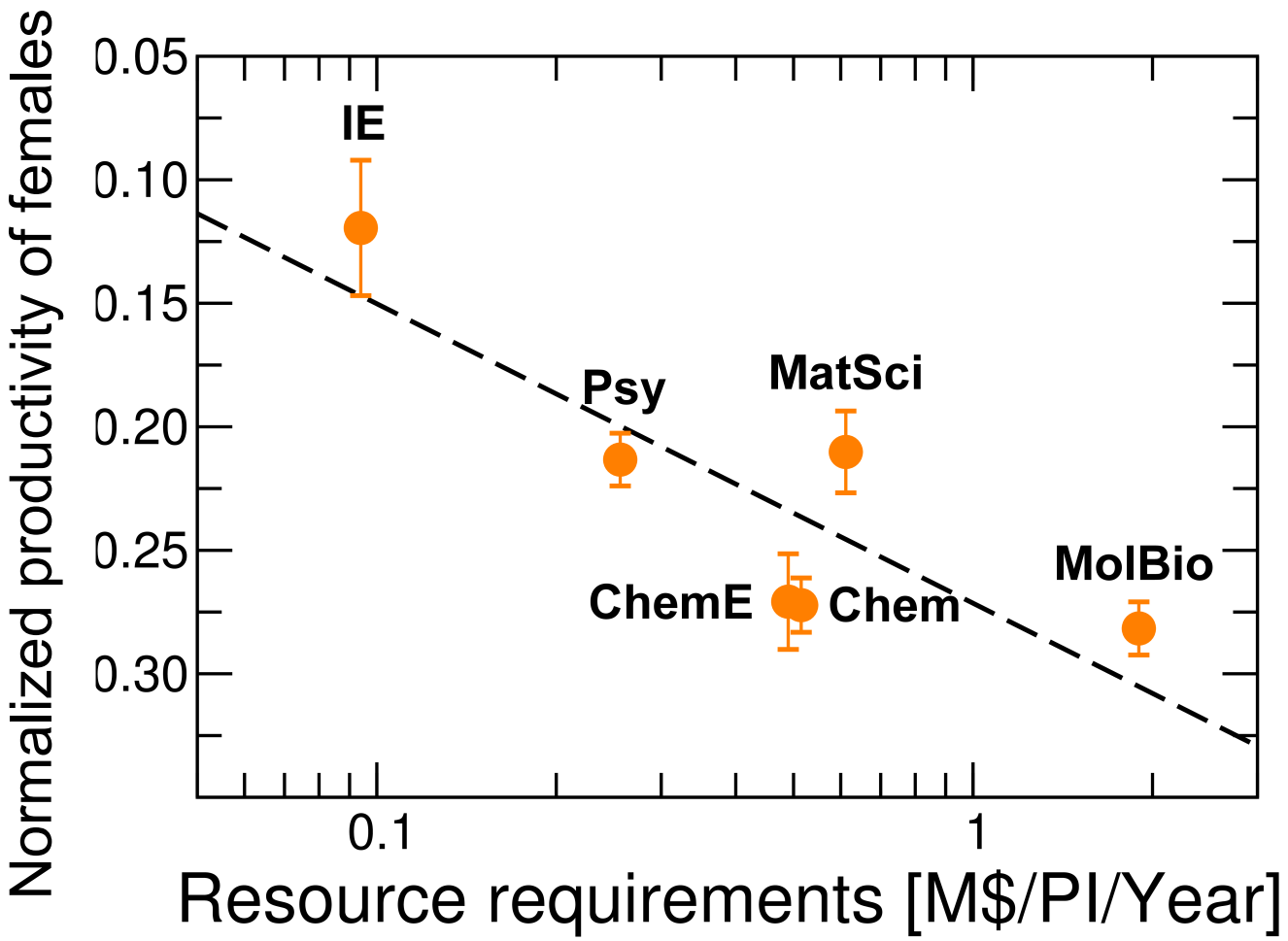


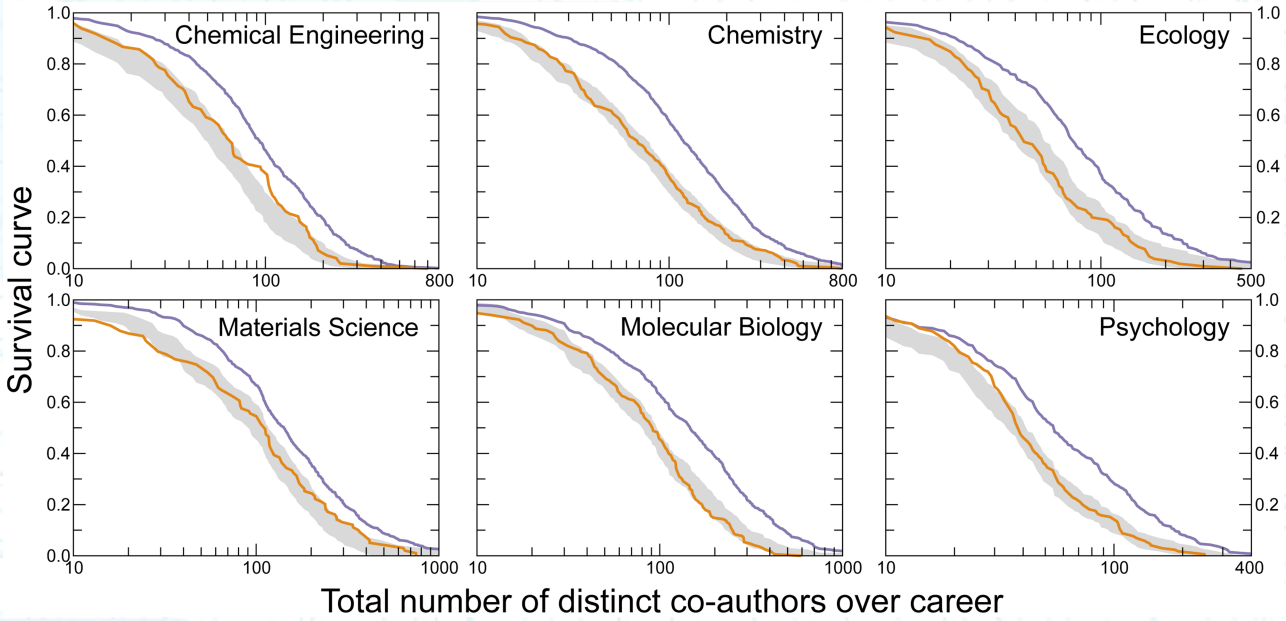
PloS ONE 2012

Going back to collaborations: what is the female collaborative signature?

Expectation: female leaders are more collaborative, empowering and interpersonal ... and therefore should be better at collaborating ...

but what does this entail in terms of measurable quantities?

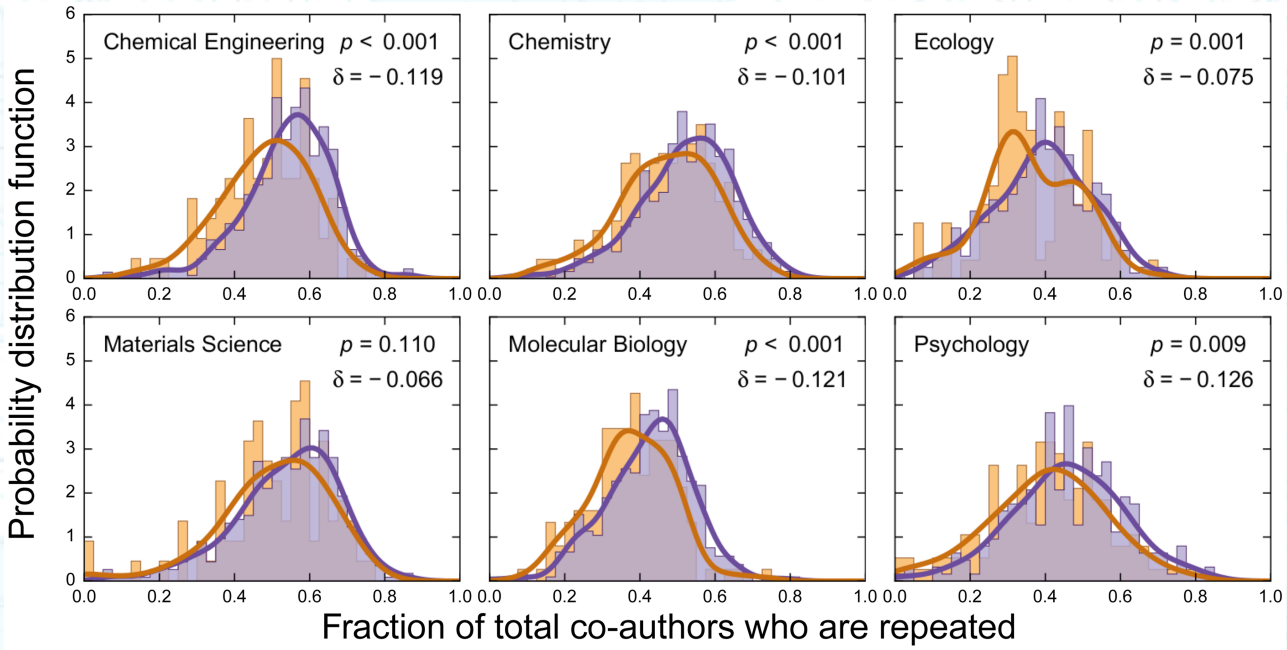
Women have the same number of distinct collaborators than male counterparts..



... if we control for the number of publications

Plos Biology 2016

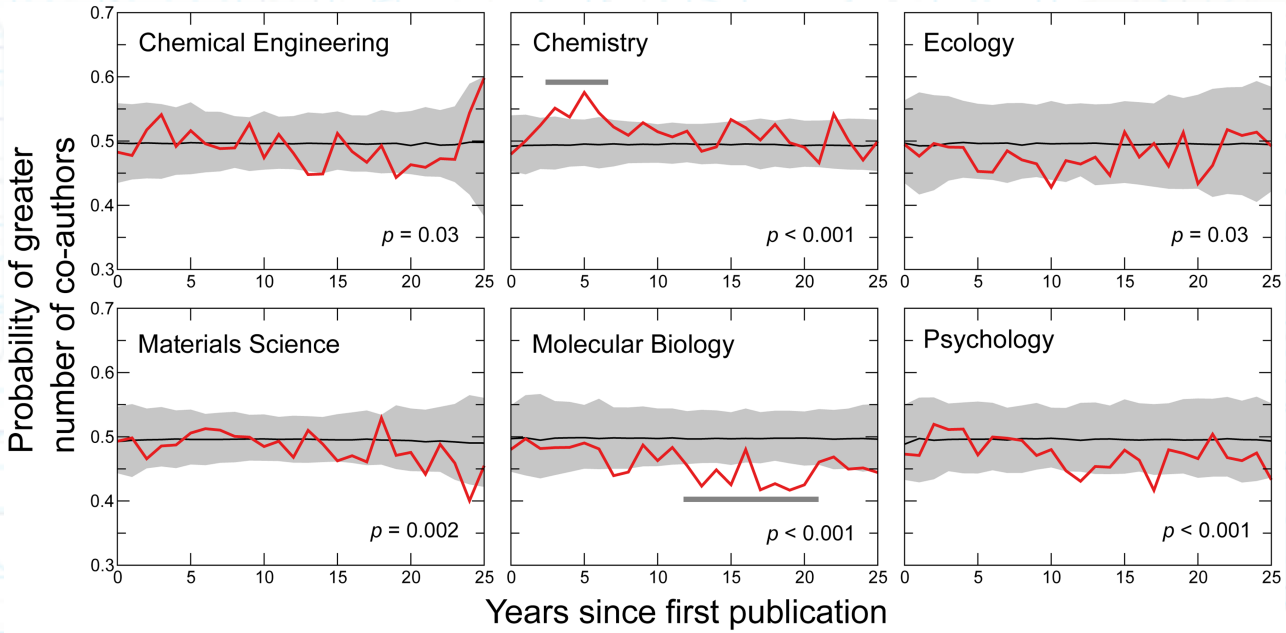
Women typically repeat less co-authors than men



Stanford, Sept 2019

Plos Biology 2016

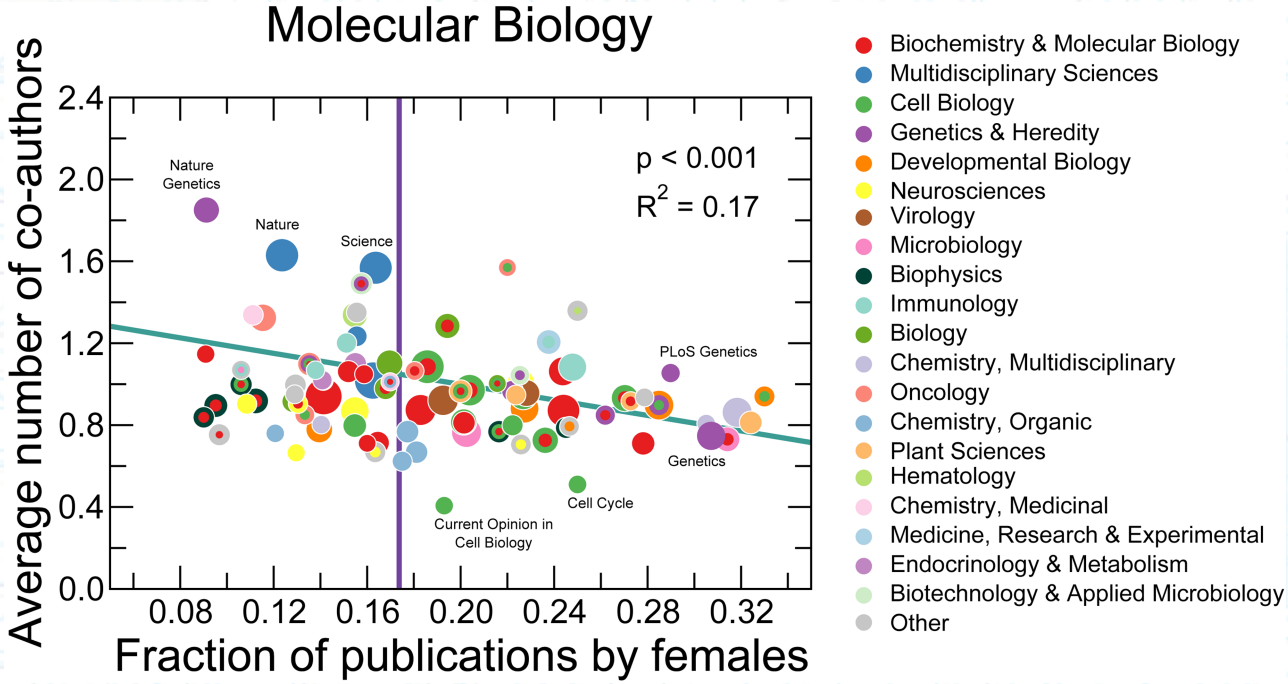
If we control for career stage, then we do not observe sustained differences in team sizes



Except for early stages in chemistry and later stages in Molecular Biology.

Plos Biology 2016

Molecular biology: there is gender segregation by sub-field



Women tend to work in areas that involve smaller teams (and probably lower funding)

Plos Biology 2016

Molecular biology: the study case of genomics

This is the epitome of a male-dominated field:

- None of the researchers in our database in within the top 10 scientists in the field – taking into account that females are 26% of the field, this event is extremely unlikely (p ~0.0095).

- There seems to be a bias of male-lead labs in the hiring practices (Sheltzer and Smith PNAS 2014)

Plos Biology 2016

Up to here:

Women who succeed in academia have slightly different collaborative practices – they repeat less collaborators.

With respect to the sizes of teams in which female PIs participate, differences are more pronounced in fields in which funding/resources play an important role.

Funding affects the way we perform science

- Topics: Decides the growth of certain scientific areas and the ‘death’ of others

- It has an effect in how we specifically favor science by favoring specific practices (e.g. big center/consortia initiatives around certain topics)

Open Mike

Helping connect you with the NIH perspective, and helping connect us with yours

Posted on April 4, 2018 by Mike Lauer

Impact of Teams Receiving NIH Funding

Almost 11 years ago, Stefan Wuchty, Benjamin Jones, and Brian Uzzi (all of Northwestern University) published an article in *Science* on "The Increasing Dominance of Team in Production of Knowledge." They analyzed nearly 20 million papers published over 5 decades and 2.1 million patents and found that across all fields the number of authors per paper (or patent) steadily increased, that teams were coming to dominate individual efforts, and that teams produced more highly cited research.

In a *Science* review paper published a few weeks ago, Santo Fortunato and colleagues offered an overview of the "Science of Science." One of their key messages was that "Research is shifting to teams, so engaging in collaboration is beneficial."

I thought it would be worth exploring this concept further using NIH grants. For this post, data were acquired using a specific NIH portfolio analysis tool called iSearch. This platform prvides easy access to carefully curated, extensively-linked datasets of global grants, patents, publications, clinical trials, and approved drugs.

Dr. Michael Lauer is NIH's Deputy Director for Extramural Research, serving as the principal scientific leader and advisor to the NIH Director on the NIH extramural research program.

One way of measu
papers. Figure 1 sh
supported papers
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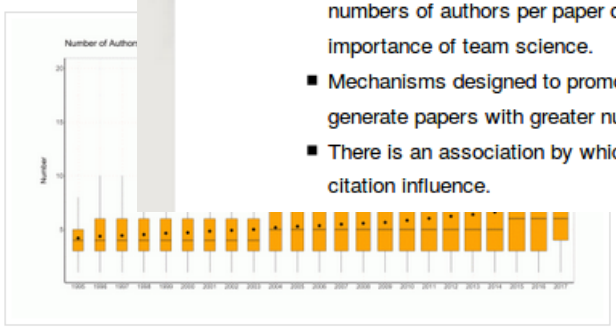


Figure 2 shows corresponding data for 765,851 papers that were supported only with research (R) grants. In other words, none cited receiving support from program project (P), cooperative agreement (U), career development (K), training (T), or fellowship (F) awards. We see a similar pattern in which author counts have increased over time (mean from 4.0 to 6.2, median from 4 to 5). Also, of note is a drifting of the mean away from the median, reflecting an increasingly skewed distribution driven by a subset of papers with large numbers of authors.

Summarizing these findings:

- Consistent with prior literature, we see that NIH-funded extramural research, including research funded by R grants, produce mostly multi-author papers, with increasing numbers of authors per paper over time. These findings are consistent with the growing importance of team science.
- Mechanisms designed to promote larger-scale team science (mainly P and U grants) generate papers with greater numbers of authors.
- There is an association by which greater numbers of authors are associated with greater citation influence.

Stanford, S

Different schemes of funding are likely to affect the way we perform science

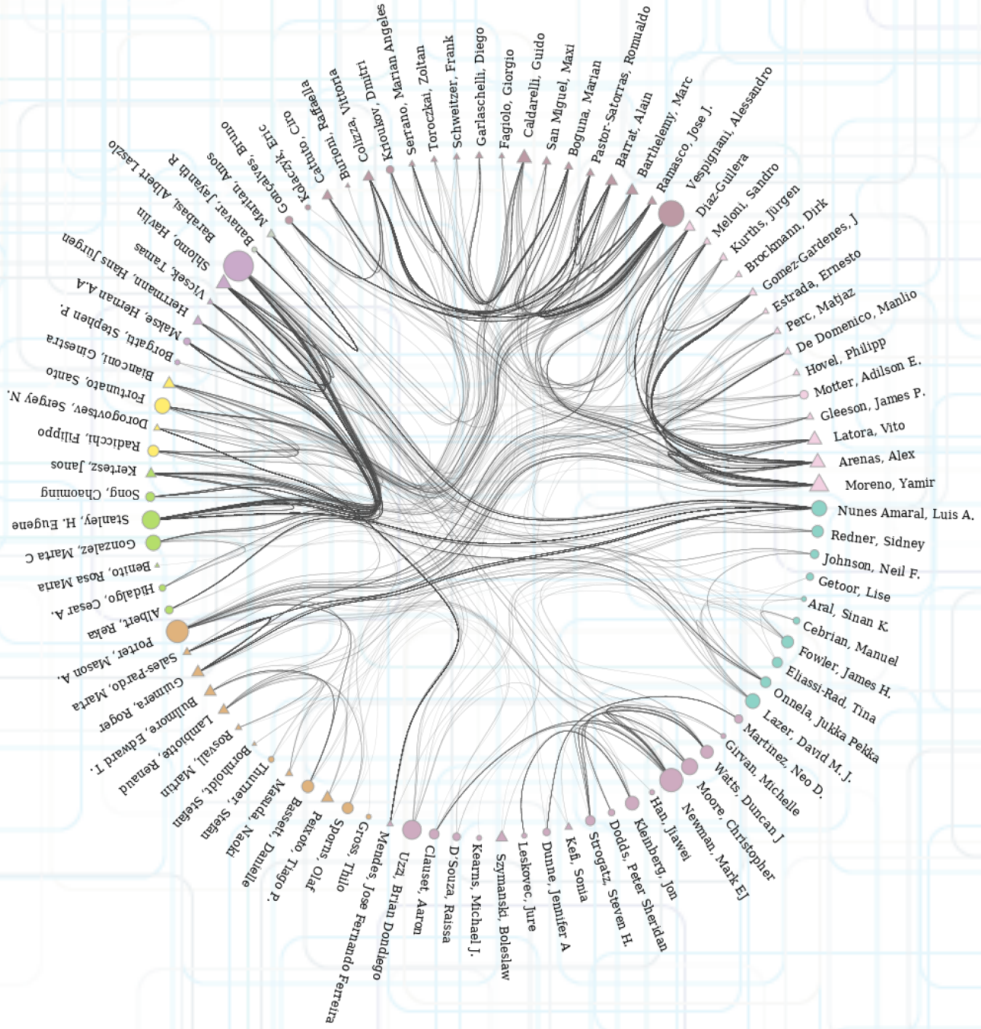
EUROPE	US
Largest grants come from the EU: H2020, ERC H2020: collaborative grants; groups participating from three different countries	Many options for reasonable grants: NIH, NSF, different departments, Foundations
Labs are constituted by groups of researchers, often with some sort of hierarchical structure (e.g. around a full professor, research deputy)	Labs grow around a single PI

How do funding and existing scientific structures affect the way we collaborate (and perform good science)?

Stanford, Sept 2019

Expectation: Successful scientists within the same field affiliated within EU countries are more likely to collaborate and repeat collaborations.

The network of collaborations among top scientists within a field reveals that US and EU based scientists play distinctively different roles within a network.



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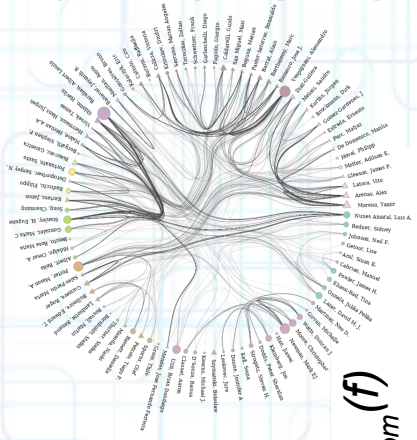
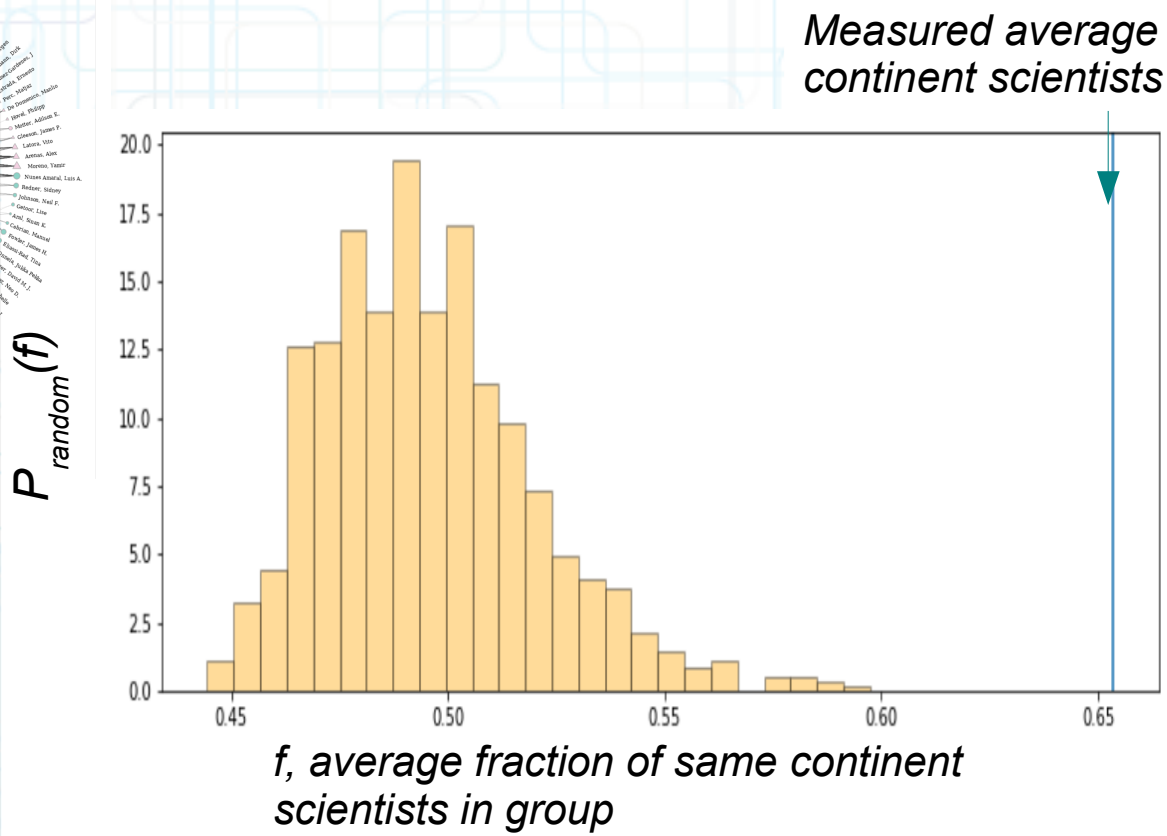
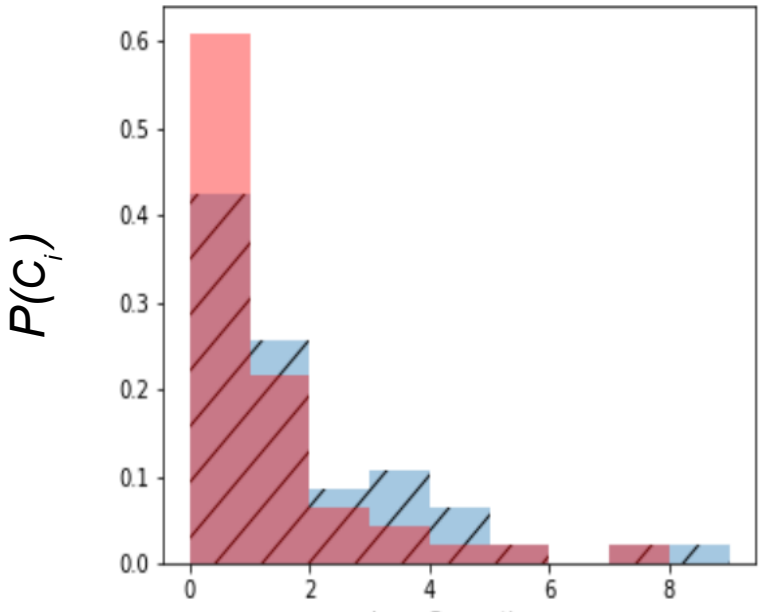


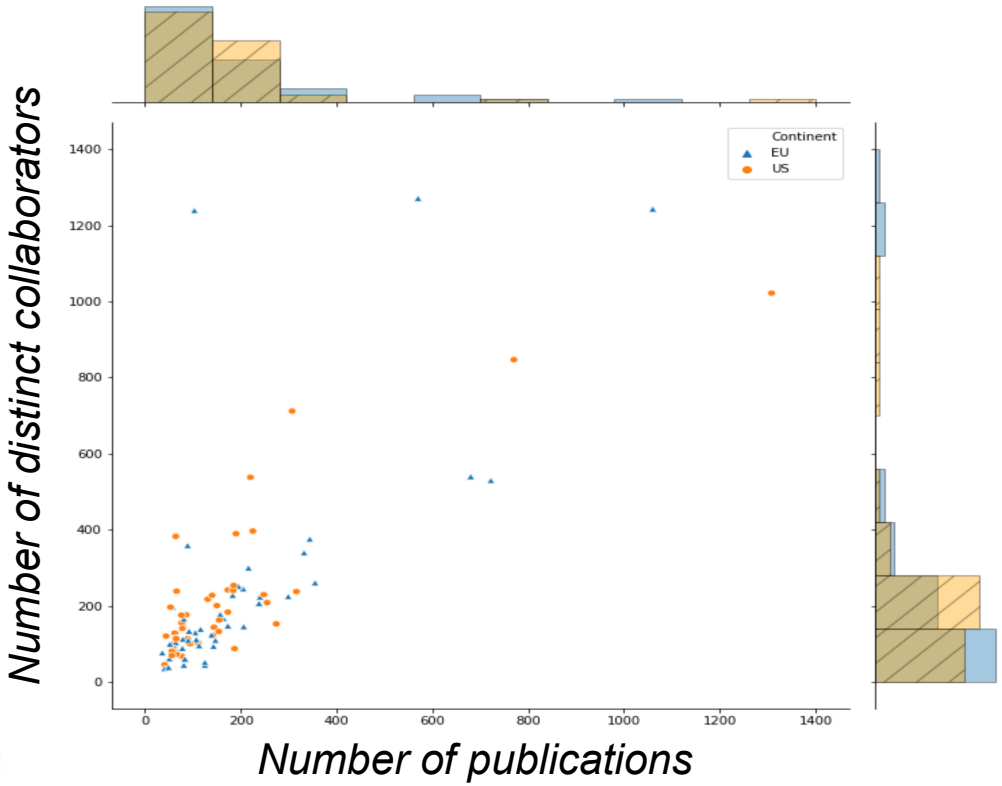


Specifically, EU top scientists within a group co-author more papers together than top US scientists in the same field do ...



C_i, normalized connections within group with same continent scientists

Even though they have the same number of co-authors if we control by the number of publications



Conclusions:

Top scientists have different patterns of collaboration depending on geographical location.

This suggests that the current funding structures (and maybe overall scientific structures) play an important role in how scientist collaborate with their peers. Future: What kind of impact does this have on scientific output?

Acknowledgements

Northwestern University: Luís Amaral, Han Zhang, Theresa Woodruf

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U. Toronto: Carles Muntaner

MARIE CURIE ACTIONS

JAMES S. MCDONNELL FOUNDATION

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

SEVENTH FRAMEWORK PROGRAMME

NATIONAL SCIENCE FOUNDATION

Scientific career and gender: What does it take to become a female academic in a STEM field?