

# Applying Science to Practice: How To Science

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# Evidence Based Medicine (EBM)



“The integration of the best available research, clinical expertise, and patient values and circumstances related to patient/client management, practice management, and health policy decision making.

- David Sackett

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“As EBM became more influential, it was also hijacked to serve agendas different from what it originally aimed for.”

“Science denialism and quacks are also flourishing and leading more people astray in their life choices, including health. EBM still remains an unmet goal, worthy to be attained.”



“Science... g and  
lead...  
incl...  
wort...  
goal,

# What the hell happened?!

[J Clin Epidemiol](#). 2016 May;73:82-6. doi: 10.1016/j.jclinepi.2016.02.012. Epub 2016 Mar 2.  
**Evidence-based medicine has been hijacked: a report to David Sackett.**  
[Ioannidis JP](#).

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# Bad Science



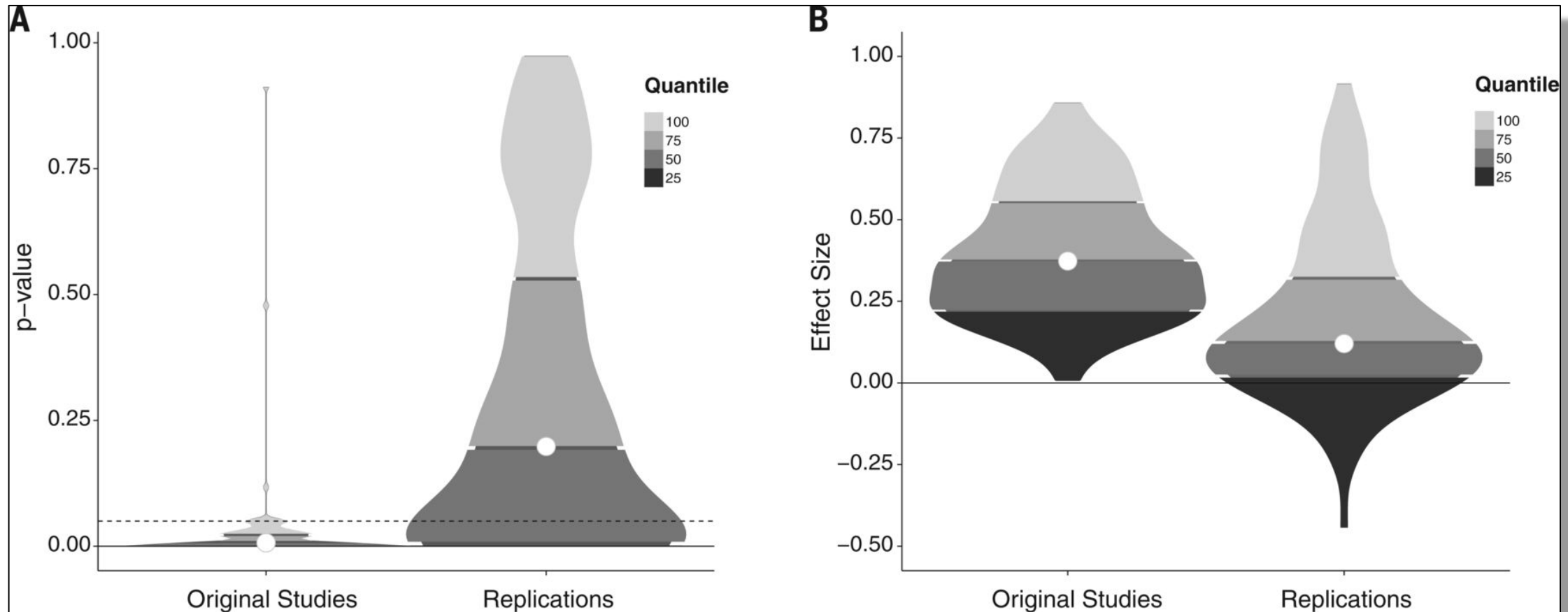


# Reproducibility

- Replicated 100 published experimental and correlational studies
- 97% of original studies had statistically significant results
- 36% of replications had statistically significant results

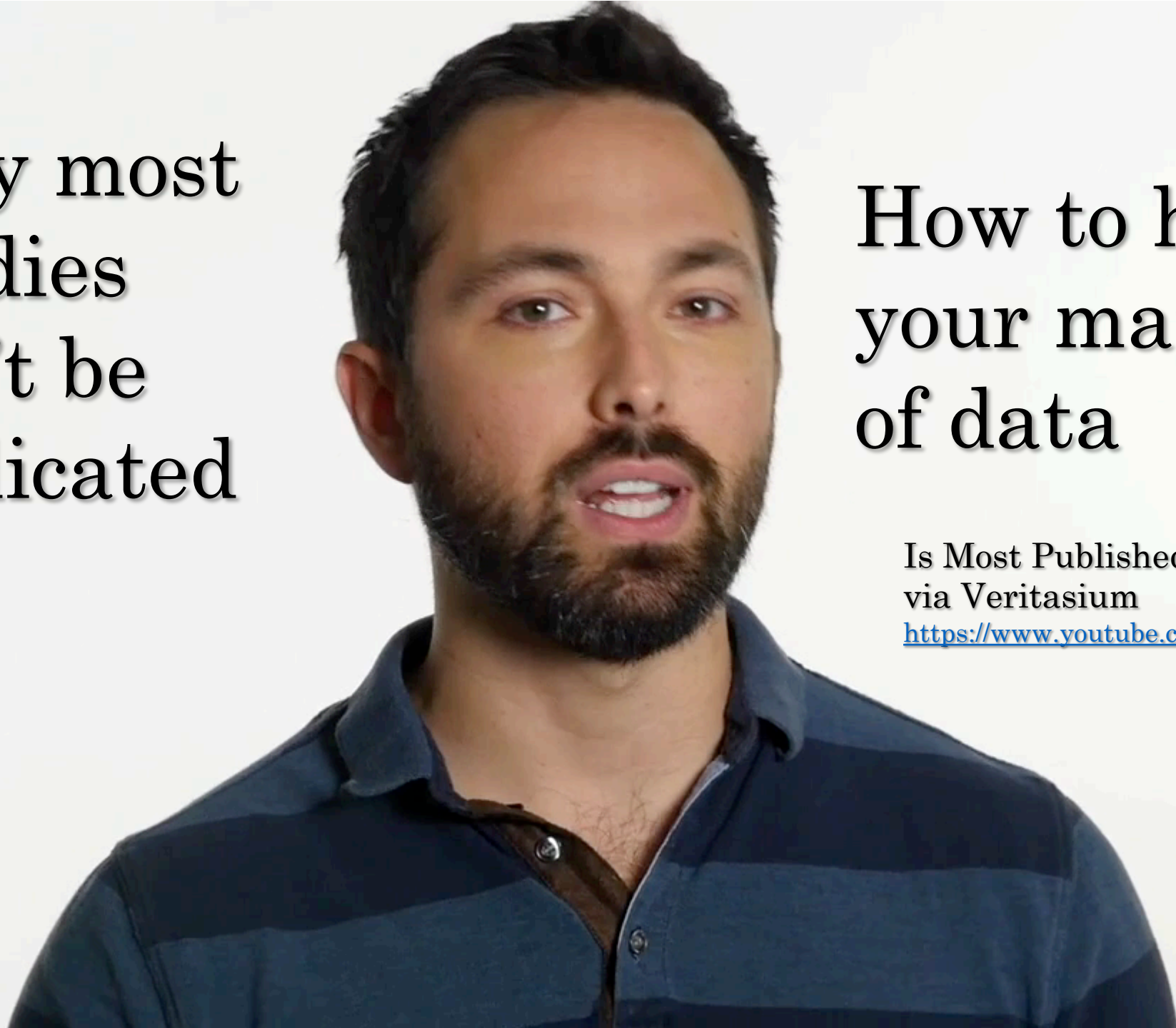


# Reproducibility



[Science](#). 2015 Aug 28;349(6251):aac4716. doi: 10.1126/science.aac4716.  
**PSYCHOLOGY. Estimating the reproducibility of psychological science.**  
[Open Science Collaboration](#).

Why most  
studies  
can't be  
replicated



How to hide  
your manipulation  
of data

Is Most Published Research Wrong?  
via Veritasium

<https://www.youtube.com/watch?v=42QuXLucH3Q>

# Key Point!

## Mechanisms of Bad “Science” (not actually science)

- Testing to see if a hypothesis is “true”
  - Seeking evidence in support of a desired conclusion
  - Study design does not rule out competing hypotheses/poor controls
- HARKing
  - Hypothesis After Results are Known
  - Presents post hoc hypothesis (one based on or informed by one's results) as if it were an a priori hypotheses
- P-Hacking
  - Retrospectively slicing data until  $p < 0.05$  emerges
  - Track more variables than the study was powered for
  - Only reports “significant” findings, hiding full scope of investigation



“There is no  
cost to getting  
things **WRONG**...

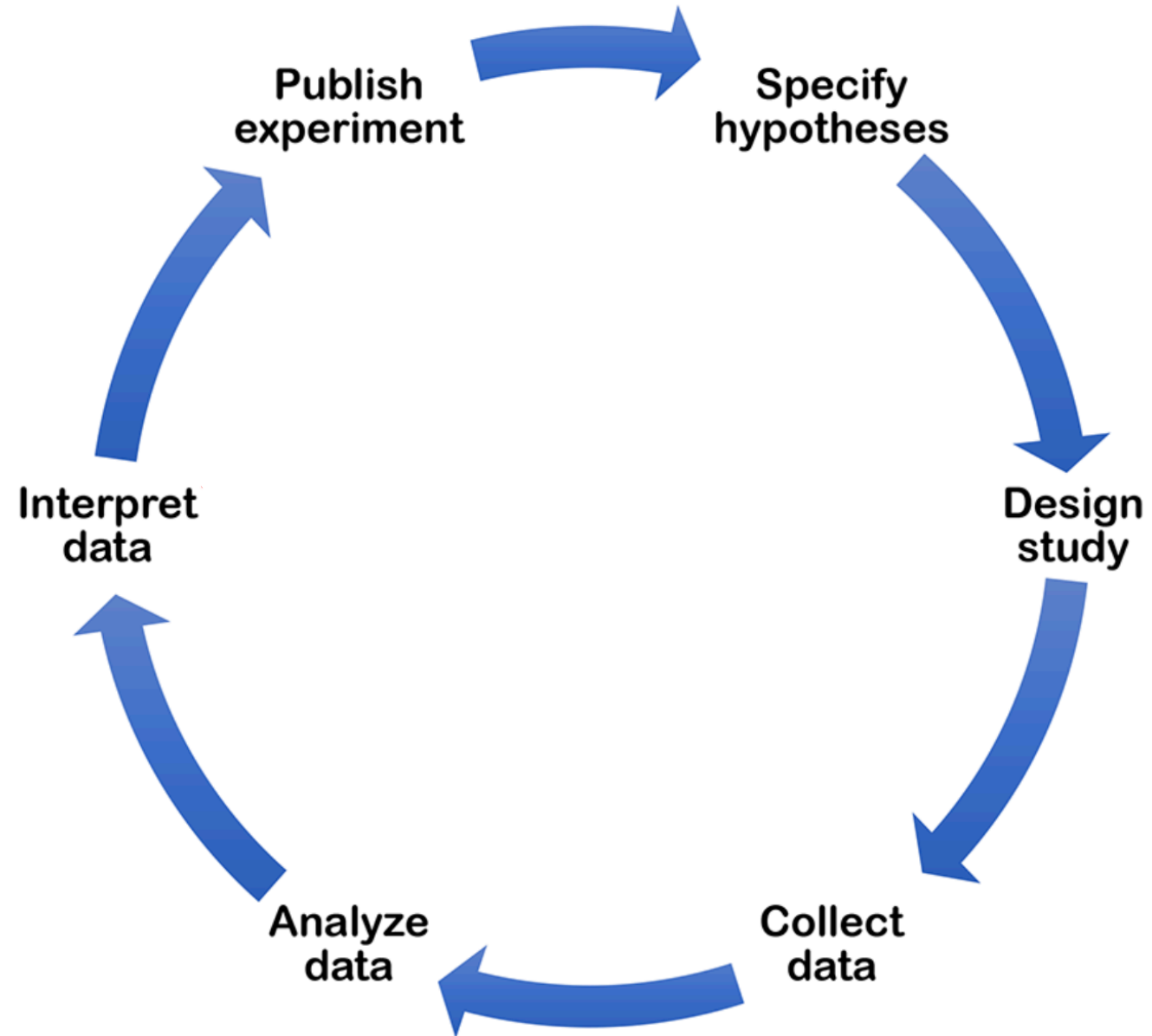


...the cost is not  
getting them  
**PUBLISHED.**”

Is Most Published Research Wrong?  
via Veritasium

<https://www.youtube.com/watch?v=42QuXLucH3Q>





<https://cos.io/rr/>

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# Understanding Uncertainty

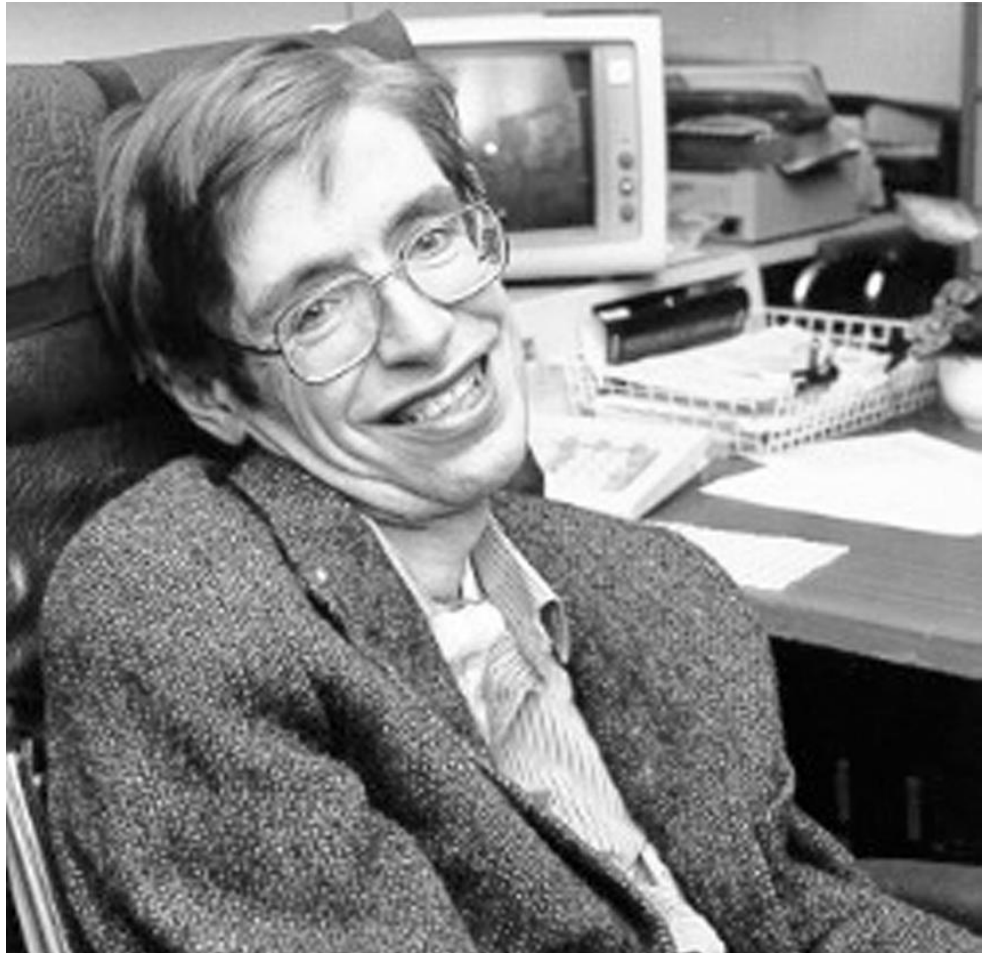
“Intelligent people can handle subtlety. They are not baffled by ambiguous or even contradictory situations—in fact, they expect them and are apt to become suspicious when things seem overly straightforward.”

- Neal Stephenson, *The Diamond Age*





# Uncertainty



“The greatest enemy of knowledge is not ignorance, it is the illusion of knowledge.”

- Stephen Hawking

# Uncertainty



“What I do not know I do not think I know...”

- Socrates



# Do Orthopaedic Surgeons Acknowledge Uncertainty?

- Level I prognostic study exploring uncertainty and overconfidence bias among orthopaedic surgeons
- Compared tendencies towards overconfidence with surgeon demographics and responses to clinical situations



You are confronted with an uncertain situation, perhaps a decision to operate or treat nonoperatively, where both choices seem reasonable and the decision is difficult; your response to a patient asking you a question about how the outcome would be different between the two is (pick your most typical response):



Best

I do not know which treatment is best

Next  
Worst

I am not entirely sure, and I am going  
to try to look this up

We, in the medical community, don't  
know the answer to that; some things  
are just not known

I make a guess based on what is most  
probable, because patients do not  
respond well to uncertainty, and my  
role is to not only treat to the best of  
my ability, but to provide reassurance

Worst

This does not happen often enough to  
me in my field of specialty practice for  
me to have a typical response; most of  
what I do is quite certain and well  
studied

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# Belief vs Epistemology

- Belief refers to *WHAT* you believe
  - Dry needling is effective
  - The Earth goes around the Sun
  - Extensive back hair is considered attractive
- Epistemology refers to *WHY* you believe
  - It makes sense

“It makes sense...”



**Why are you arguing  
with me?! This idea  
makes so much sense  
to me it has to be  
TRUE!!!**





**Just because it makes sense,  
even a lot of sense,  
doesn't make it true...**



# Belief vs Epistemology

*Key Point!*

- Belief refers to *WHAT* you believe
  - Dry needling is effective
  - The Earth goes around the Sun
  - Extensive back hair is considered attractive
- Epistemology refers to *WHY* you believe
  - It makes sense
  - I heard it from some person I like
  - I saw it on the internet
  - It fits with the way I see the world
  - I used the scientific method – critical thinking

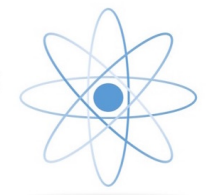
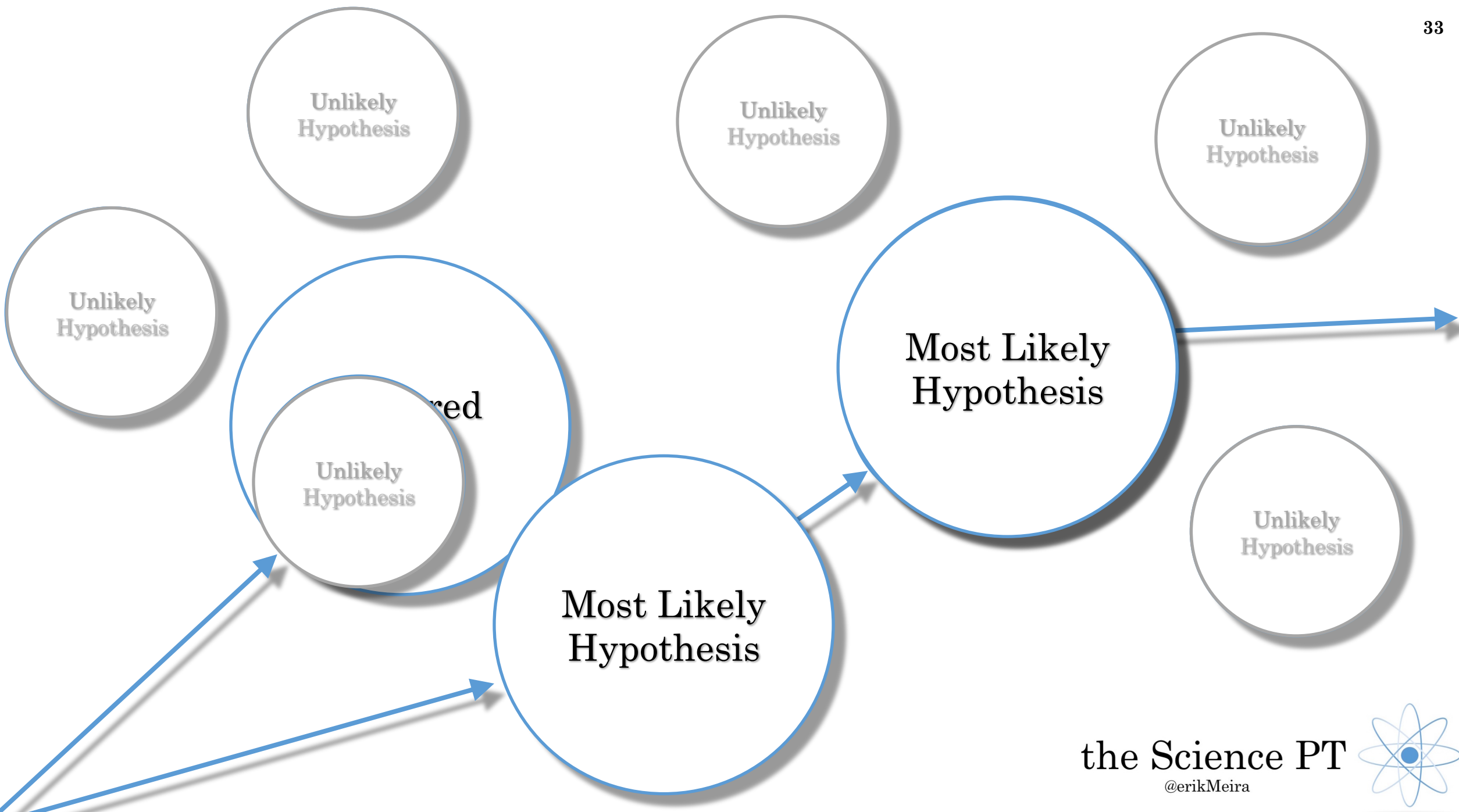


# What is “Science”?

*Key Point!*

- The search for *objective* knowledge
- *Objective* knowledge refers to objects and processes that exist independently of us and our beliefs or language about them
- Contrast against *subjective* knowledge which refers to personal truths based on individual perceptions
- Science is an epistemology for separating the two - which is really, *really*, difficult
- Requires critical thinking



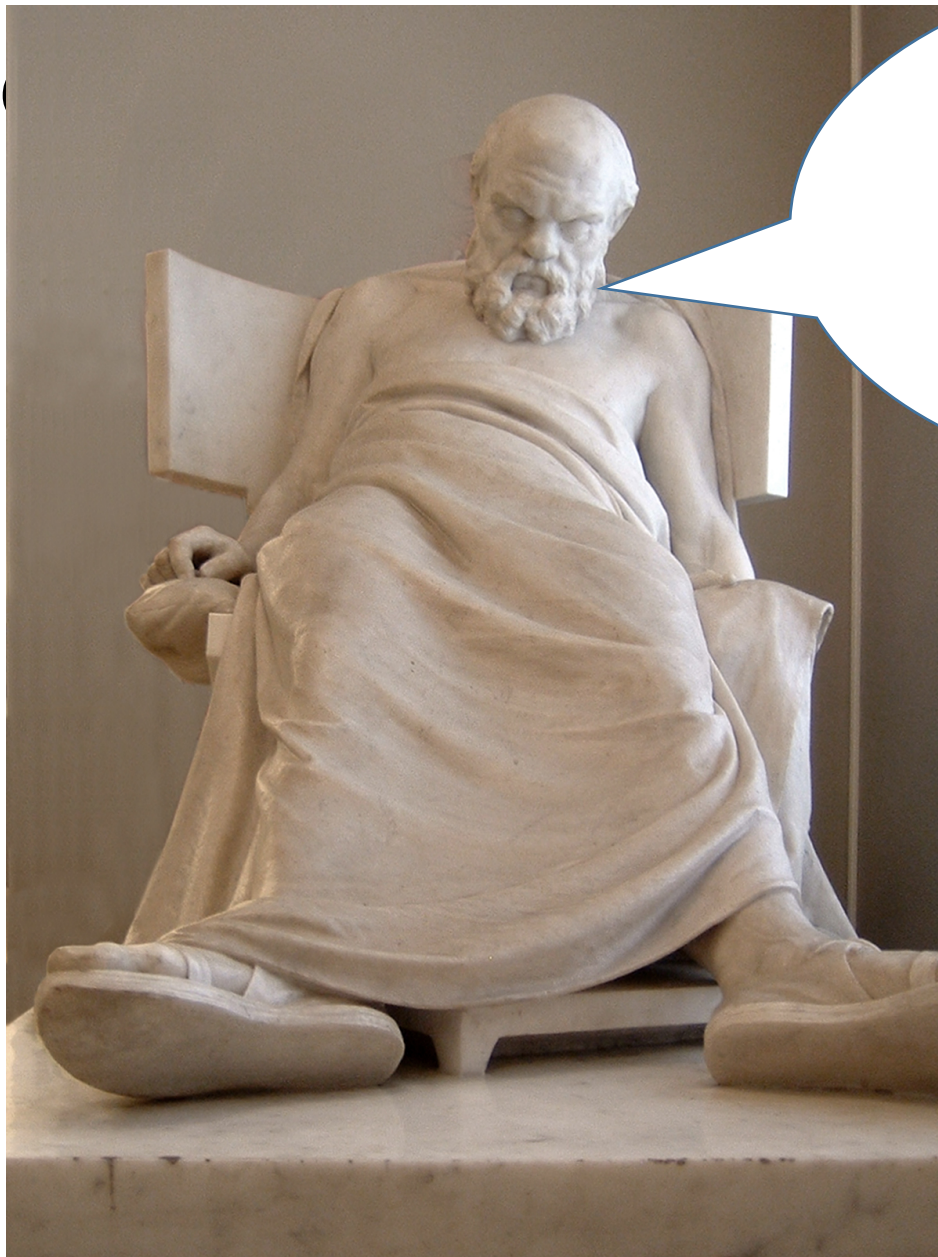


# Beliefs vs Epistemology

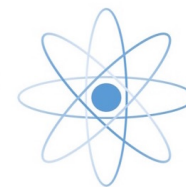
- Argue epistemology not beliefs
  - Why do you think that?
  - What else could be defended using that reasoning?
  - Why do you support this over here *but reject that over there?*
  - What would it take to convince you that you are wrong?



The So



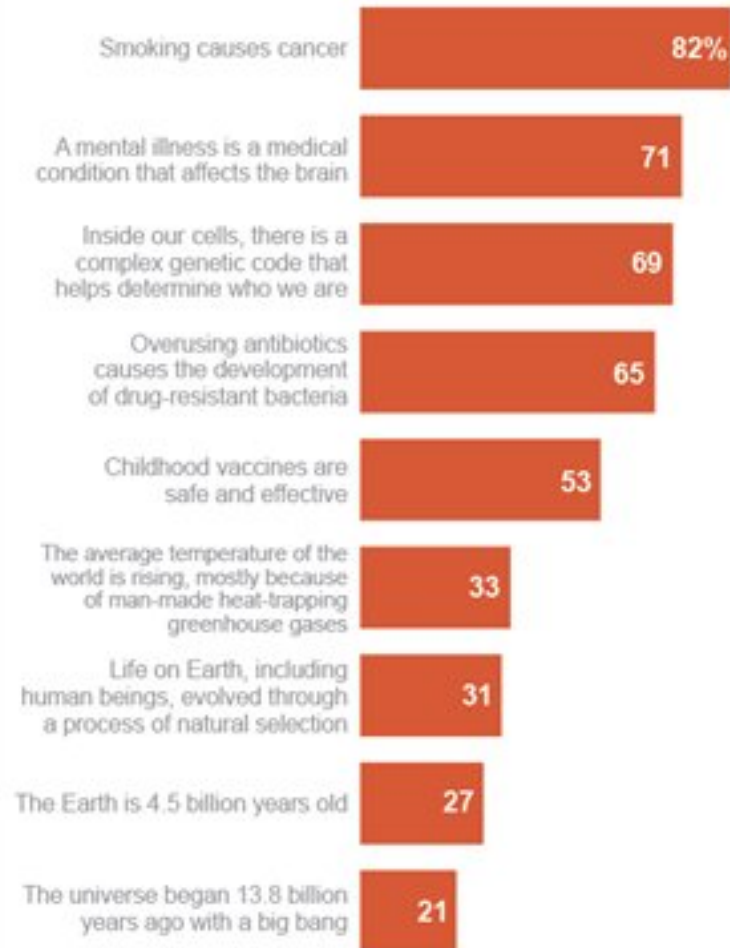
**LOL!**



## Science and skepticism

U.S. adults buy some concepts scientists consider truths but are broadly skeptical of others, an AP-GfK poll finds.

Percentage answering "extremely confident" or "very confident" that each statement is correct:



NOTE: Poll results are based on interviews March 20 to 24 with 1,012 U.S. adults. Margin of error is  $\pm 3.4$  percentage points.

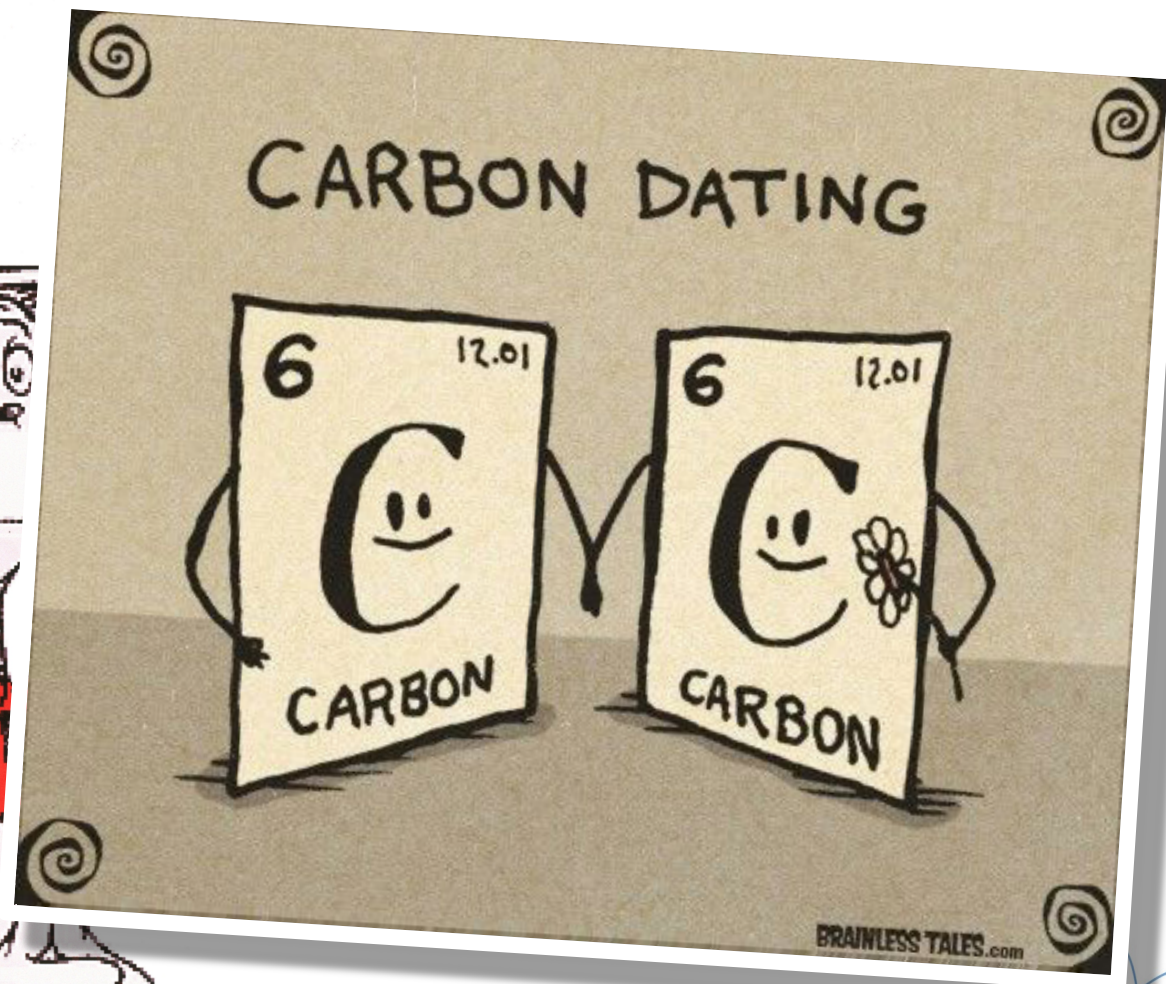
SOURCE: GfK Public Affairs & Corporate Communications

AP

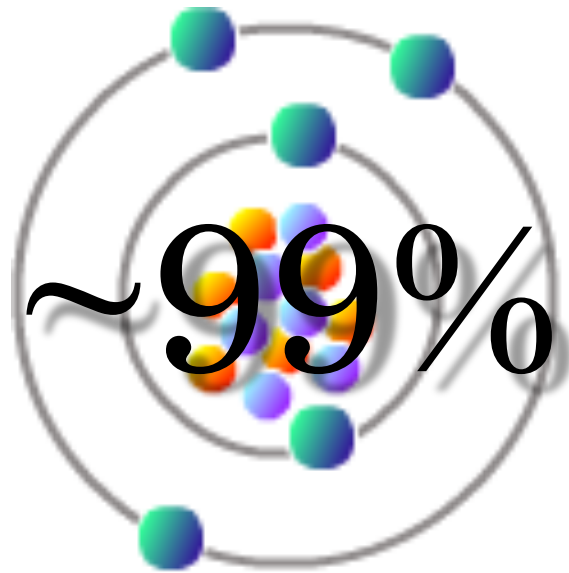
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# Dr Suess







**Carbon**

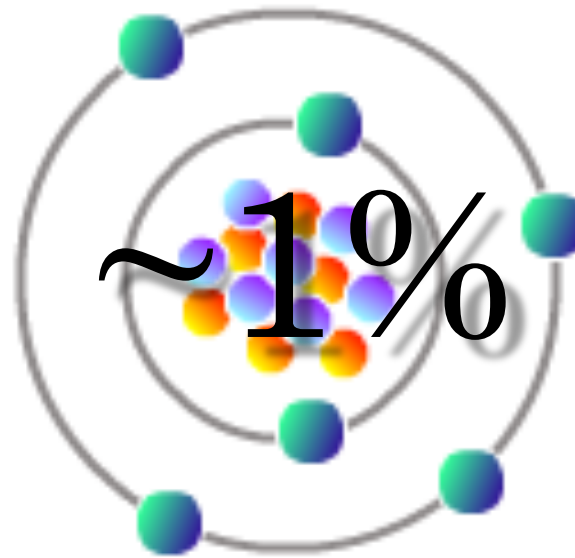
● 6 Protons

● 6 Neutrons

**Nuclear number**

$$= 6 + 6$$

$$= 12$$



**Carbon-13**

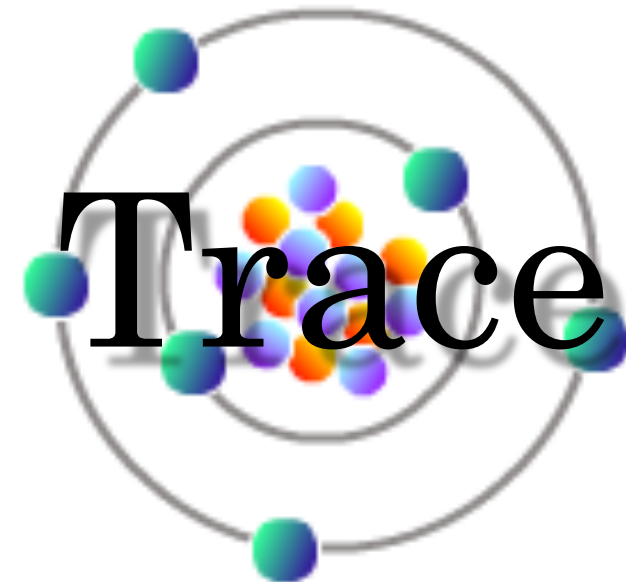
● 6 Protons

● 7 Neutrons

**Nuclear number**

$$= 6 + 7$$

$$= 13$$



**Carbon-14**

● 6 Protons

● 8 Neutrons

**Nuclear number**

$$= 6 + 8$$

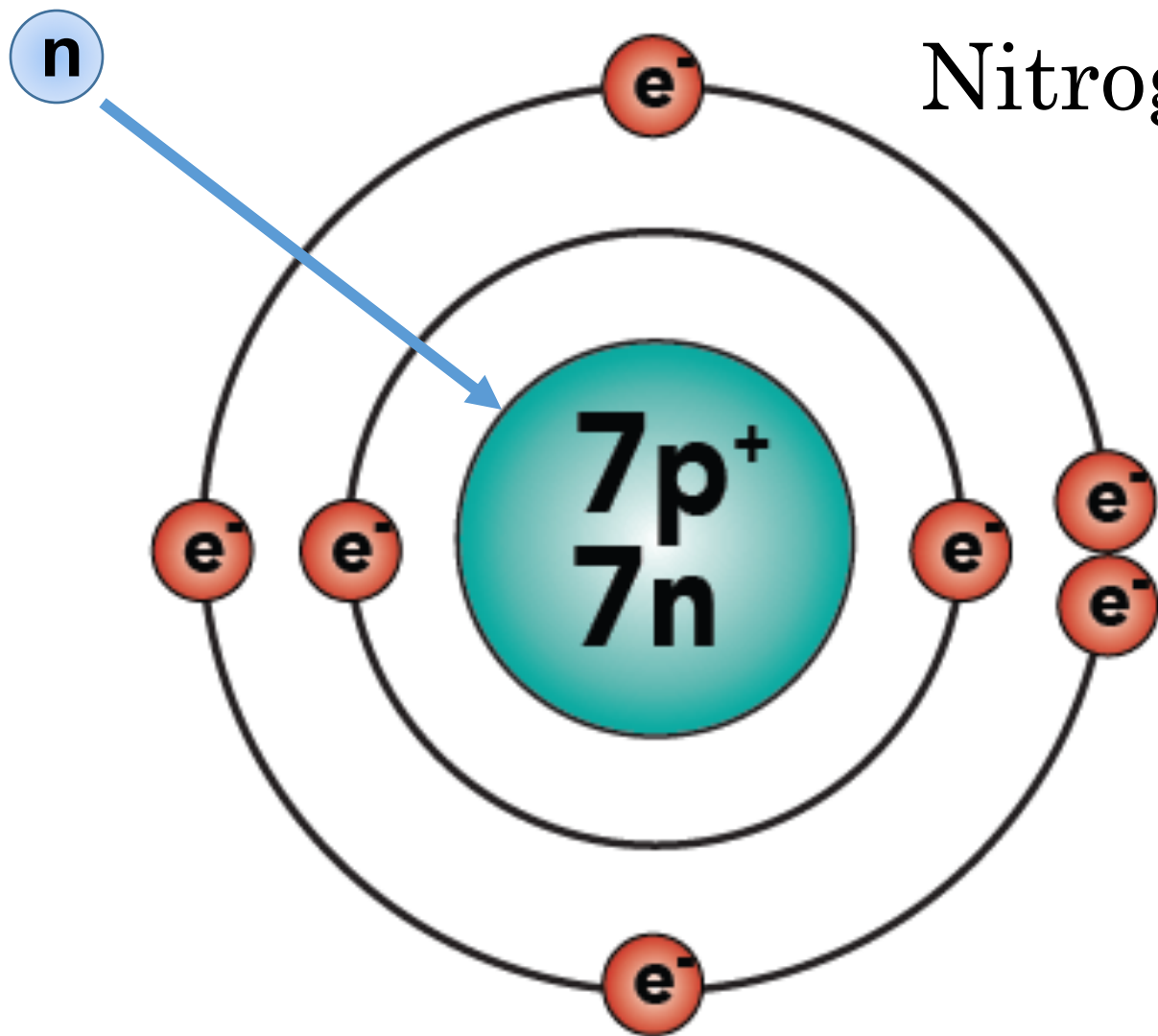
$$= 14$$

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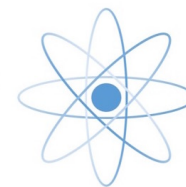


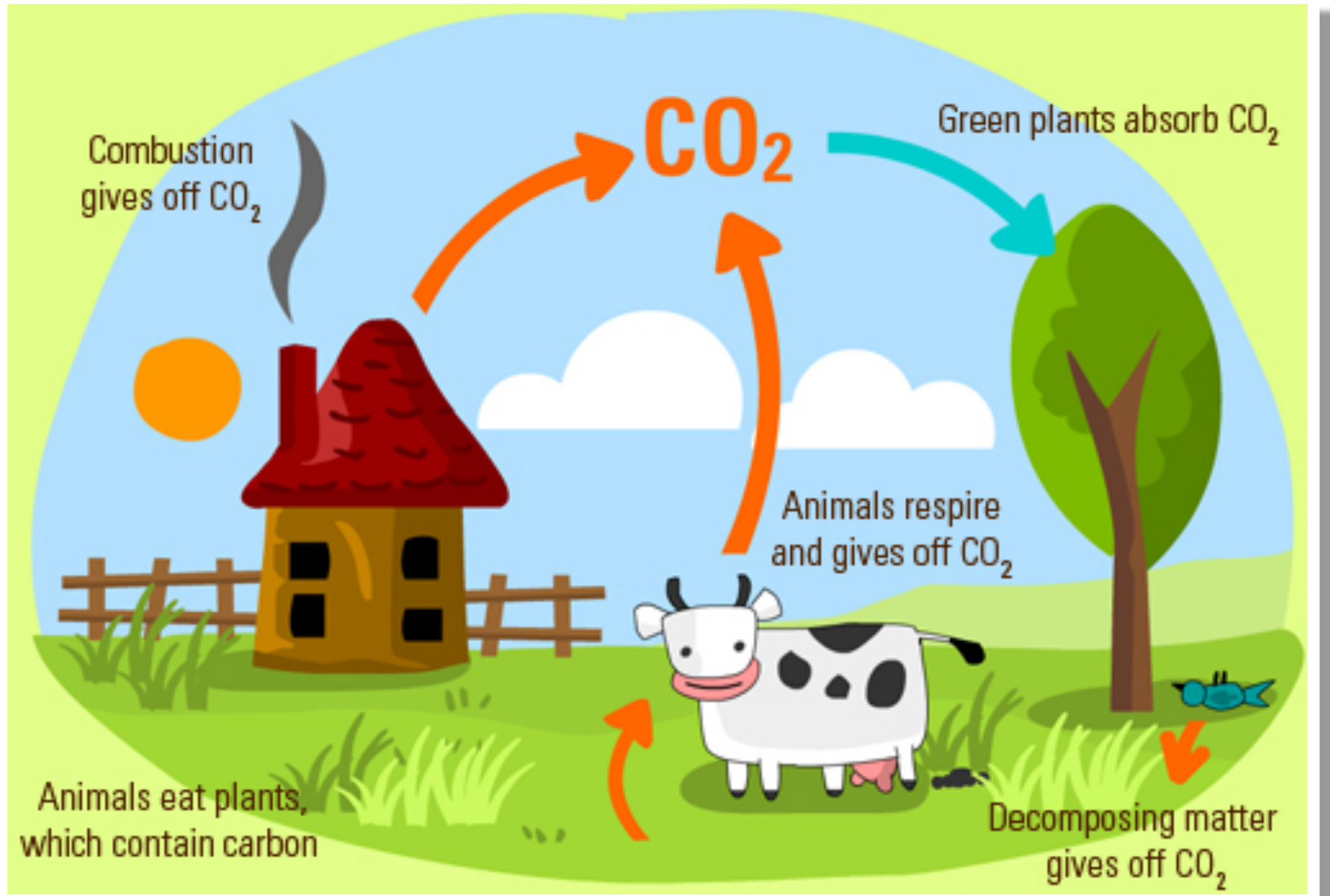
Nitrogen-14



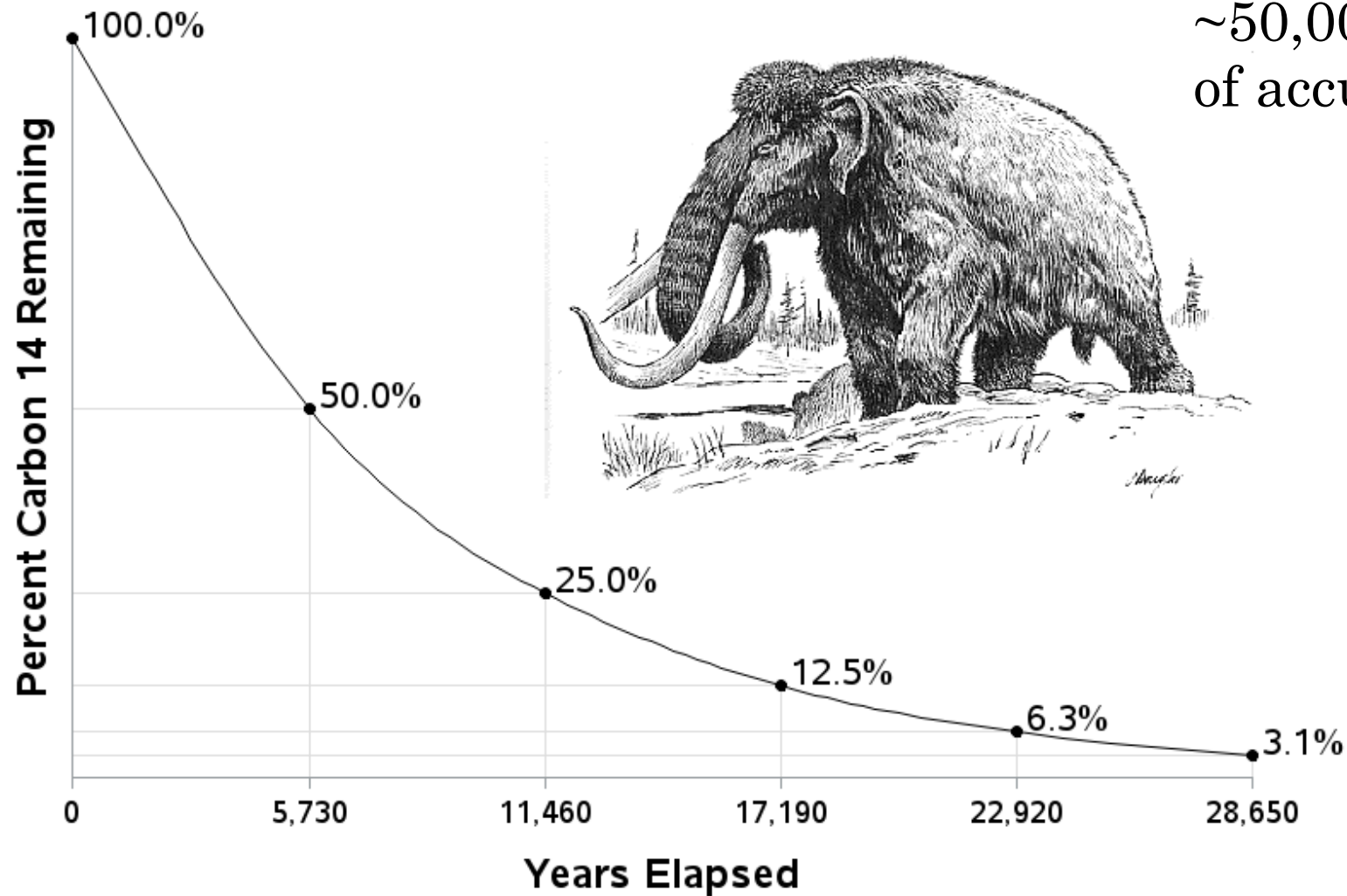
$6p^+$   
 $8n$

Carbon-14

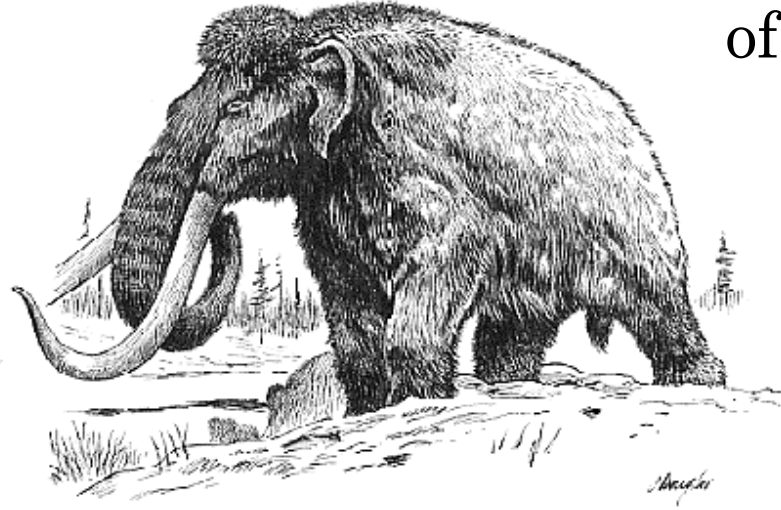




## Rate of Decay for Carbon 14



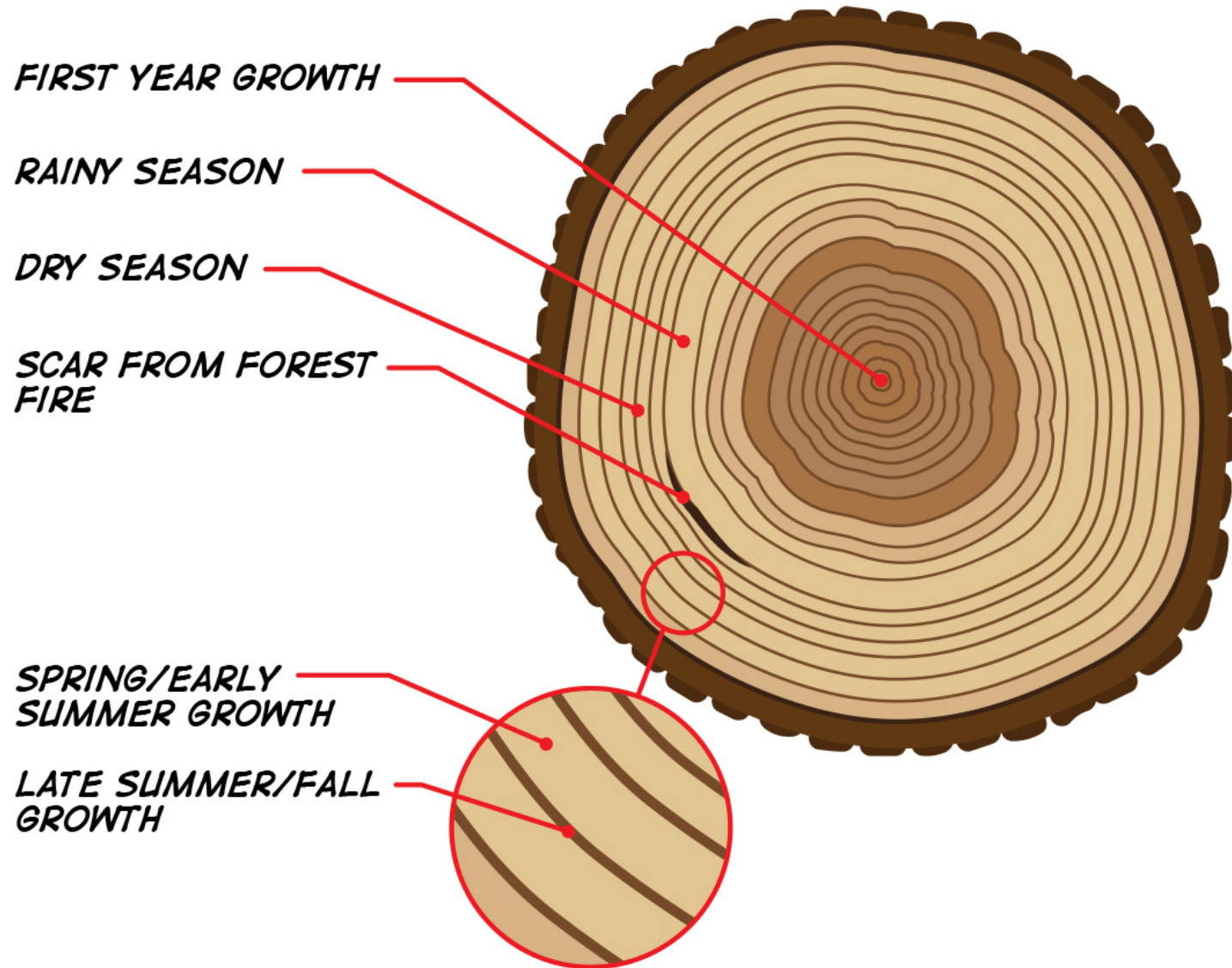
~50,000 – 75,000 yrs  
of accuracy

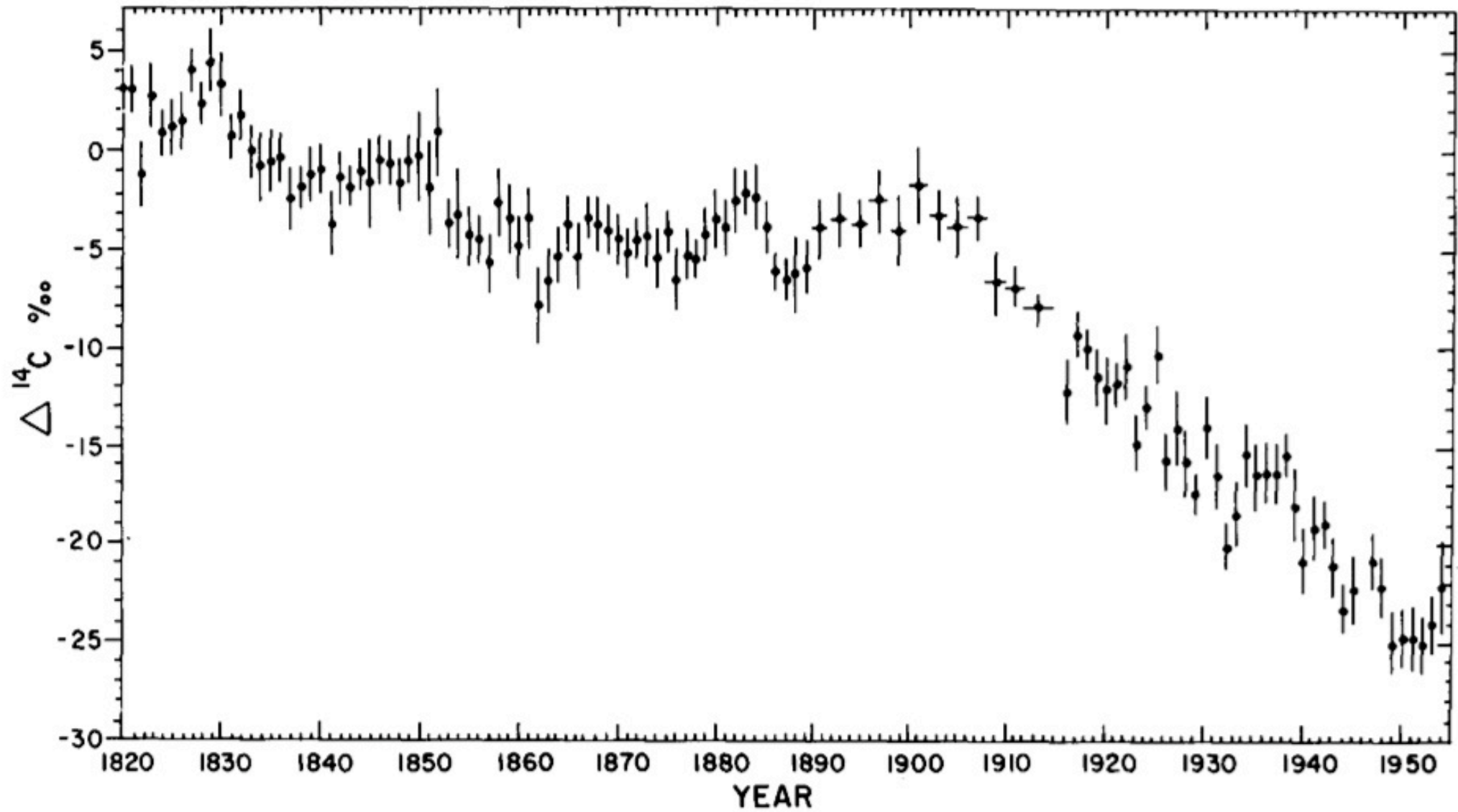


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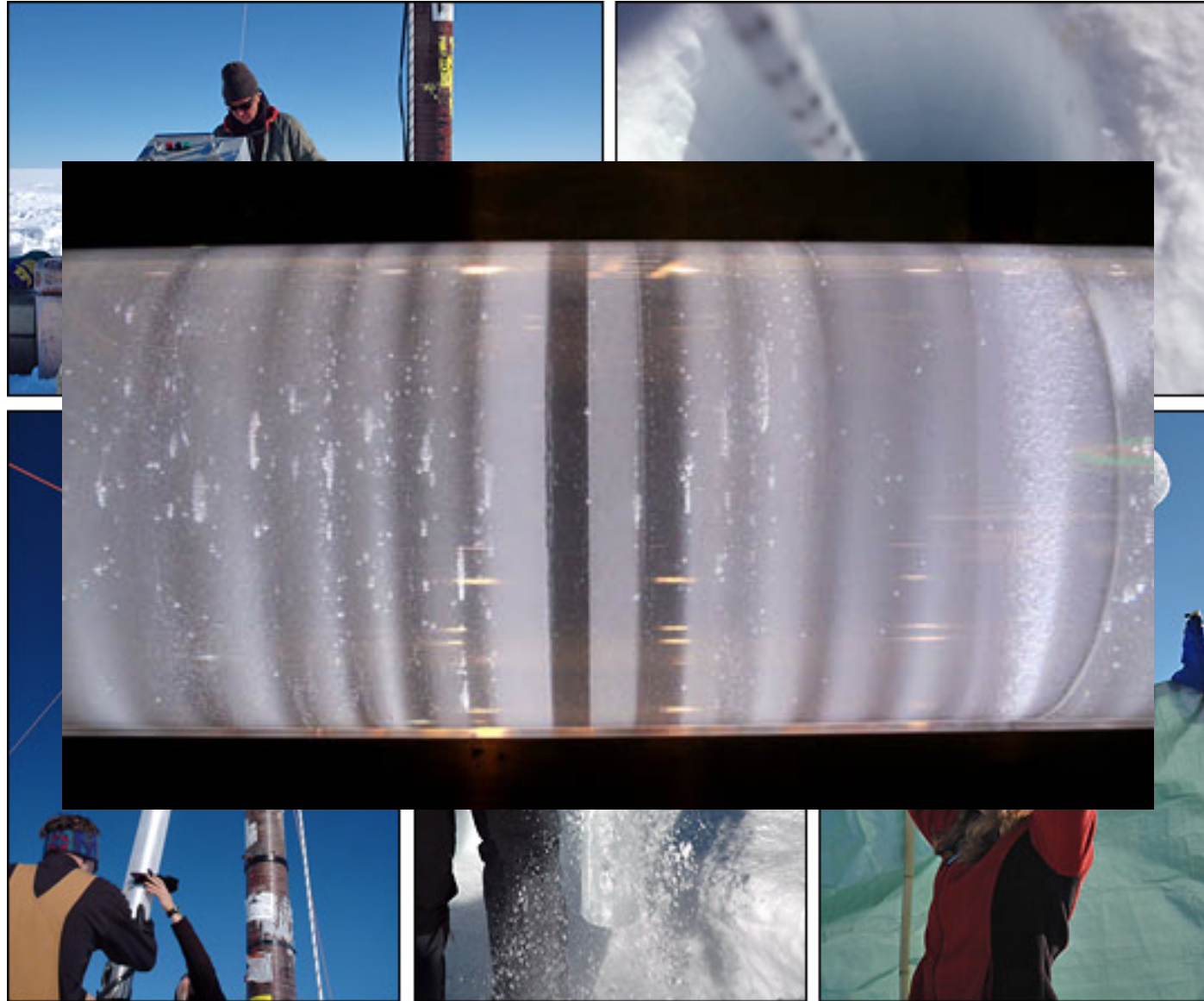
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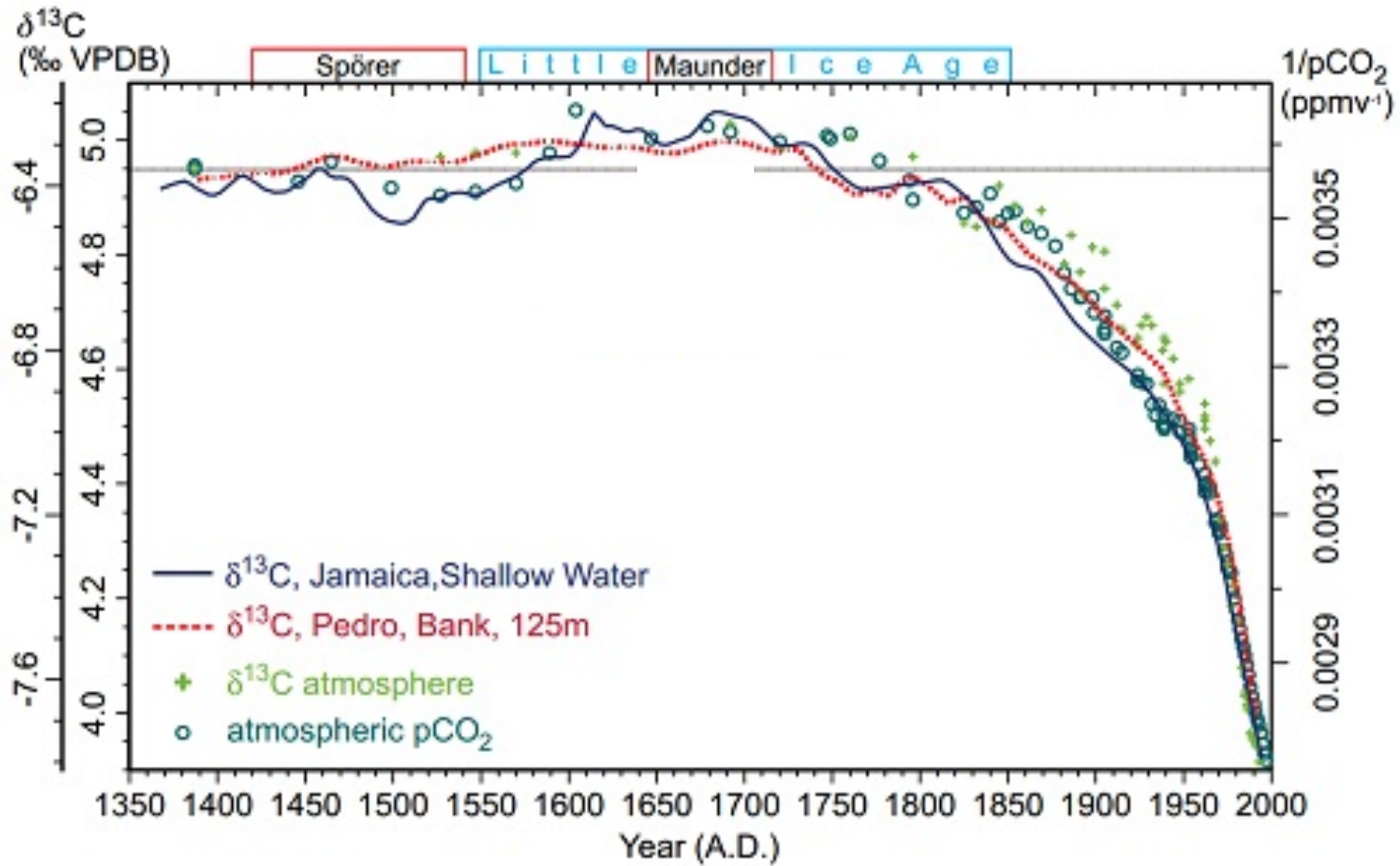


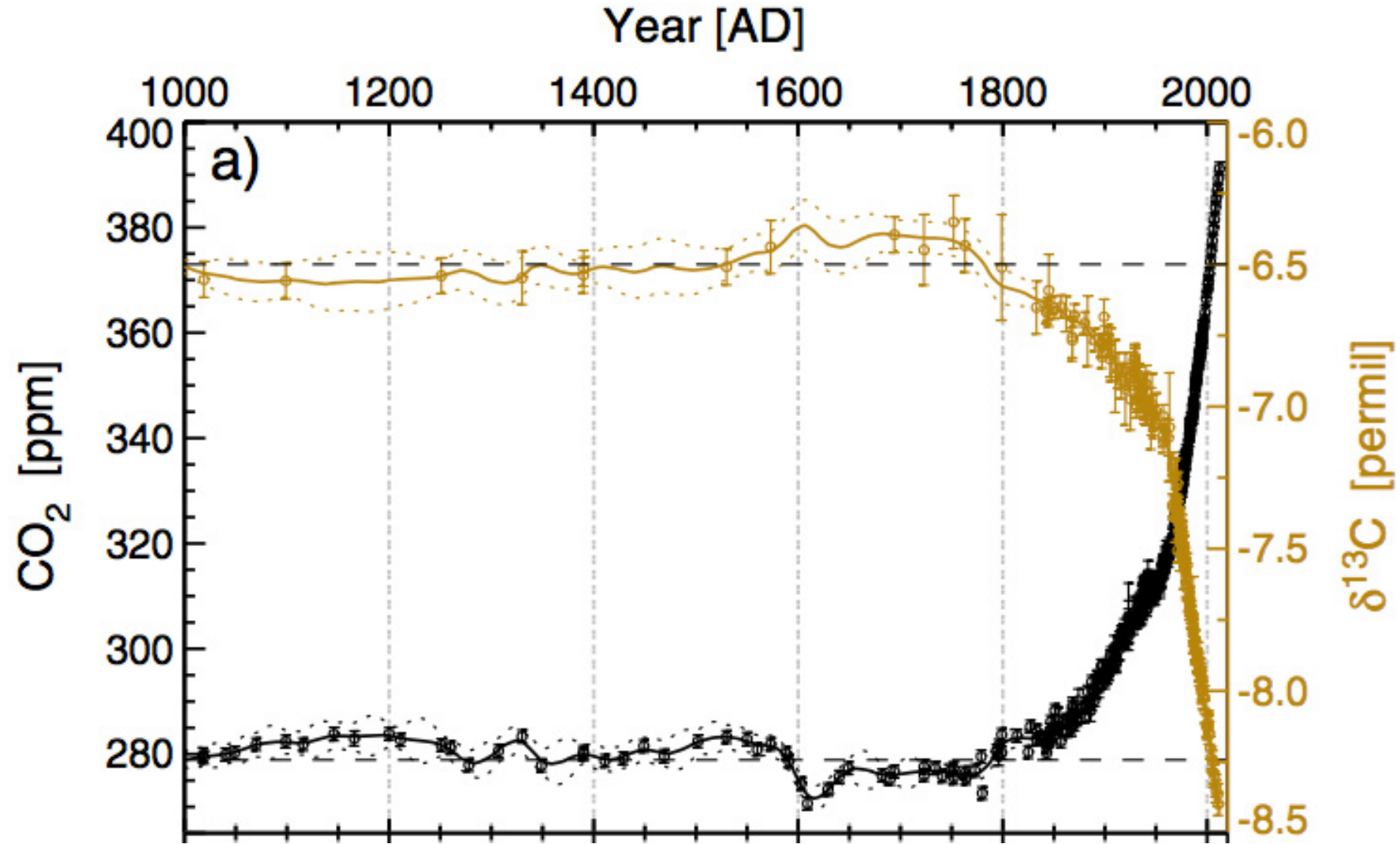
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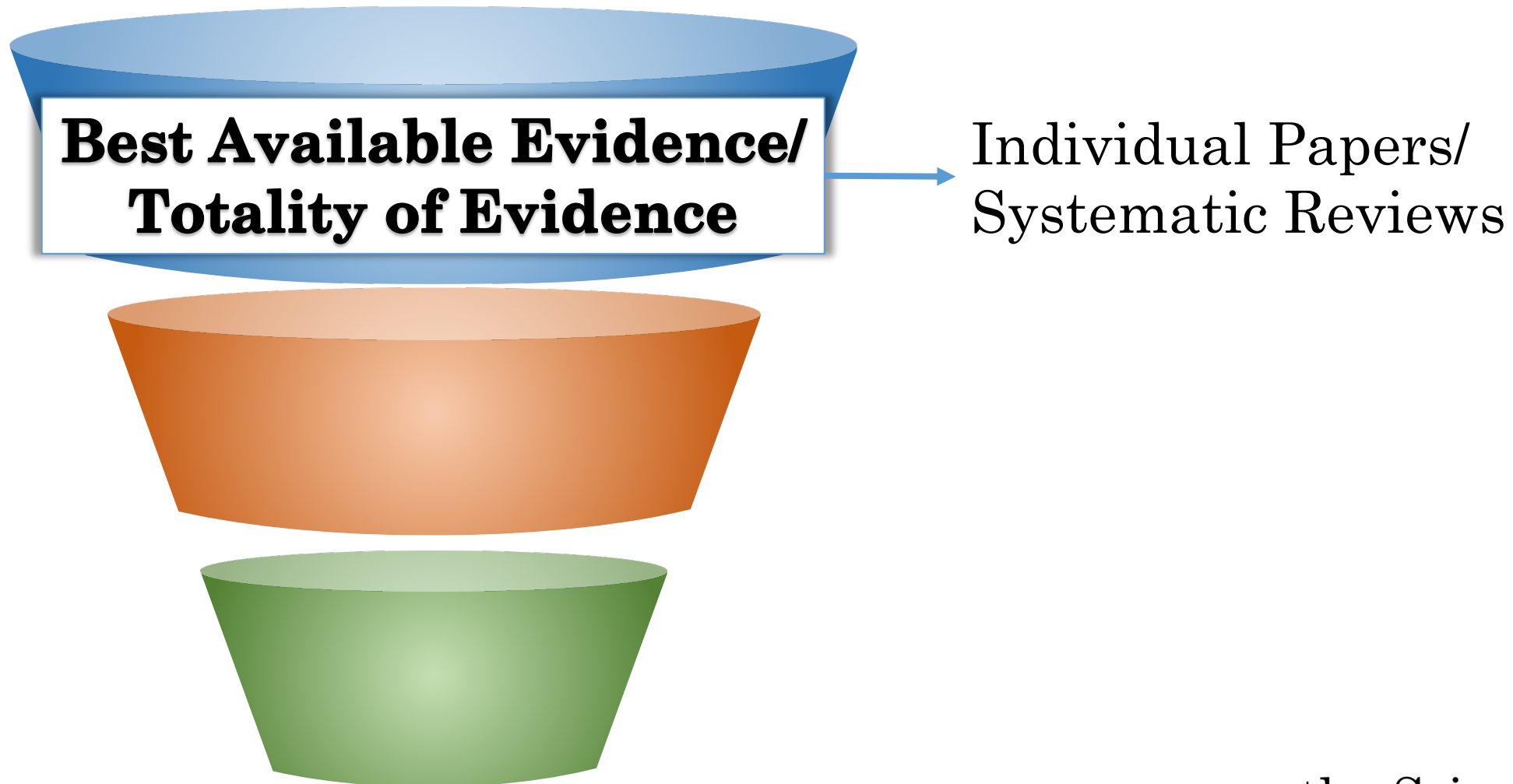


# 3 Epistemological Principles of EBM

- They are **NOT** equal components that are weighed individually
- They are a series of epistemological principles to guide the provider to the most accurate objective information regarding the patient in front of them
- The patient's values and circumstances are then applied for final decision

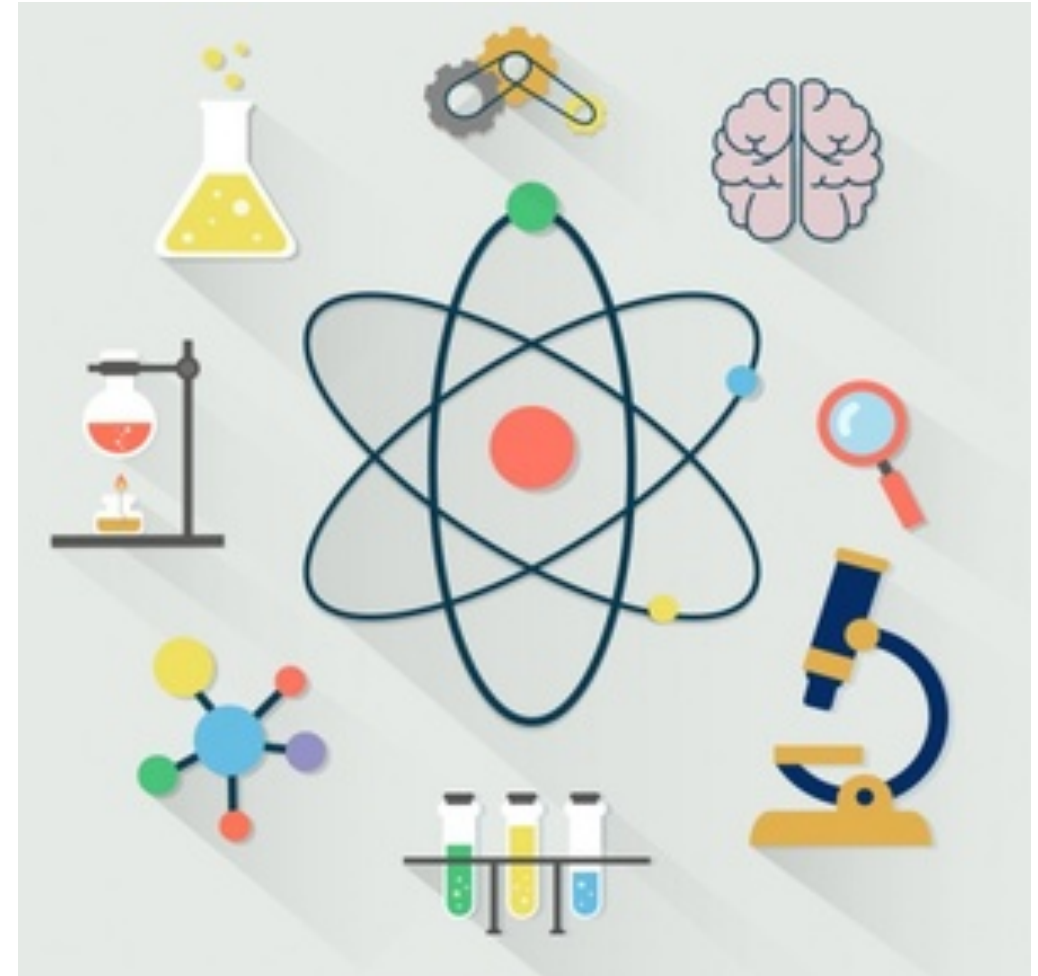


# EBM is a funnel not a stool...



# Totality of Evidence

- All levels of literature
  - Published papers of varying design and quality
    - RCT
    - Basic science
    - Observational
    - Case studies

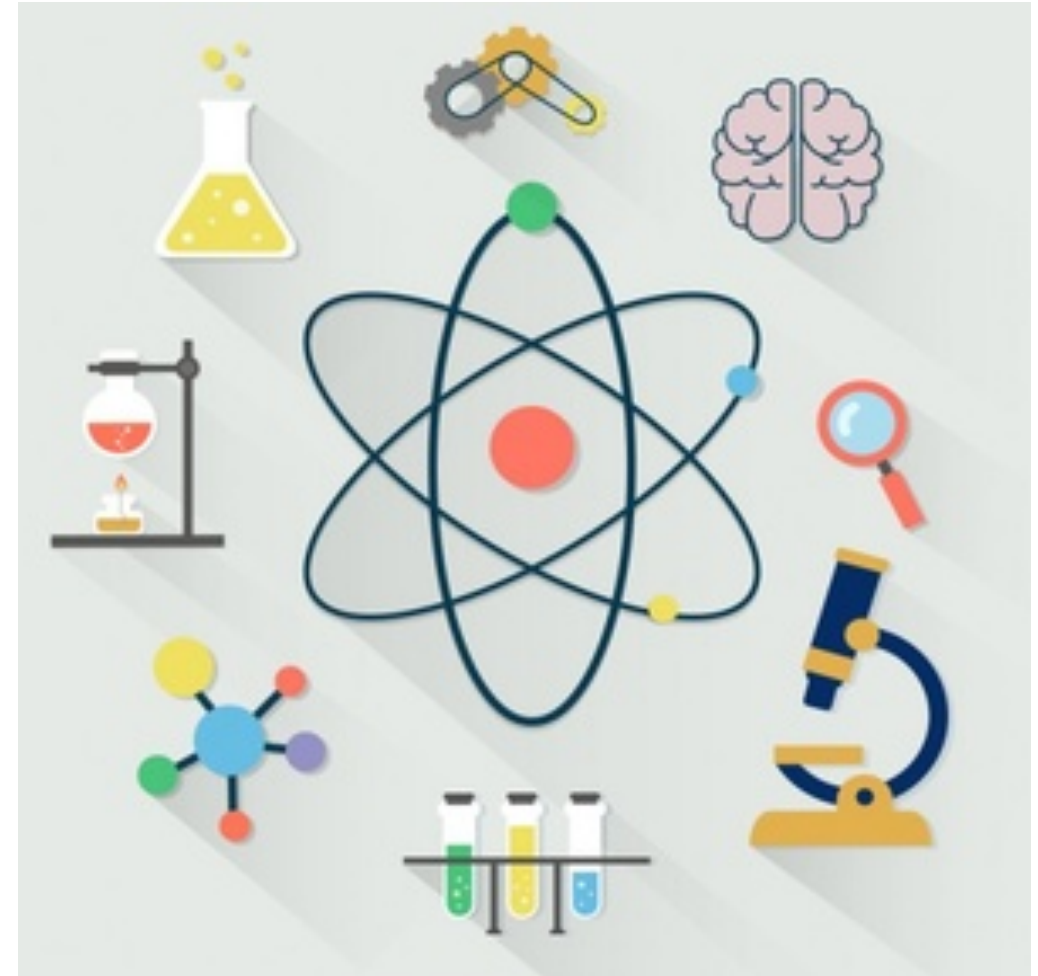


**If one study changes  
EVERYTHING for you it is  
because you only read  
one study!!!**



# Totality of Evidence

- All levels of literature
  - Published papers of varying design and quality
    - RCT
    - Basic science
    - Observational
    - Case studies
    - Poorly conducted garbage





# Pre-trial Solutions

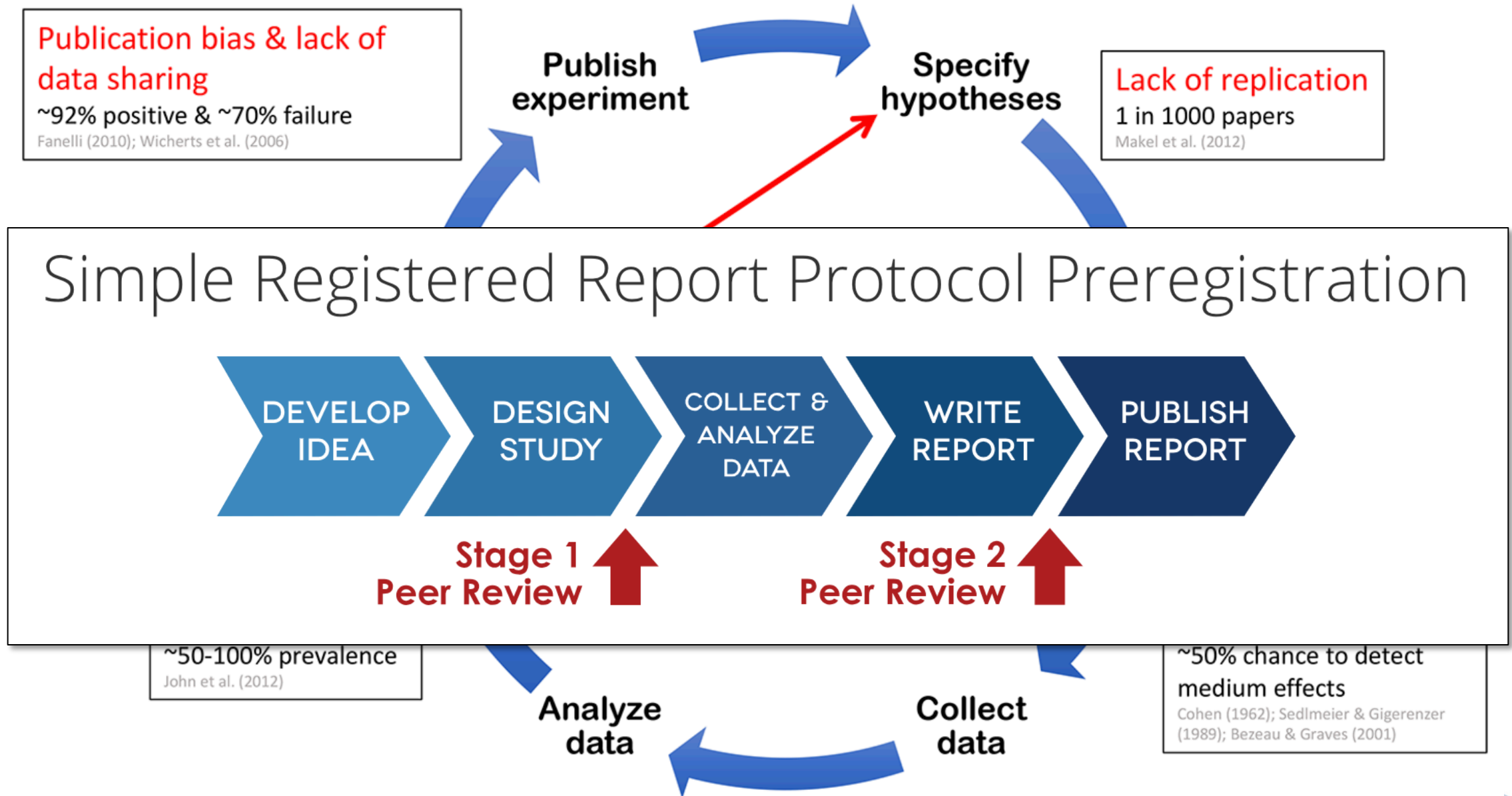
## Pre-trial Registration

- Registering a trial before data collection begins
- Reports on:
  - Primary/secondary outcomes
  - Design/Methodology
- All cards on the table
- [ClinicalTrials.gov](https://www.clinicaltrials.gov)

## Registered Report

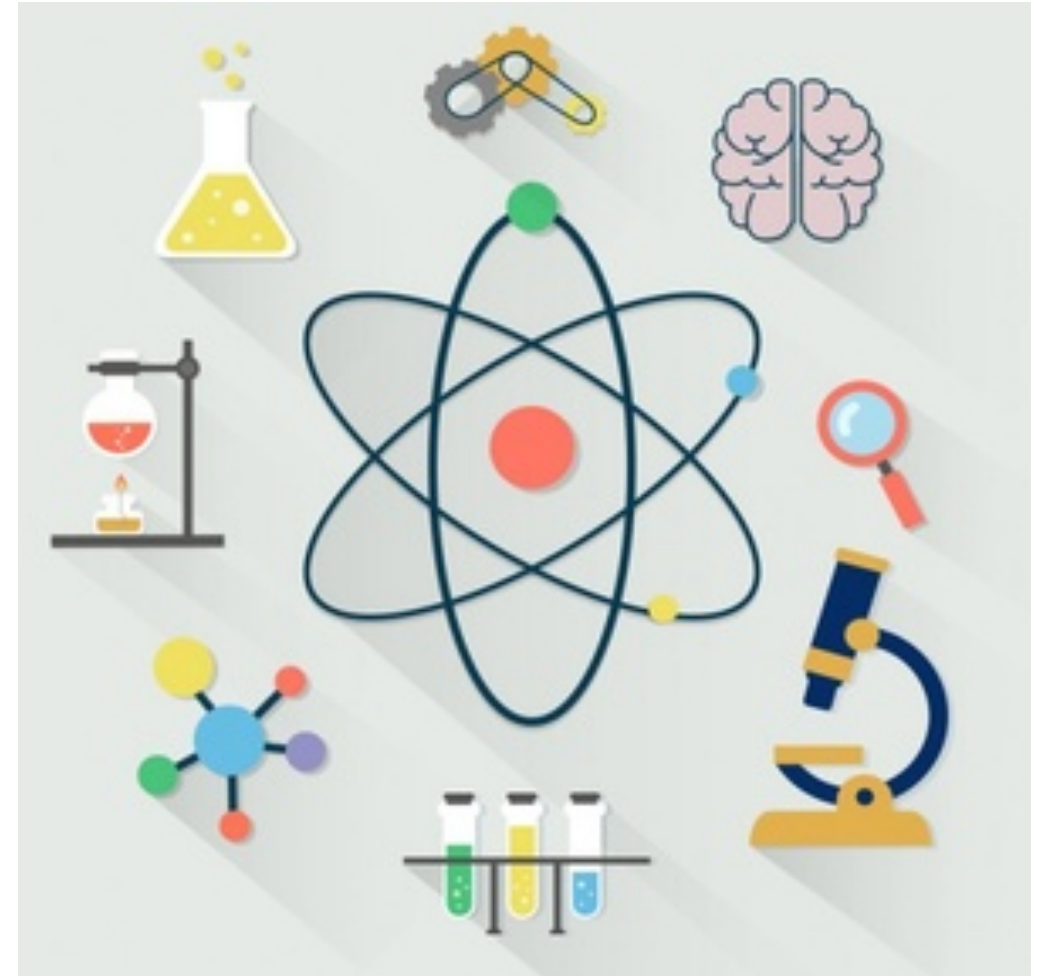
- Having a trial peer reviewed before data collection begins
- Reviewers comment on design/methodology and advise on corrections
- Once accepted, final article is published regardless of findings
- [Open Science Framework](#)





# Totality of Evidence

- All levels of literature
  - Published papers of varying design and quality
    - RCT
    - Basic science
    - Observational
    - Case studies
    - Poorly conducted garbage
  - Efficacy vs effectiveness



# Efficacy vs Effectiveness

## **Efficacy**

- Eff “i” = Internally valid
- Lab controlled environment
- Mechanism
- How it works in a perfect situation

## **Effectiveness**

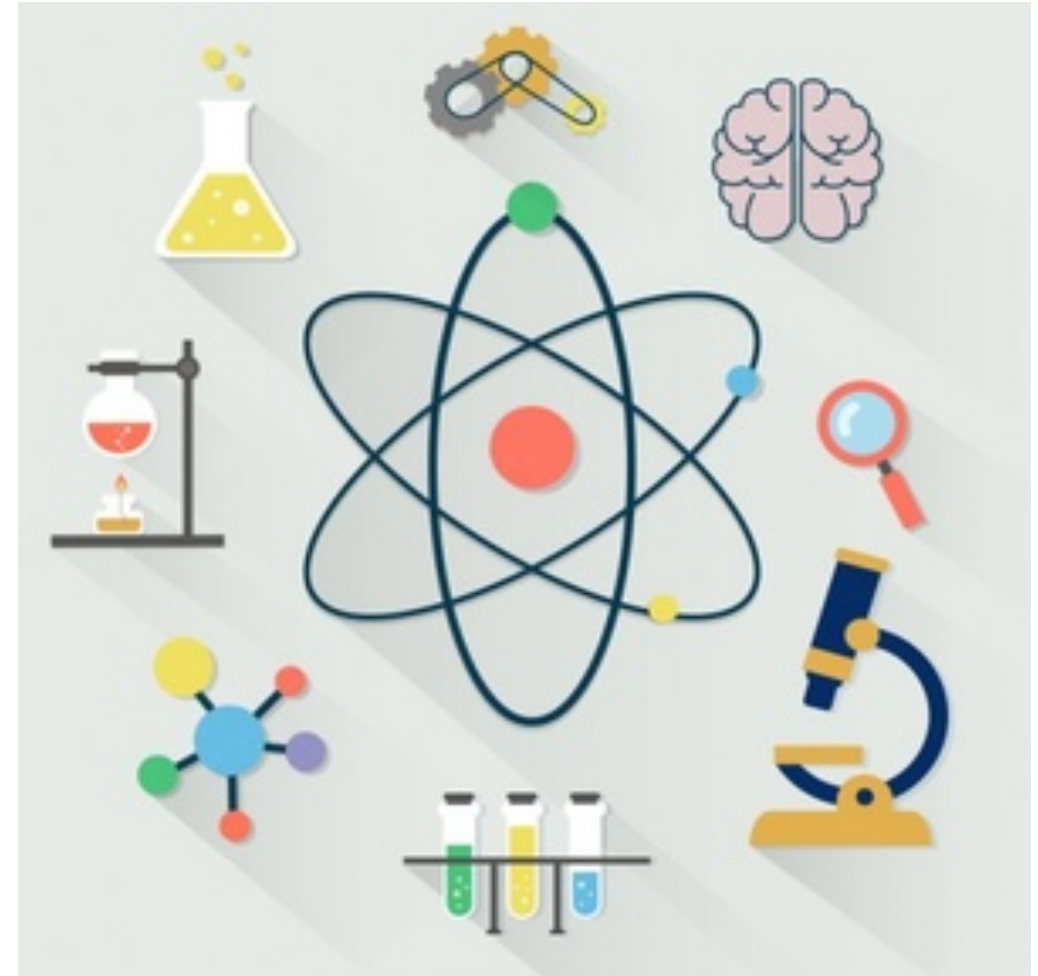
- Eff “e” = Externally valid
- Messy real world application
- Confounders
- How it works in practice

# Totality of Evidence

- All levels of literature
  - Published papers
  - Grey literature

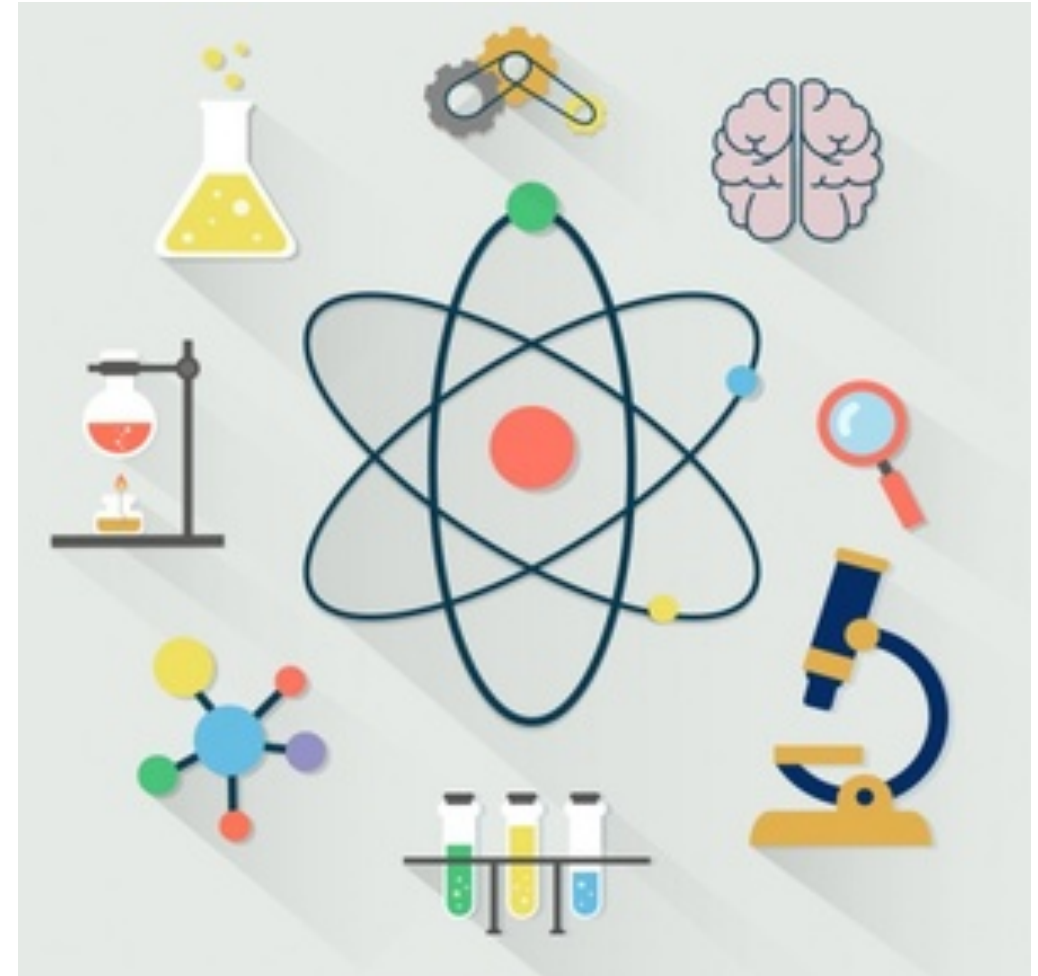
## Systematic Review

- Poorly conducted garbage
- Efficacy vs effectiveness

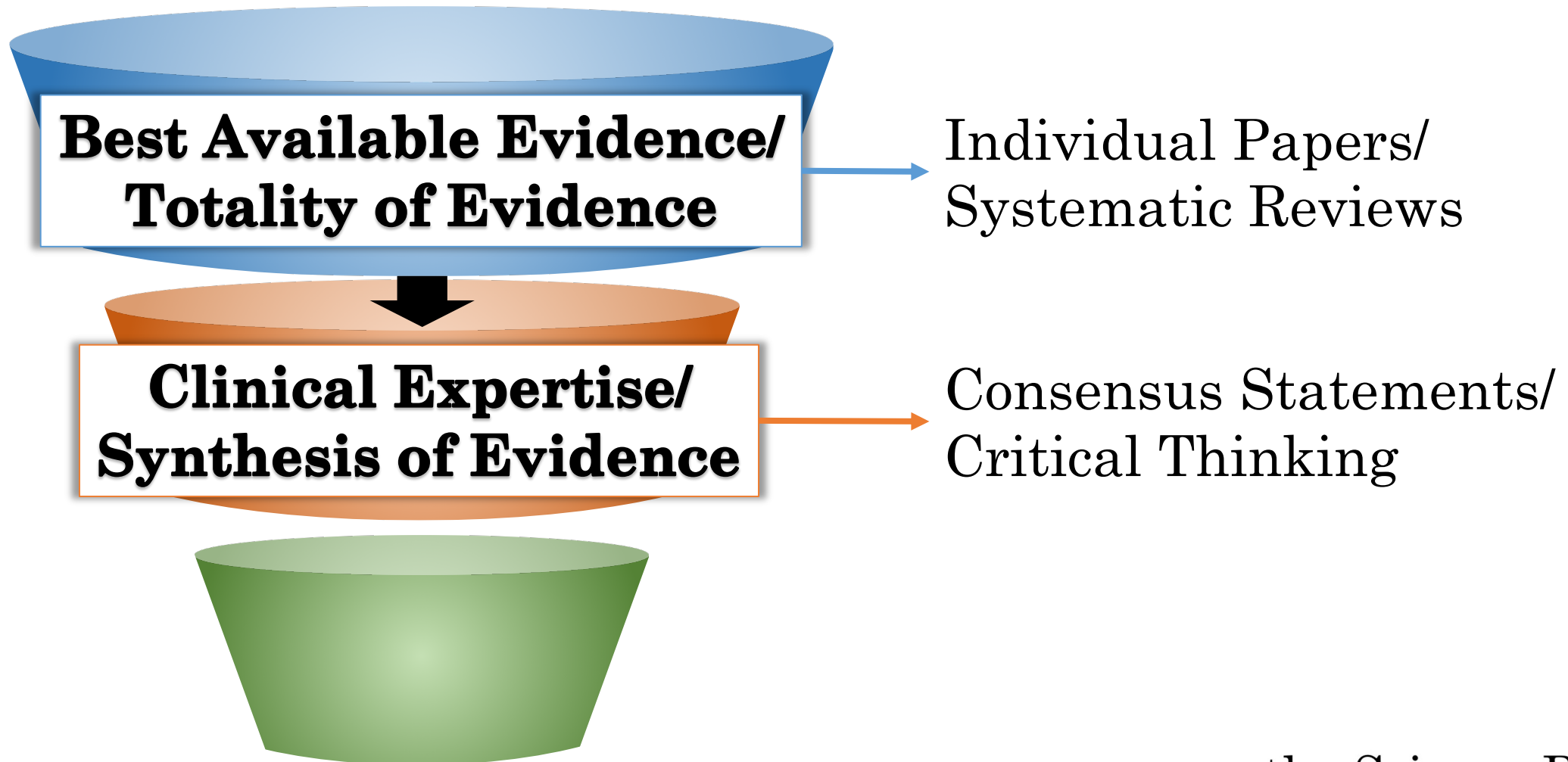


# Totality of Evidence

- All levels of literature
  - Published papers of varying design and quality
    - RCT
    - Basic science
    - Observational
    - Case studies
    - Poorly conducted garbage
  - Efficacy vs effectiveness
- What you see in the clinic



# EBM is a funnel not a stool...



Study quality?

idence

ature

- Published papers of varying design and quality

- RCT
- Basic science
- Observational studies

garba

ness

e clinic

What might I be missing?

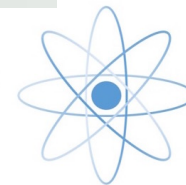


Remaining possibilities?

Placebo?

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Study quality? Evidence

nature

Remaining possibilities?

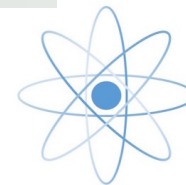
- Publication design and
- RCT
- Basic
- Observational

# Consensus Statements

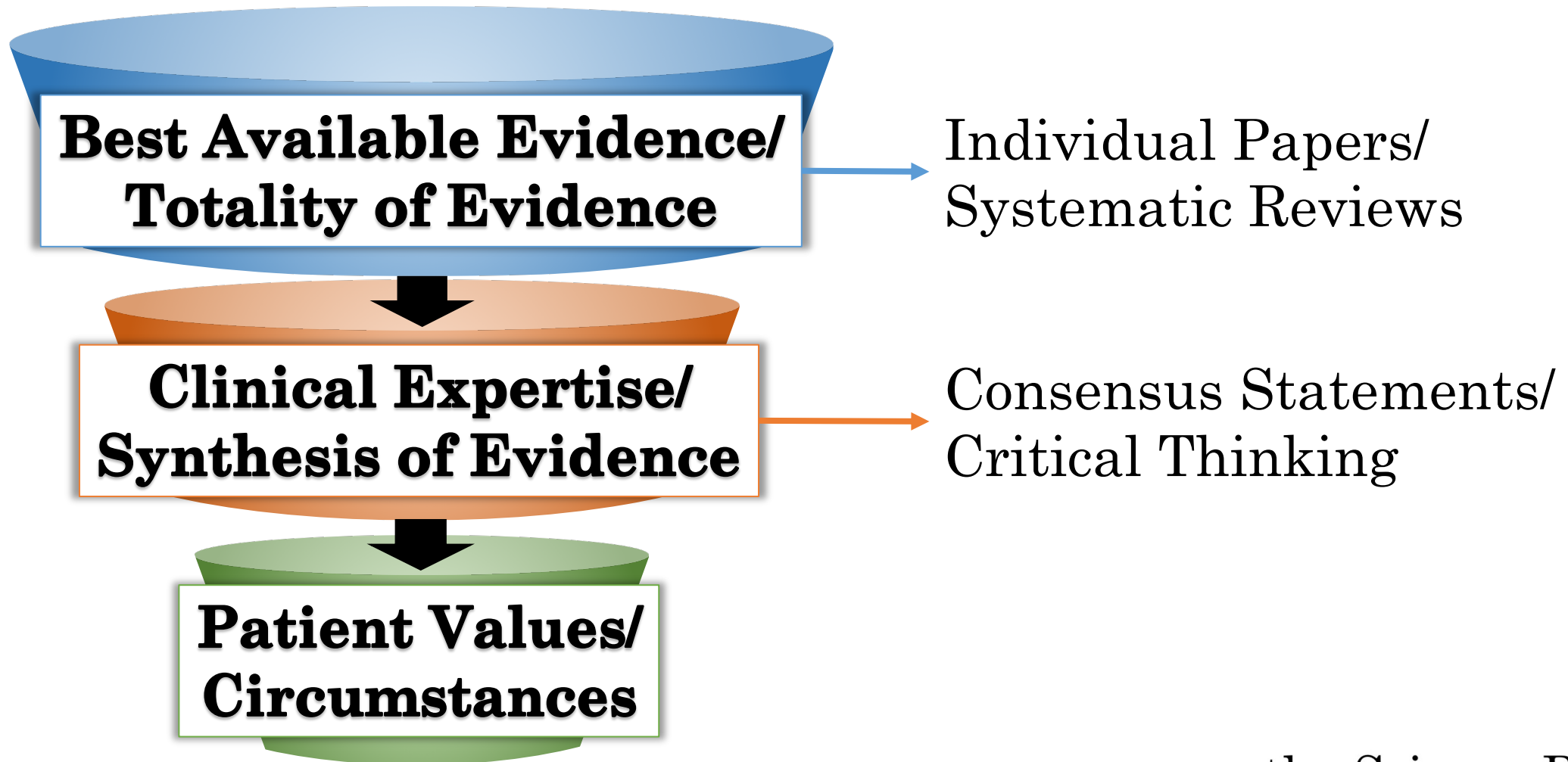
What might I be missing?

business clinic

Placebo?



# EBM is a funnel not a stool...



# How to Decide What to Do?

Asked of the authors of the uncertainty in orthopedics article...

“If you had a health condition, how would your findings influence how you might converse with the physician who is caring for you?”



# How to Decide What to Do?

“It is no surprise that the art of medicine has a lot to do with the preferences and values of the physician. And I would be curious about how the physician caring for me evaluates the evidence and the uncertainty in it. But in the end, I would want my preferences and values to determine management...”



# How to Decide What to Do?

“...I am a fan of attempts to provide complete, balanced, dispassionate, and hopeful information to patients in the form of a decision aid. As a patient, I see a decision aid as a way of getting multiple opinions all at once, in language that I can understand, in a form that I can review repeatedly, with language that anticipates my vulnerabilities as a patient, and with the primary goal of helping me determine my preferences based on current best evidence and the range of available options and opinions.”



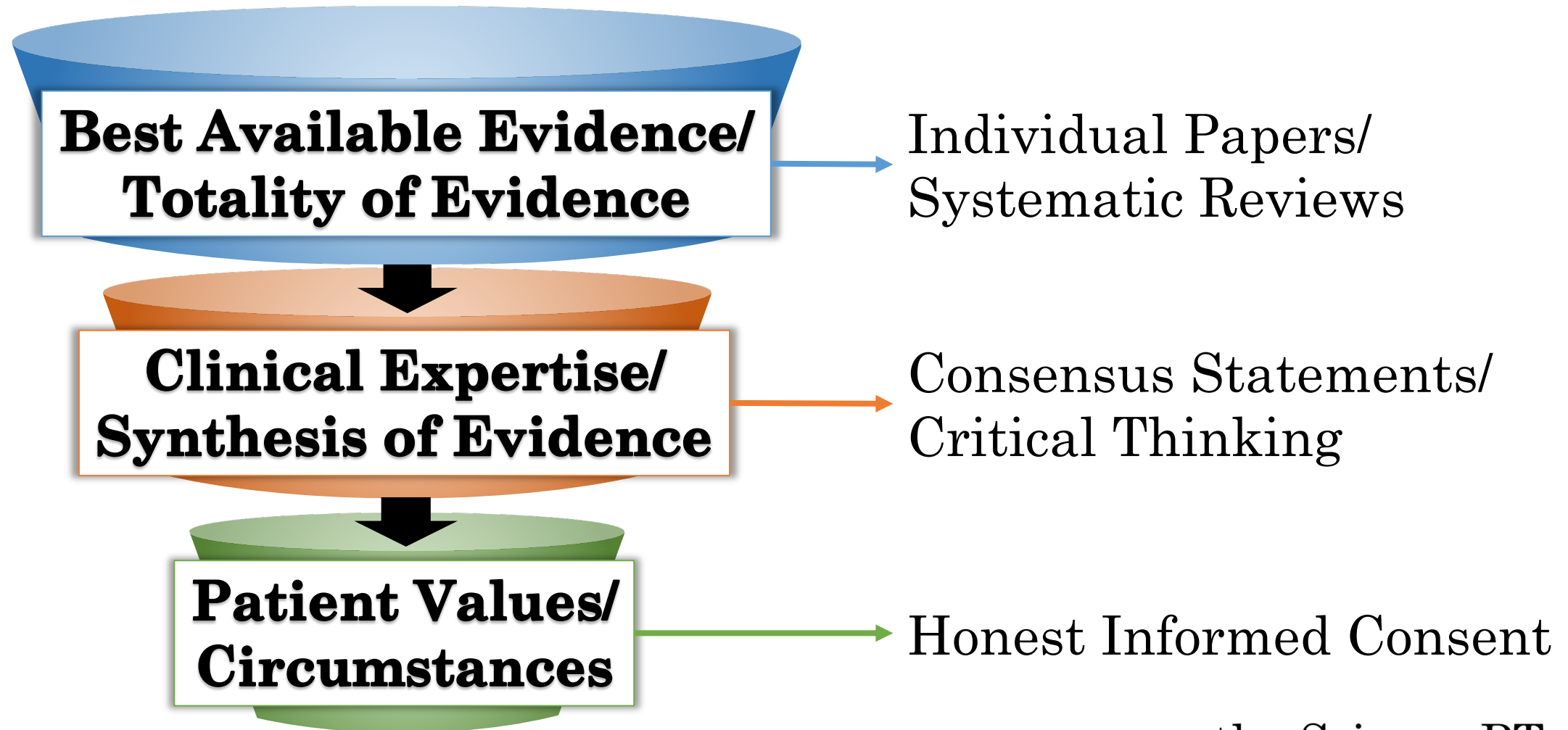
# How to Decide What to Do? *Key Point!*

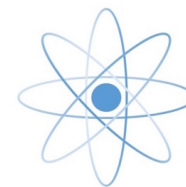
“...I am a fan of attempts to provide complete, balanced, dispassionate, and hopeful information to patients in the form of a decision aid. As a patient, I am interested in getting multiple opinions, with uncertainty, with vulnerabilities as a patient, and with the primary goal of helping me determine my preferences based on current best evidence and the range of available options and opinions.”

## Informed Consent



EBM is a funnel not a stool... *Key Point!*







# In Summary...

- Subjective vs objective knowledge
- Open, honest, and transparent data
- HARKing & p-hacking for false *positives*
- Beliefs vs Epistemology
- Funnel not stool
- True informed consent