

science or
voodoo



Logos

William Whewell's Theory of Scientific Method



EDITED BY ROBERT E. BUTTS

Our knowledge about the external world
depends *only* on the external world

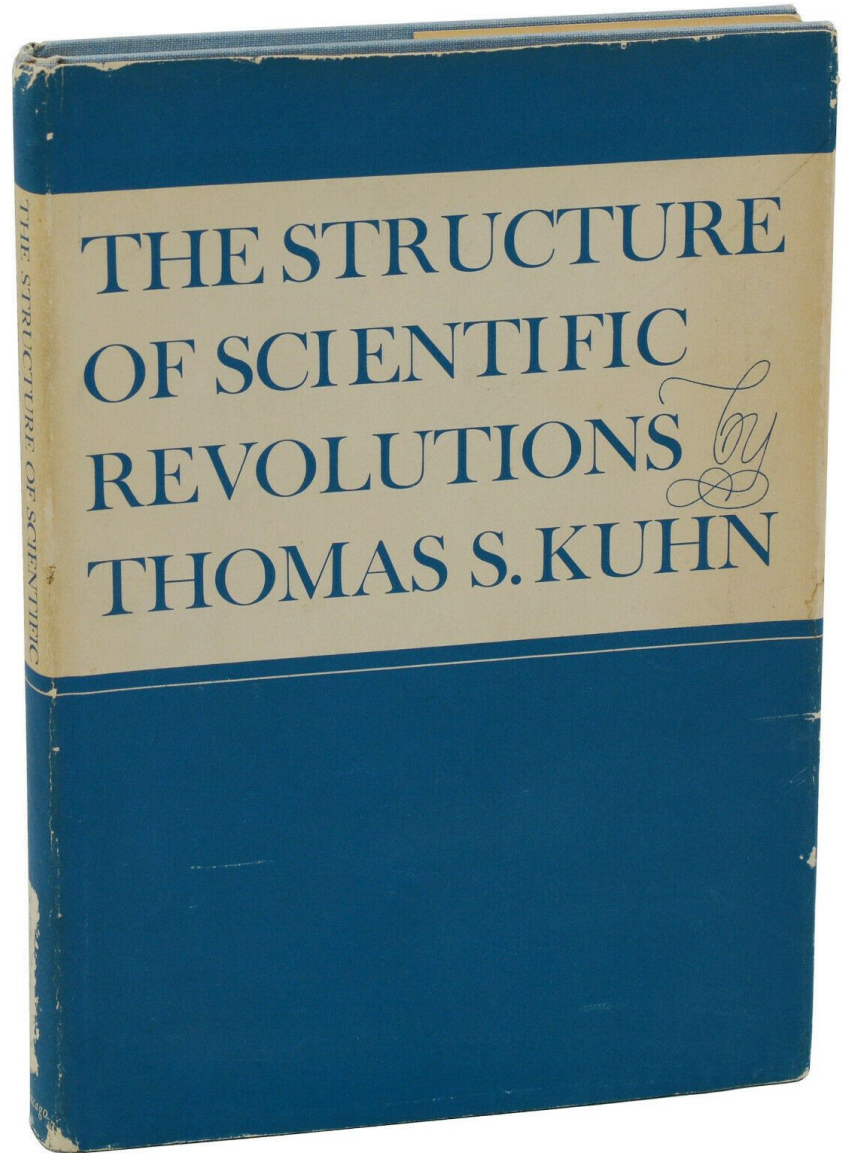
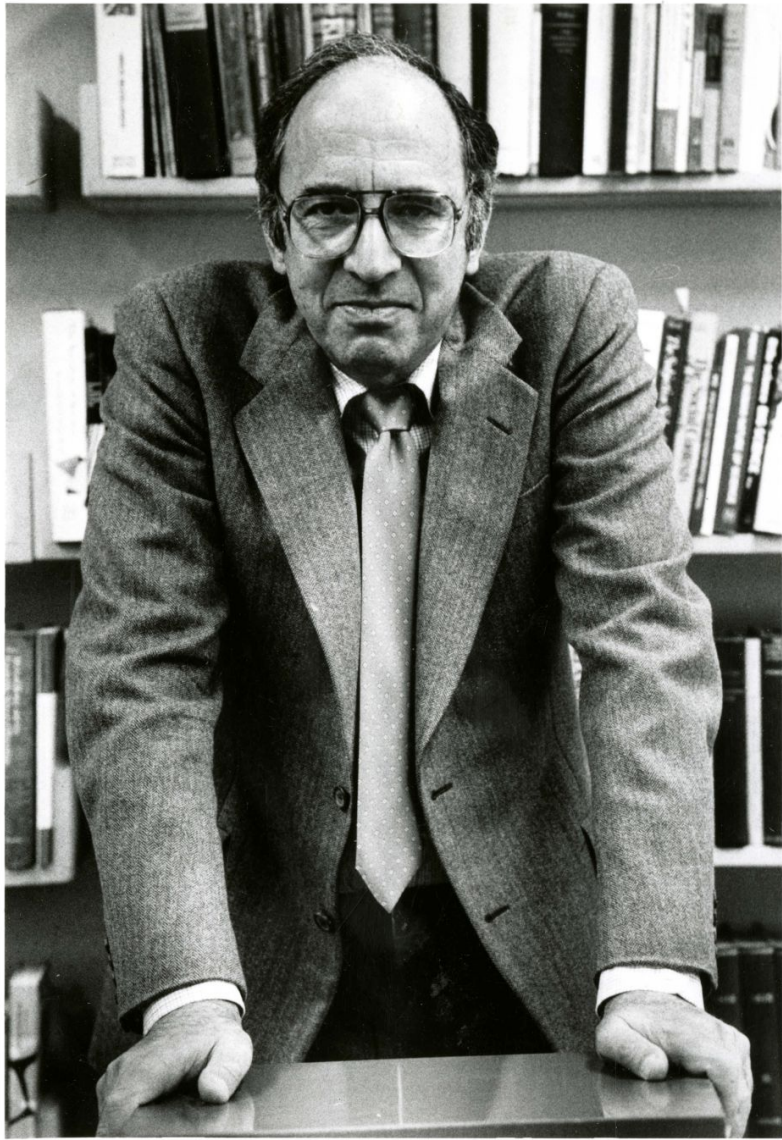
Objective and certain knowledge is attainable

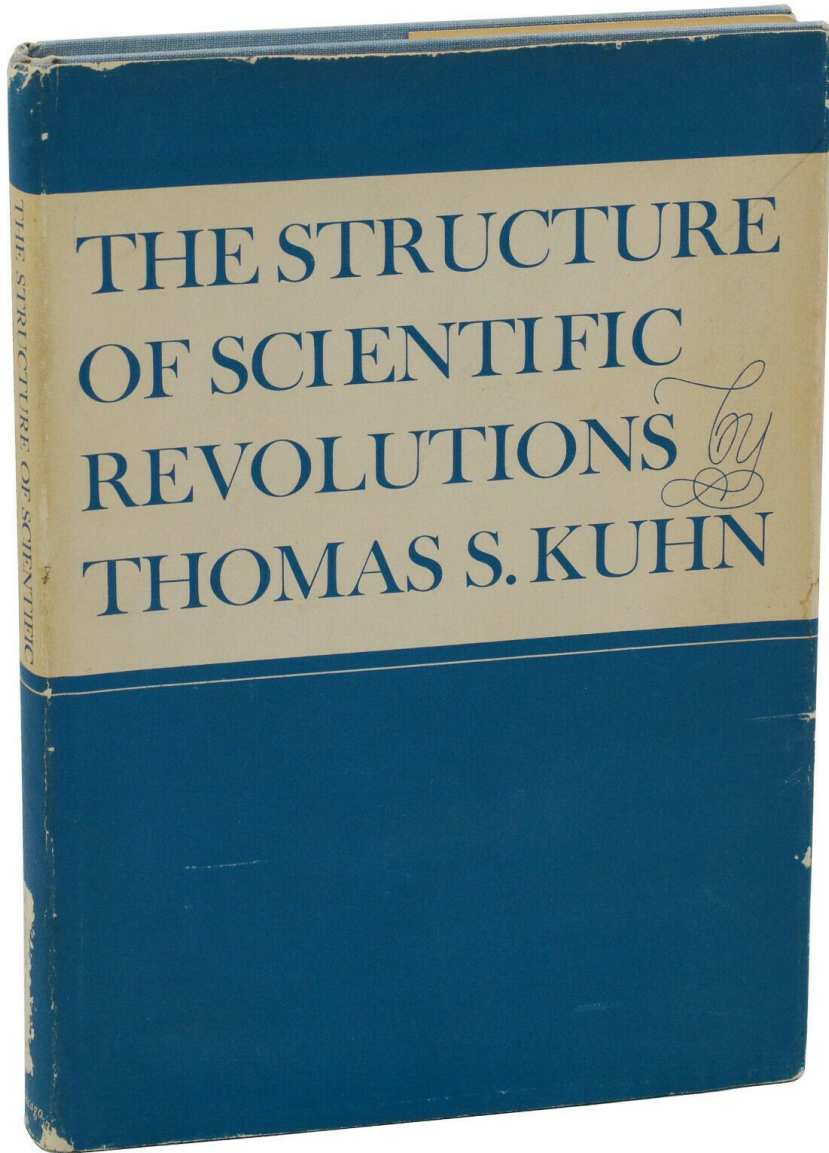


If there is a cat, we can know that there is a cat

*Post*modernism

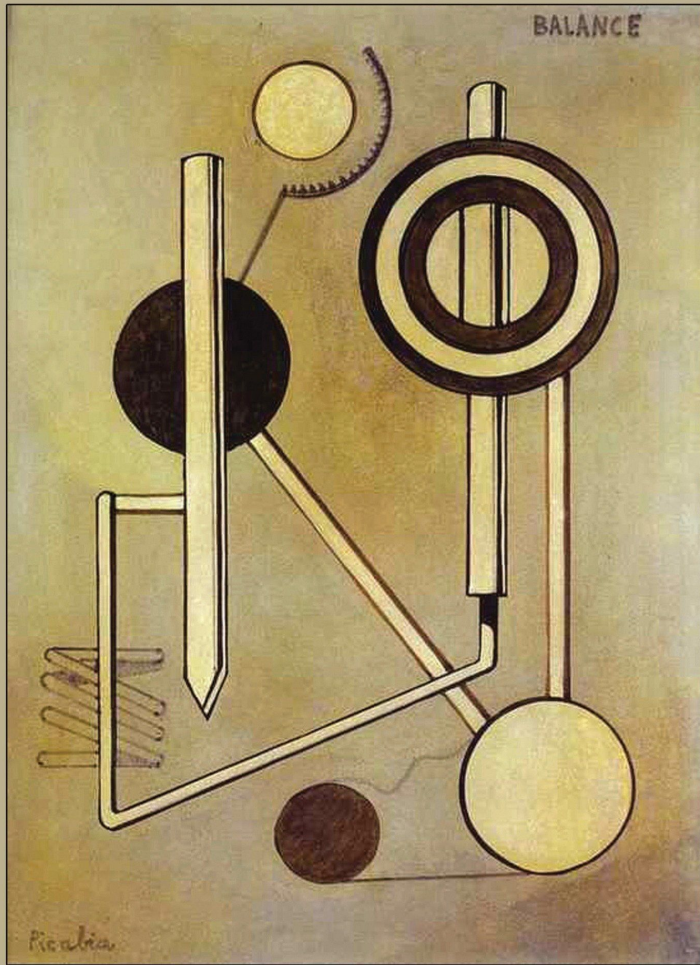
J A !



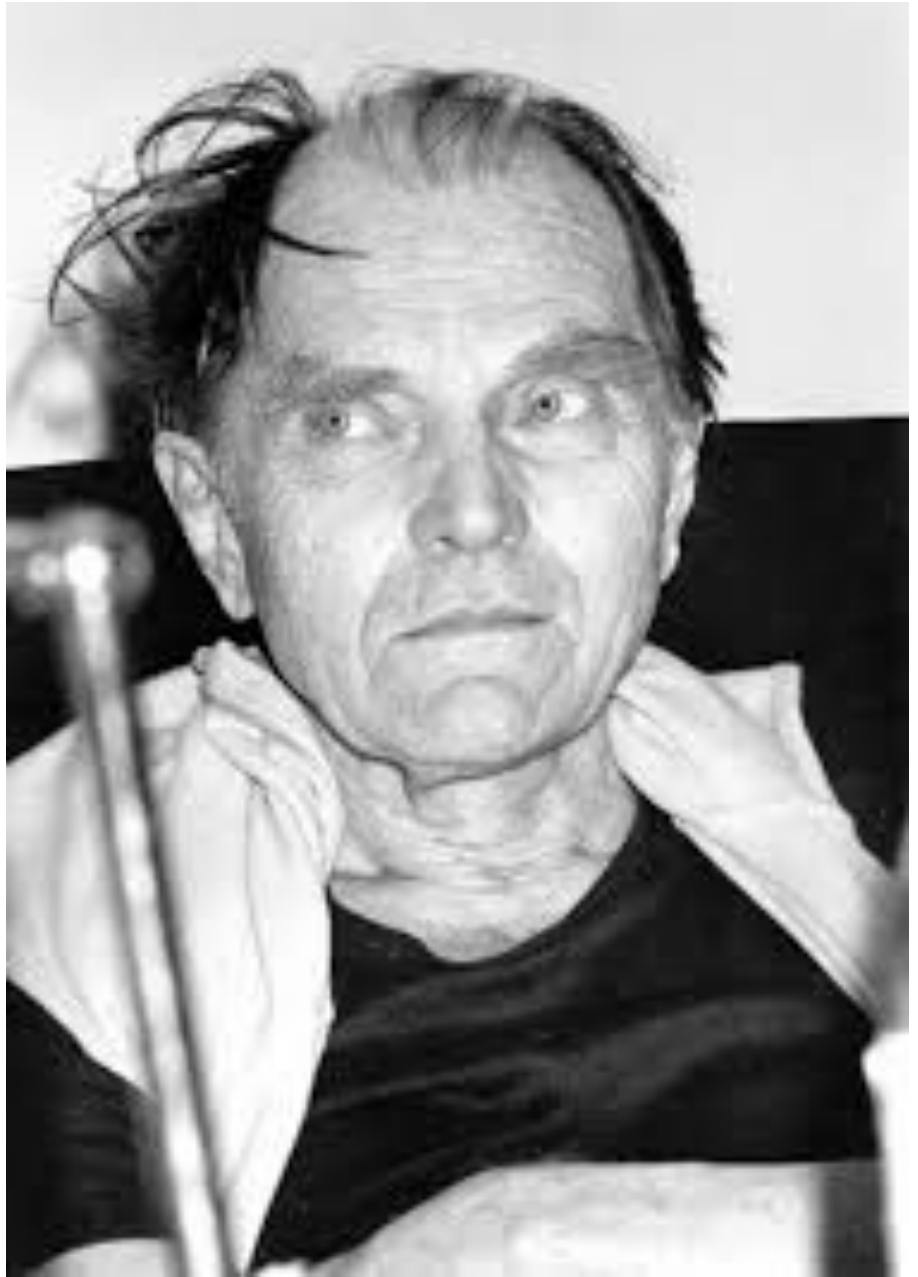


Observation and experience can and must drastically restrict the range of admissible scientific belief, else there would be no science. But (...) **An apparently arbitrary element, compounded of personal and historical accident**, is always a formative ingredient of the beliefs espoused by a given scientific community at a given time.

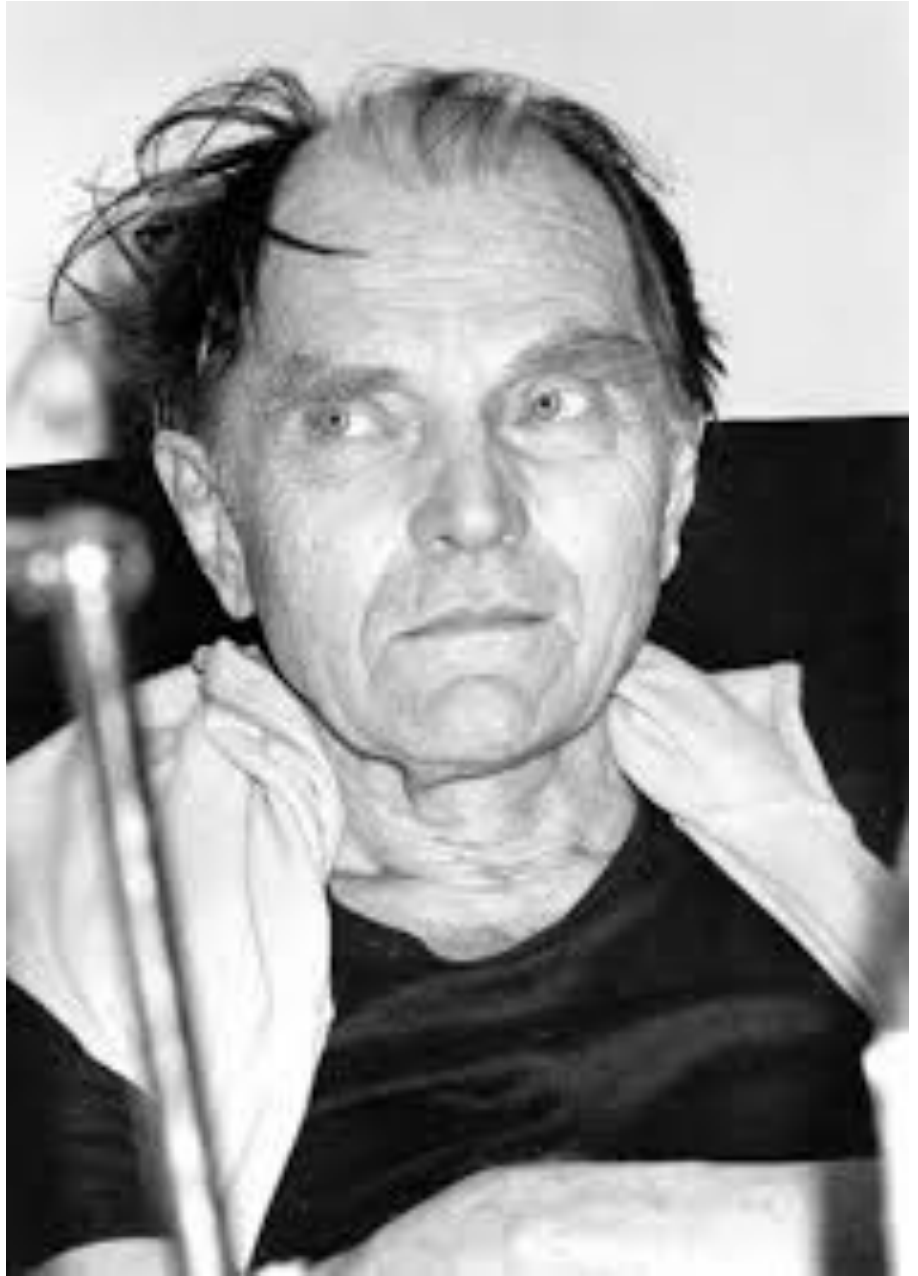
Not only the external world



New Edition
AGAINST METHOD
Paul Feyerabend
Introduced by Ian Hacking



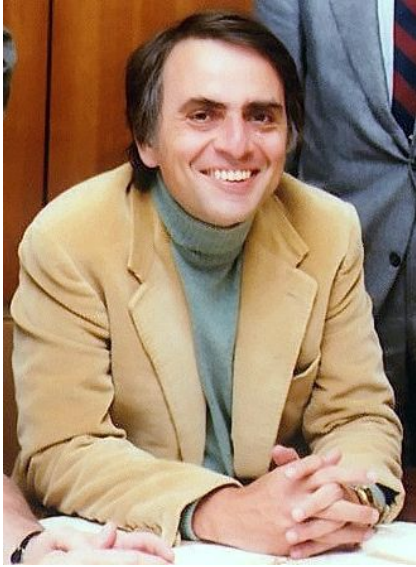
The separation of state and church must be complemented by the separation of state and science, that most recent, most aggressive, and most dogmatic religious institution.



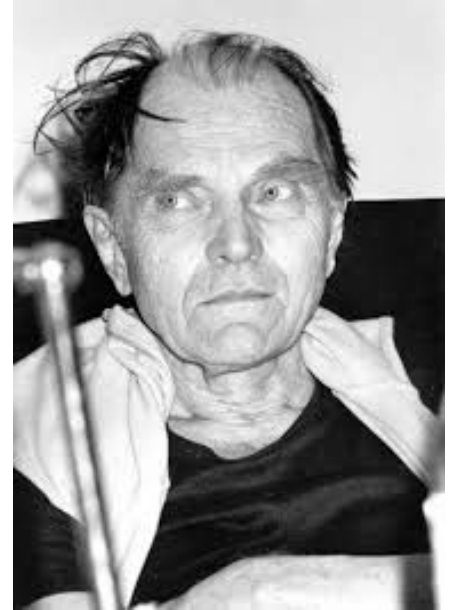
Postmodernism

Science is just another narrative created by a social group, just like voodoo





Naive scientist



Radical postmodernist

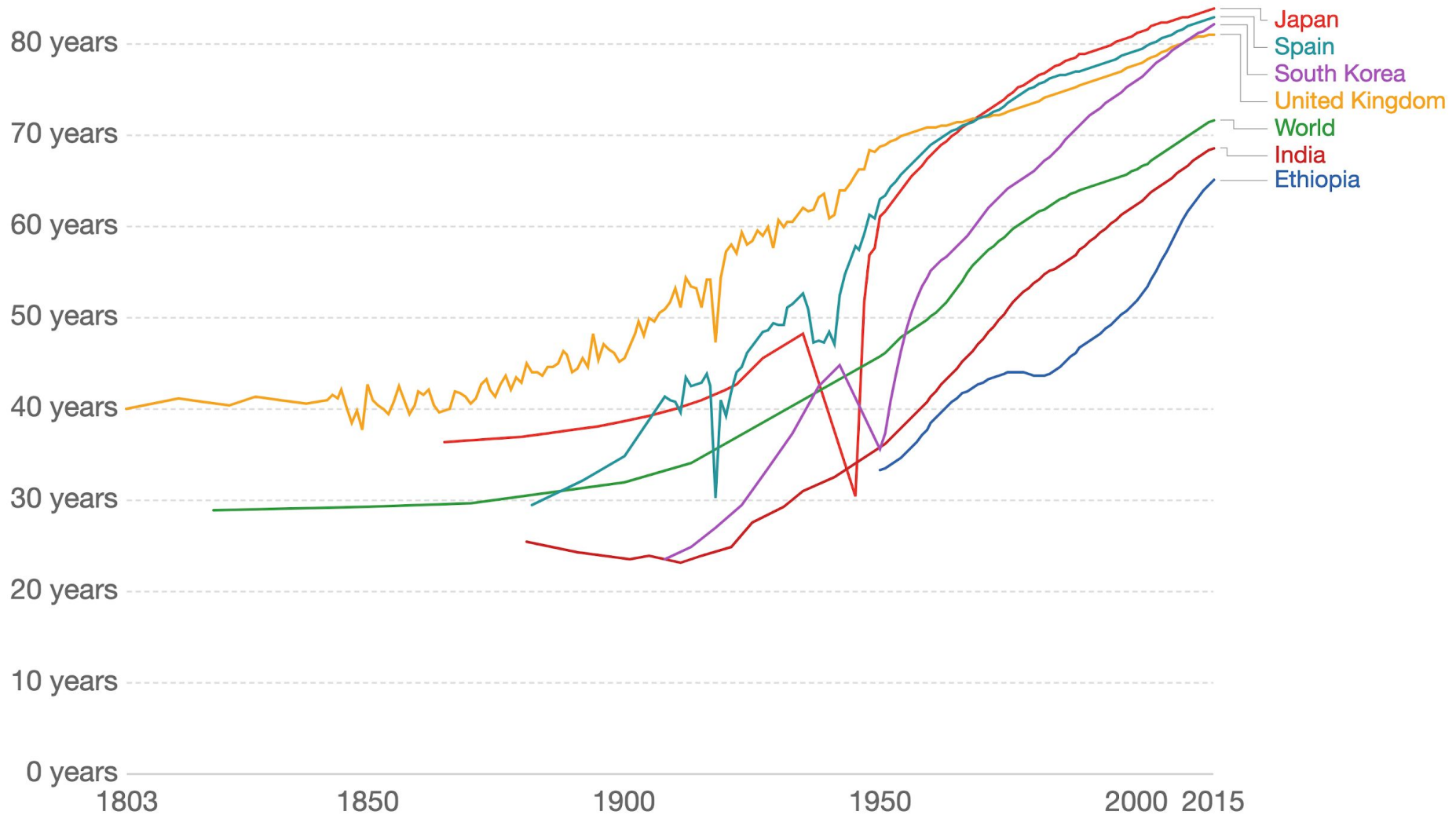




SCIENCE
IT WORKS.
BITCHES

EvolveFISH.com

Life expectancy



Source: Riley (2005), Clio Infra (2015), and UN Population Division (2019)

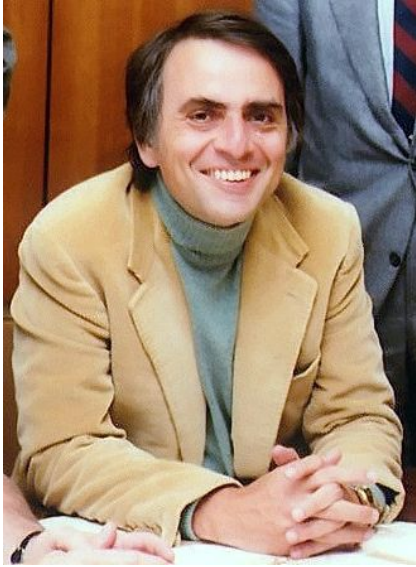
OurWorldInData.org/life-expectancy • CC BY

Note: Shown is period life expectancy at birth, the average number of years a newborn would live if the pattern of mortality in the given year were to stay the same throughout its life.





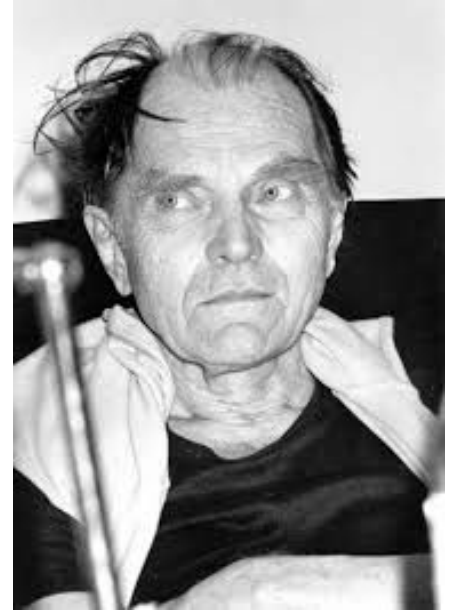
Conclusion: science works,
at least sometimes



Naive scientist

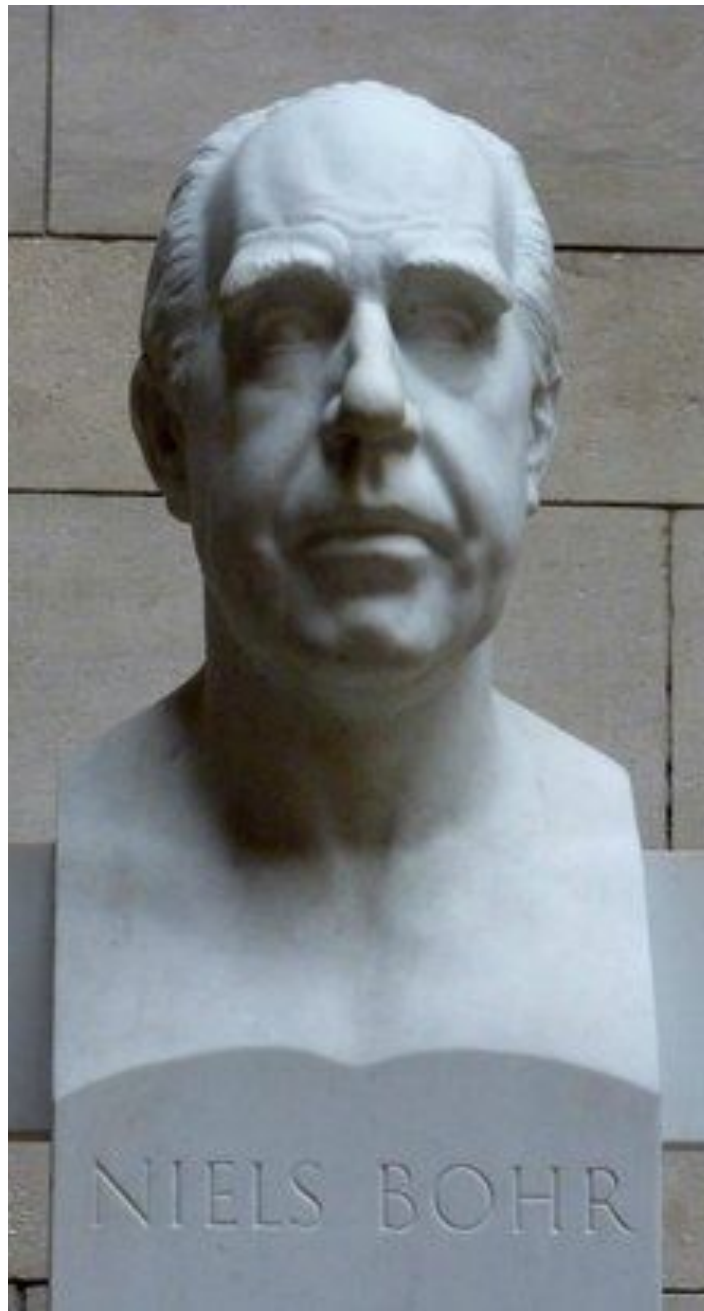


Some
science
results
work



Radical postmodernist

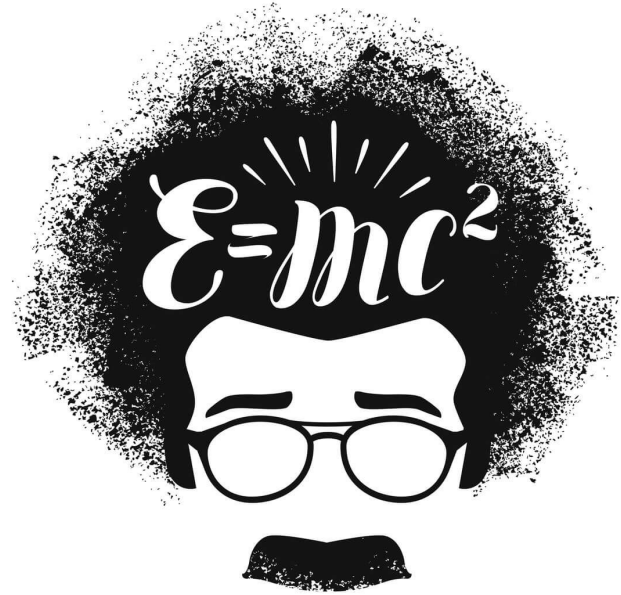
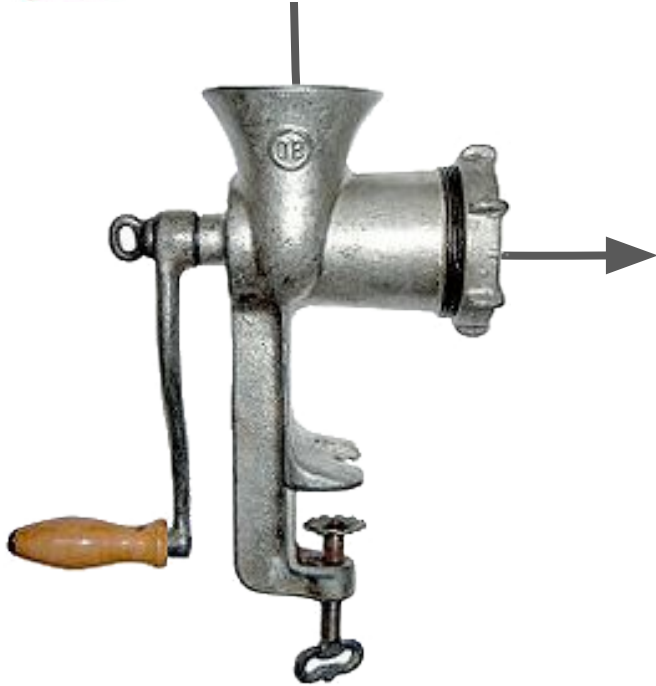




How does science works?

(naive idea)

EVIDENCE





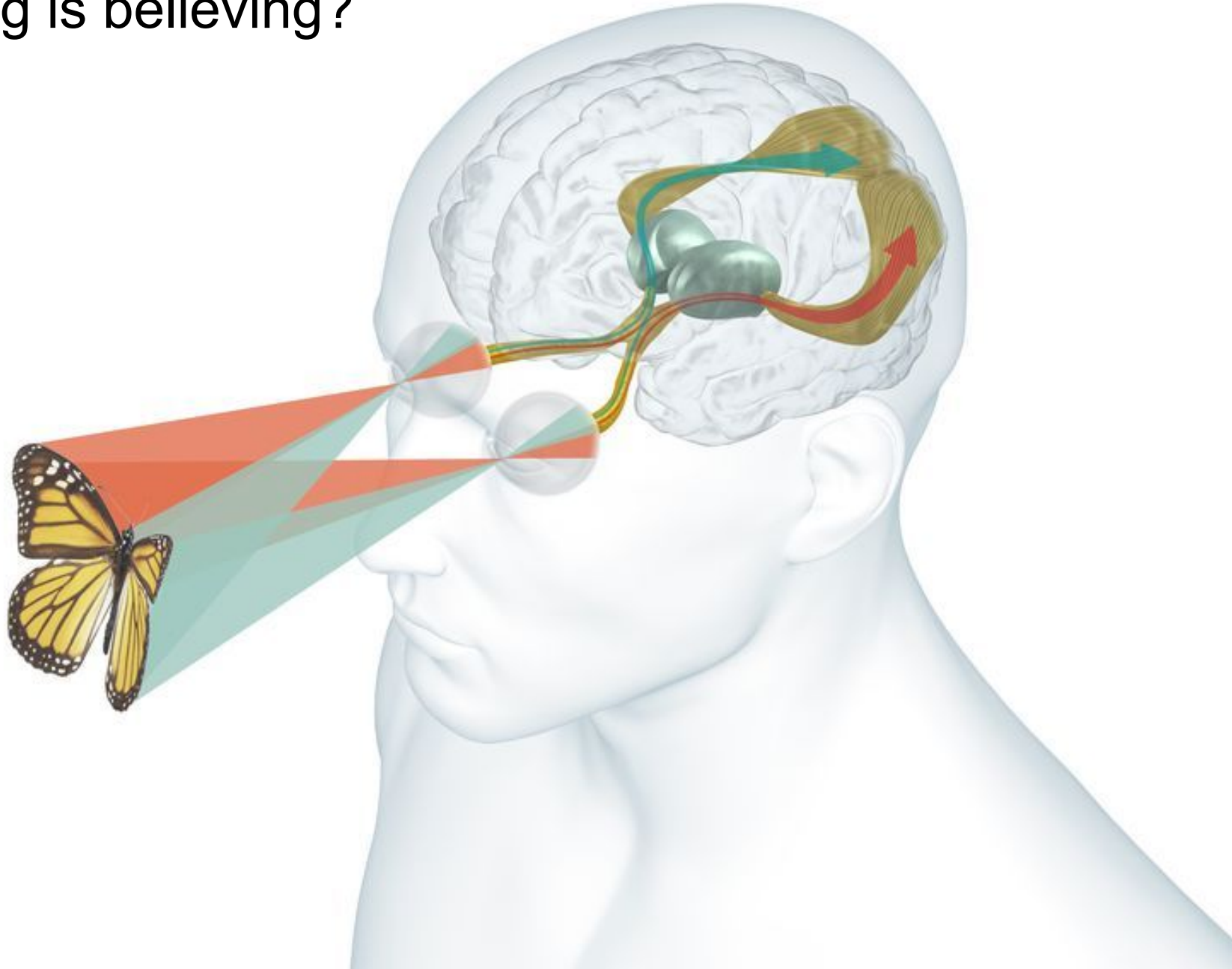
Problem 1: facts do not depend ***only*** on
the external world

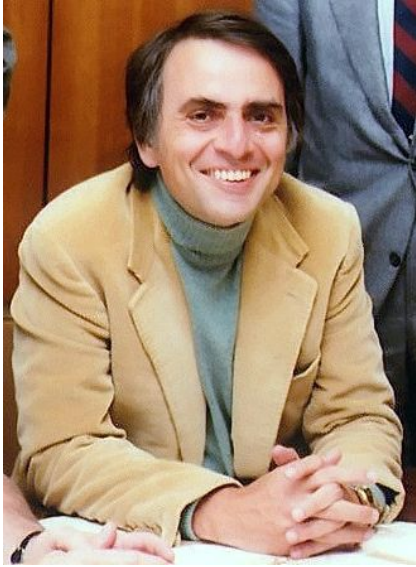


If there is a cat, we see a cat



Seeing is believing?





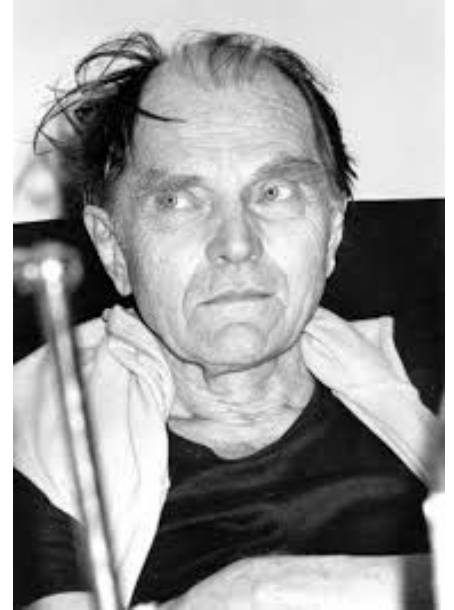
Naive scientist



Some
science
results
work



Facts are
theory-laden,
they depend
on the external
world and on
our previous
ideas

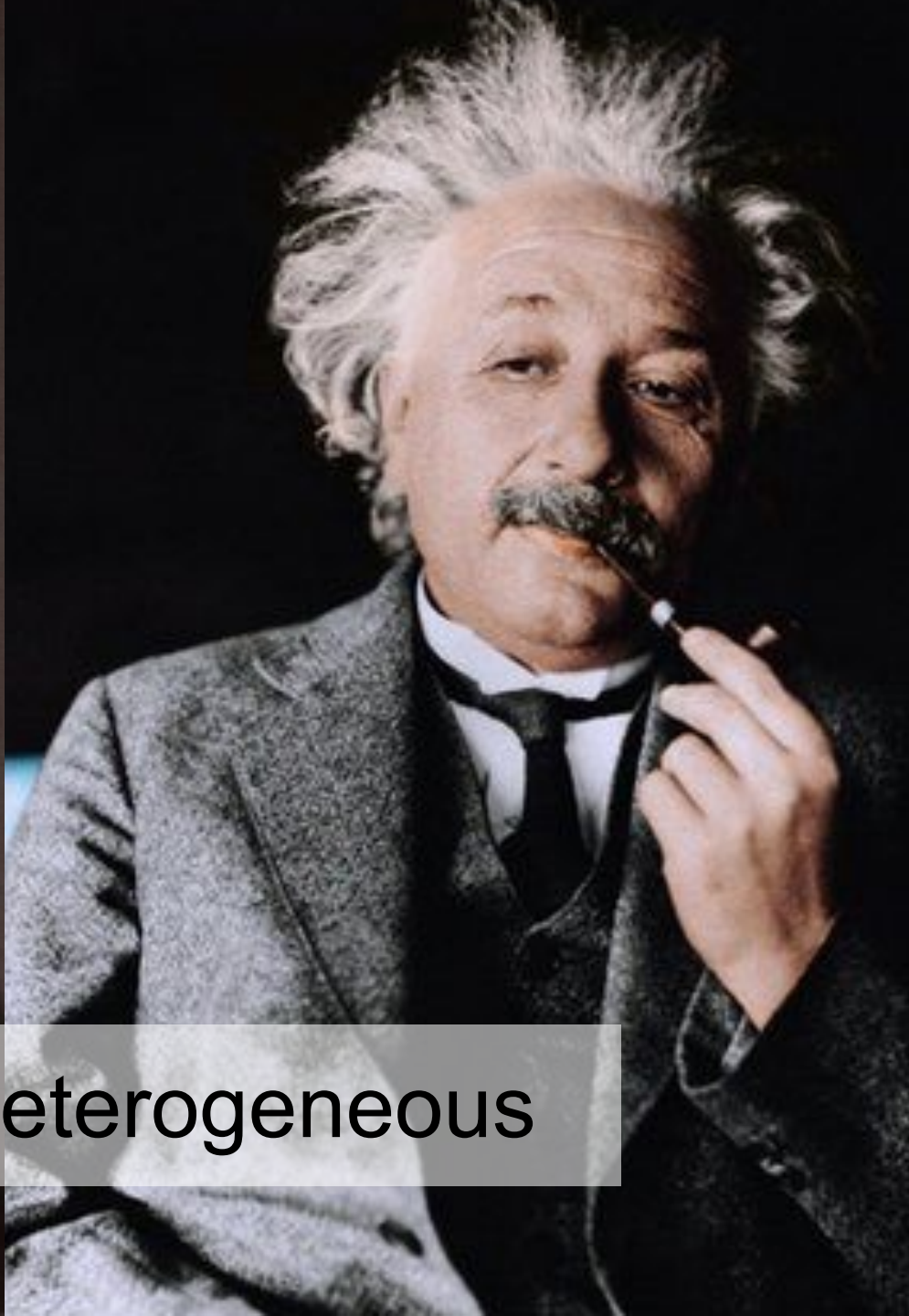
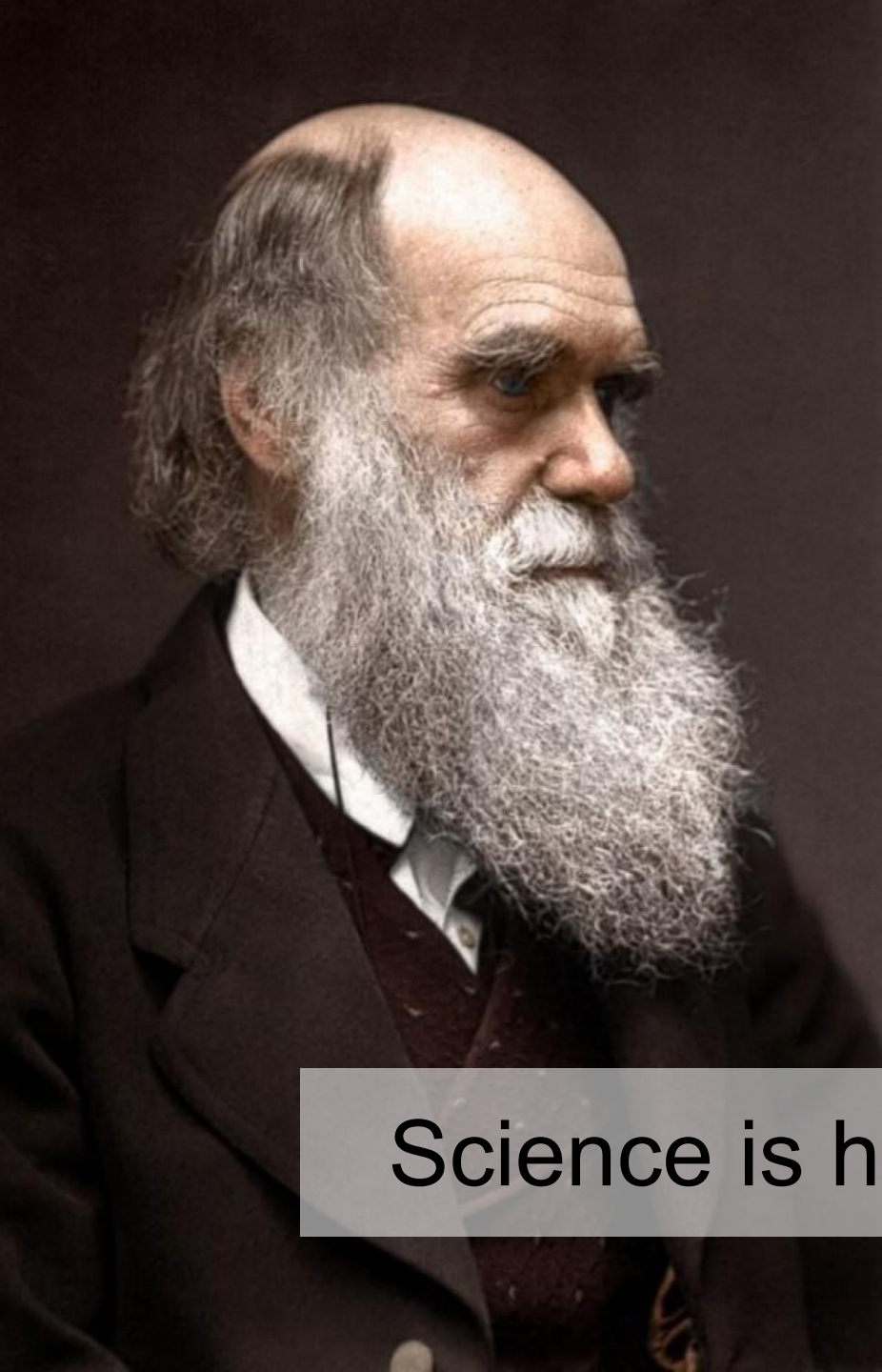


Radical postmodernist



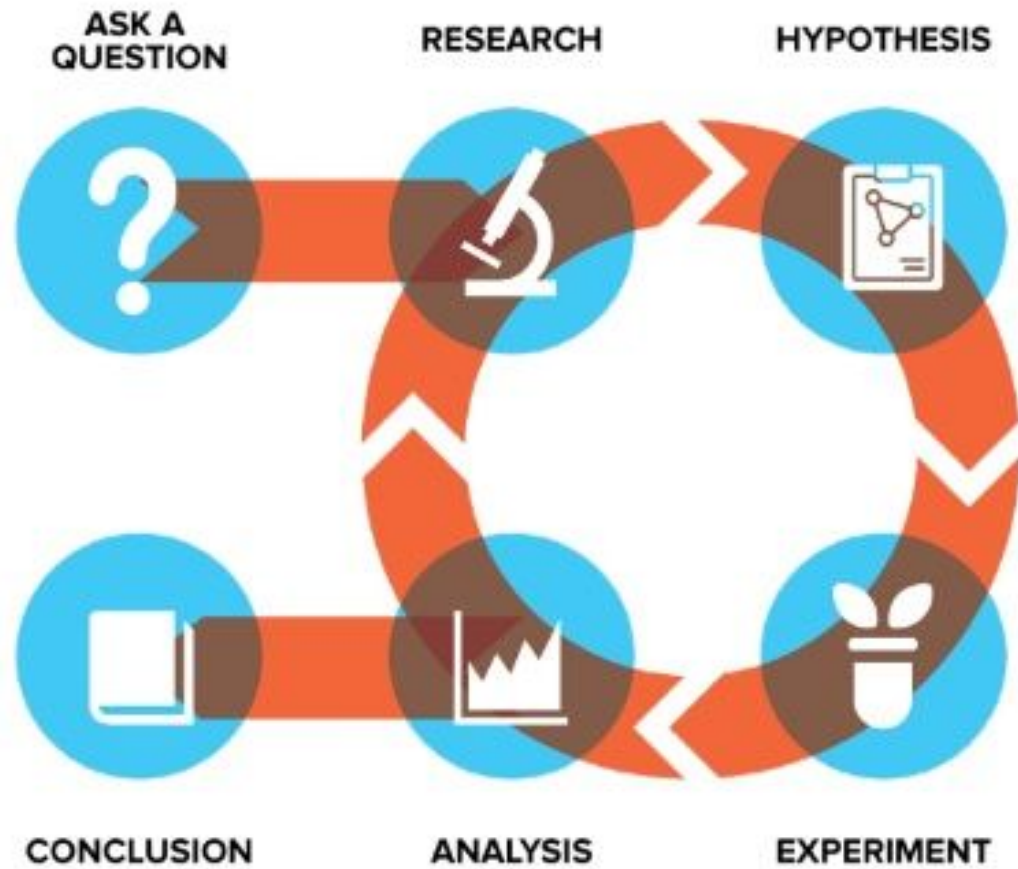


Problem 2: There is no method

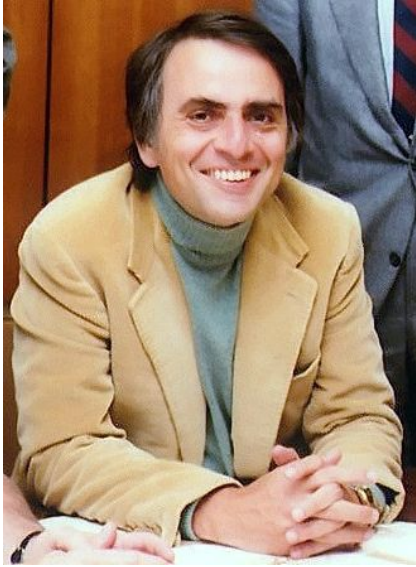


Science is heterogeneous

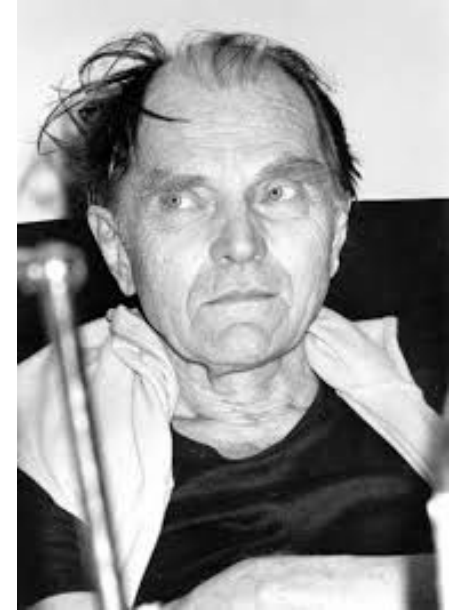
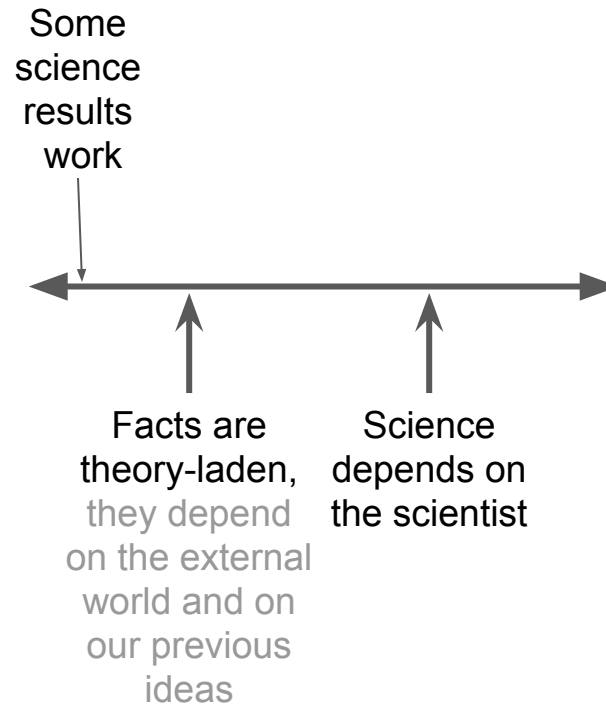
There's no algorithm for science



Science depends on the scientist,
there's an art to it



Naive scientist



Radical postmodernist



But scientists are *rational!*



p-value definition

How many of you have used p-values?

p-value definition

How many of you have used p-values?

p-value is the probability of the null hypothesis

If it is lower than the threshold you have to reject the null hypothesis

Yes?

No?

p-value definition

How many of you have used p-values?

p-value is the probability of the null hypothesis

If it is lower than the threshold you have to reject the null hypothesis

so, if the p-value is lower than 0.05 that means that your hypothesis is true

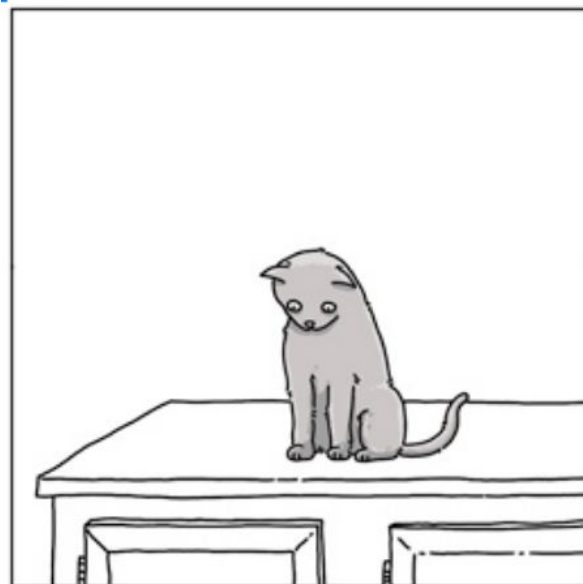
Yes?

No?

p-values are related with falsation

A “good” p-value never indicates that we accept an hypothesis, only that it could be reasonable to reject one

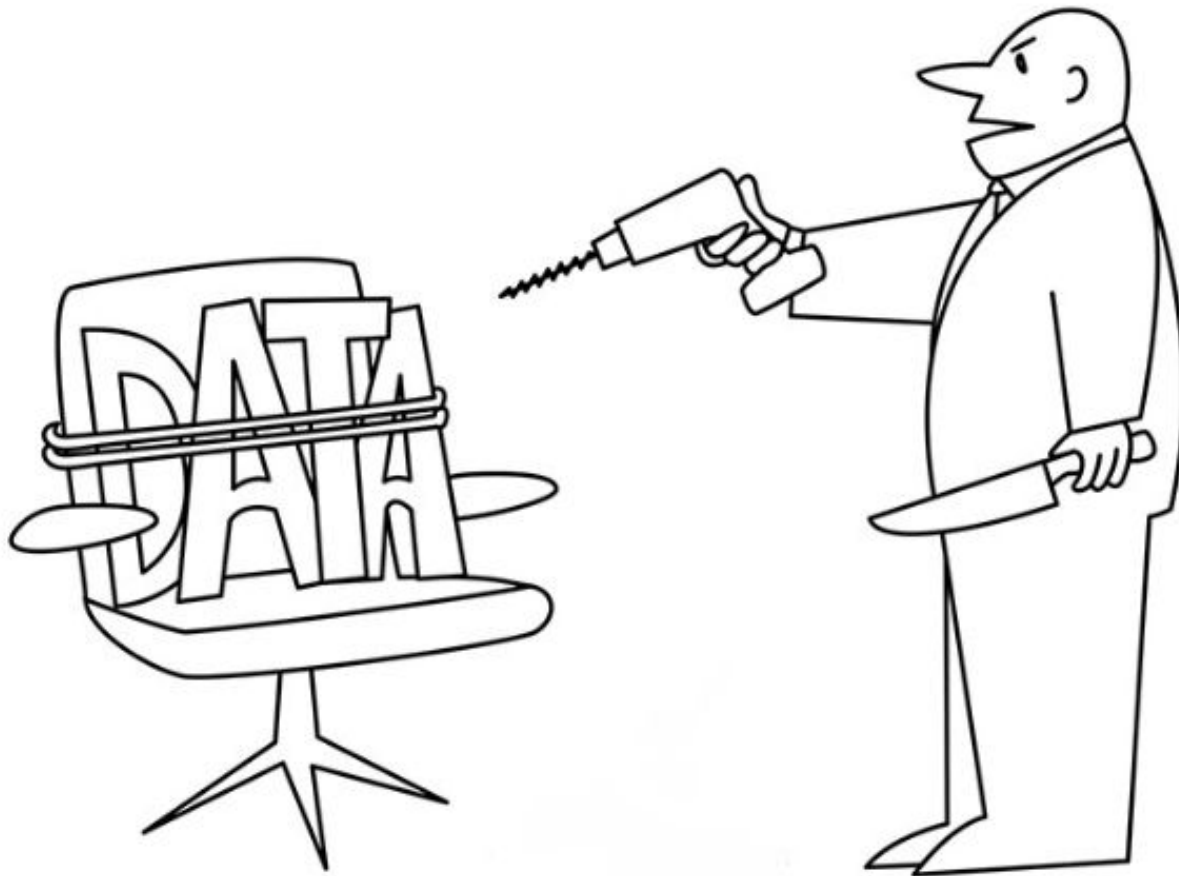
Falsation



Multiple tests



p-hacking



“If you don't reveal some insights soon, I'm going to be forced to slice, dice, and drill!”

Why Most Published Research Findings Are False

John P. A. Ioannidis

Summary

There is increasing concern that most current published research findings are false. The probability that a research claim is true may depend on study power and bias, the number of other studies on the same question, and, importantly, the ratio of true to no relationships among the relationships probed in each scientific field. In this framework, a research finding is less likely to be true when the studies conducted in a field are smaller; when effect sizes are smaller; when there is a greater number and lesser preselection of tested relationships; where there is greater flexibility in designs, definitions, outcomes, and analytical modes; when there is greater financial and other interest and prejudice; and when more teams are involved in a scientific field in chase of statistical significance. Simulations show that for most study designs and settings, it is more likely for

factors that influence this problem and some corollaries thereof.

Modeling the Framework for False Positive Findings

Several methodologists have pointed out [9–11] that the high rate of nonreplication (lack of confirmation) of research discoveries is a consequence of the convenient, yet ill-founded strategy of claiming conclusive research findings solely on the basis of a single study assessed by formal statistical significance, typically for a p -value less than 0.05. Research is not most appropriately represented and summarized by p -values, but, unfortunately, there is a widespread notion that medical research articles

It can be proven that most claimed research findings are false.

is characteristic of the field and can vary a lot depending on whether the field targets highly likely relationships or searches for only one or a few true relationships among thousands and millions of hypotheses that may be postulated. Let us also consider, for computational simplicity, circumscribed fields where either there is only one true relationship (among many that can be hypothesized) or the power is similar to find any of the several existing true relationships. The pre-study probability of a relationship being true is $R/(R + 1)$. The probability of a study finding a true relationship reflects the power $1 - \beta$ (one minus the Type II error rate). The probability of claiming a relationship when none truly exists reflects the Type I error rate, α . Assuming that c relationships are being probed in the field, the expected values of the 2×2 table are given in Table 1. After a research finding has been claimed based on



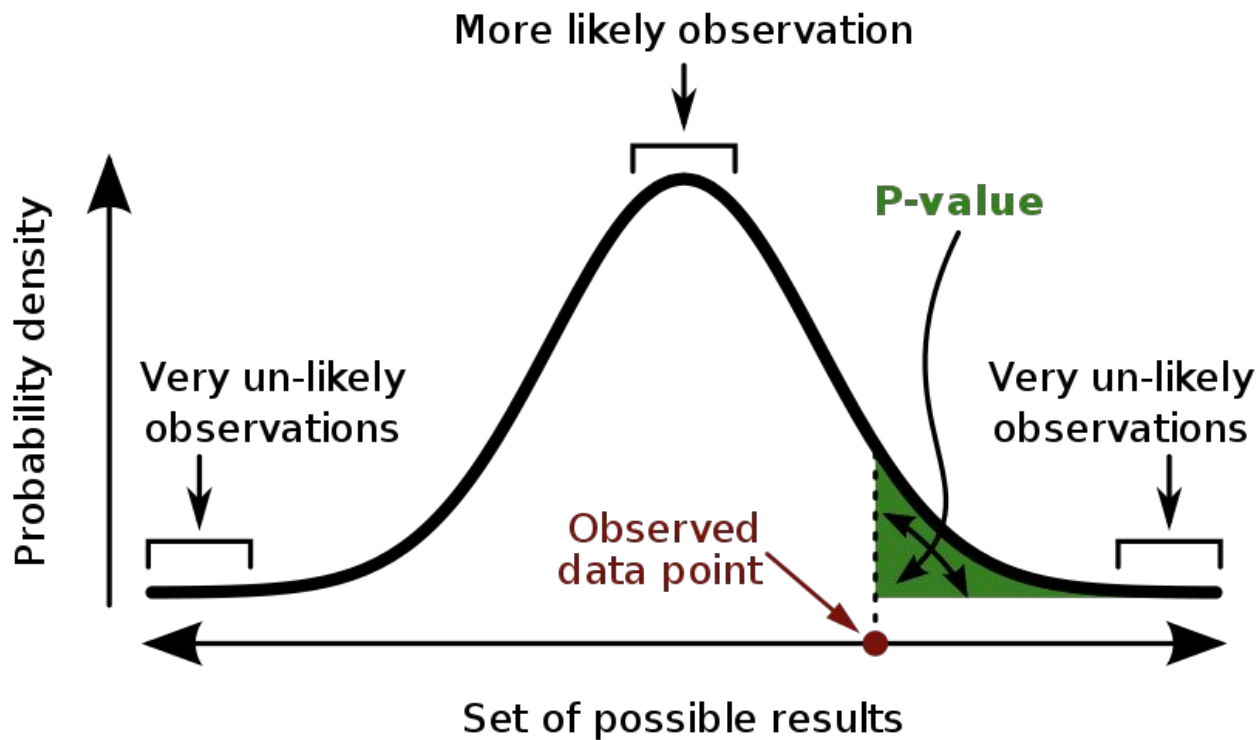
Replication crisis

From Wikipedia, the free encyclopedia

The **replication crisis** (or **replicability crisis** or **reproducibility crisis**) is, as of 2019, an ongoing [methodological](#) crisis in which it has been found that many scientific studies are difficult or impossible to [replicate or reproduce](#). The replication crisis affects the [social](#) and [life sciences](#) most severely.^{[1][2]} The crisis has long-standing roots; the phrase was coined in the early 2010s^[3] as part of a growing awareness of the problem. The replication crisis represents an important body of research in the field of [metascience](#).^[4]

Because the reproducibility of experiments is an essential part of the [scientific method](#),^[5] the inability to replicate the studies of others has potentially grave consequences for many fields of science in which significant theories are grounded on unreproducible experimental work. The replication crisis has been particularly widely discussed in the field of [psychology](#) and in [medicine](#), where a number of efforts have been made to re-investigate classic results, to determine both the reliability of the results, and, if found to be unreliable, the reasons for the failure of replication.^{[6][7]}

p-values can indicate how incompatible the data are with a specified statistical model



Confusion of the inverse

p-value is related to *probability of the evidence*

Do you want the *probability of the hypothesis*?

$$p(H|E) = p(H) \frac{p(E|H)}{p(E)}$$

SCIENTIFIC REASONING

The Bayesian Approach

Colin Howson and Peter Urbach

THIRD EDITION

The rational approach is to look for evidence in favor of your hypothesis:

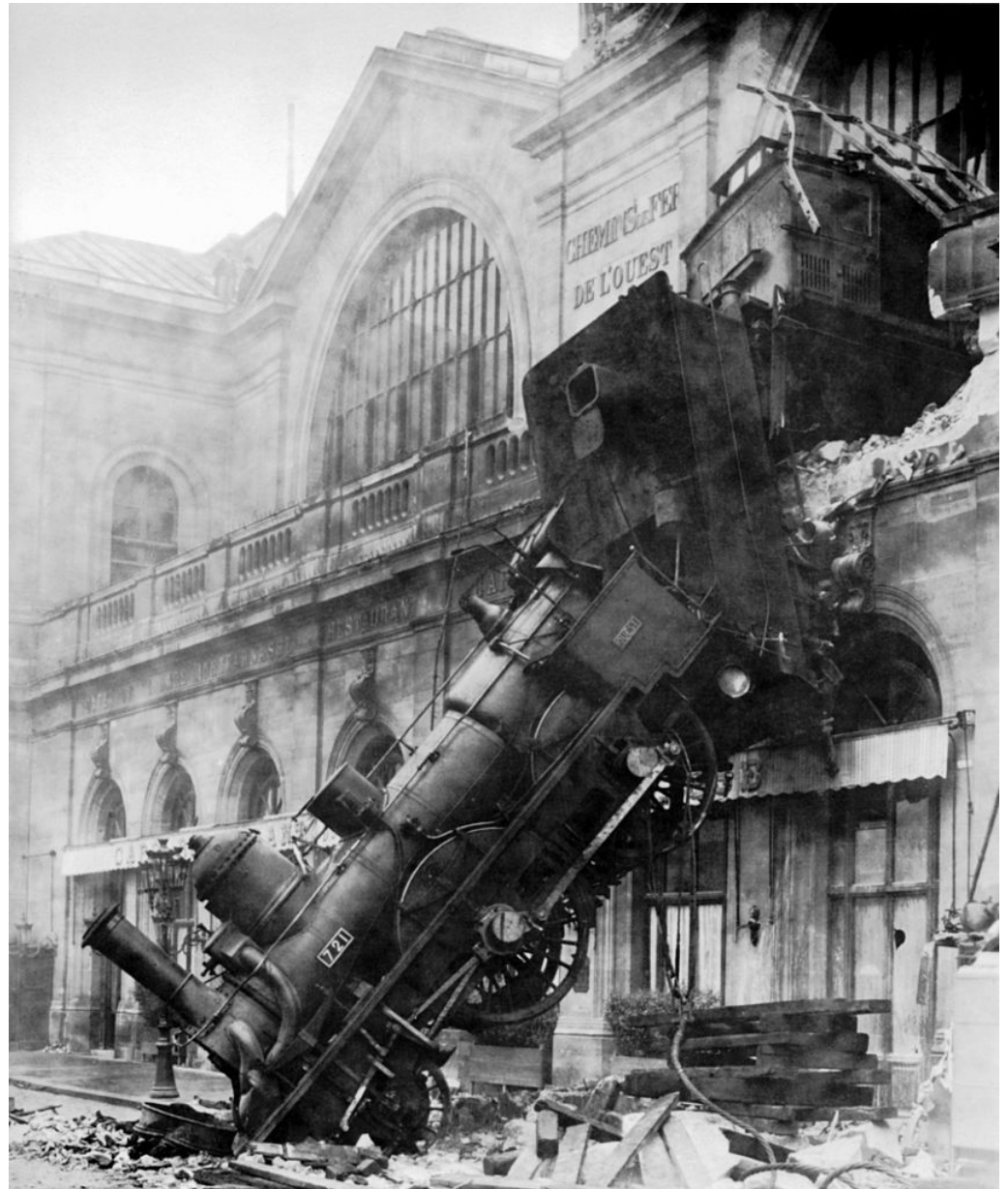
Yes?

No?

Wrong!

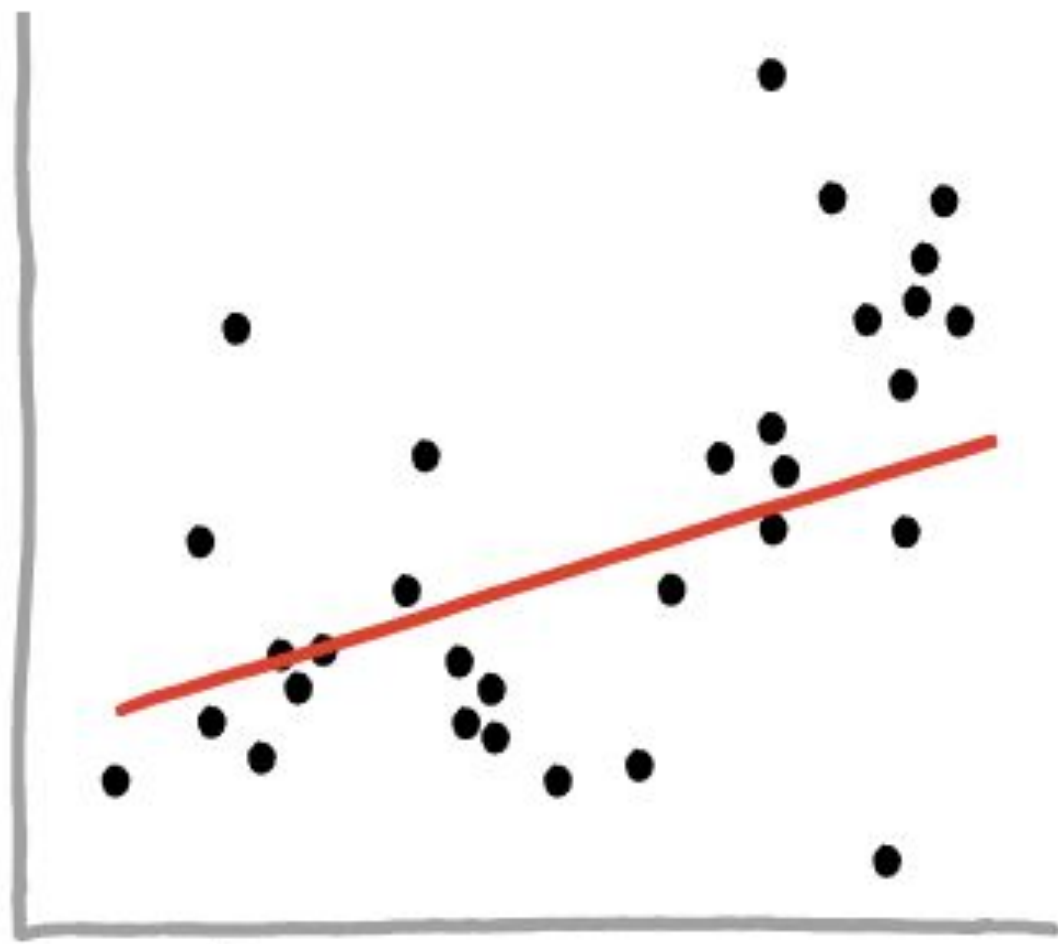
Again

**Confirmation
bias**



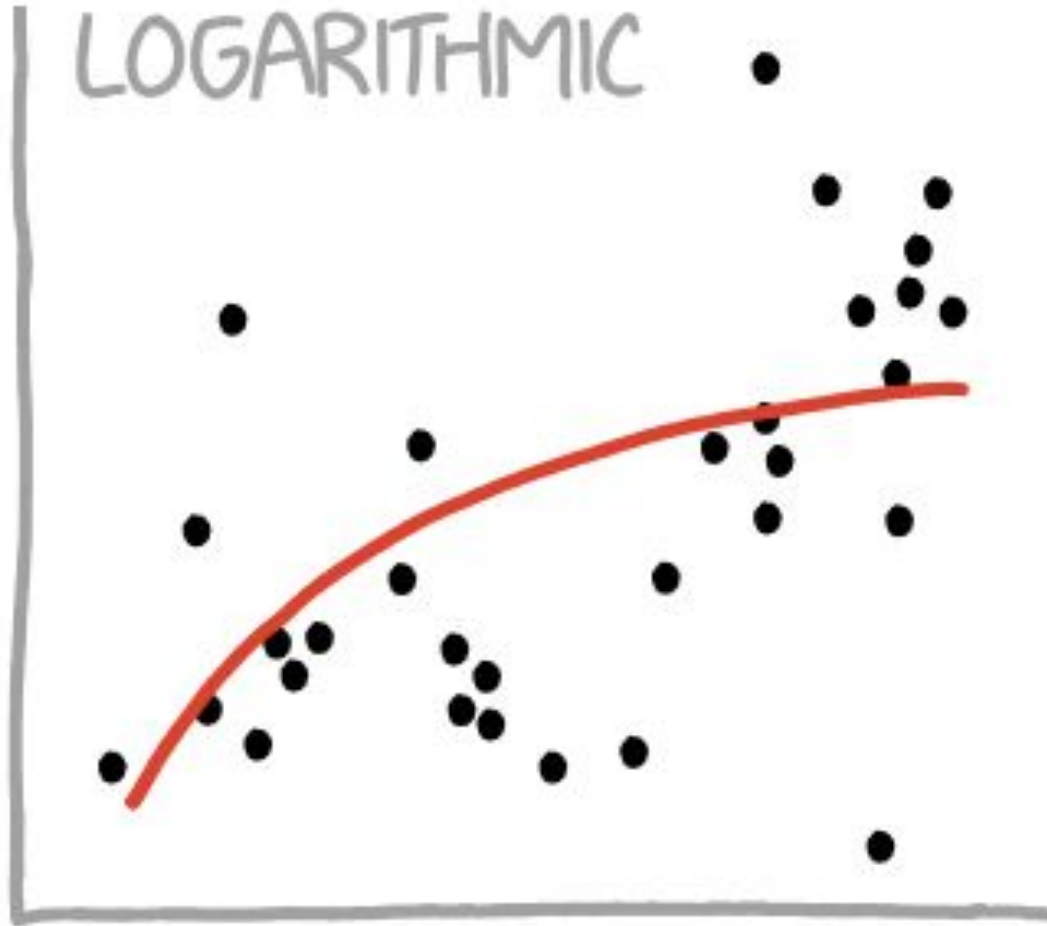
The problem of induction





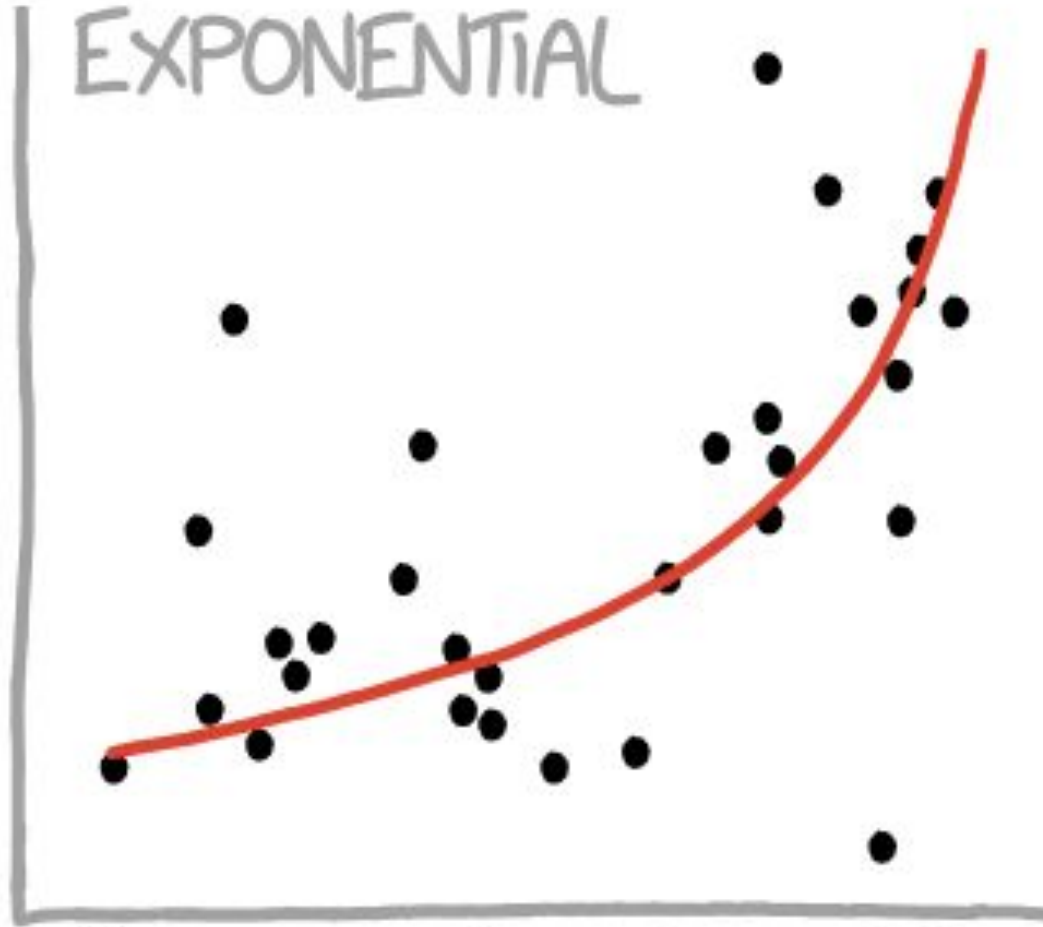
XKCD

Linear regression



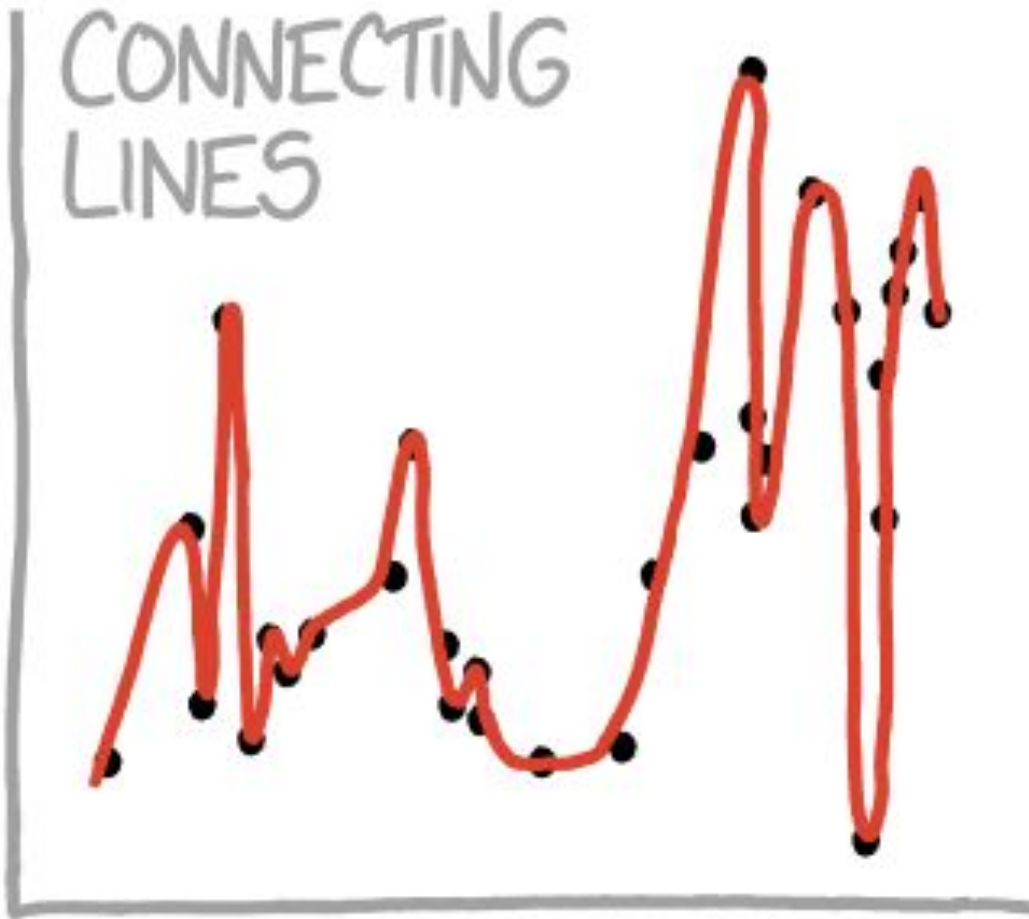
XKCD

Look, it's tapering off!



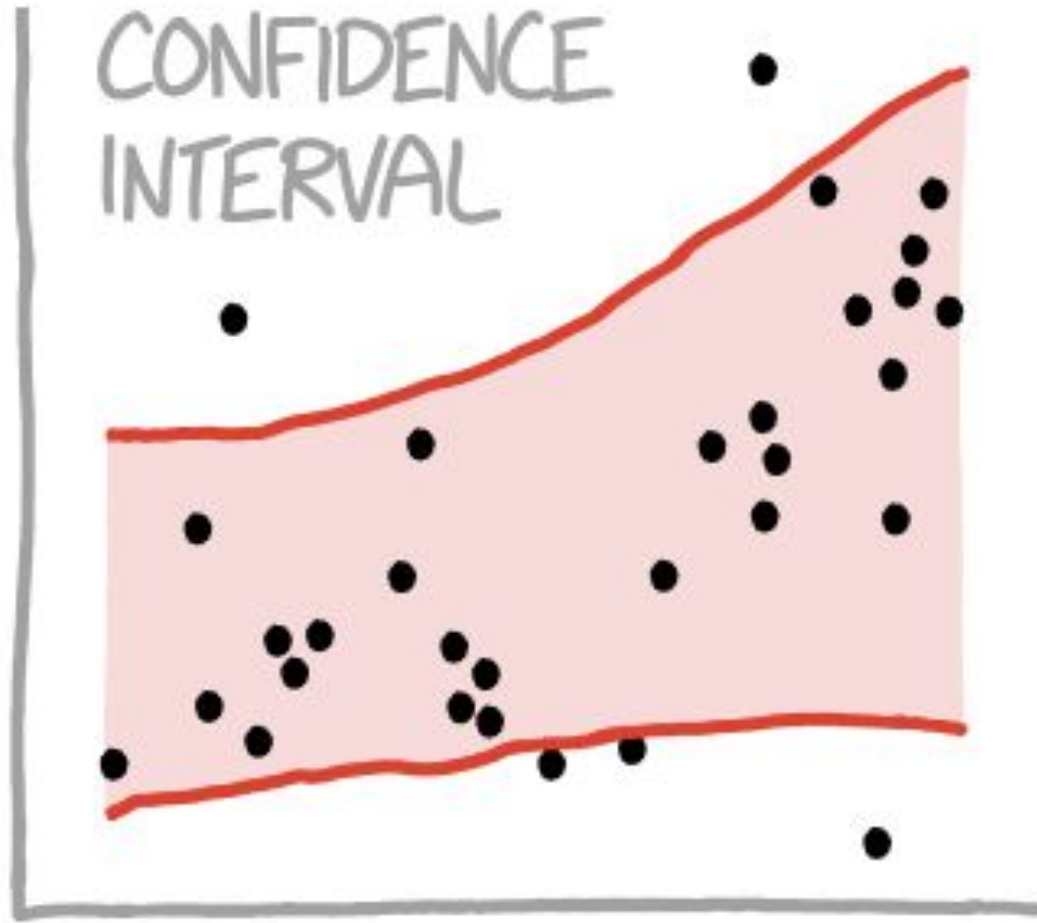
XKCD

Look, it's growing uncontrollably!



XKCD

Overfitting



XKCD

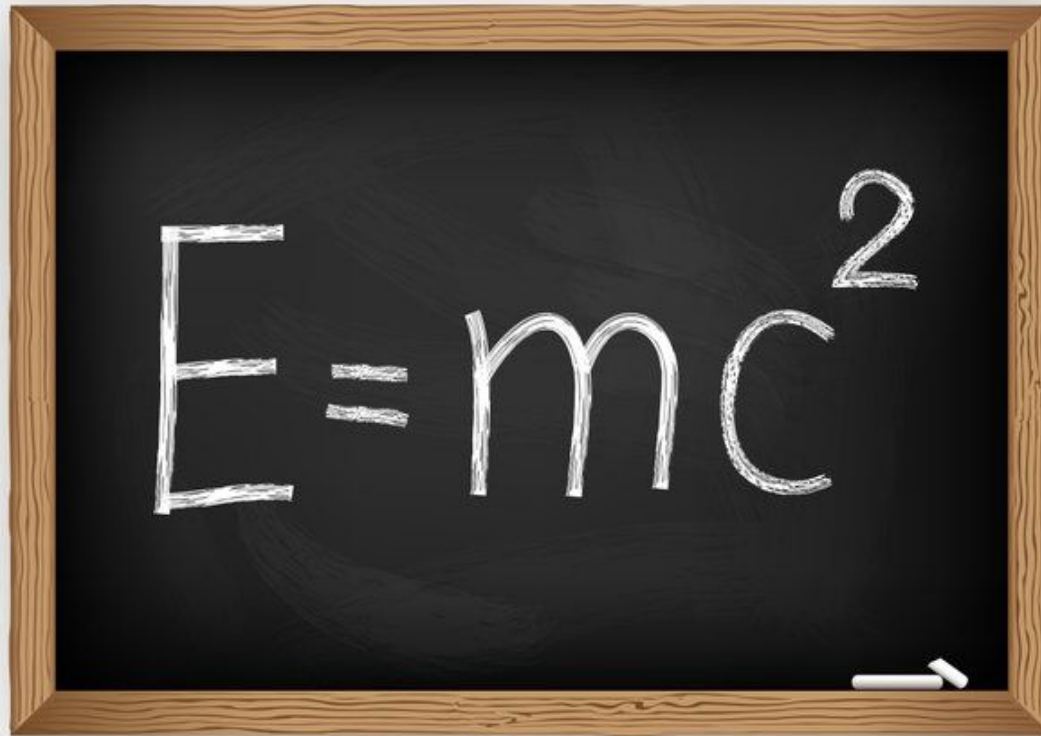
Science is hard. But I'm a serious person doing my best

Science depends on the scientist,
there's an art to it



Here comes the skeptical inquisition

Science should be skeptical



Just a theory, knowledge is fallible

Rational discussion community



Plato is my friend, but truth is a better friend

Scientific communities should foster rational discussions



Not every community fosters rational discussions



How many criticisms have been voiced
in this meeting?

Main costs of criticism

Self-criticism:

Less papers

Criticism to others:

Less friends

Less money

Less papers



So, please,
don't listen to
me



Look for the sacred 0.05 p-value and
publish!

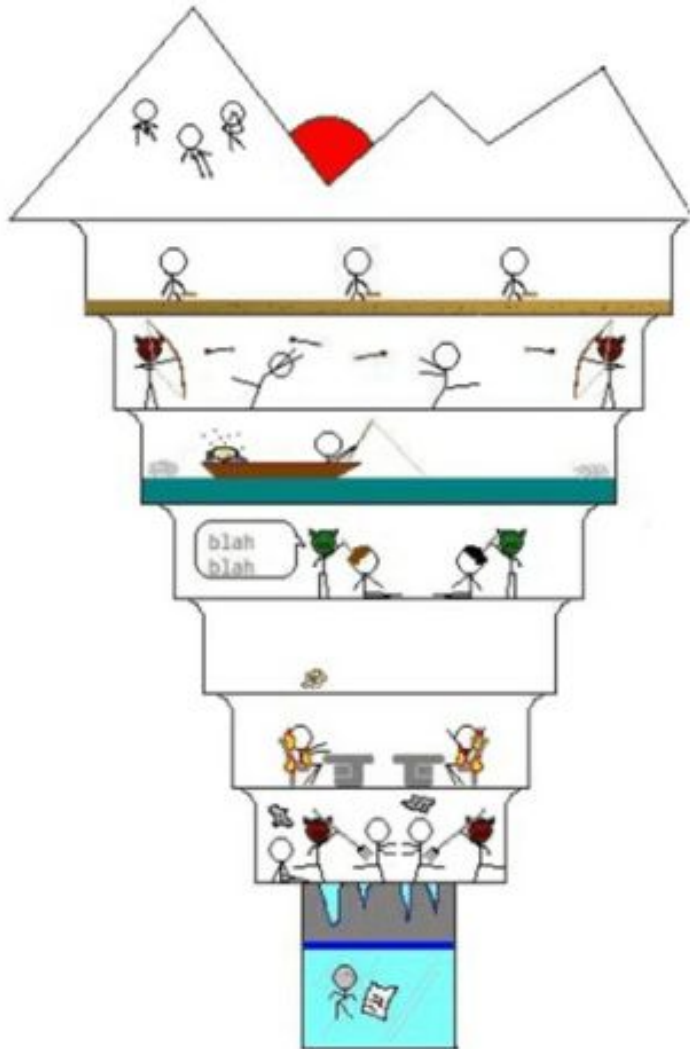
Humans love stories, so **tell stories**



Postmodernism

Science is just another narrative created by a social group, just like voodoo

The Nine Circles of Scientific Hell



First Circle: Limbo

Second Circle: Overselling

Third Circle: Post-Hoc Storytelling

Fourth Circle: P-Value Fishing

Fifth Circle: Creative Use of Outliers

Sixth Circle: Plagiarism

Seventh Circle: Non-Publication of Data

Eighth Circle: Partial Publication of Data

Ninth Circle: Inventing Data



Cargo cult

“But it doesn't work. No airplanes land. So I call these things **cargo cult science**, because they follow all the apparent precepts and forms of scientific investigation, but they're missing something essential, because the planes don't land.”

Richard Feynman



Institut de
Ciències de
l'Educació



UNIVERSITAT
POLITÈCNICA
DE VALÈNCIA



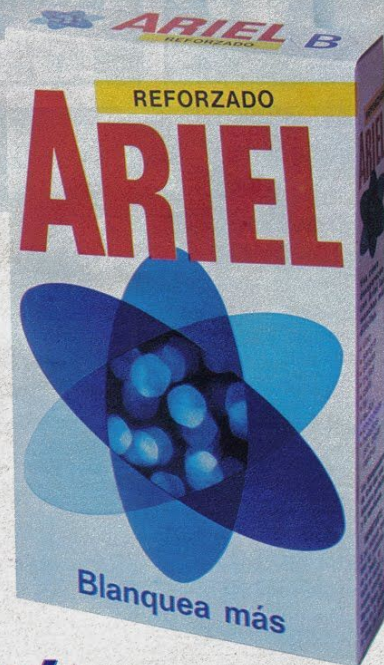
**pura
blancura**

Ariel lava más blanco que ningún otro detergente.

Y lo consigue por su fórmula especial, capaz de eliminar la suciedad profunda y hasta las manchas más tenaces. Además, los blanqueadores especiales de Ariel dan a la ropa una blancura inimitable.

Una blancura tan superior, que resalta entre la ropa lavada con otros detergentes.

Haga la prueba y lave con Ariel. Verá cómo Ariel lava más blanco que ningún otro detergente.



Ariel blanquea más.



**pura
blancura**

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REFORZADO
ARIEL
Blanquea más



Final remarks

Science results depend on the *external world* **and** on the *scientists*

Finding out if a gene is controlling a metabolic path is more involved than spotting a cat

Individual scientists are limited and so, their community should try be
be *rational (and critical)*

But there are *perverse incentives* that undermine the critical attitudes



**WITH GREAT
POWER
COMES GREAT
RESPONSIBILITY**

Strive for
perfection,
assume that
you will fail to
attain it, and
have fun in the
process



Reality won't
listen to your
excuses



Rational thinking resources

General

Rationally speaking podcast

The skeptics guide to the universe, book and podcast

Thinking fast and slow, a classic book by Kahneman

Harry Potter and the methods of rationality. Fanfic by Yudkowsky

Science

The Pleasure of Finding Things Out, interview and book. Feynman

Bad pharma, an exposé by Goldacre

Philosophy

Scientific Reasoning: The Bayesian Approach. Accessible philosophy of statistics by Howson

Philosophy of Science: A Very Short Introduction by Okasha