How Current Incentives for Scientists Lead to Poor Science for Everyone

*Everything is F*cked*

Dr. Alexander Mark Weber

Assistant Professor, Department of Pediatrics,
Division of Neurology, Faculty of Medicine
Imaging Staff Scientist, BC Children's Hospital Research Institute
University of British Columbia

Oct 12th, 2023

Overview

1. Toot
2. Incentives
3. Publishing World
4. Grants
5. Grad Students
6. Philosophy of Science
7. Metascience
8. Solutions

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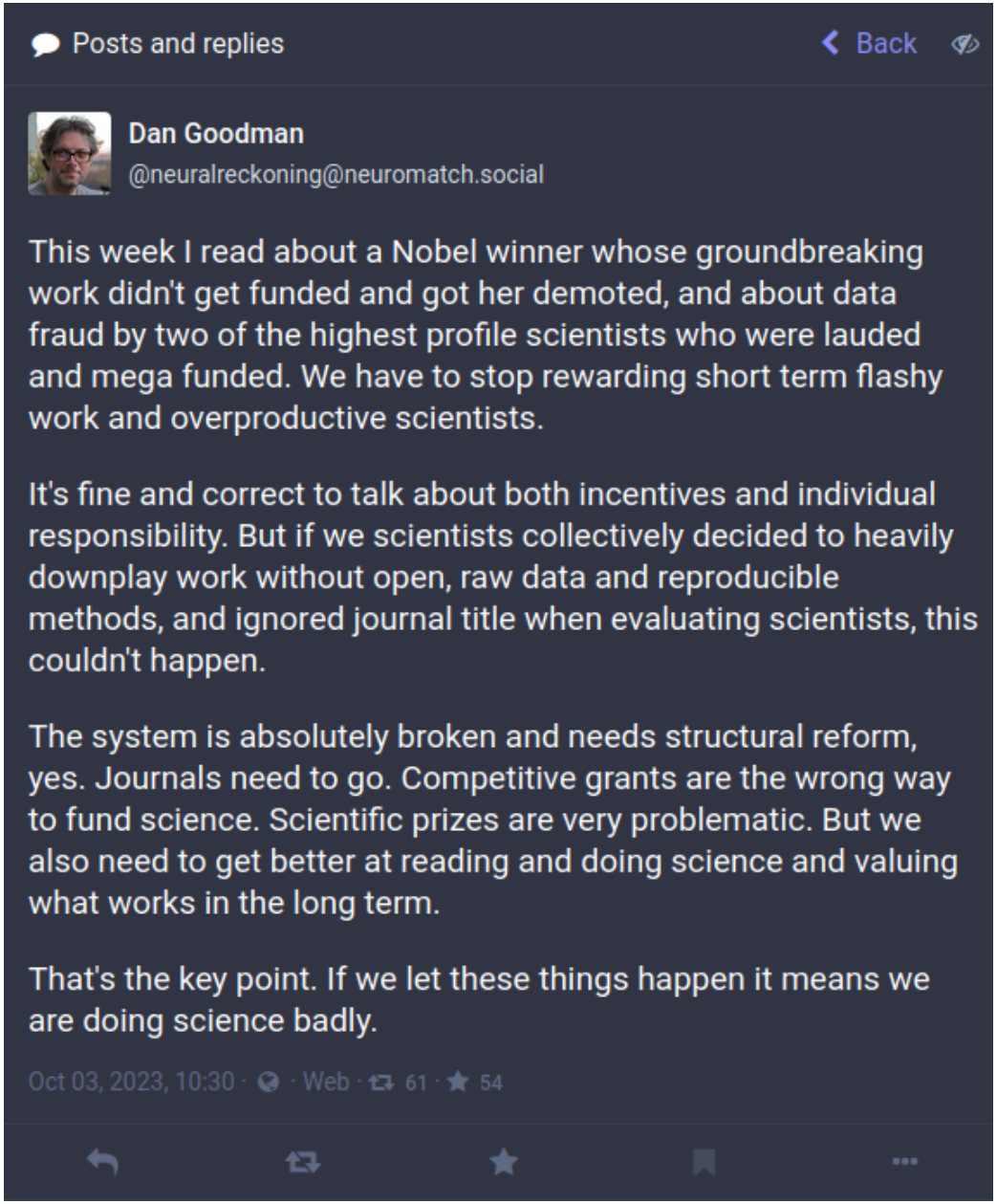
A Toot


Posts and replies
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Dan Goodman
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It's fine and correct to talk about both incentives and individual responsibility. But if we scientists collectively decided to heavily downplay work without open, raw data and reproducible methods, and ignored journal title when evaluating scientists, this couldn't happen.
The system is absolutely broken and needs structural reform, yes. Journals need to go. Competitive grants are the wrong way to fund science. Scientific prizes are very problematic. But we also need to get better at reading and doing science and valuing what works in the long term.
That's the key point. If we let these things happen it means we are doing science badly.
Oct 03, 2023, 10:30 · · Web · 61 · 54

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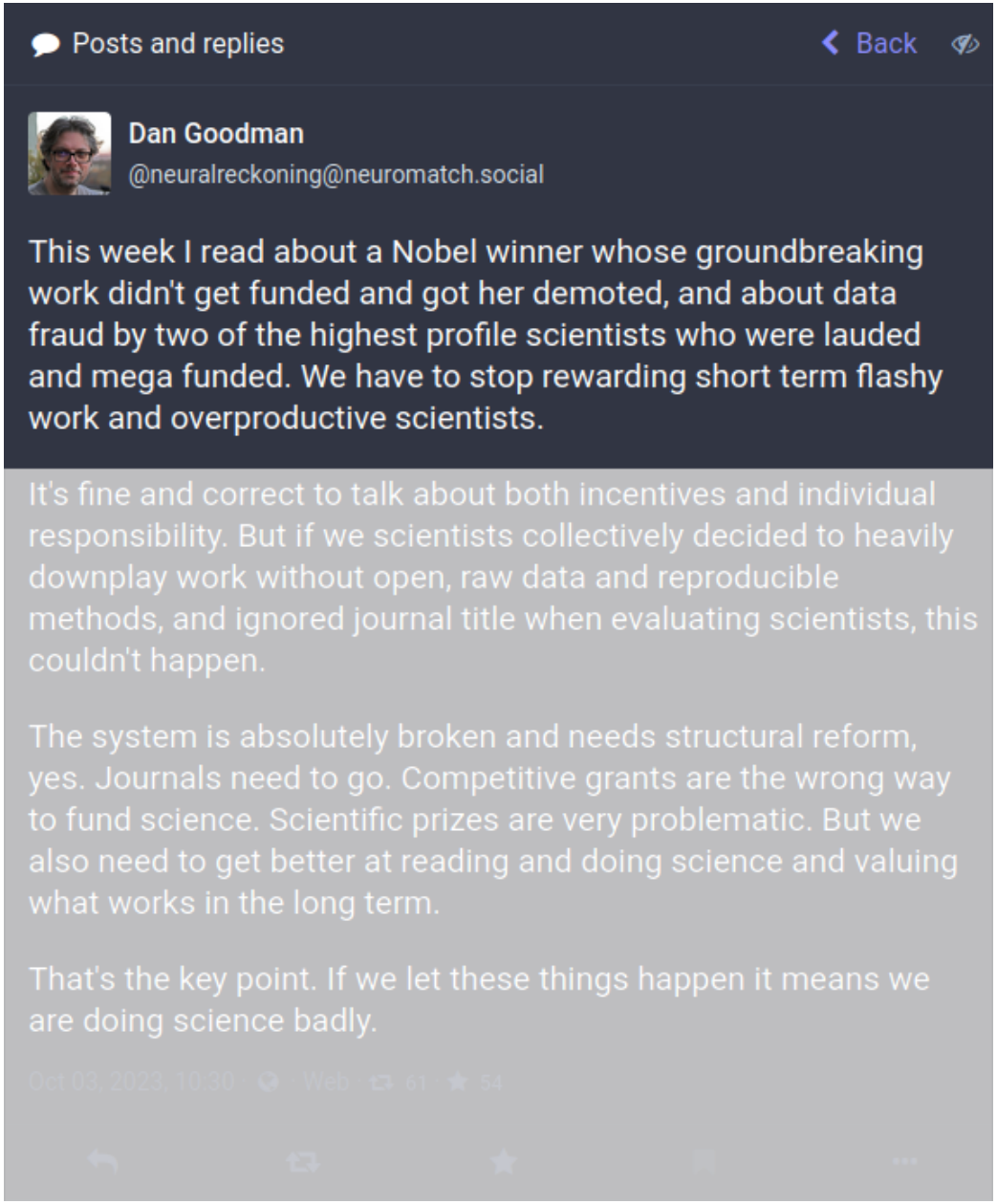
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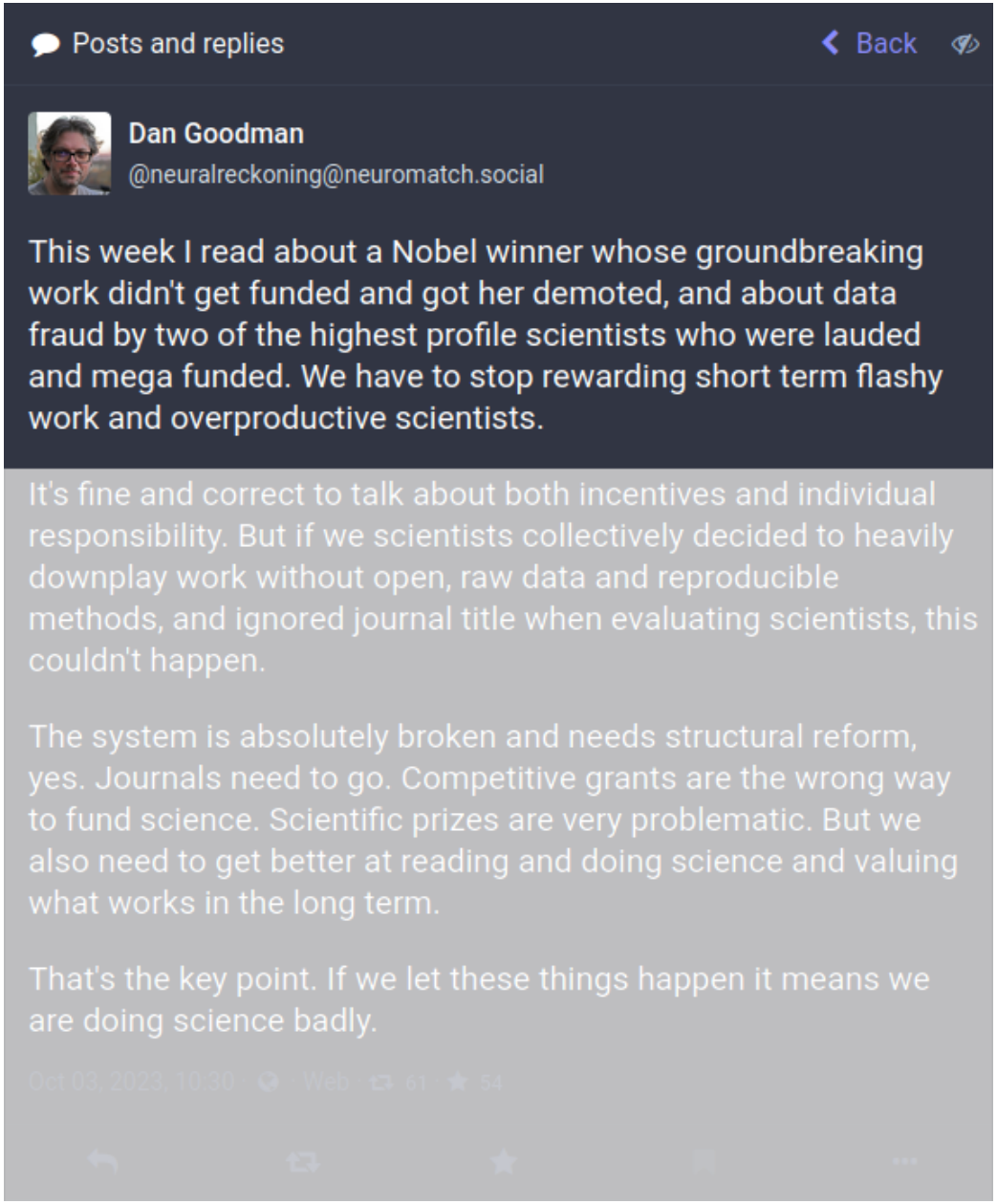

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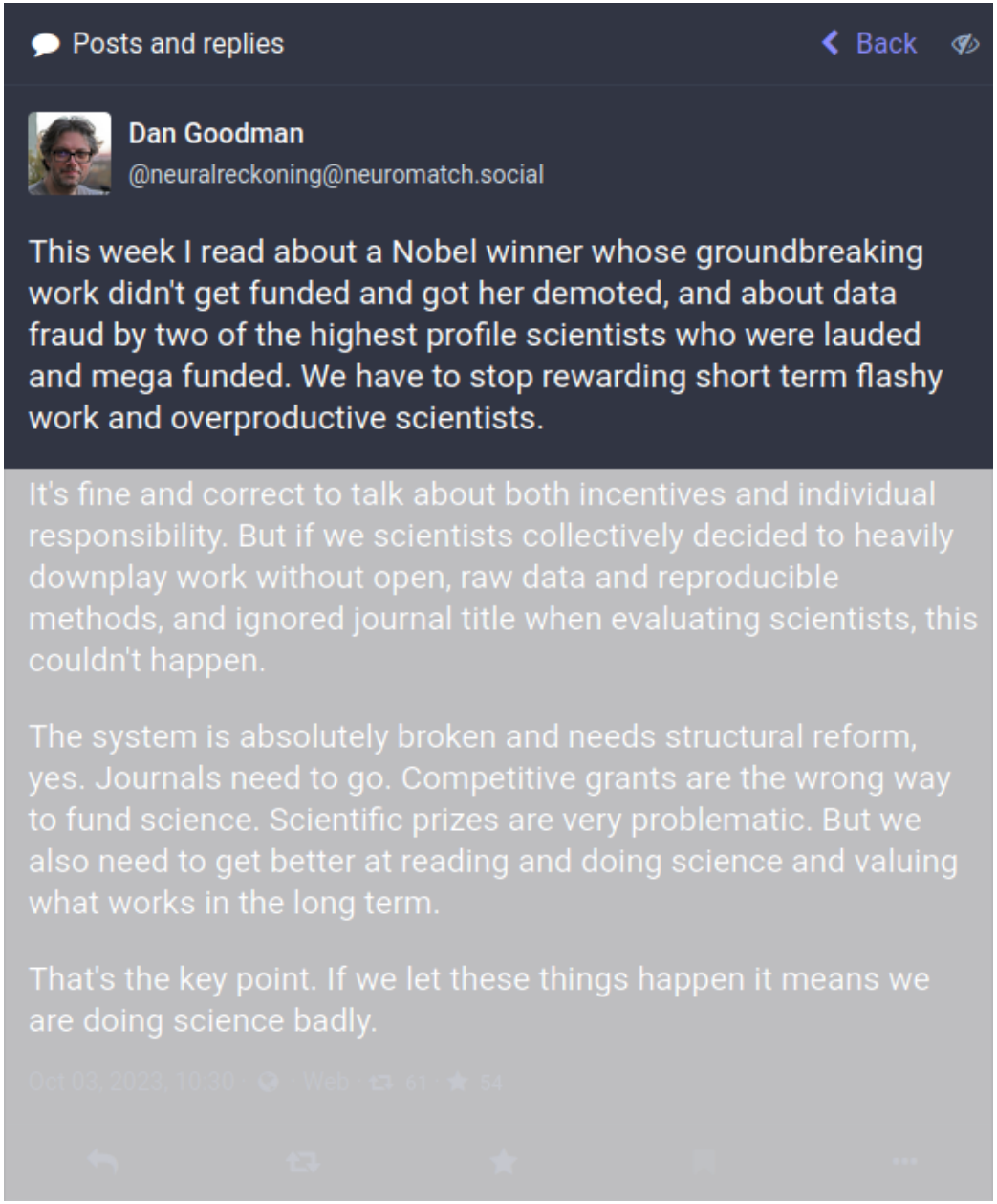

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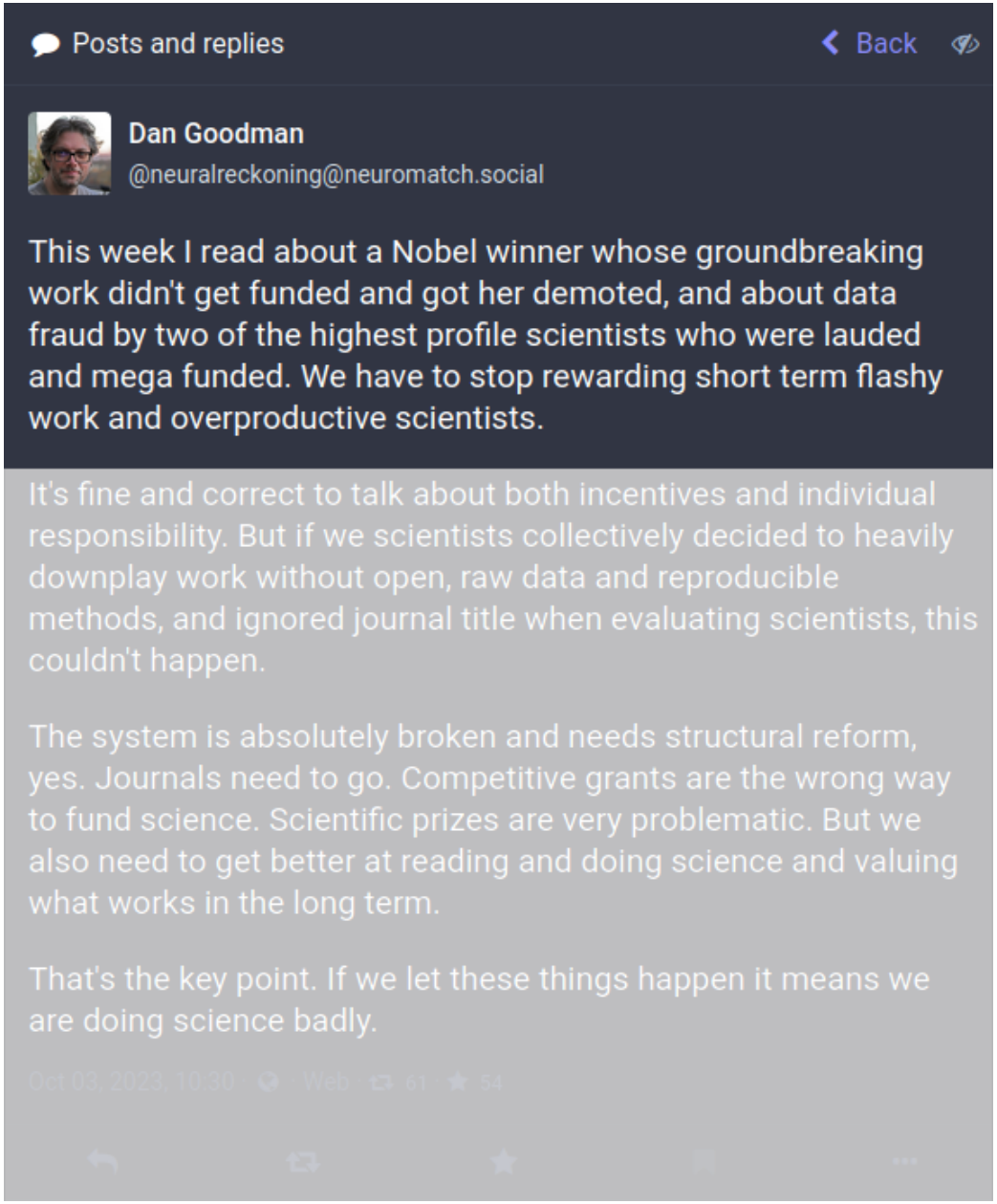

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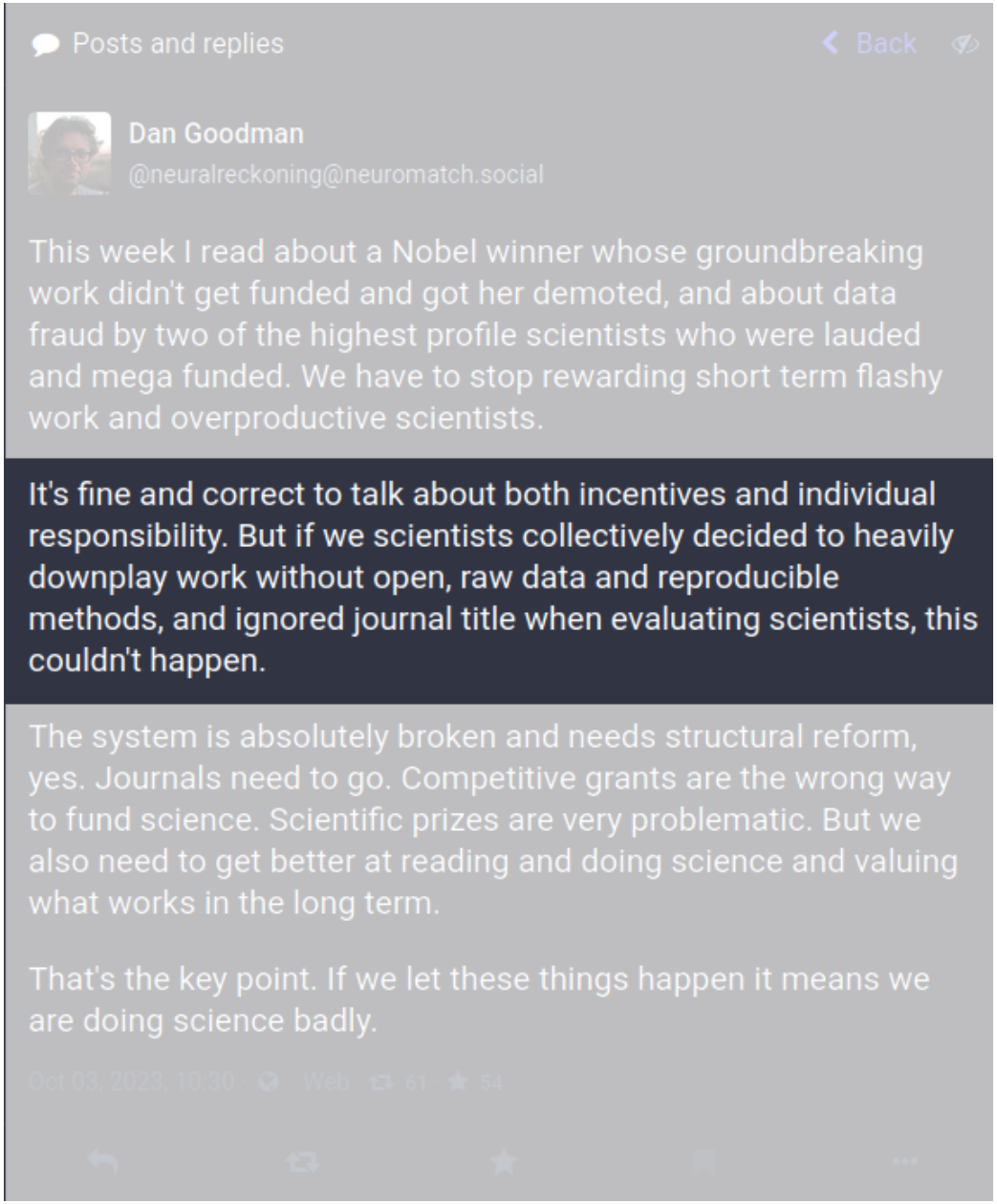
A Toot: Incentives



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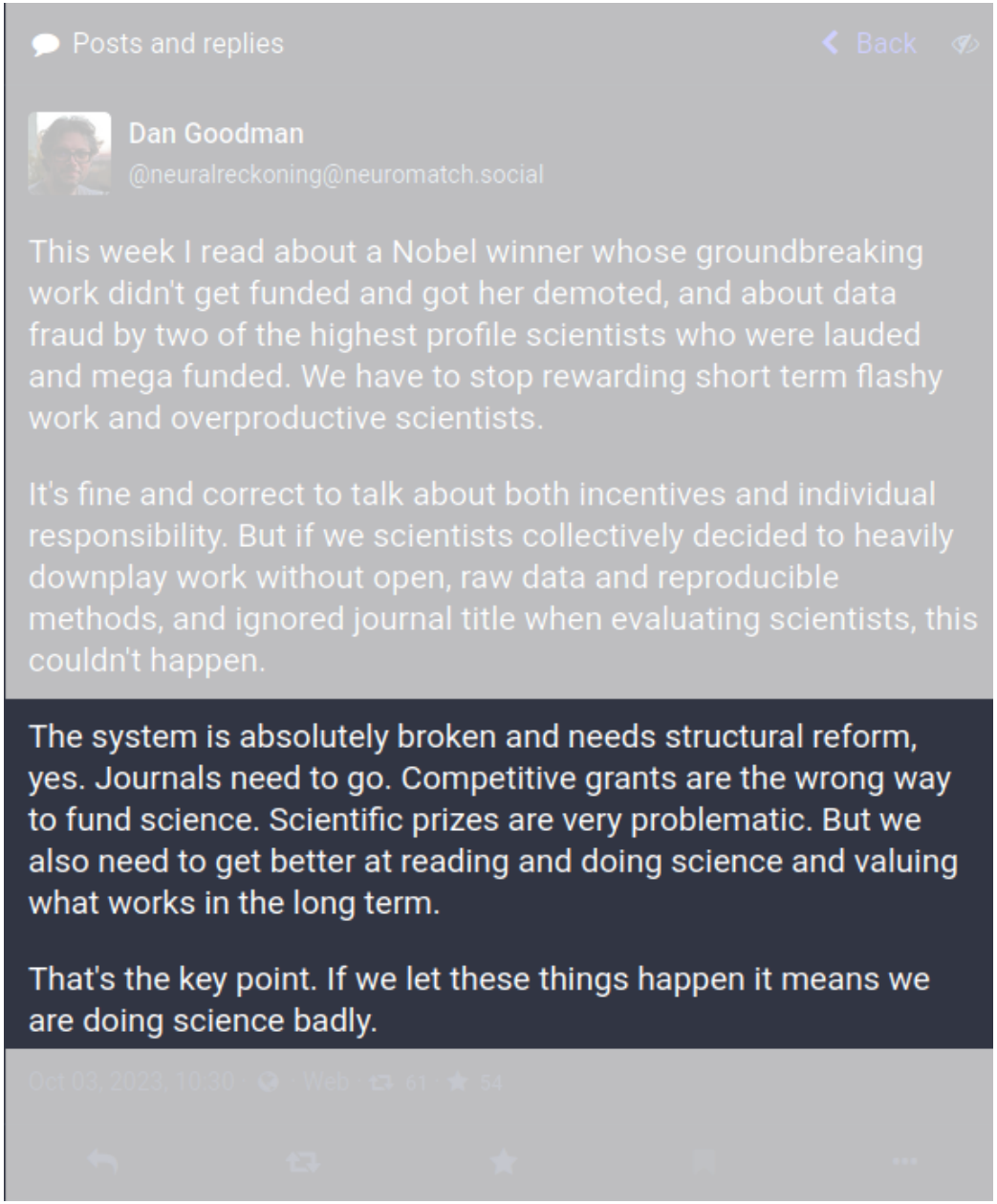
A Toot: Broken System



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POLICY

Science Funding Is Broken

The way we pay for science does not encourage the best results

By John P. A. Ioannidis on October 1, 2018

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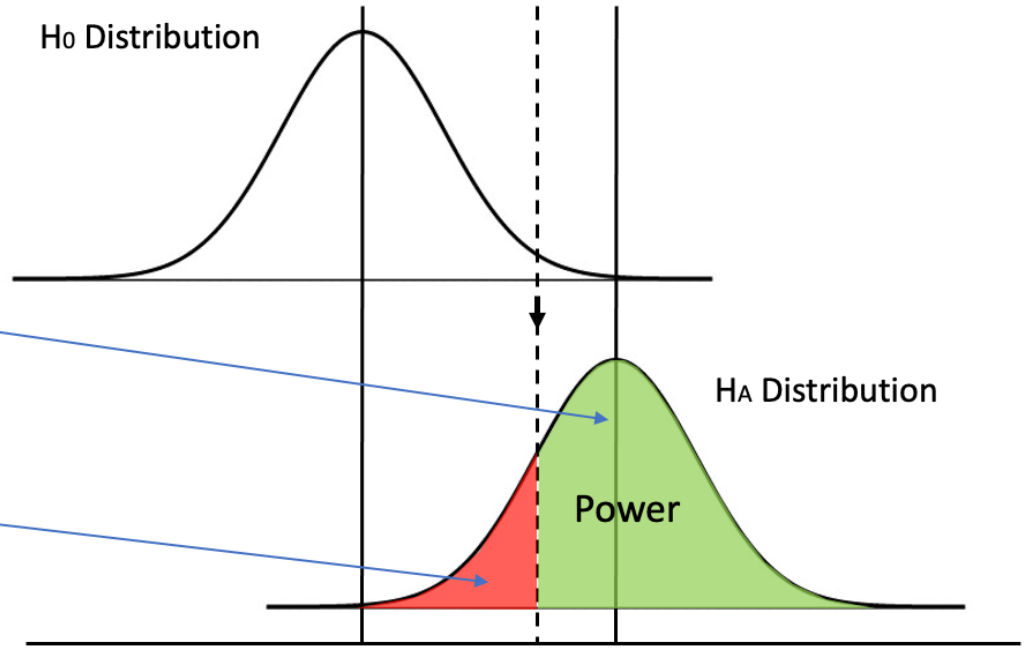
"researchers acting to maximise their fitness should spend most of their effort seeking novel results and conduct small studies that have only **10% – 40% statistical power**"

"**half** of the studies they publish will report erroneous conclusions. Current incentive structures are in conflict with maximising the scientific value of research"

Aside: What is Power?

	H_0 is True	H_A is True
Reject H_0	Type I Error False Positive α (alpha)	Correct True Positive 1-β (power)
Fail to reject H_0	Correct True Negative 1-α	Type II Error False Nagative β (beta)



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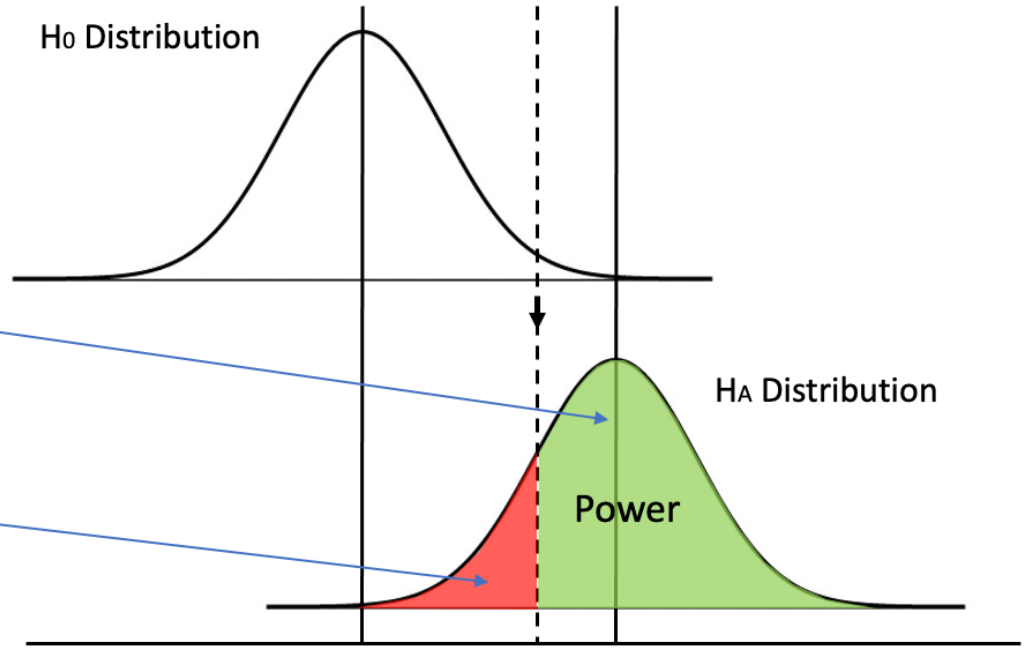

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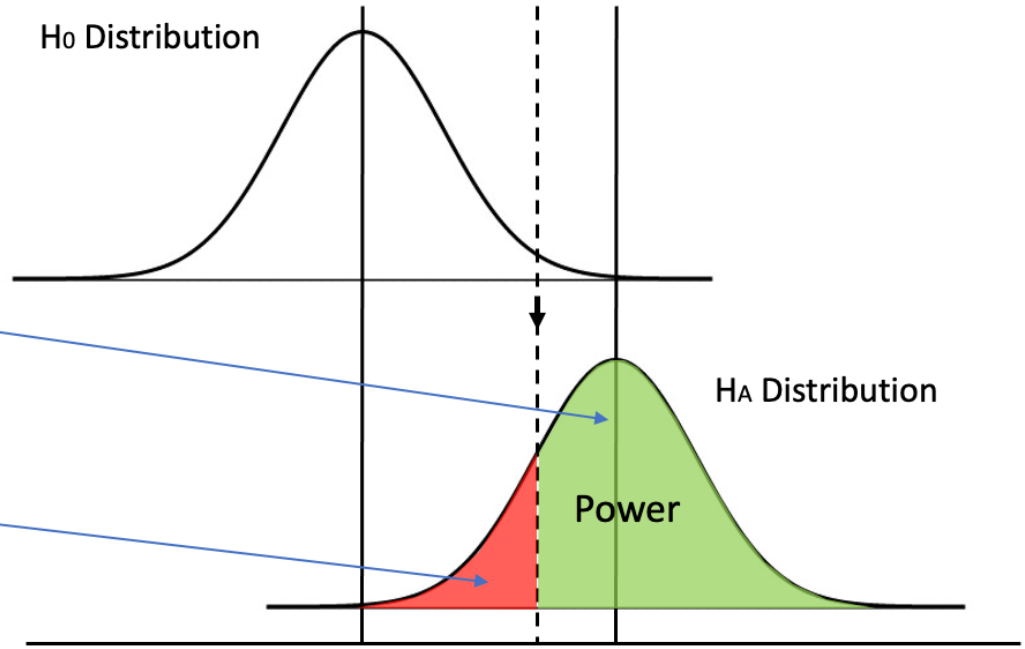

"But wait, shouldn't underpowered studies just lead to false negatives?"
"Underpowered studies are a major contributing factor to the reporting of both false positives and false negatives (Button et al., 2013)."
i.e. "winner's curse" and "file drawer problem"

Aside: Winner's Curse

Winner's Curse

In an auction bid, the winner is the bidder making the highest estimate. If we assume that the average bid (before auction) is accurate, then the highest bidder overestimates the item's value. Thus, the auction's winner is likely to overpay.

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Winner's Curse in Science

The term winner's curse is also used in statistics to refer to the regression toward the mean phenomenon, where the the first person to report a significant test (the winner) will also report an effect size much larger than is likely to be seen in subsequent replication studies

Aside: File-Drawer Problem

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Publication-Bias

Why? Because journals are biased to published **positive results** (3x more likely)
This motivates researchers to manipulate their findings to ensure statistically significant results (either consciously or unconsicously)

Back to the Incentives Paper

"Exploratory studies (i.e., those with low R) are much less likely to be true than confirmatory studies (i.e., those with high R) **even if the p-value generated is the same**, but arguably, current incentive studies reward novel (i.e., exploratory) findings over replication (i.e., confirmatory) studies."

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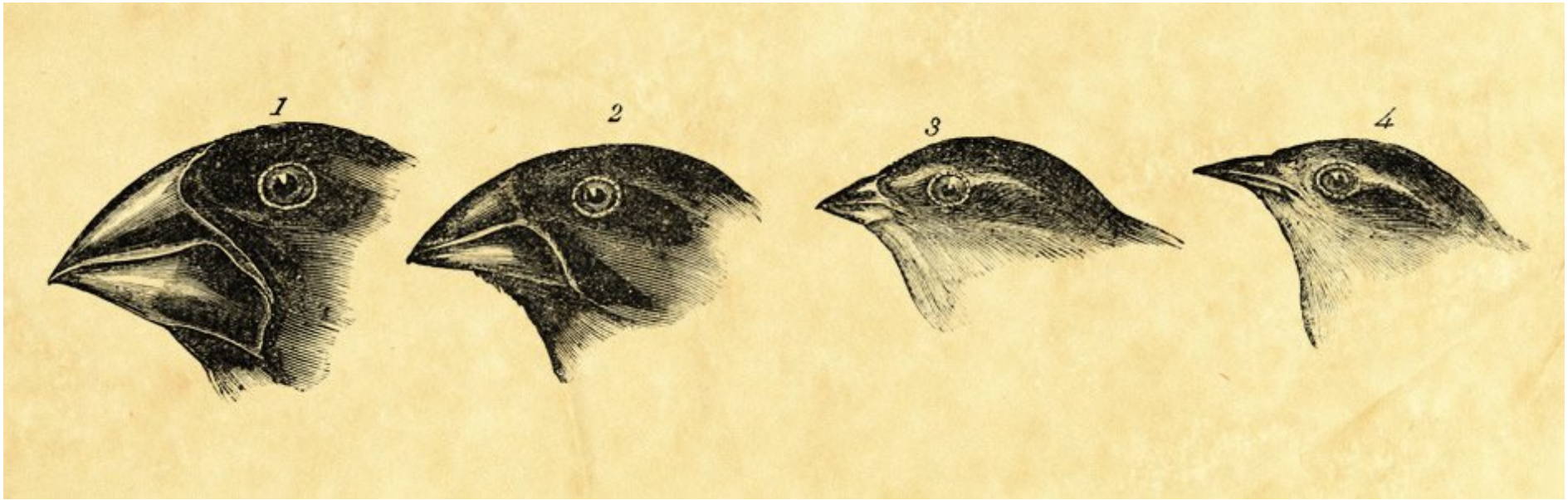
- publish often (easier to publish if findings are positive)

Incentives: Maximising Fitness



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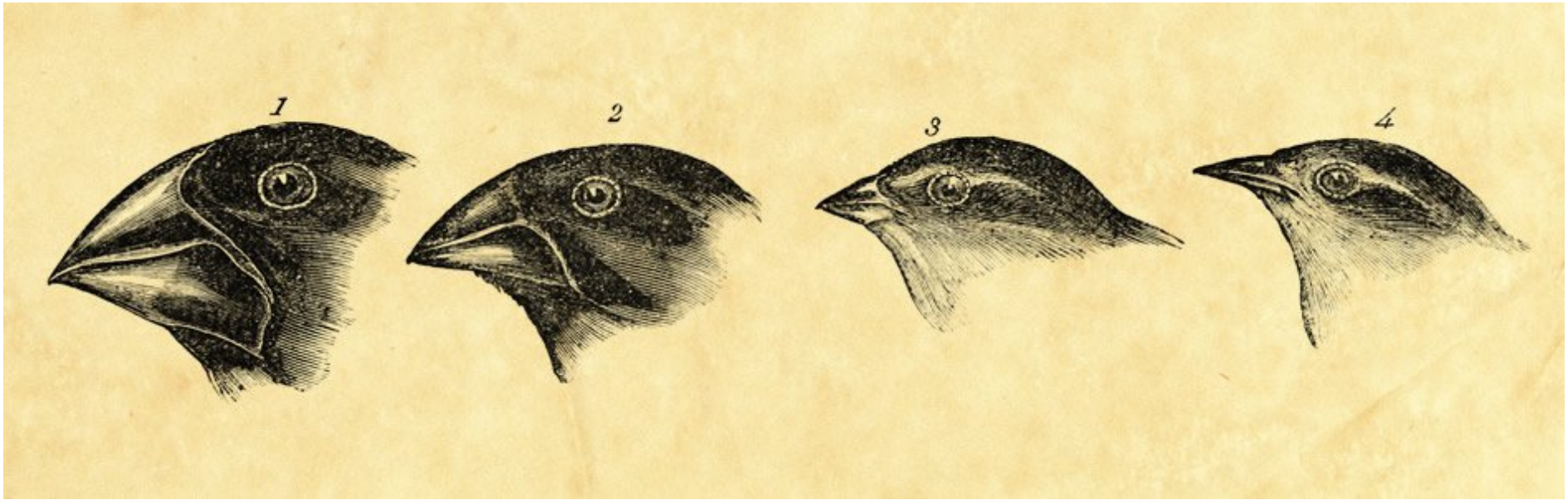

- "We used optimality theory to predict the rational strategy of a scientist possessing finite resources who seeks to maximise the career value of his or her publications."
- "We considered that researchers must choose how to divide their resources between exploratory studies that seek to identify new phenomena and confirmatory studies that attempt to verify previous findings and that they must decide the amount of resources to invest per study."

Incentives: Results

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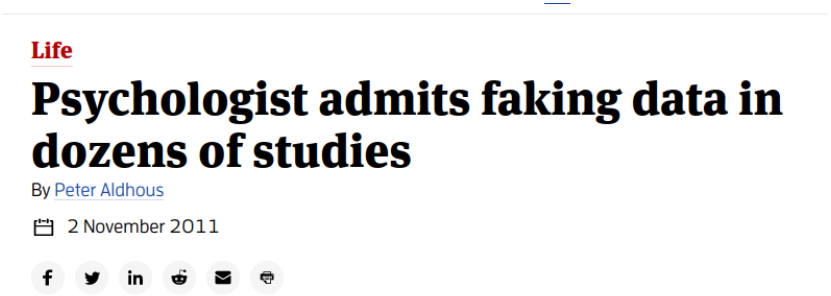

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Psychologist admits faking data in dozens of studies

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SCIENCE

LISTEN & FOLLOW

Did an honesty researcher fabricate data?

July 28, 2023 · 4:49 AM ET

Heard on Morning Edition

Nick Fountain

3-Minute Listen + PLAYLIST

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EDUCATION

Stanford president resigns after fallout from falsified data in his research

Updated July 20, 2023 · 6:36 PM ET

By Ayana Archie

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HOW MANY CLINICAL TRIALS CAN'T BE TRUSTED?

Investigations suggest that, in some fields, at least one-quarter of clinical trials might be problematic or fake, warn researchers. They urge stronger scrutiny. **By Richard Van Noorden**

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- "Similar results have been obtained by the pharmaceutical industry attempting to reproduce "landmark" findings from the published academic literature"

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Article | Open access | Published: 16 March 2022

Essay

Wh
Are

John P.

Reproducible brain-wide association studies require thousands of individuals

Scott Marek, Brenden Tervo-Clemmens, Finnegan J. Calabro, David F. Montez, Benjamin P. Kay, Alexander S. Hatoum, Meghan Rose Donohue, William Foran, Ryland L. Miller, Timothy J. Hendrickson, Stephen M. Malone, Sridhar Kandala, Eric Feczko, Oscar Miranda-Dominguez, Alice M. Graham, Eric A. Earl, Anders J. Perrone, Michaela Cordova, Olivia Doyle, Lucille A. Moore, Gregory M. Conan, Johnny Uriarte, Kathy Snider, Benjamin J. Lynch, ... Nico U. F. Dosenbach + Show authors

BE

[illegible], at least one-quarter of clinical trials might be problematic or fake, warn researchers. They urge stronger scrutiny. **By Richard Van Noorden**

- "Similar results have been obtained by the pharmaceutical industry attempting to reproduce "landmark" findings from the published academic literature"

Incentives: Results

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- Current incentives that encourage scientists to build momentum around a single research focus may also be problematic [24]
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Note

I don't actually think these suggestions are all that great...

Everything is F*cked

The Hardest Science

Everything is fucked: The syllabus

PUBLISHED ON *August 11, 2016*

PSY 607: Everything is Fucked

Prof. Sanjay Srivastava

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thehardestscience.com/2016/08/11/everything-is-fucked-the-syllabus/

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- Week 2: Significance testing is f*cked
- Week 3: Causal inference from experiments is f*cked
- Week 5: Covariates are f*cked
- Week 6: Replicability is f*cked
- Week 8: Scientific publishing is f*cked
- Week 9: Meta-analysis is f*cked
- Week 10: The scientific profession is f*cked

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Overview

1. Toot
2. Incentives
3. Publishing World
4. Grants
5. Grad Students
6. Philosophy of Science
7. Metascience
8. Solutions

Publishing World

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- Finally: journal makes money... "bigger profit margins than Google, Amazon and Apple"

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- This is public money that could be spent on research

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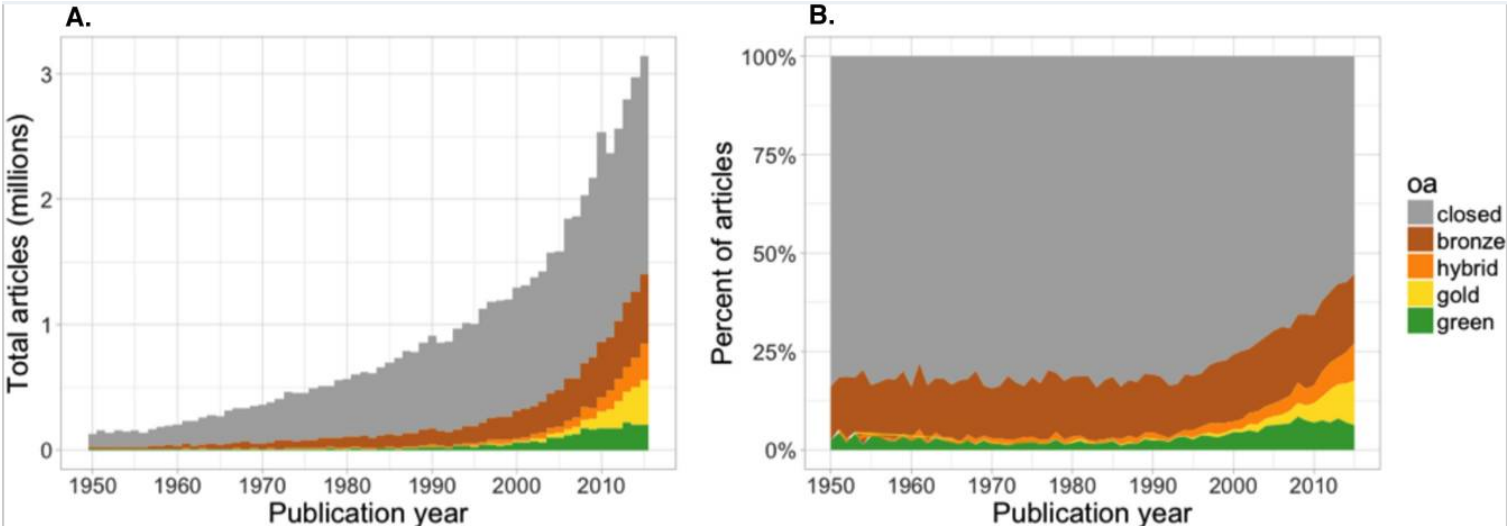

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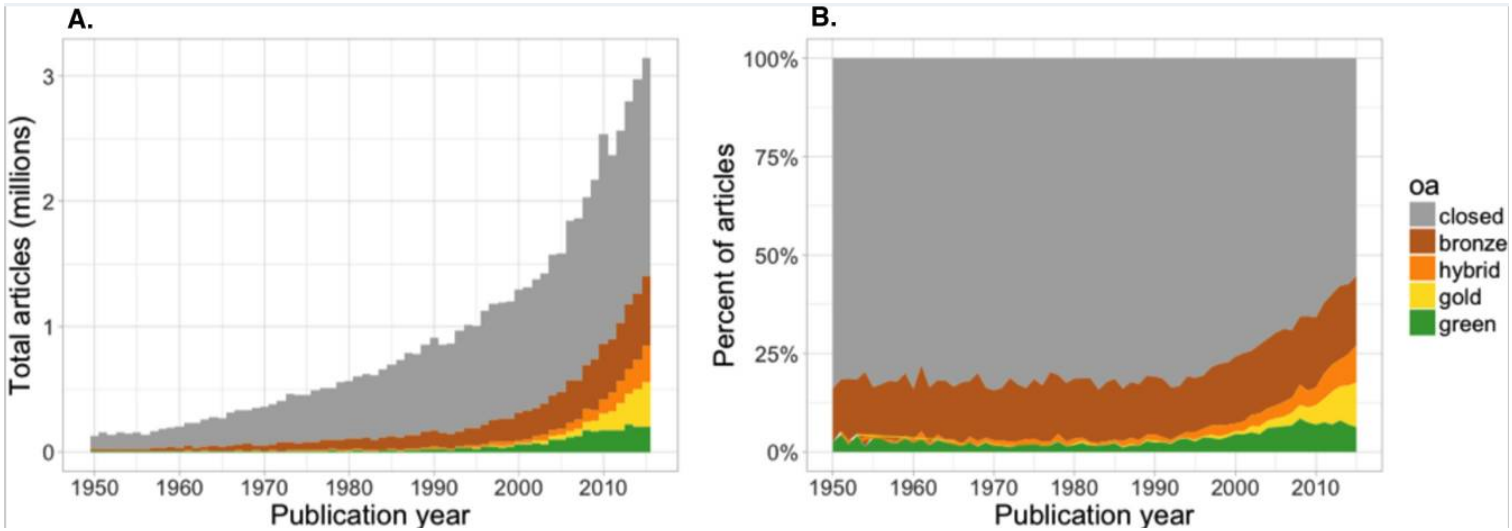

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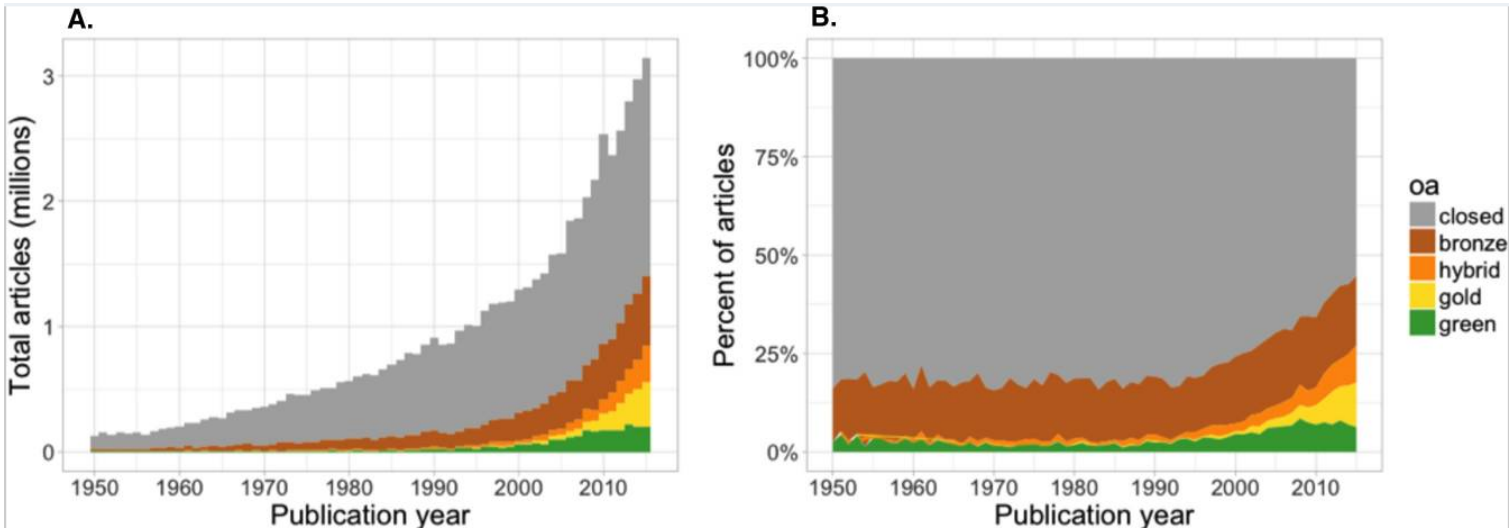

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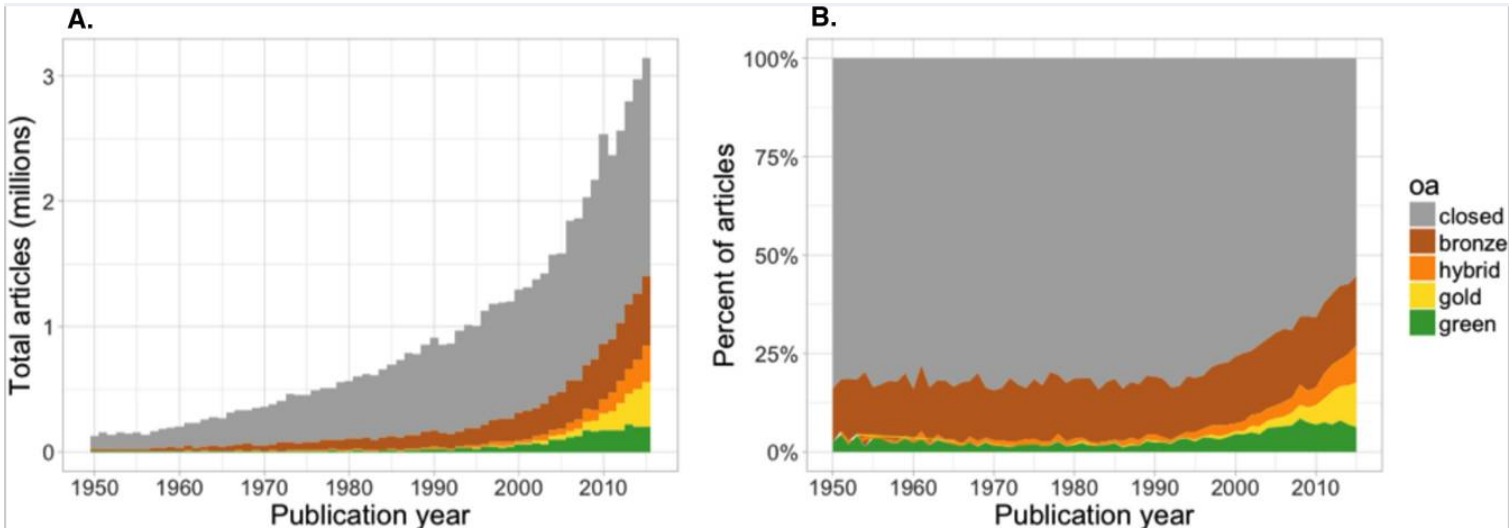

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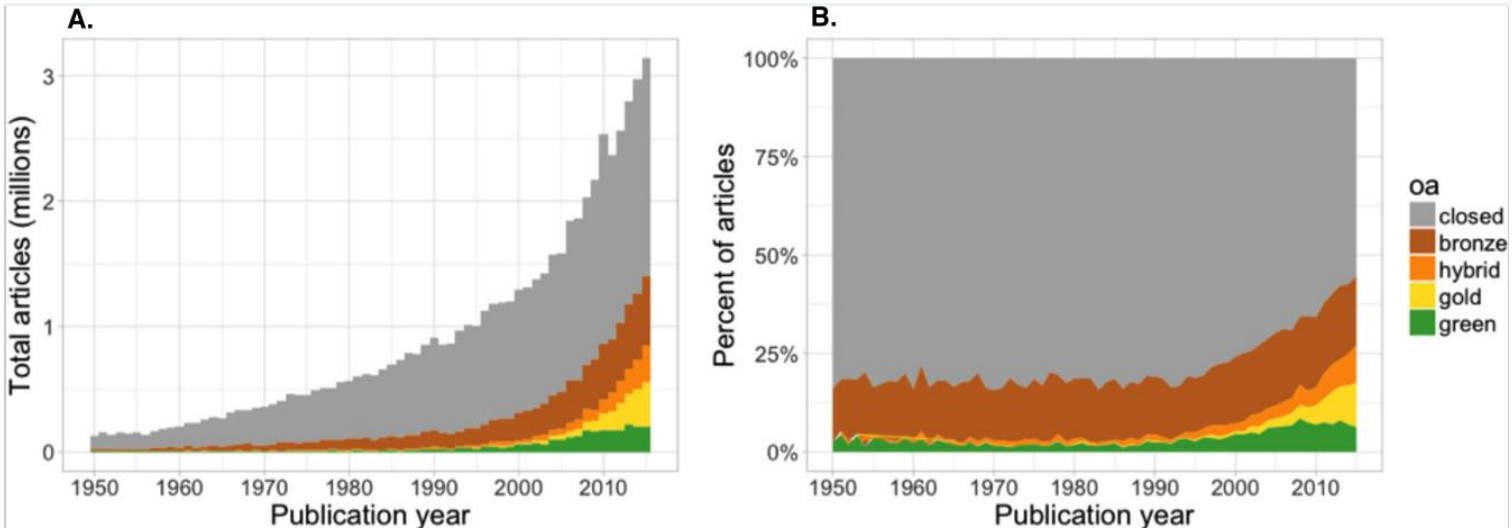

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- Green: Green articles are published in a toll-access journal, but self-archived in an OA archive (such as ArXiv preprint)

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Publishing World

And people are taking things into their own hands. . .

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NEWS | 21 April 2023

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85% of investments in biomedical research is wasted (due to cumulative effects of bad production and reporting of research)[1]

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- We fund the wrong fields: well-funded fields attract more scientists to work for them, which increases their lobbying reach, fueling a vicious cycle. Allocation of bio-medical resources can be more strongly correlated to previous allocations and research than to BoD.

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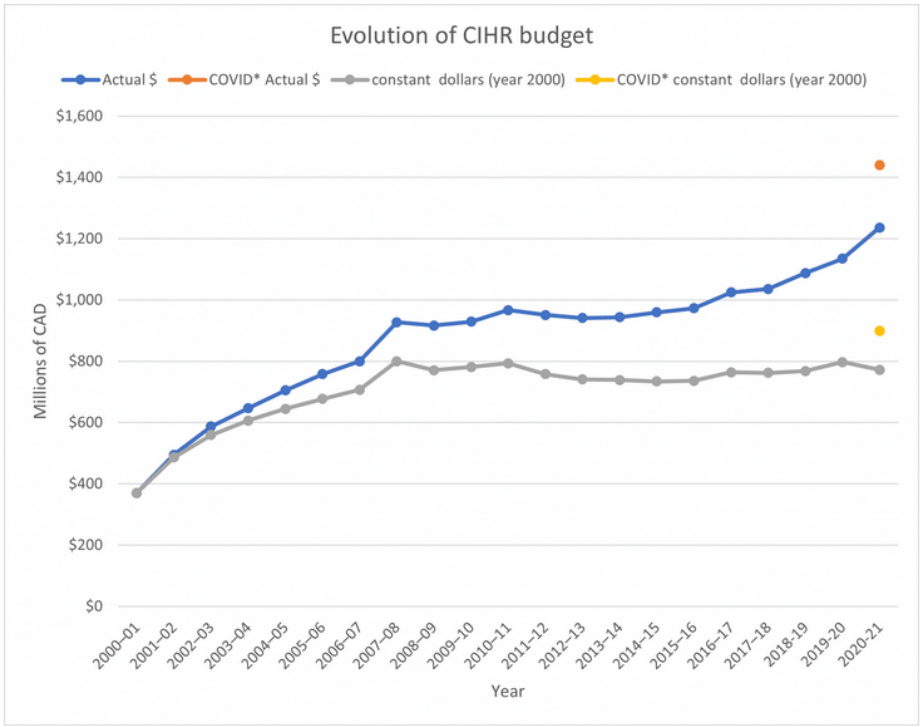
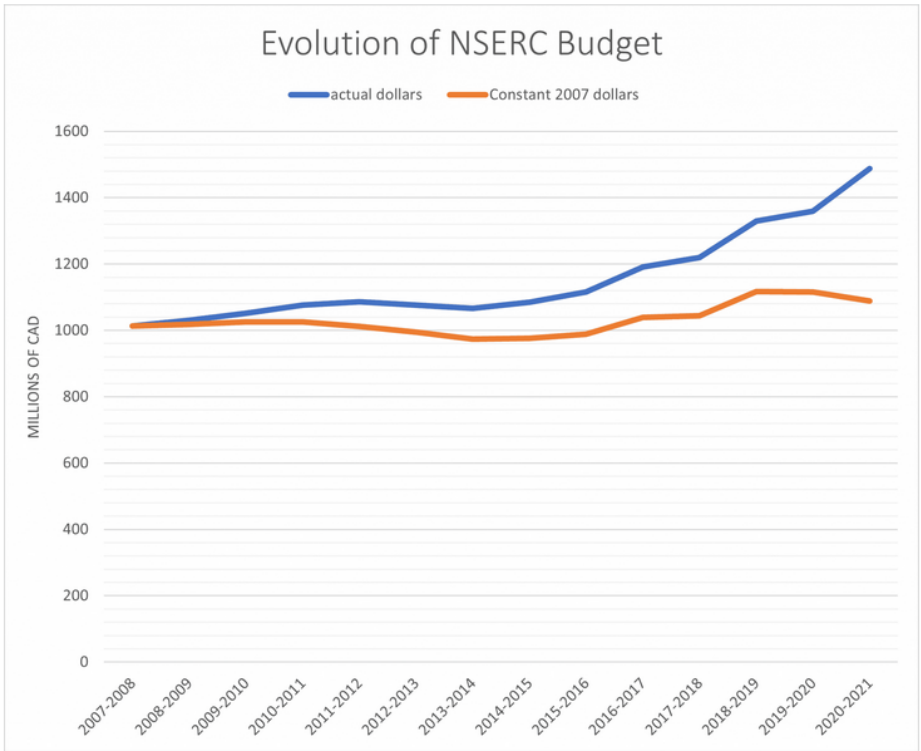
Grants

- We do not spend enough: in many countries, public funding has stagnated and is under increasing threat from contesting budget items

CIHR budget 2000-2021



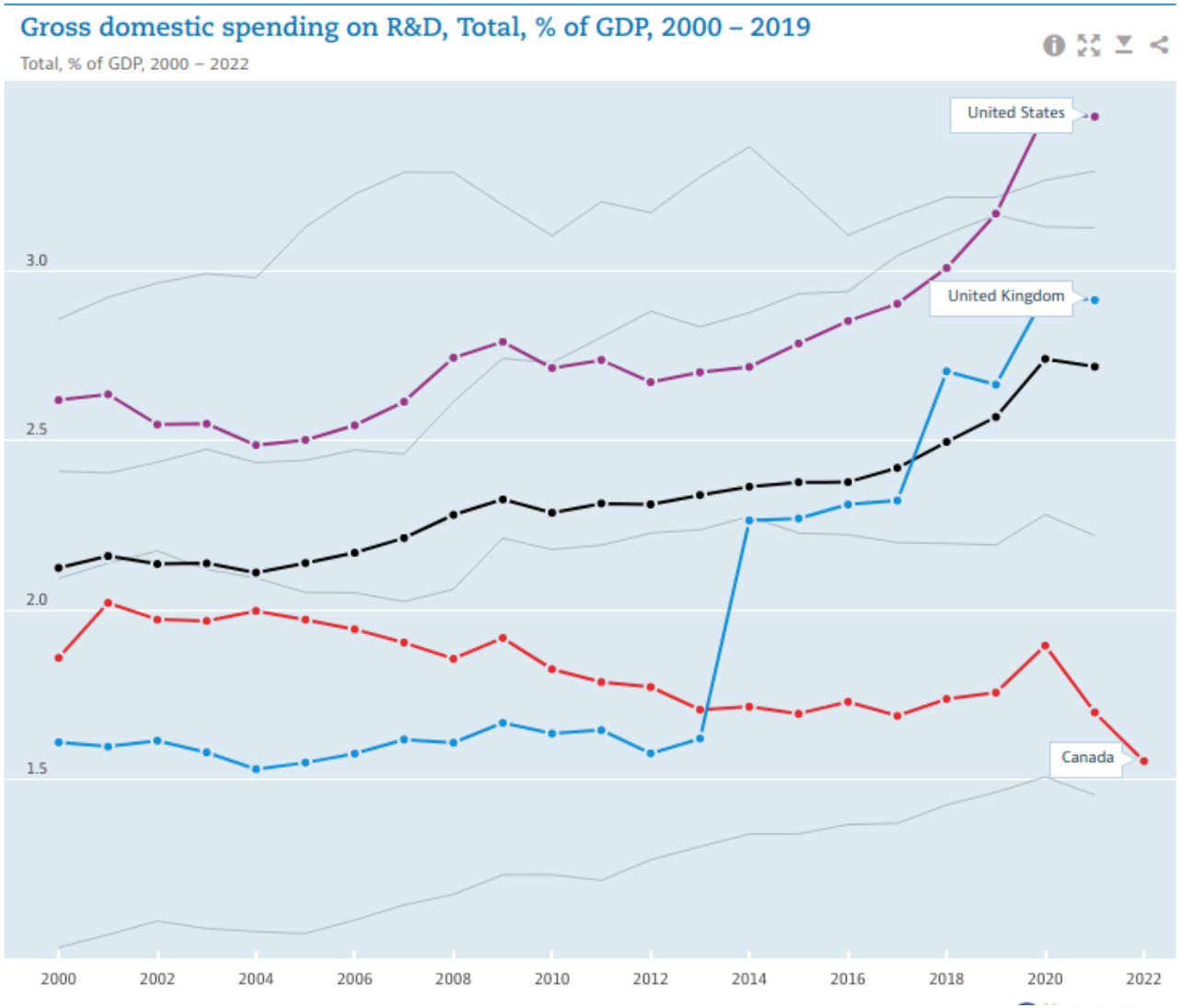
NSERC budget 2007-2021



https://can-acn.org/science-funding-in-canada-statistics/

Grants

This problem is especially bad in Canada:



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- Researchers spend too much of their time applying for grants (some estimates have them spending 50% of their time writing grants instead of doing research)

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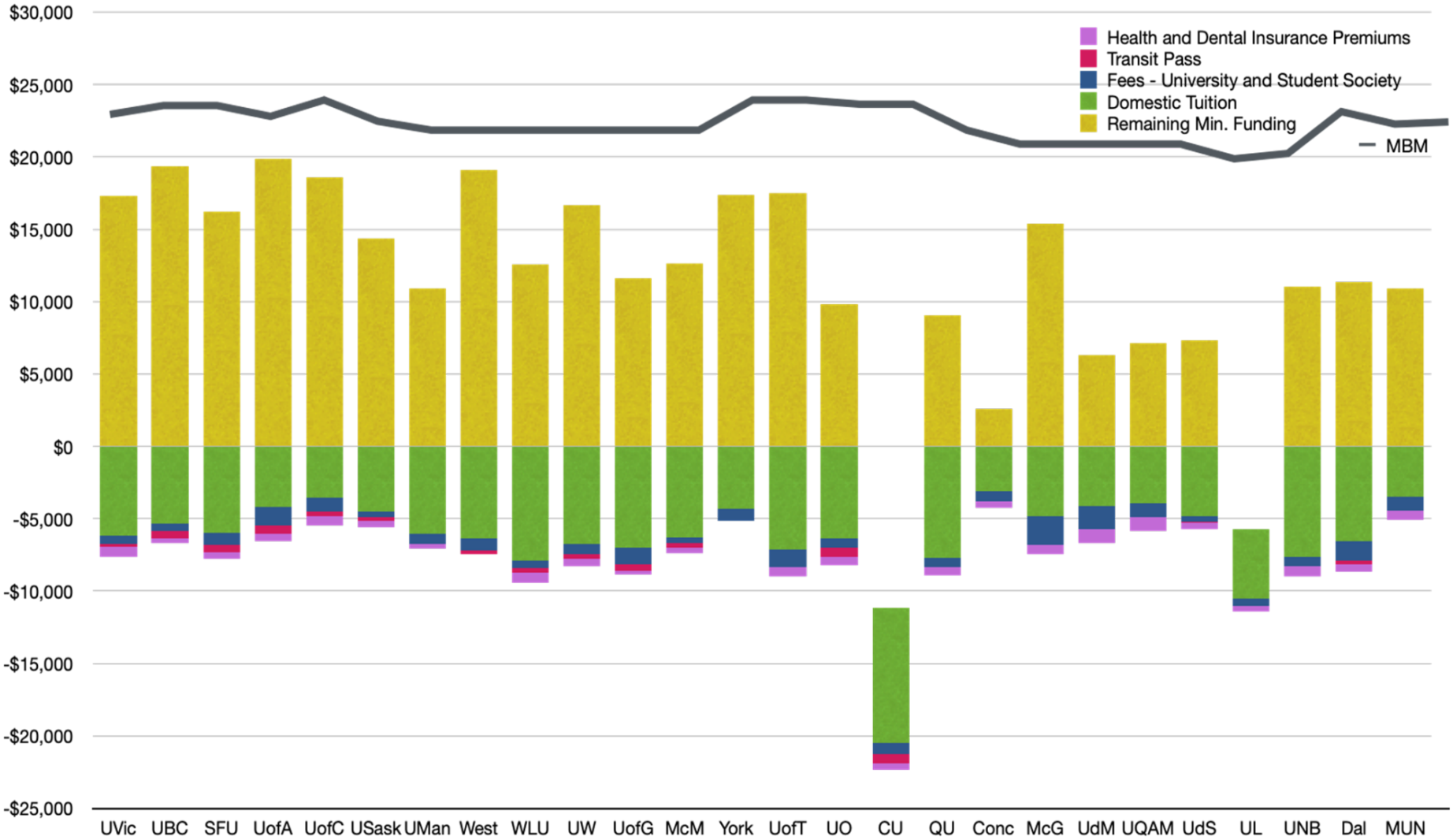
Grad Students

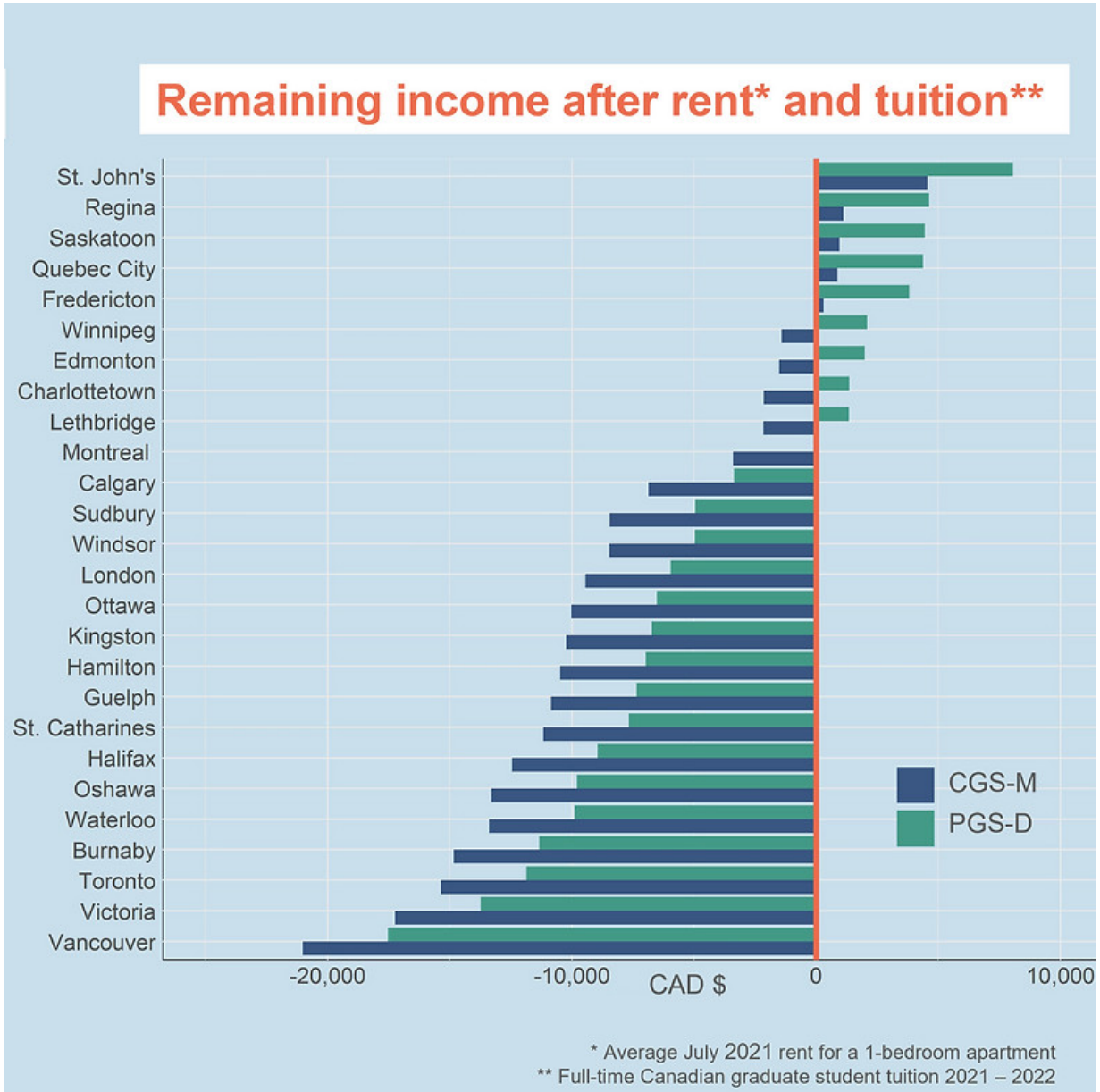
Funding for grad students is well below the poverty line



https://www.universityaffairs.ca/career-advice/career-advice-article/the-high-cost-of-inadequate-funding-for-grad-students/

Grad Students

This situation is even worse when you take into account the cost of living in those cities



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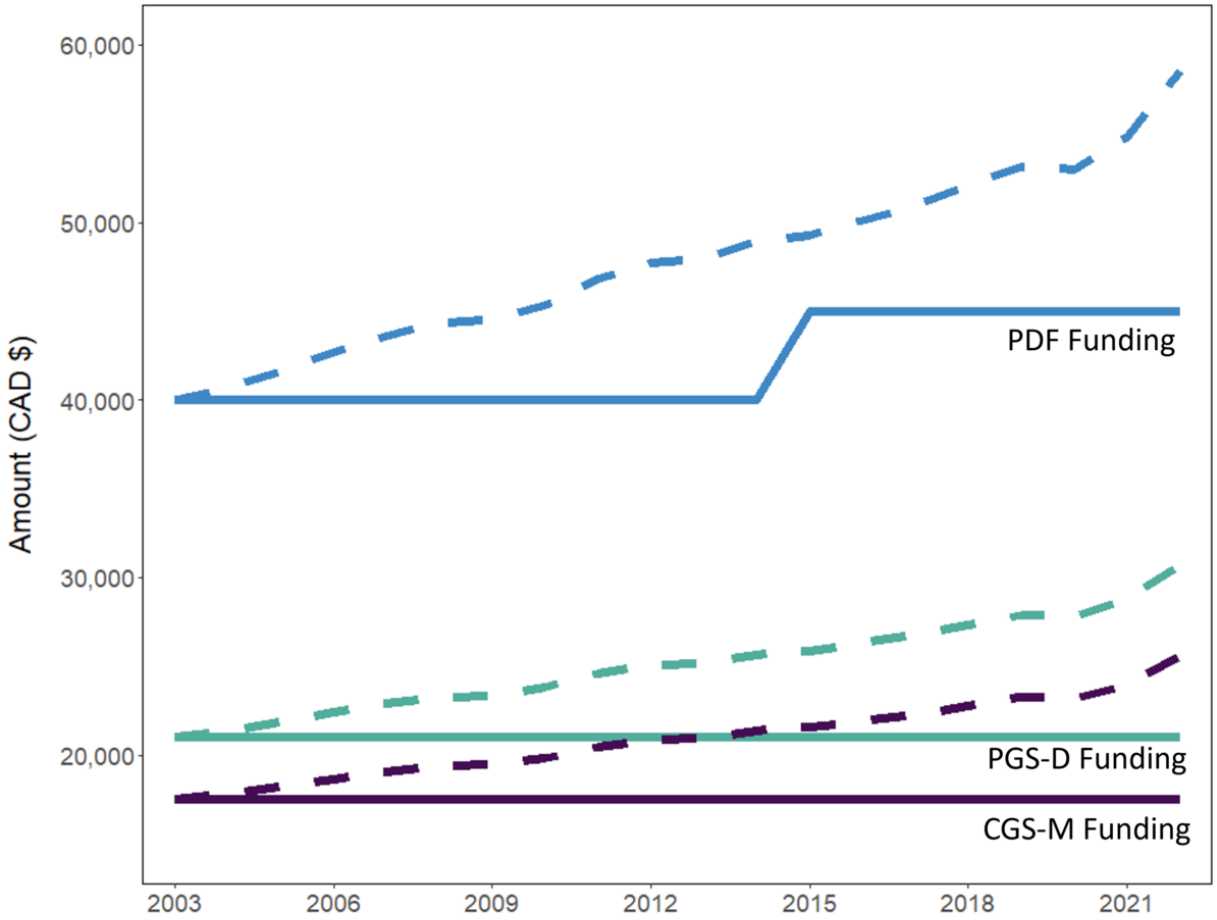

Graduate student scholarship (CGS-M & PGS-D) and postdoctoral scholar fellowship (PDF) award amounts have not kept pace with inflation (dashed lines) in Canada. Data available in the Support Our Science Data Repository.

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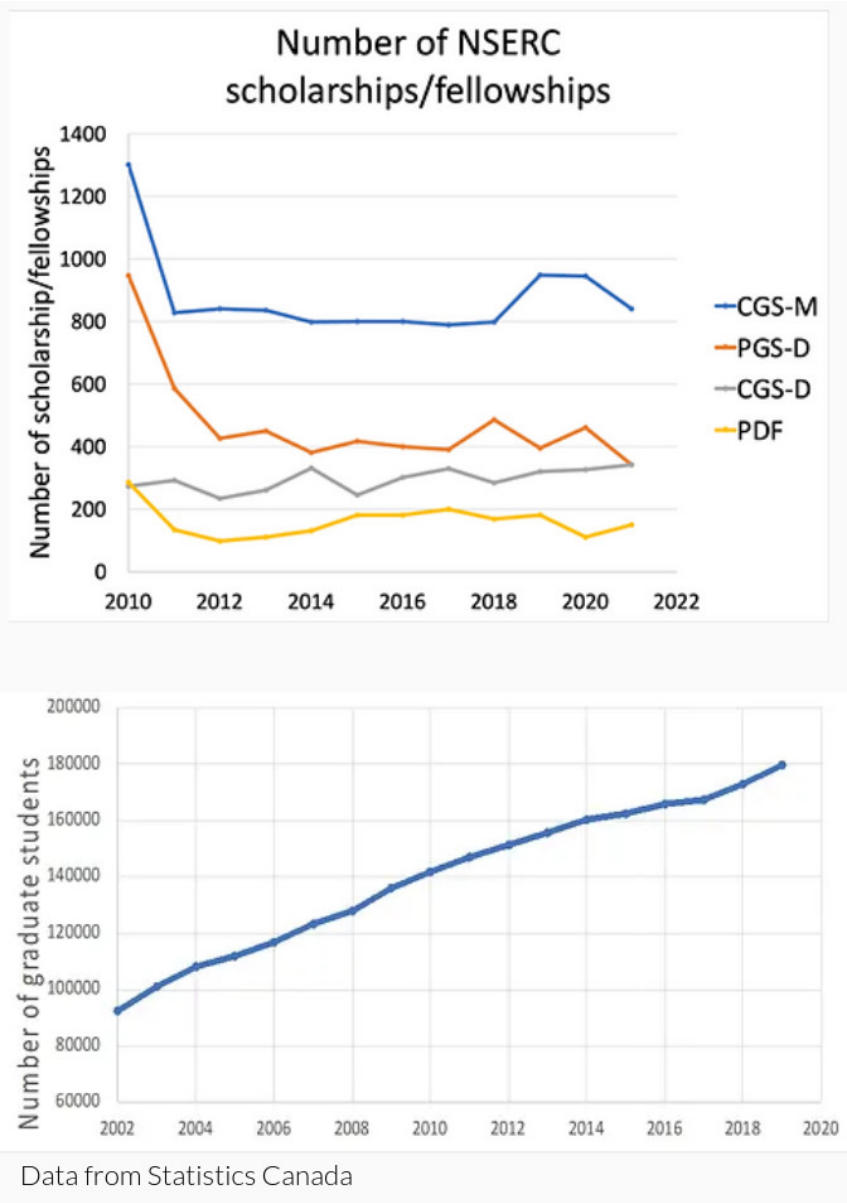
Grad Students

It gets worse. The number of graduate scholarships (CGS-M, PGS-D, CGS-D) decreased in 2010, and has remained relatively steady since. However, in that same time period graduate student enrolment in Canada has steadily increased.



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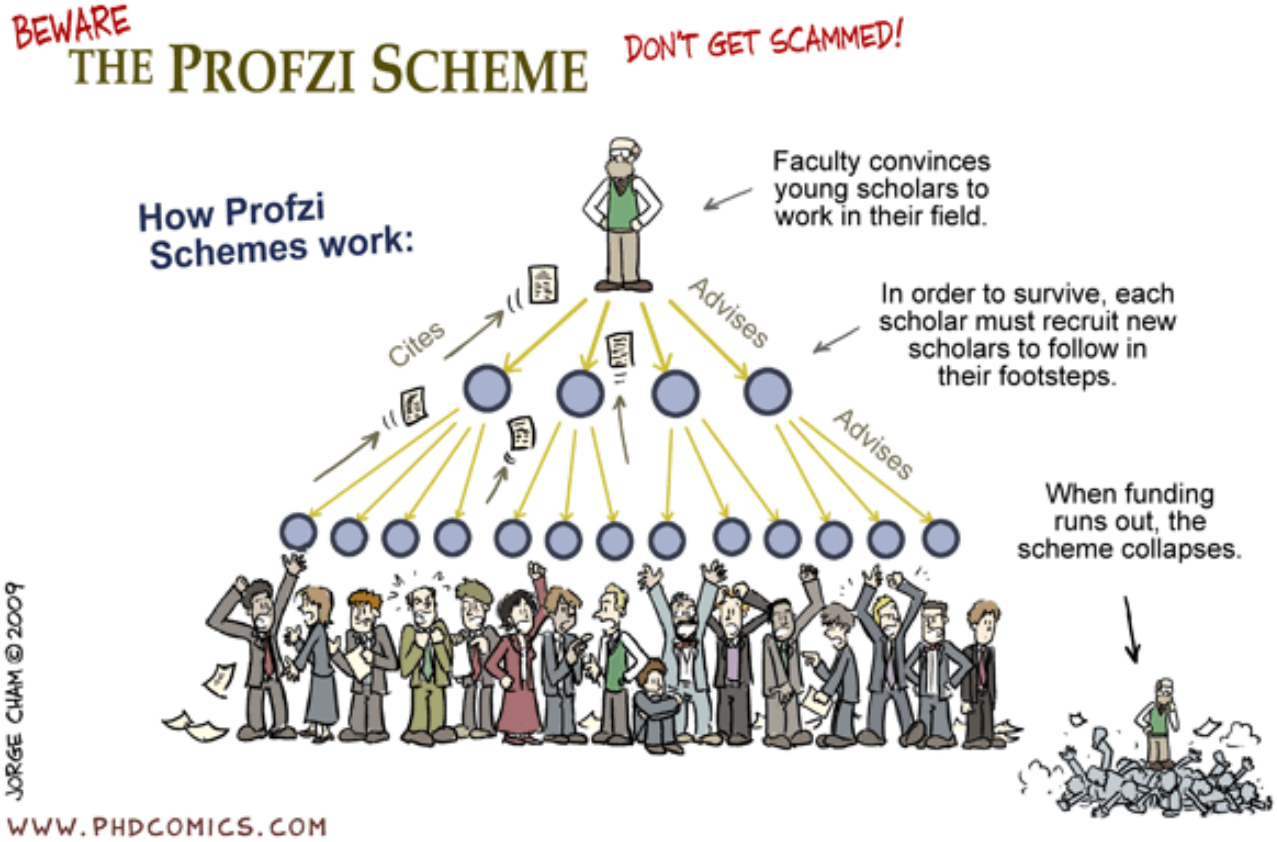
Is academia a pyramid scheme? "The number of PhD graduates in Canada is growing while the number of open tenure-track positions is stagnant or declining"



Counter: these students gain skills that serve them well in other careers

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- On the other hand: "For men with PhDs working full-time, the economic return of a PhD over a master's degree has been declining; furthermore, the return is lower and dropping more quickly for those under 40 years of age. In contrast, for women with PhDs working full-time, the economic return has been rising for the overall population and for those under 40. Having said this, the earnings of men are still considerably higher than those of women overall. "

Grad Students

What about mental health?

1: https://www.nature.com/articles/s41587-019-0179-y
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Grad Students

What about mental health?

- Graduate students are around two to six times more likely to experience depression and anxiety than the general population[1]
- Mental health is the major factor behind the high attrition rates in PhD programs.

What are the causes?

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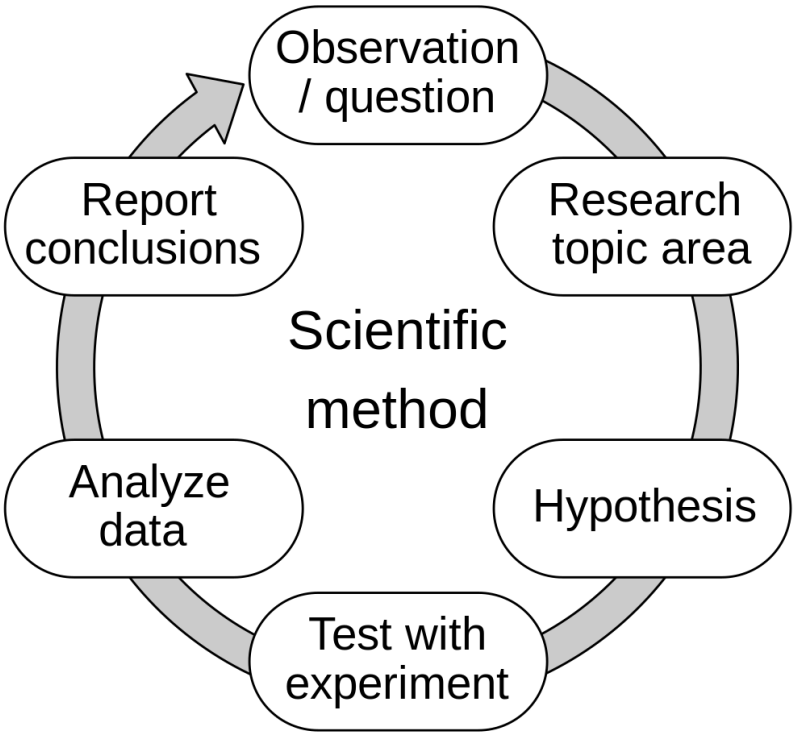
Overview

1. Toot
2. Incentives
3. Publishing World
4. Grants
5. Grad Students
6. Philosophy of Science
7. Metascience
8. Solutions

Philosophy of Science



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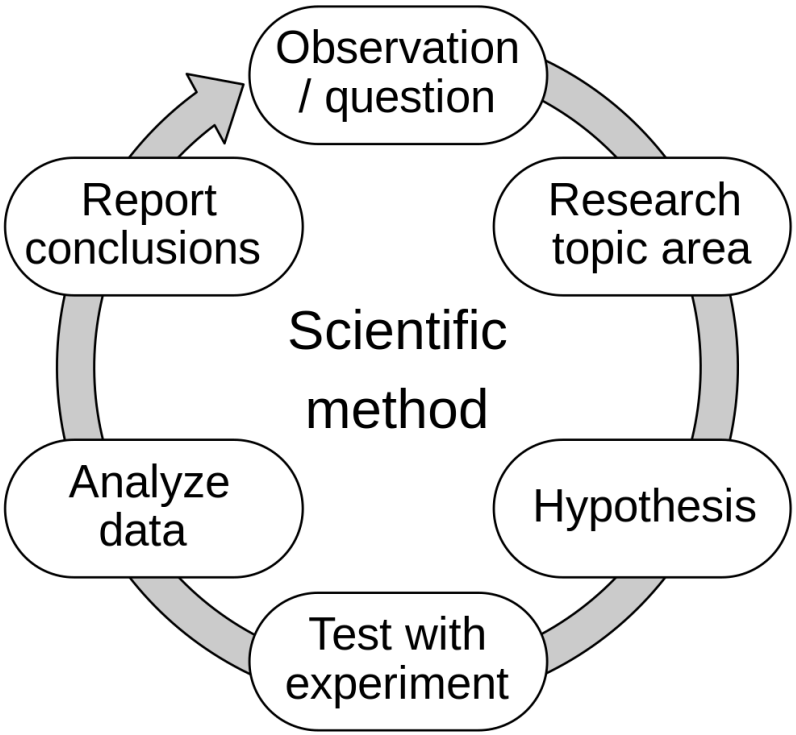

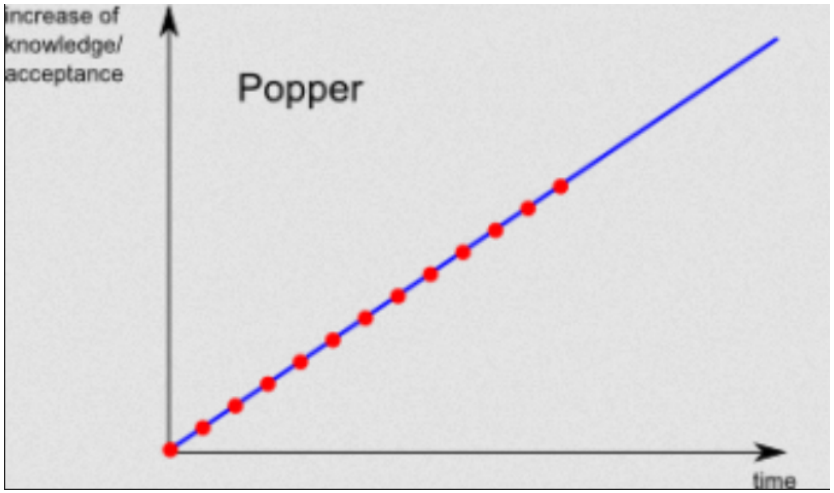

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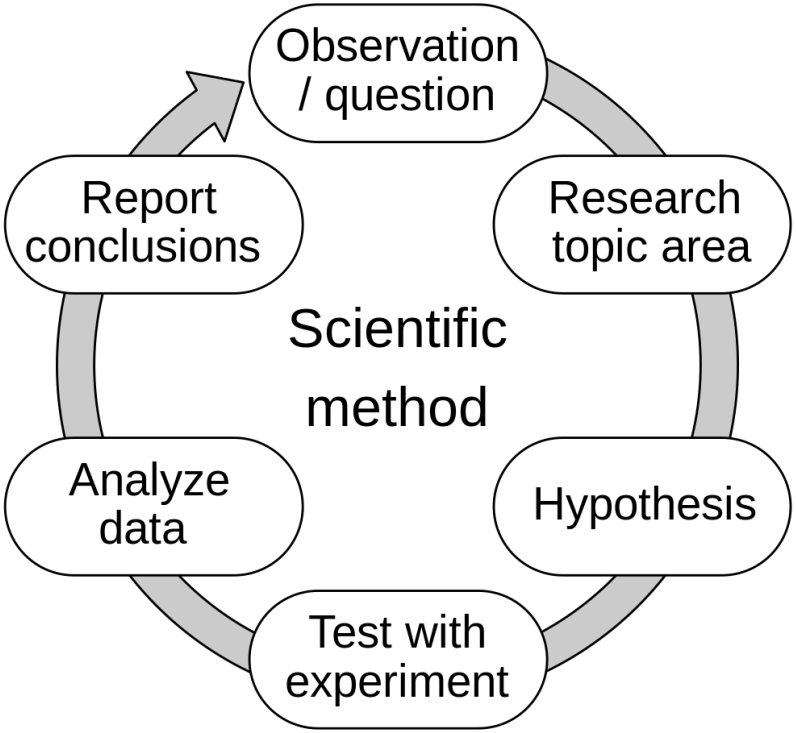

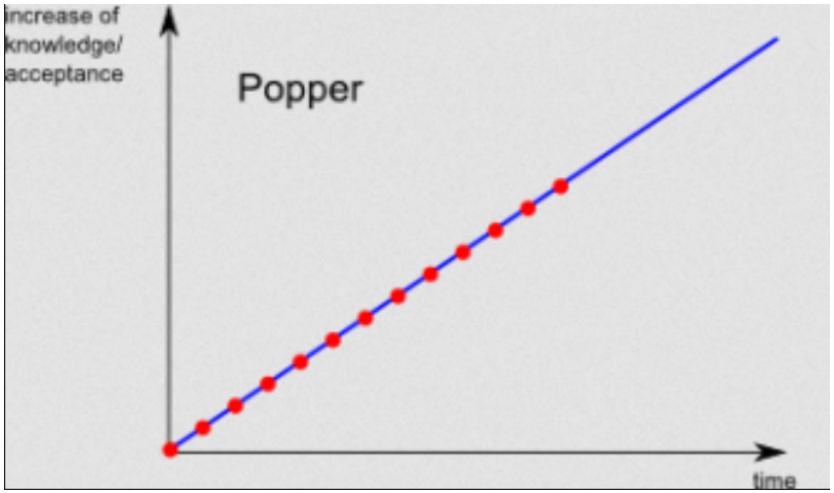

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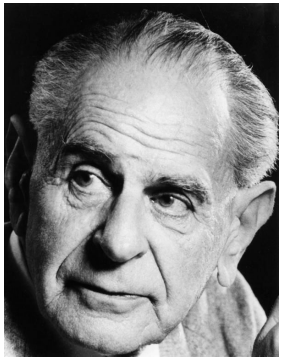

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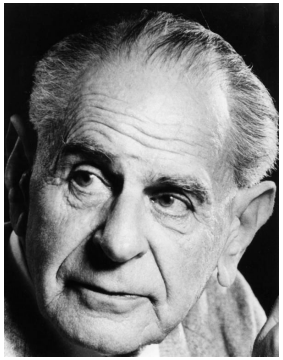

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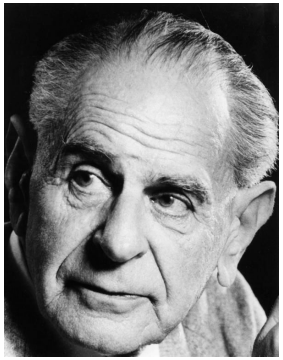

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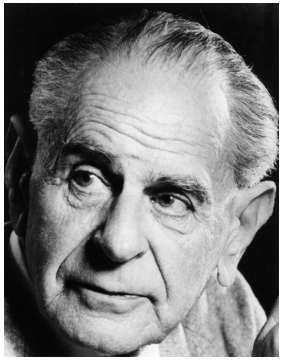

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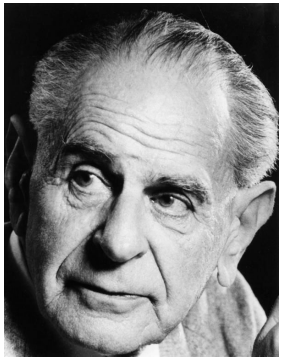

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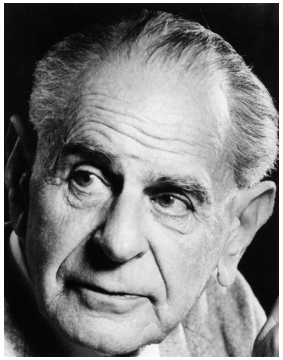

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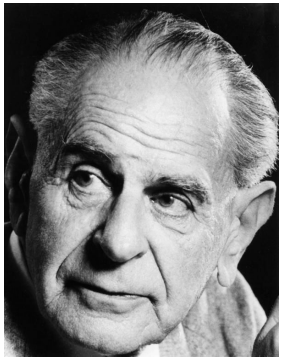

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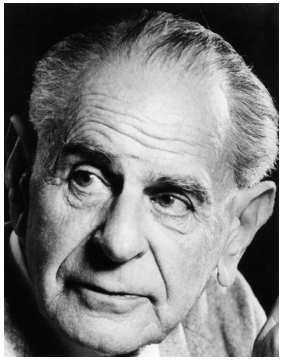

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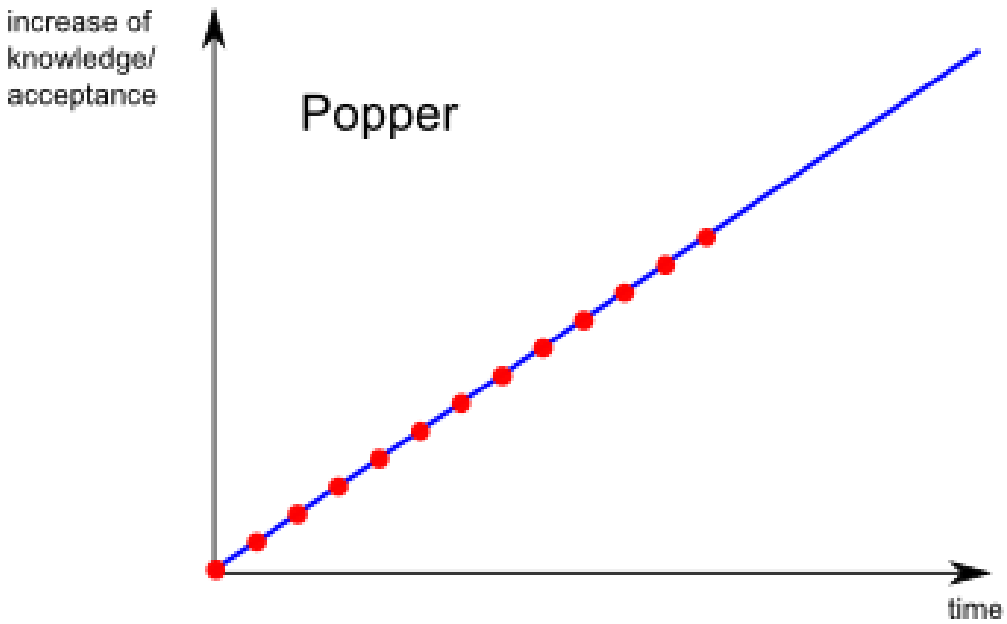

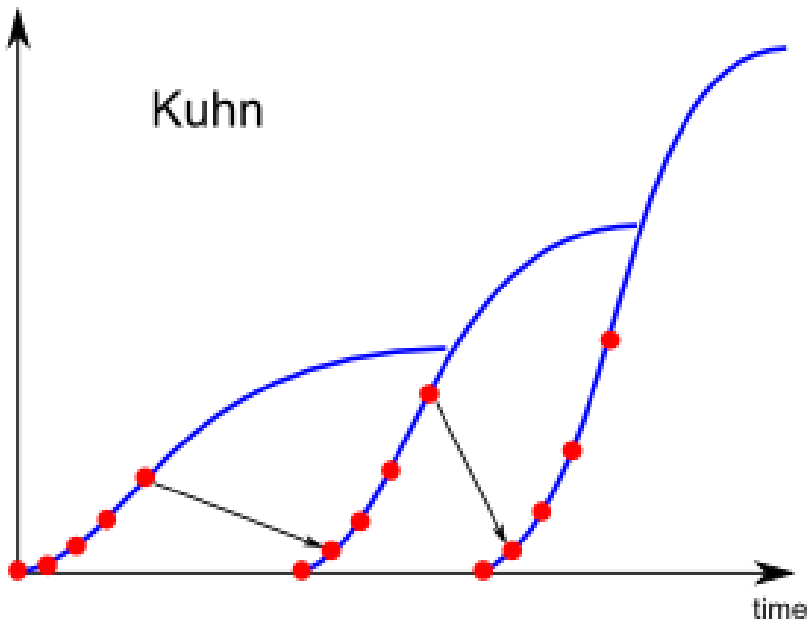

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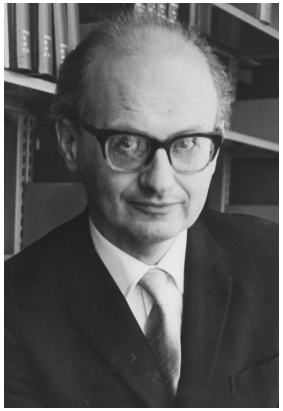

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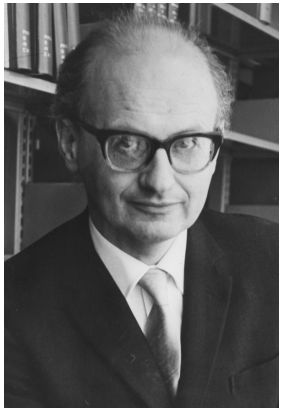

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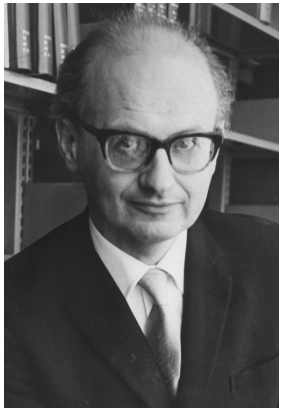

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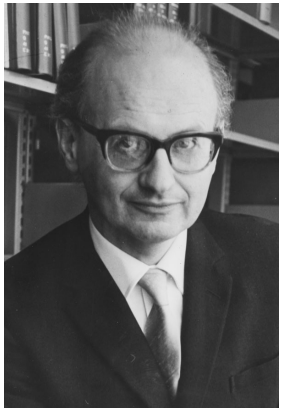

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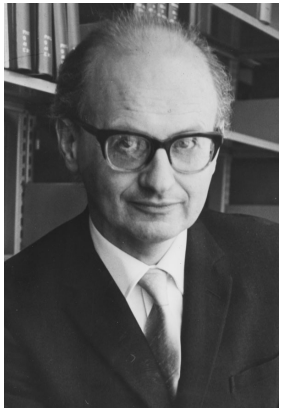

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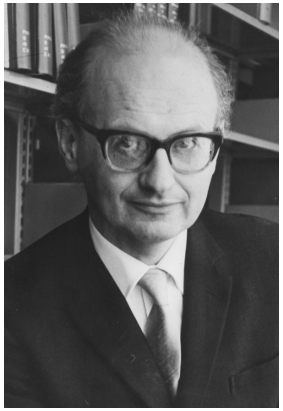

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- Essentially, Lakatos is a more *nuanced* take on Kuhn

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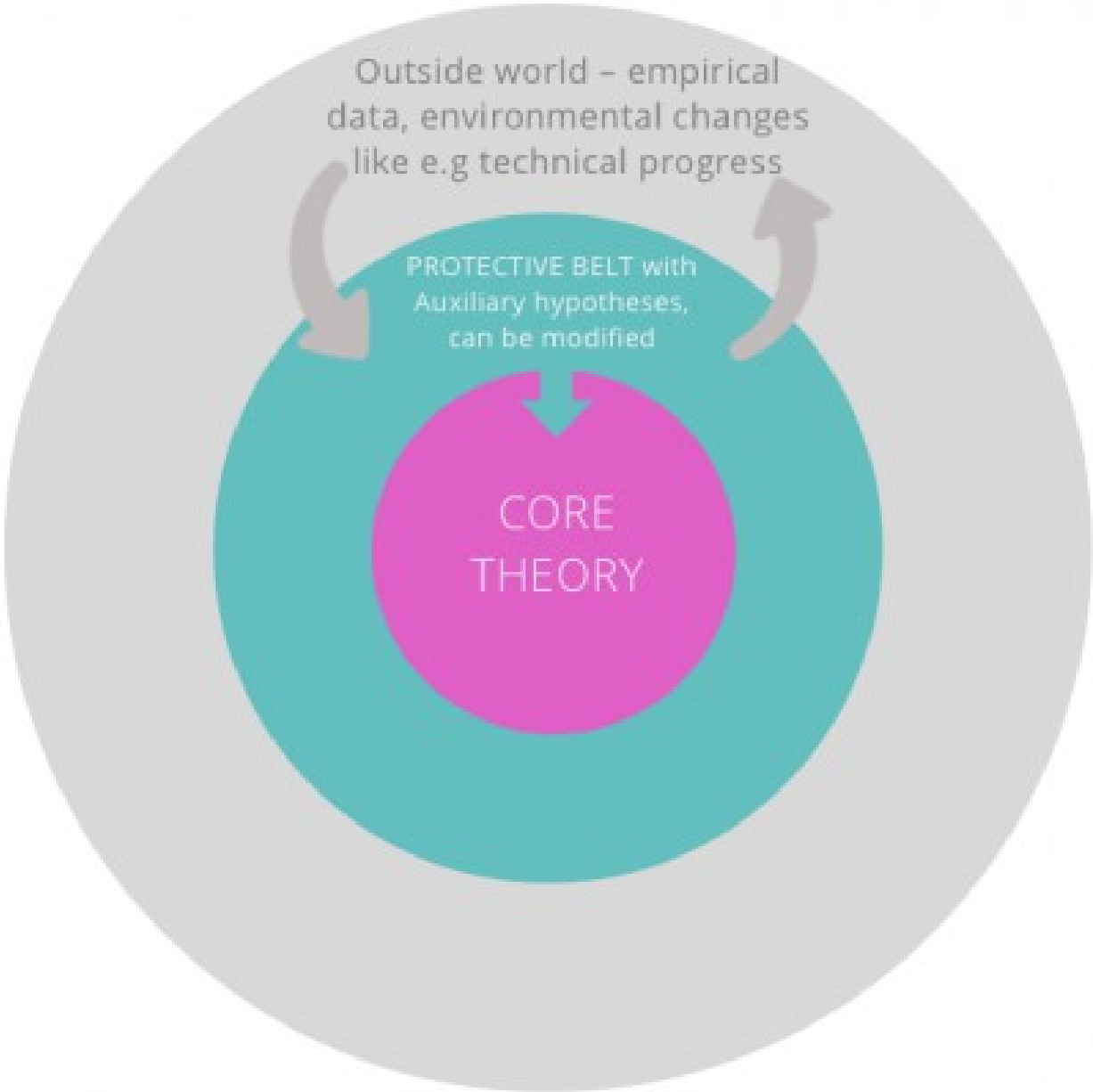

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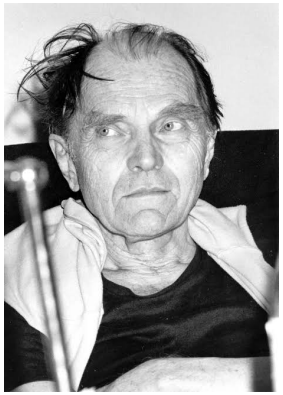

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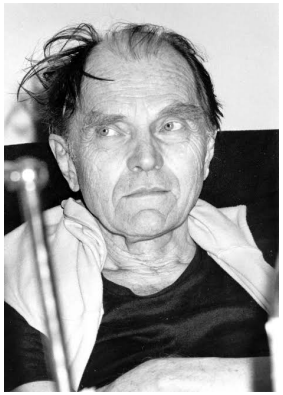

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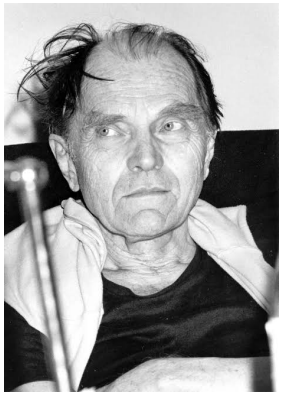

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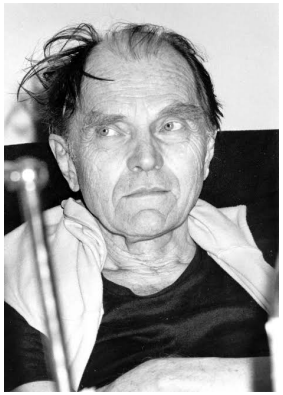

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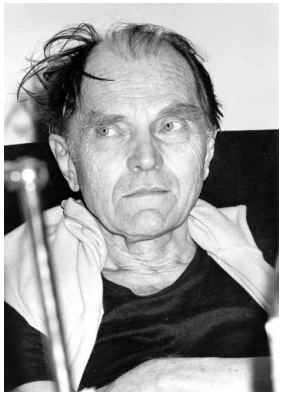

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- These episodes violated all common prescriptive rules of science. Feyerabend argues that applying such rules in these historical situations would actually have prevented scientific revolution.

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- Phosphorus (1669): Hennig Brand was attempting to create the philosopher's stone by boiling his own urine. Brand noticed that a white substance glowed in the dark and emitted a faint light. This discovery was unintentional and occurred as a byproduct of his alchemical experiments.

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"Science is the best thing that has happened to human beings . . .
but we can do it better."
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Essay

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- Later meta-research identified widespread difficulty in replicating results in many scientific fields, including psychology and medicine. This problem was termed "the replication crisis"

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Metascience

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2. Reporting (how to communicate)
3. Reproducibility (how to verify)
4. Evaluation (how to evaluate)
5. Incentives (how to reward research)

Metascience

Methods examples:

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Reporting:

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- reduces public's confidence in science
- solutions include the implementation of reporting standards, and greater transparency in scientific studies (conflict of interest)

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Reproducibility:

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- Way more than I can fit in this slide . . .

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Incentives:

- Critics argue that perverse incentives have created a publish-or-perish environment in academia which promotes the production of junk science, low quality research, and false positives.
- "the number of publications has ceased to be a good metric as a result of longer author lists, shorter papers, and surging publication numbers"
- using number of publications, citation number, or impact factor can lead to: "overproduction, unnecessary fragmentations, overselling, predatory journals (pay and publish), clever plagiarism, and deliberate obfuscation of scientific results so as to sell and oversell"

Metascience

Is science stagnating?

Article | Published: 04 January 2023

Papers and patents are becoming less disruptive over time

Michael Park, Erin Leahey & Russell J. Funk

Nature **613**, 138–144 (2023) | Cite this article

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CD index

If a paper or patent is disruptive, the subsequent work that cites it is less likely to also cite its predecessors; for future researchers, the ideas that went into its production are less relevant (for example, Pauling's triple helix)

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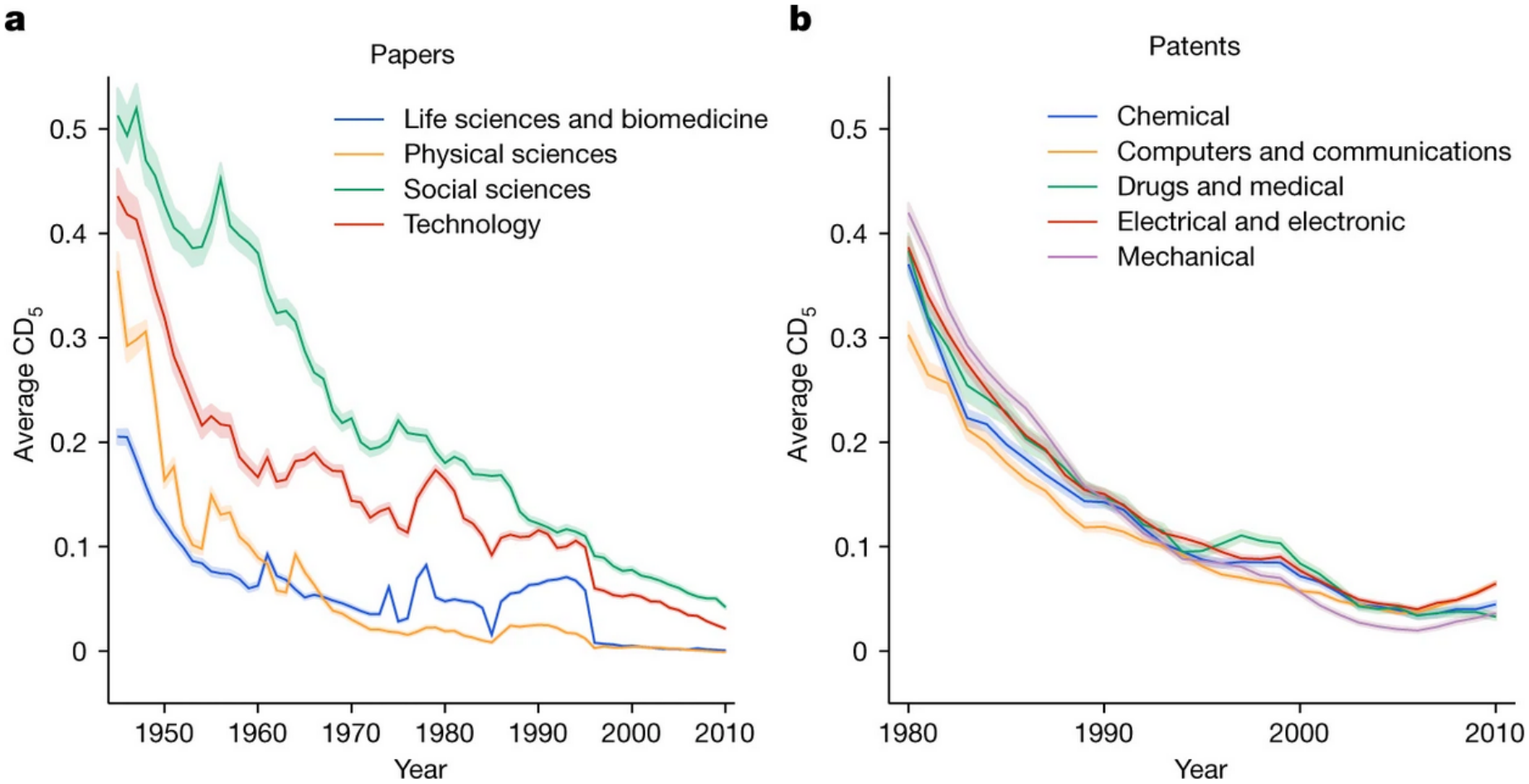

Overview

1. Toot
2. Incentives
3. Publishing World
4. Grants
5. Grad Students
6. Philosophy of Science
7. Metascience
8. Solutions

Solutions

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- Shift funding from senior people to younger researchers (even in the same lab; the average age of biomedical scientists receiving their first substantial grant is 46 and is increasing over time)

More Solutions

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- Researchers should be encouraged to switch fields, whereas currently they are incentivized to focus in one area
- We should invest in studying how to get the best science and how to choose and reward the best scientists. We should not trust opinion (including my own) without evidence. This will improve public opinion and hopefully funding!

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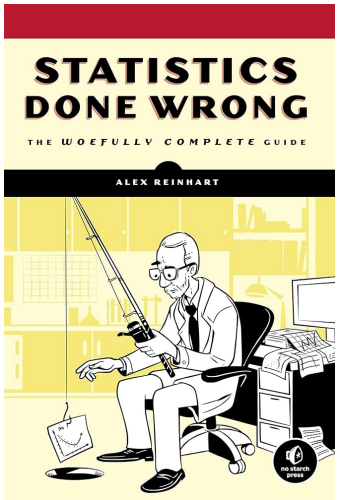
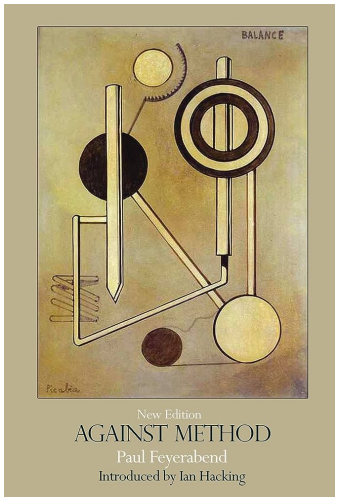
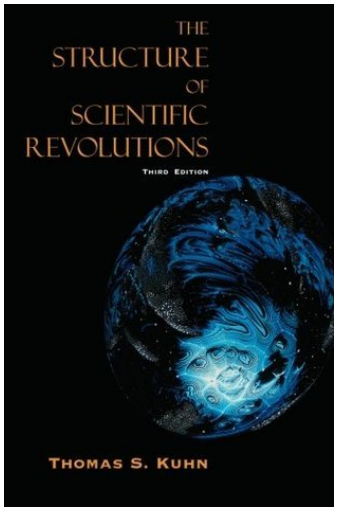
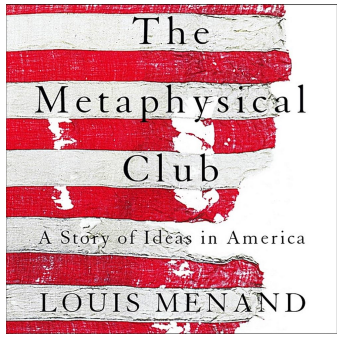
- Science doesn't necessarily work the way we might think
- Metascience - the science of science - can help us improve how we do good science

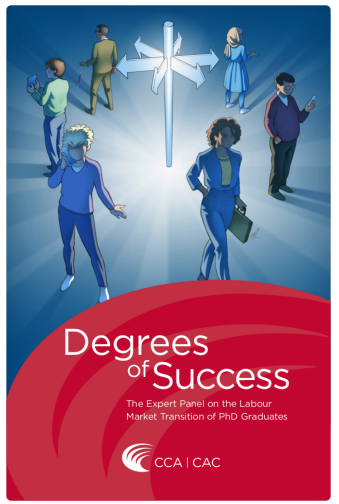
Further Reading

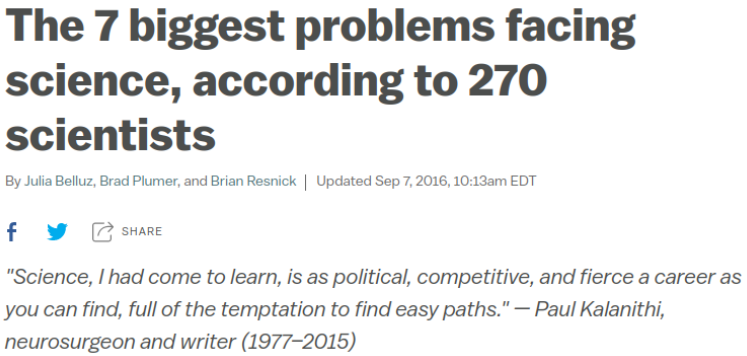












This talk can be downloaded from:
https://github.com/WeberLab/MetascienceTalk
You can find me on Mastodon:
@weberam2@qoto.org