

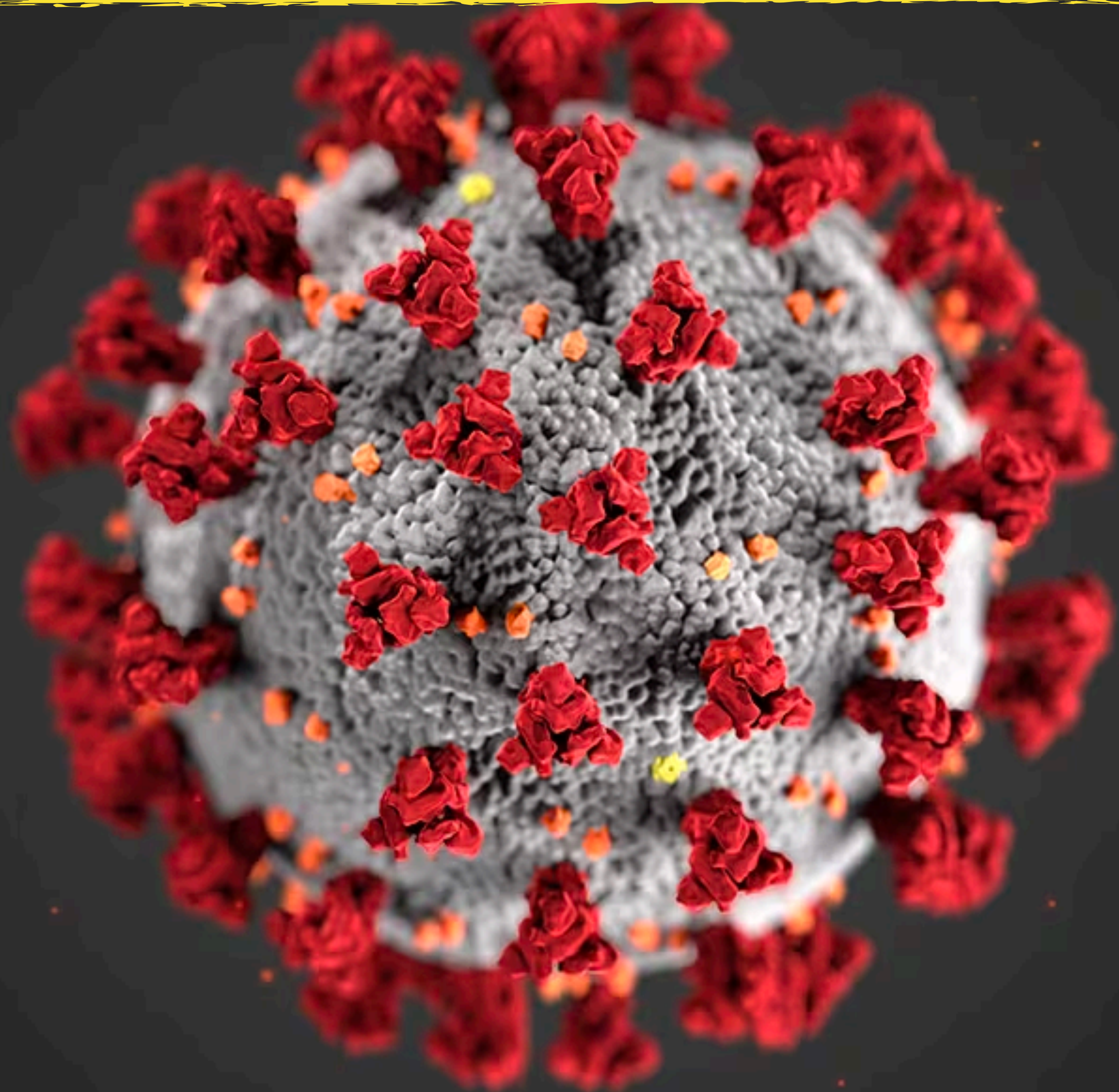
Philosophy of Science I

March 1st 2024

Session 6 - Induction and Evidence



Analogy warning!





Symptoms of COVID-19

People with COVID-19 have had a wide range of symptoms reported – ranging from mild symptoms to severe illness. Symptoms may appear 2-14 days after exposure to the virus. Anyone can have mild to severe symptoms. Possible symptoms include:

- Fever or chills
- Cough
- Shortness of breath or difficulty breathing
- Fatigue
- Muscle or body aches
- Headache
- New loss of taste or smell
- Sore throat
- Congestion or runny nose
- Nausea or vomiting
- Diarrhea



Question:

“...given that so many people who have had COVID so far presented the same symptoms, you of course think you are infected.”

Is that warranted?

The Problem of Induction

Given our current sensory experience, how can we justify inferences from them and from our records of the past, to the future, and to the sorts of scientific laws and theories that we seek?



Recap!

Deductive argument:

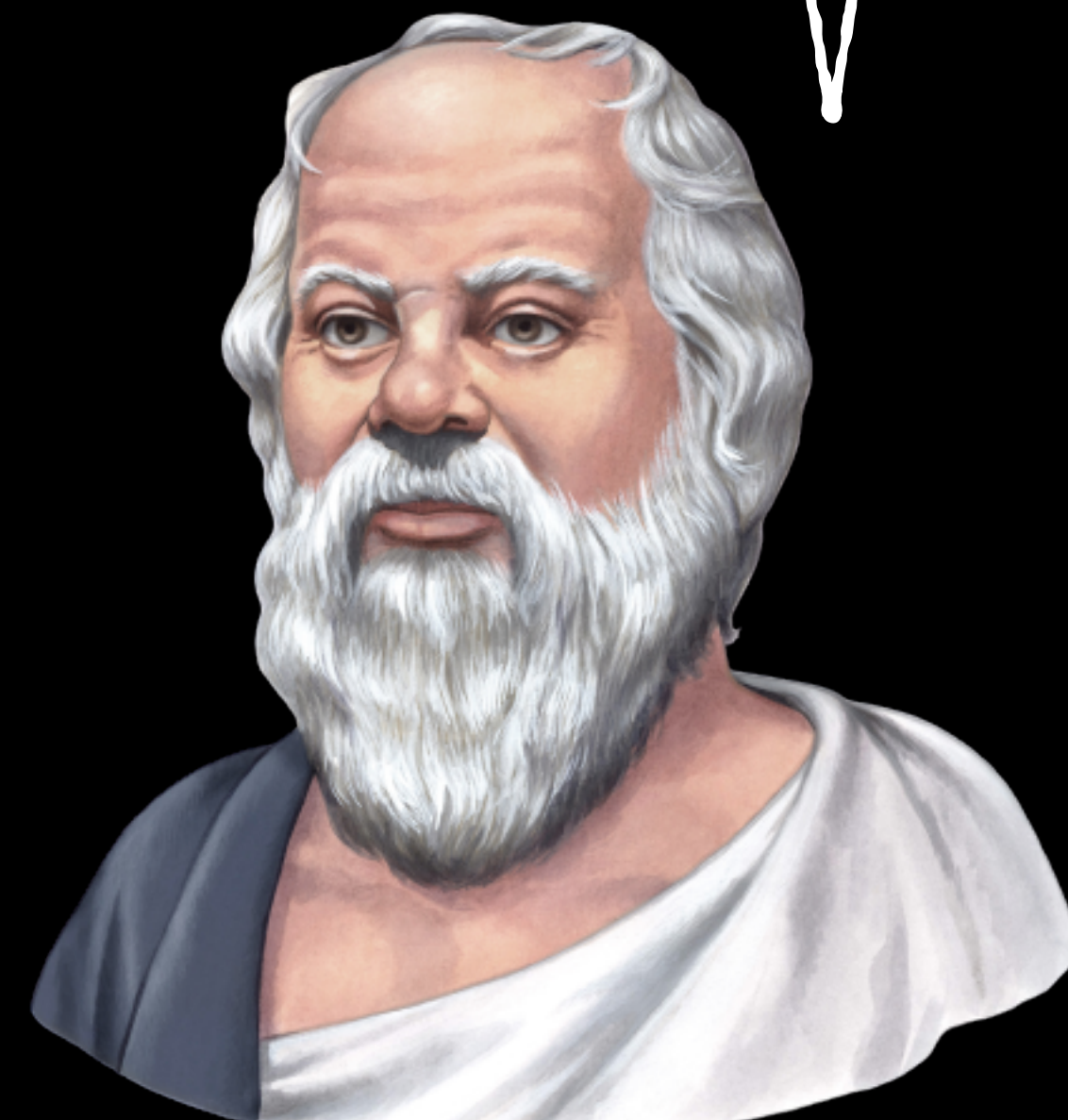
- All men are mortal.
- Socrates is a man.
- Socrates is mortal.

Guaranteed!

Inductive argument:

- All men I met so far are mortal.
- Socrates is a man.
- Socrates is mortal.

Not Guaranteed!



How do I justify a conclusion? Well, I can either have a **deductive** or **inductive** argument. But if I want to justify why inductive arguments will be reliable in the future, **I will have to rely on a deductive argument:**

- If a practice has been reliable in the past, it will be reliable in the future (principle of the uniformity of nature).
- In the past, inductive arguments have been reliable.
- **Therefore, inductive arguments will be reliable in the future.**

But this sounds like saying I didn't lie when questioned about lying!



Question 1:

What do you think about his argument?

Question 2:

Is the D-N model safe from this criticism?

Question 3:

Do you think the different types of transcendence (from past to future vs. from specific to general) are equally troubled?

Well, if there is **any** predictive method which is valid at all, so must be induction!

But that's circular! It depends on proving the very reliability of induction it aims to establish in the sense of proving that indeed there is any method that does work!

C'mon man, what do you want from me?
Clearly induction is our best tool for making predictions, even if cannot be logically justified.

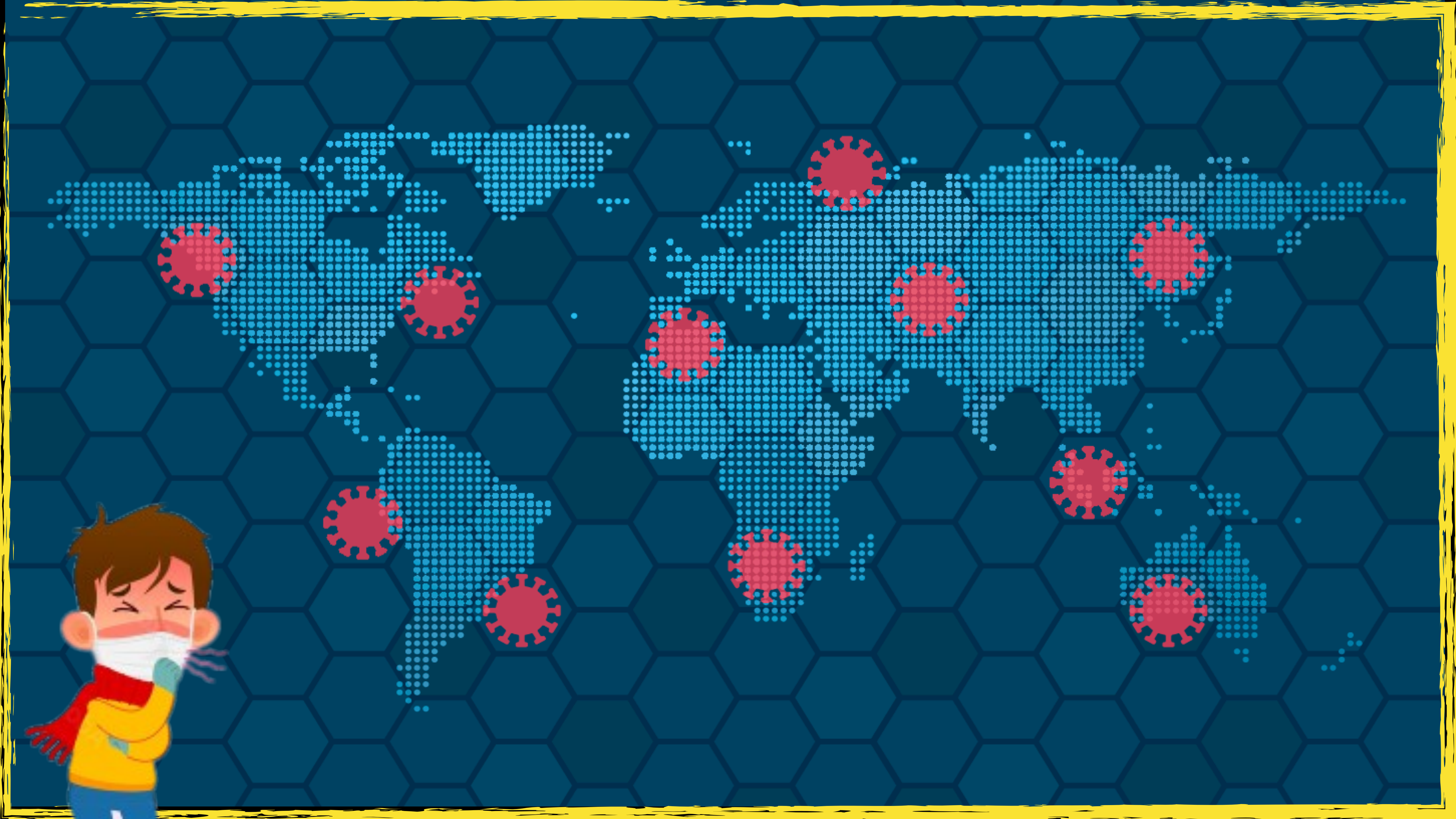


Others tried to frame rules of inductive inference that could be justified. In the same way that the D-N model was proposed to rationally reconstruct the concept of scientific explanation, people like Carnap and Hempel tried to develop a “confirmation theory” that would formalize and explicate the notion of inductive inference. Their attempt relied on formalizing probability theory.

Questions?



Vårdcentral



"...the likelihood you have covid given there is a pandemic happening is **higher** now that you have these symptoms. "

Hypothesis (H): you have covid

Background (B): pandemic

Experimental observation (E): symptoms

$$P(H, B \text{ and } E) > P(H, B)$$

That could be a way to define what we usually think of positive evidence for a given hypothesis.

Q: Does that sound reasonable to you?

Another example (?): The probability that I can fly given that I am a human is **higher** because I exist.

Hypothesis (h): I can fly

Background (b): being human

Experimental observation (e): I exist

$$P(h, b \text{ and } e) > P(h, b)$$

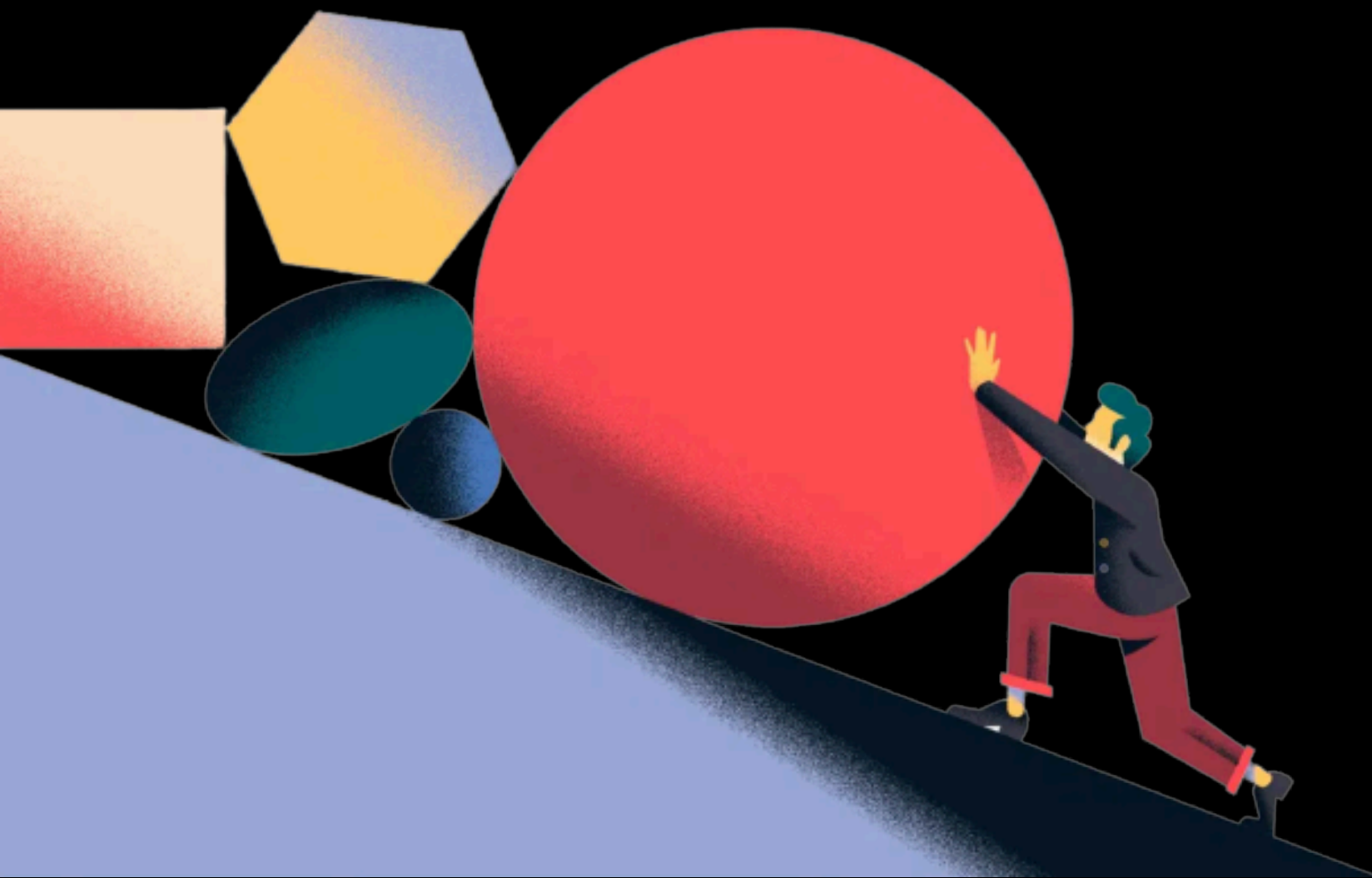
Q: What's the difference between them?

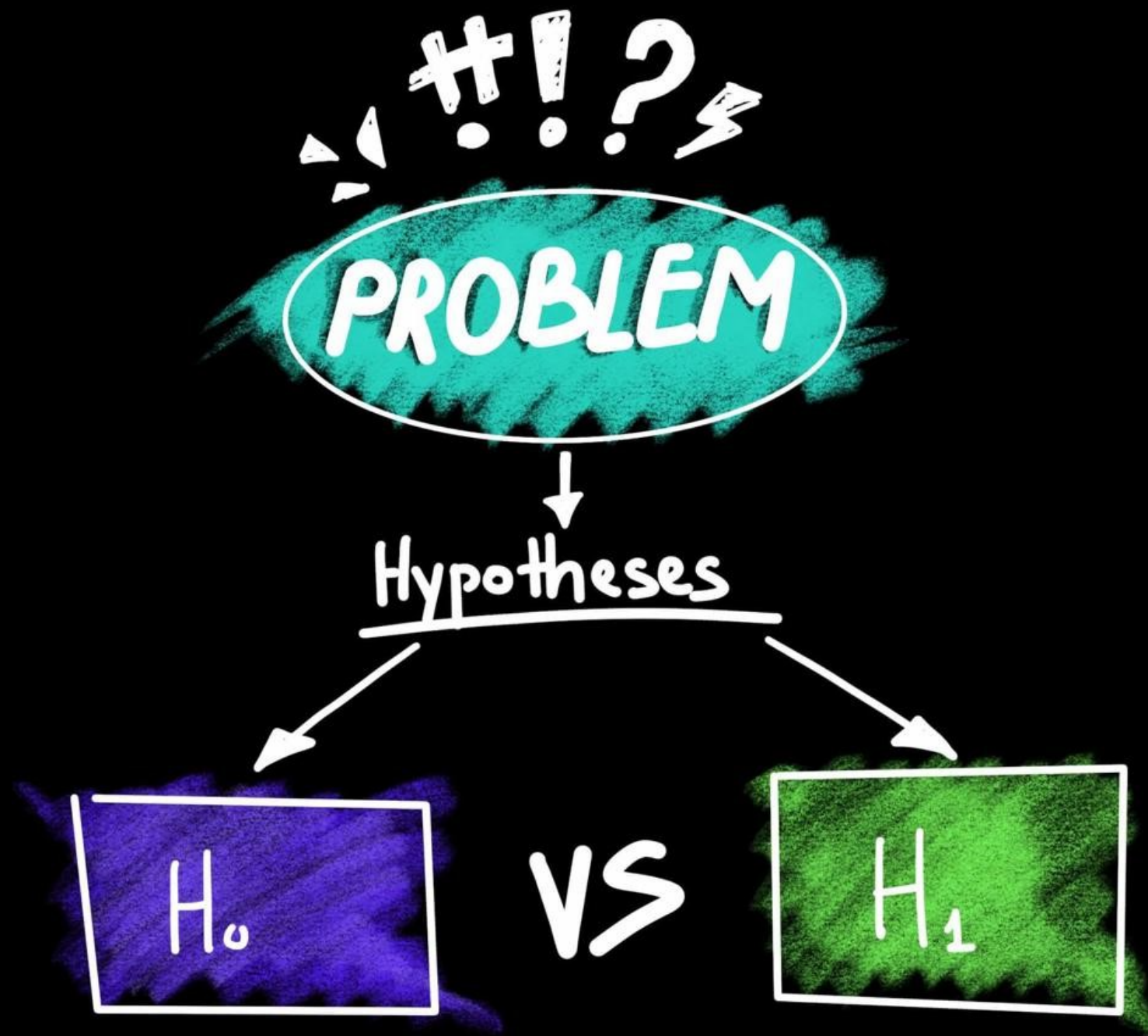
What constitutes positive evidence?

Maybe define a **probability threshold** (usually 0.5) positive evidence needs to achieve?

However, sometimes the background alone raises the probability quite high, and even though **E** might not be evidence for **H** by itself, **B + E** is.

Really, what we want to say is that **E** is irrelevant, but it turns out that this task is as hard as providing a clear test for positive evidence...





Perhaps our issue is a language one.
After all, it might only make sense to talk
about hypotheses **in comparison** anyways.

Moreover, if we look closely into
probability theory, all these things can
be properly and coherently defined.





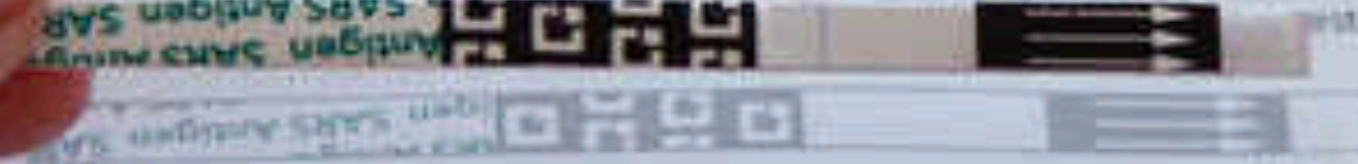




PASO 10

Comprobación de un Resultado Positivo de la COVID-19

Continúe la TIRA DE PRUEBA en el perfil de la tira de prueba que se muestra abajo.



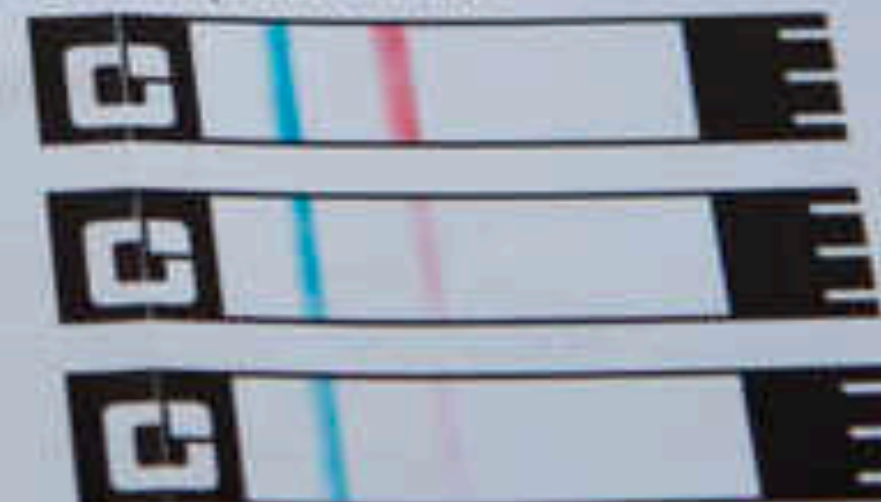
Resultado Positivo

Un resultado POSITIVO debe mostrar una línea AZUL y una línea ROSA cerca de la línea AZUL.

Fíjese bien. Incluso si ve la línea de prueba de color rosa y la línea de control color azul muy tenues, se debe informar del resultado como POSITIVO. La intensidad de las líneas podría variar.



Resultados mostrados con ampliación 2x.



Resultado Positivo para la COVID-19

El resultado positivo de la prueba significa que se encontraron en su muestra las proteínas del virus que causa la COVID-19, es muy probable que tenga la COVID-19 y es importante que se ponga bajo el cuidado de su profesional sanitario. También es probable que le ponga en aislamiento para evitar que contagie a otras personas. Son muy bajas las probabilidades de que esta prueba dé un resultado positivo erróneo (positivo falso). Si el resultado es positivo con la COVID-19 QuickVue At-Home OTC, se debe buscar atención de seguimiento con su profesional sanitario, ya que se podrían necesitar pruebas. Su profesional sanitario colaborará con usted para determinar cuál es la mejor manera de atender la función del o de los resultados de sus pruebas, su historia clínica y sus síntomas.

Cont

LABEL INFORMATION

Identify 99% of true cases (**1% false negative**).

Identify 99% of negative cases (**1% false positive**).

BACKGROUND

0.1% of the population were
estimated to have covid.

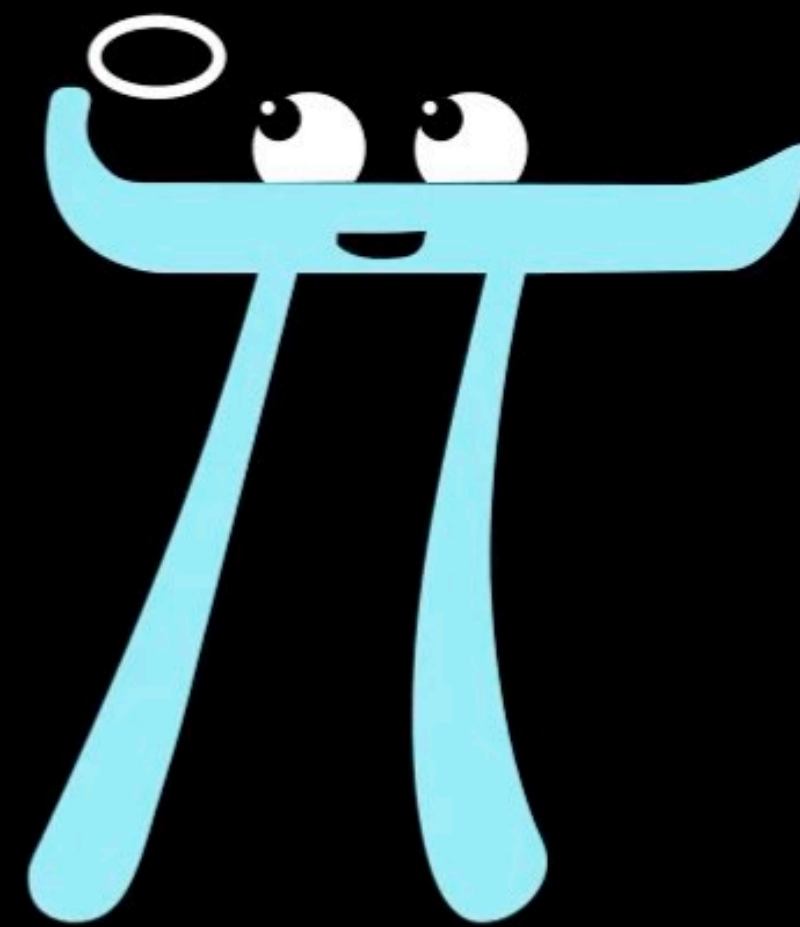


Question:

Are you justified to react like that?

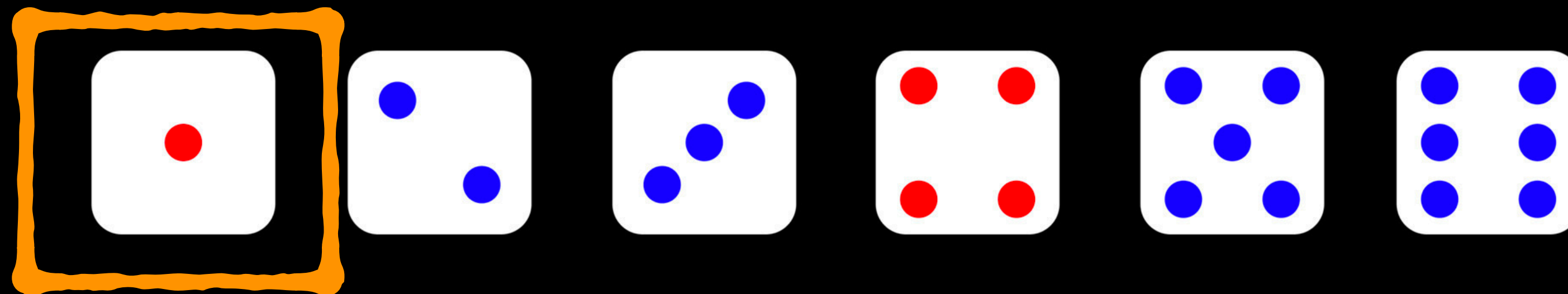
Bayes' Theorem

$$P(H|E) = \frac{P(H) \cdot P(E|H)}{P(E)}$$



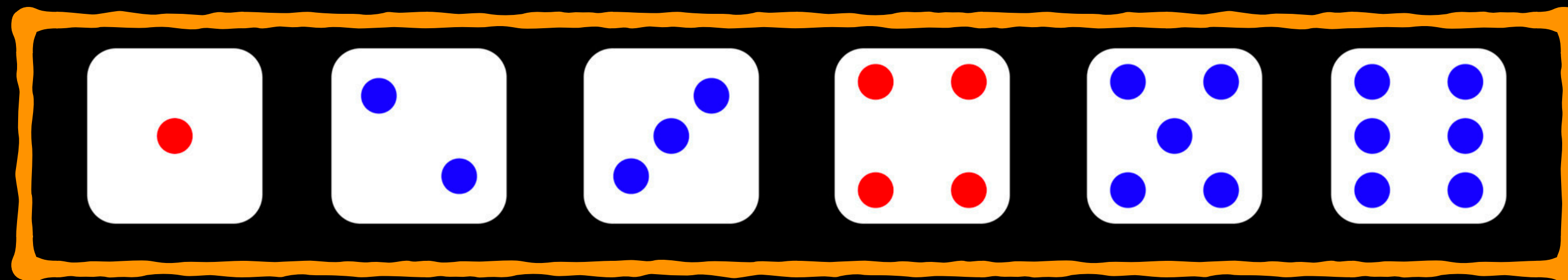
Probability theory is quite simple and relies on three assumptions:

- Probabilities are measured in numbers from 0 to 1
- The probability of a necessary truth is 1
- If hypothesis h and j are incompatible, then $P(h \text{ or } j) = P(h) + P(j)$.



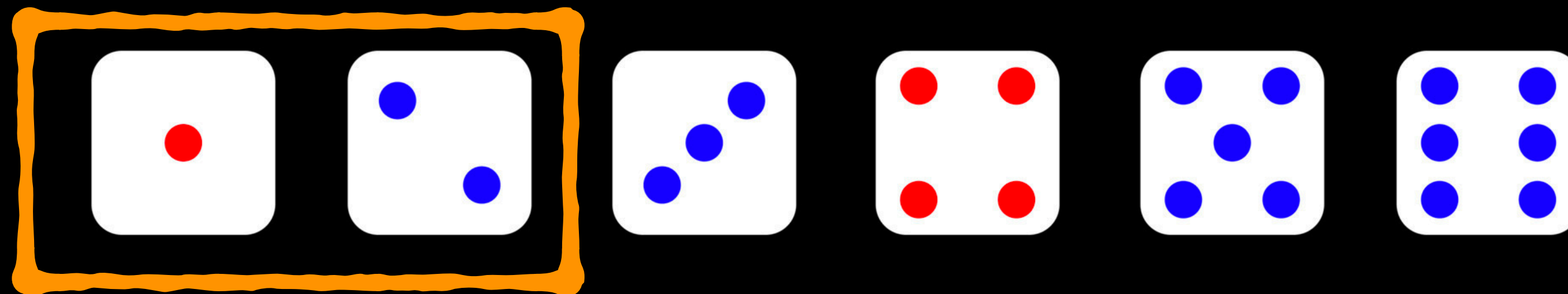
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- Probabilities are measured in numbers from 0 to 1
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P(E) [prior]: the probability that the statement describing the data is true independent from any hypotheses

- a) neutrinos were observed traveling faster than the speed of light;
- b) higher levels of CO2 in the atmosphere increase the global temperatures.

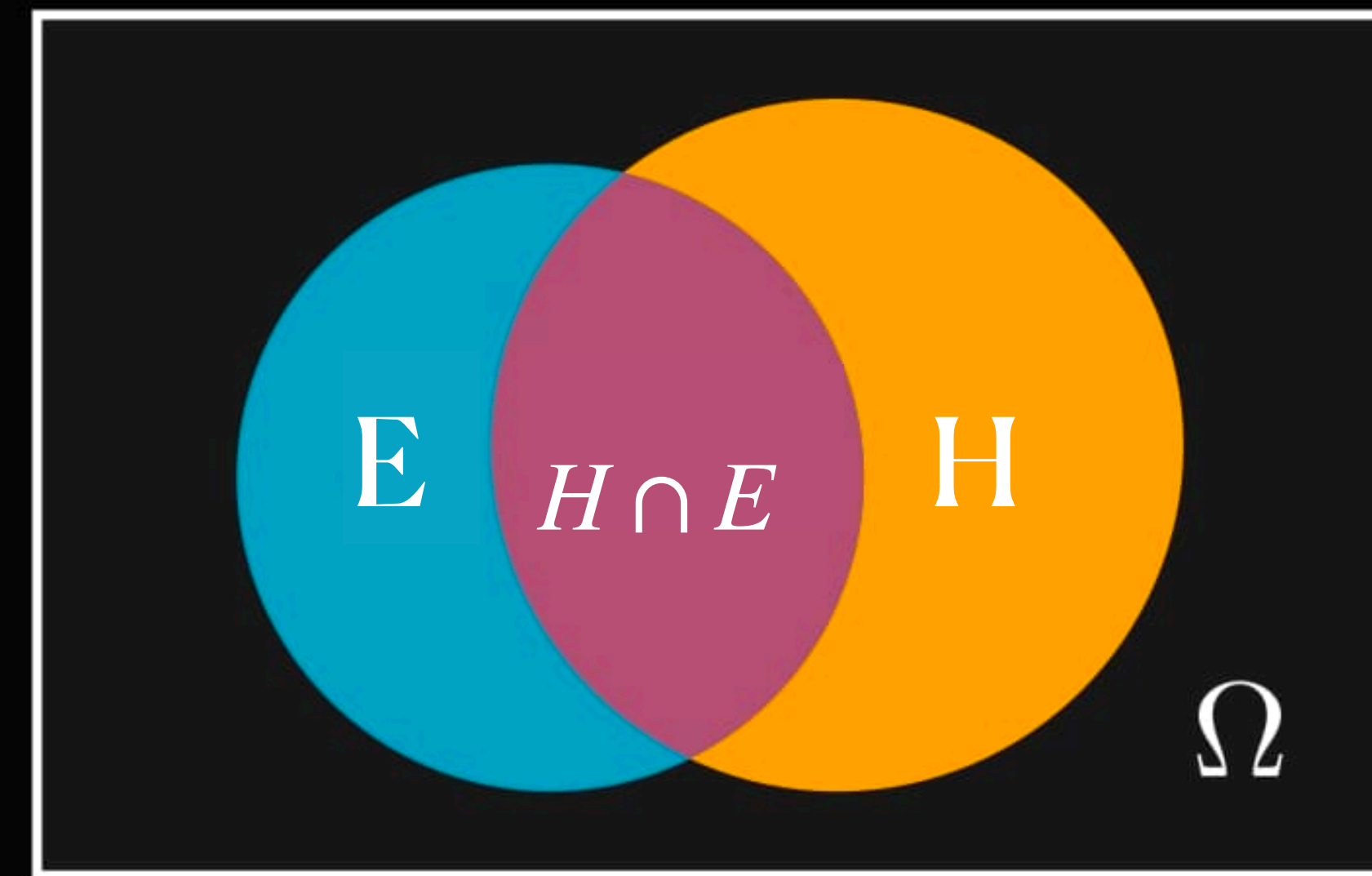
$$P(H|E) = \frac{P(H) \cdot P(E|H)}{P(E)}$$

P(H) [prior]: the probability we assign to a hypothesis before testing it (e.g.: my dice is fair)

P(E|H) [likelihood]: the probability that E is true assuming that H is true

- a) All the swans are white, and then observe a white swan;
- b) All the swans are white, and then observe a black swan (maybe not a swan?).

P(H|E) [posterior]: the probability that H is true given that E is true (e.g.: e – 100 swans are white, h - all swans are white)



$$P(H|E) = \frac{P(H \cap E)}{P(E)}$$

Example 1: Consider how data on observing swans in a new lake provides a test for the hypothesis:

“All swans are white”.

Suppose that $P(E)$, the probability that the swans are white is 0.8. This allows for dirt, etc. Prior to observations $P(E|H)$ is also high, the expected color of the swans will be mostly the one predicted by our hypothesis, say 0.95. And let's assume that prior to the acquisition of E , the new lake's data, the probability that H is true is, say, $P(H)=0.8$.

Thus, if we do observe the swans in the new lake to be white, we have that $P(H/E)=0.95$.



Example 2: Consider how the COVID test provides a test for the hypothesis:

“You have COVID”.

From the context, $P(H)=0.001$ since 0.1% of the population had COVID at the time. Now, $P(E|H)$, the probability you would test positive if you had the disease, is 0.99 (as the test can identify 99% of the positive cases). Then, we only need to determine $P(E)$, which accounts for both true and false positives:

$$P(E) = 0.99 * 0.001 + 0.01 * .999 = 0.011.$$

Example 2: Consider how the COVID test provides a test for the hypothesis:

“You have COVID”.

From the context, $P(H)=0.001$ since 0.1% of the population had COVID at the time. Now, $P(E|H)$, the probability you would test positive if you had the disease, is 0.99 (as the test can identify 99% of the positive cases). Then, we only need to determine $P(E)$, which accounts for both true and false positives:

$$P(E) = 0.99 * 0.001 + 0.01 * 0.99 = 0.011.$$

Then, in the end, $P(H|E) \sim 0.09$, or 9%.



Questions?



Example 3: Consider how the second COVID test provides a test for the hypothesis:

“You have COVID”.

From the first test, $P(H)=0.09$, $P(E|H)$ remains 0.99 while $P(E)$, the group that took the second test and is positive, is $0.99*0.09 + 0.01*.091=0.098$.

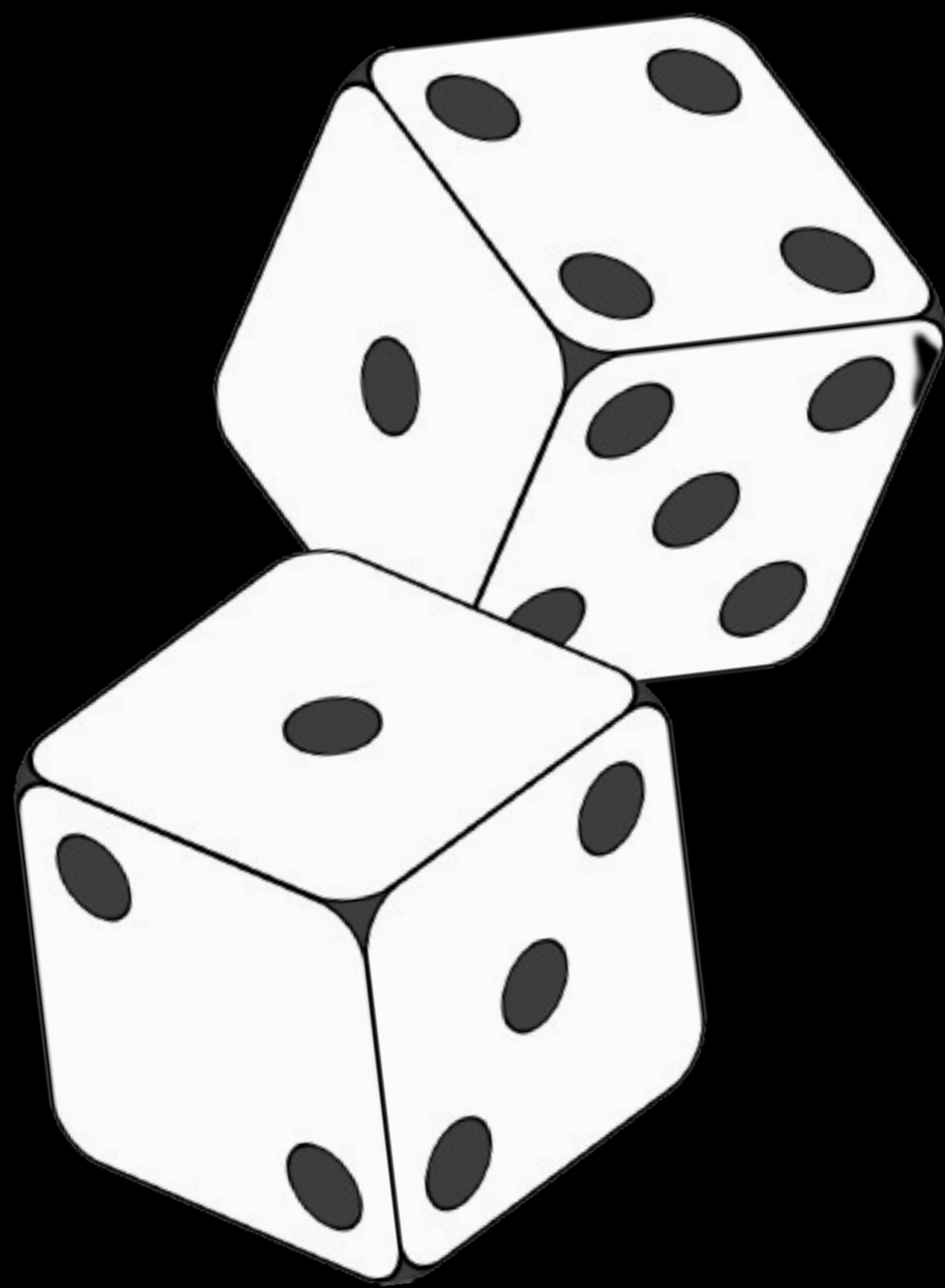
Then, in the end, $P(H|E)\sim 0.91$, or 91%.

Question:

**Did we make progress on Hume's problem of
induction?**

Question:

What makes $P(H)$ correct? How do we justify its estimate?



Like dices?
(a priori)

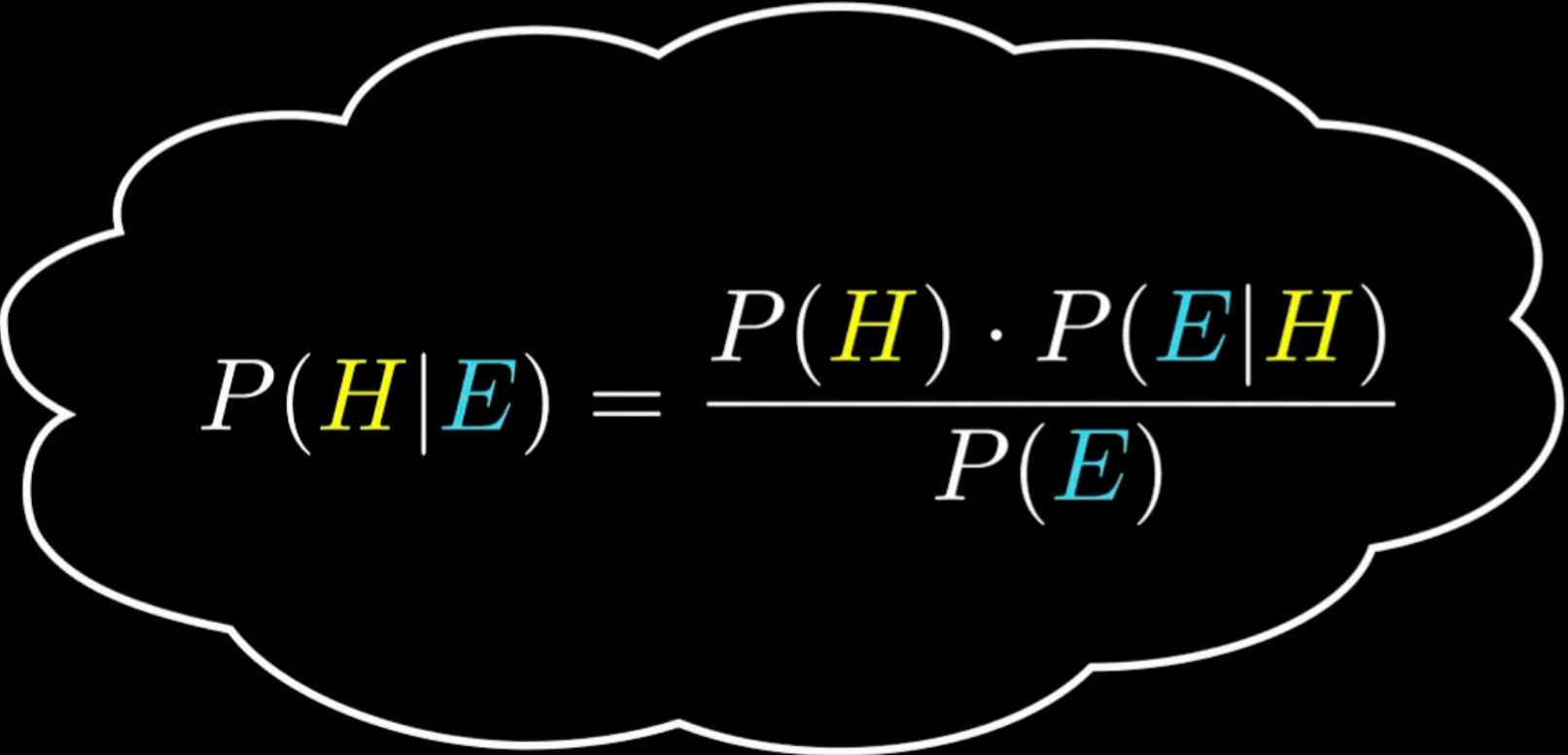


**Maybe flipping
coins?**
(empirically)

Question:

**What about hypotheses without track record
and the whole business of auxiliary hypotheses?**



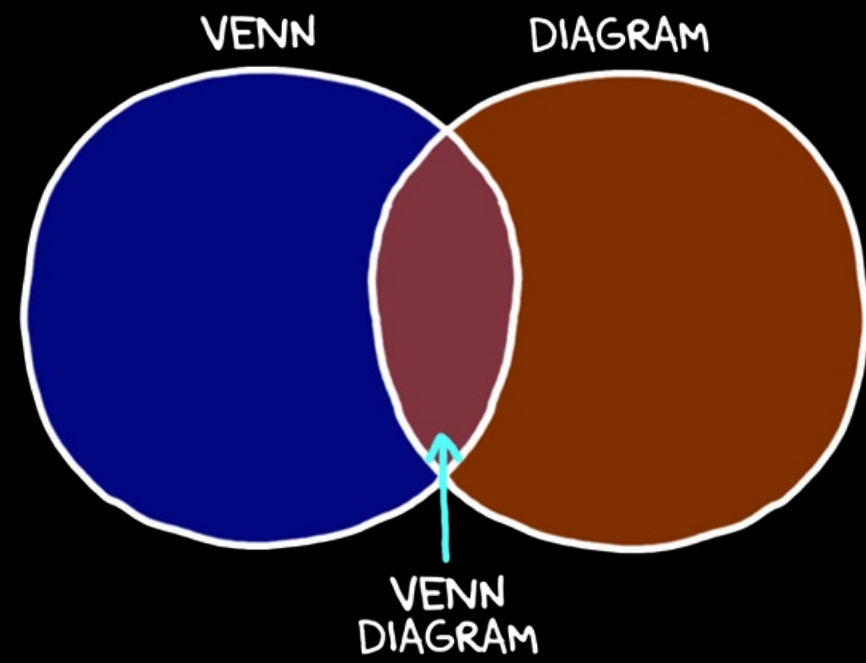

$$P(H|E) = \frac{P(H) \cdot P(E|H)}{P(E)}$$

Question:

What happens if you set P(H) to zero or 1?

Three other 'issues':

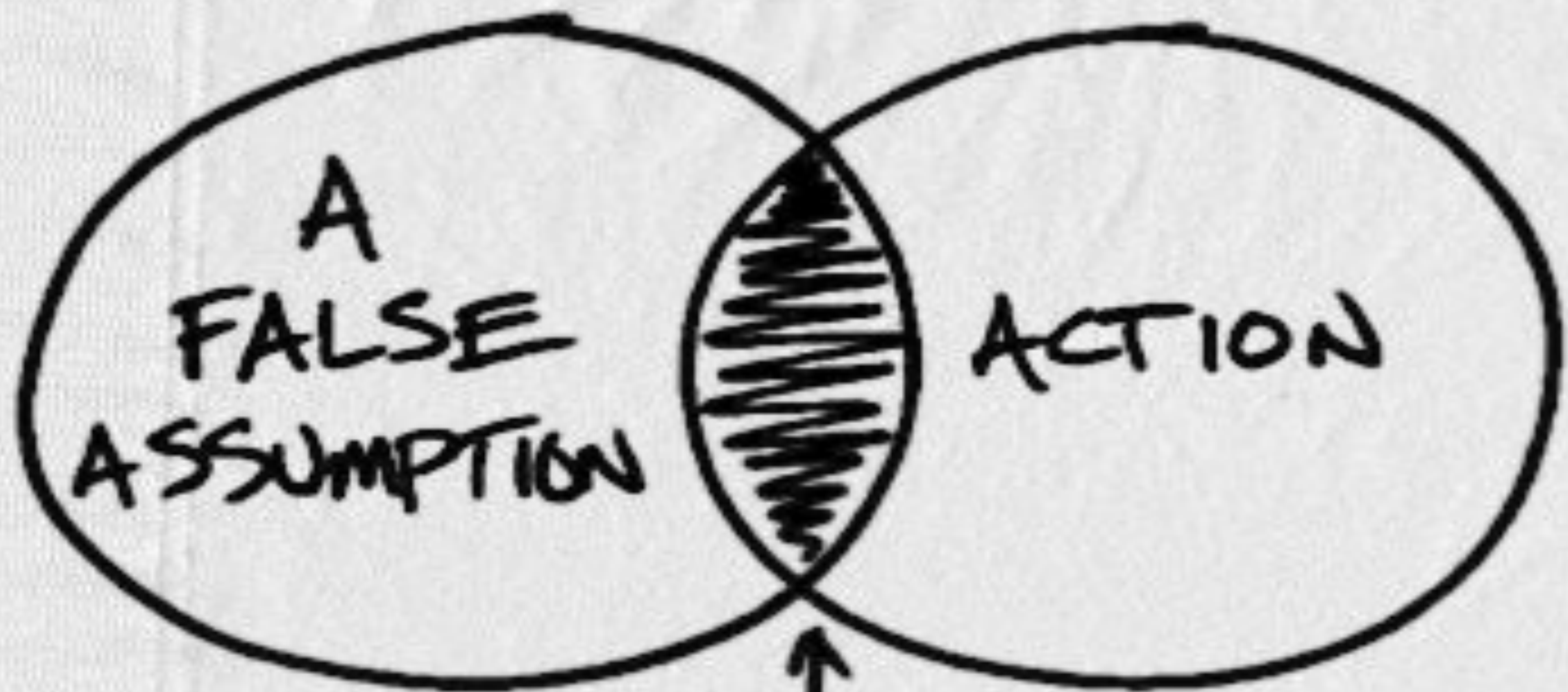
1) What about **old evidence** for which $P(E)=1$?



2) **Convergence of the posterior** if, and only if, set of hypotheses is exhaustive and they are exclusive competitors.

3) Imagine some hypothesis with $P(H)$. Imagine some theory accounting for it, $P(T \text{ and } T \rightarrow H)$. The former would be higher, **but scientist do adhere to theories!**





↑
SCARY!
o

Problems of Hypothesis Testing



Well, maybe induction will be eventually solved. In fact, the pragmatic scientist does not even care about it.

However, as hypotheses are usually indefinite while empirical sets finite, they are only supported to some extent (Bayes!).

One way out is to change the focus, as it takes **only a single** black swan after all to prove us all wrong.

Q: Right?



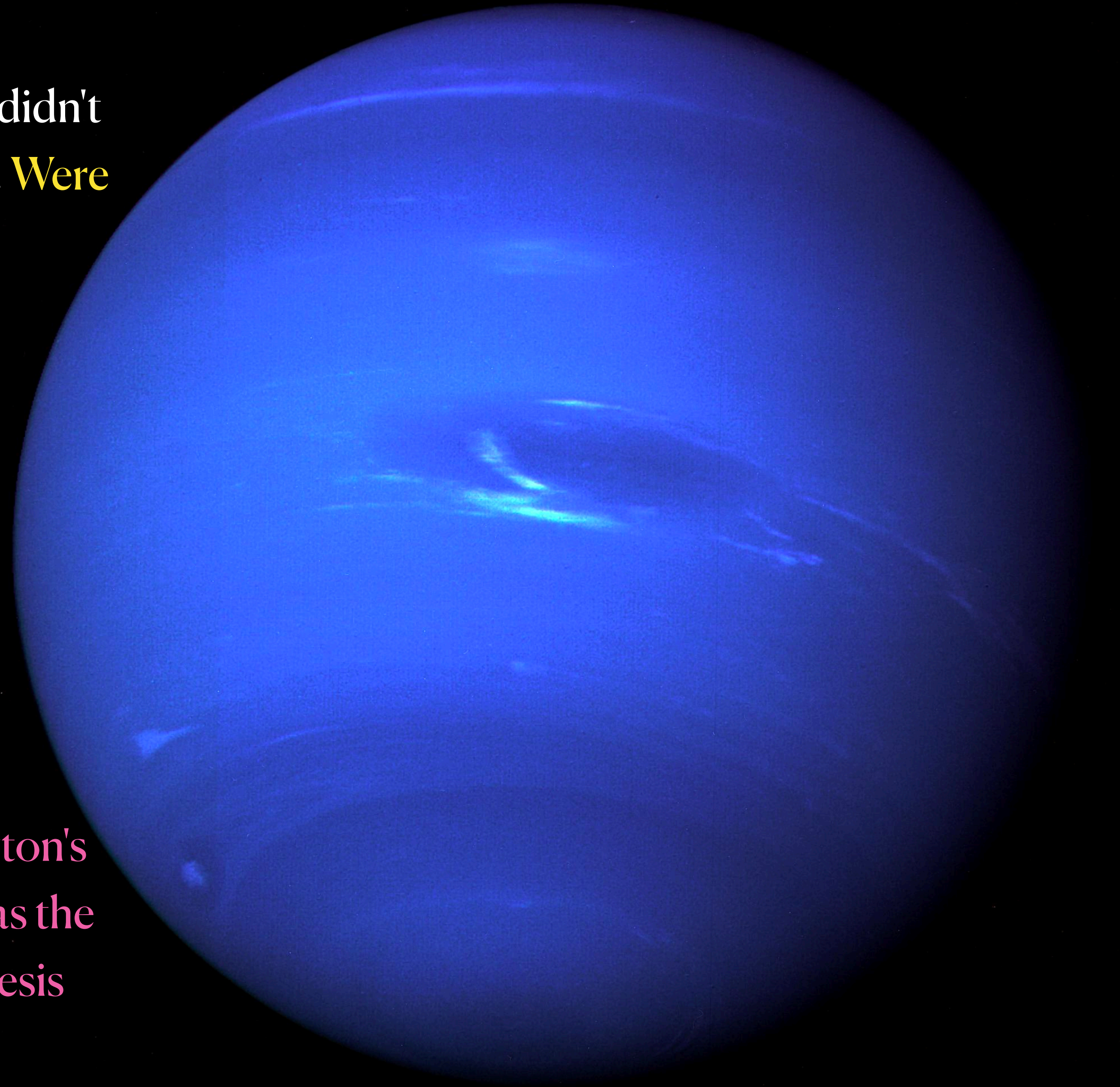
The Discovery of Neptune: A Case Study -

Early 1900s, astronomers observed that Uranus's orbit didn't exactly match the predictions made by Newton's gravity. **Were they incorrect or incomplete?**

Instead of questioning Newton's laws, Adams and Le Verrier hypothesised: **What if there was another, as-yet-undiscovered planet whose gravitational pull was affecting Uranus's orbit?**

They predicted where this hypothetical planet should be. When astronomers pointed their telescopes to the predicted location, they did find **Neptune**.

From a falsificationist perspective, **the point is that Newton's laws themselves were never strictly "on trial"; rather, it was the entire system of Newton's laws plus the auxiliary hypothesis about Uranus that faced empirical testing.**



As we are not always fully aware of all possible auxiliary hypotheses,
scientific laws can neither ~~completely established~~ by available
evidence, nor ~~conclusively falsified~~ by a finite body of evidence.

Questions?

PARADOX OF CONFIRMATION

LET'S
GET
WEIRD

Everything

White
Things

Swans

"All swans are white"

is the same as

"all non-white things are non-swans".



(Carl Hempel)



Question:

How could this be solved in Bayesianism?

THE NEW RIDDLE OF INDUCTION!

"All swans are actually whick!"

2030

Whi ck



Well, that's clearly incompatible with them being white, but equally confirmed?! If not, why?

2030

Whi ck

Bla te

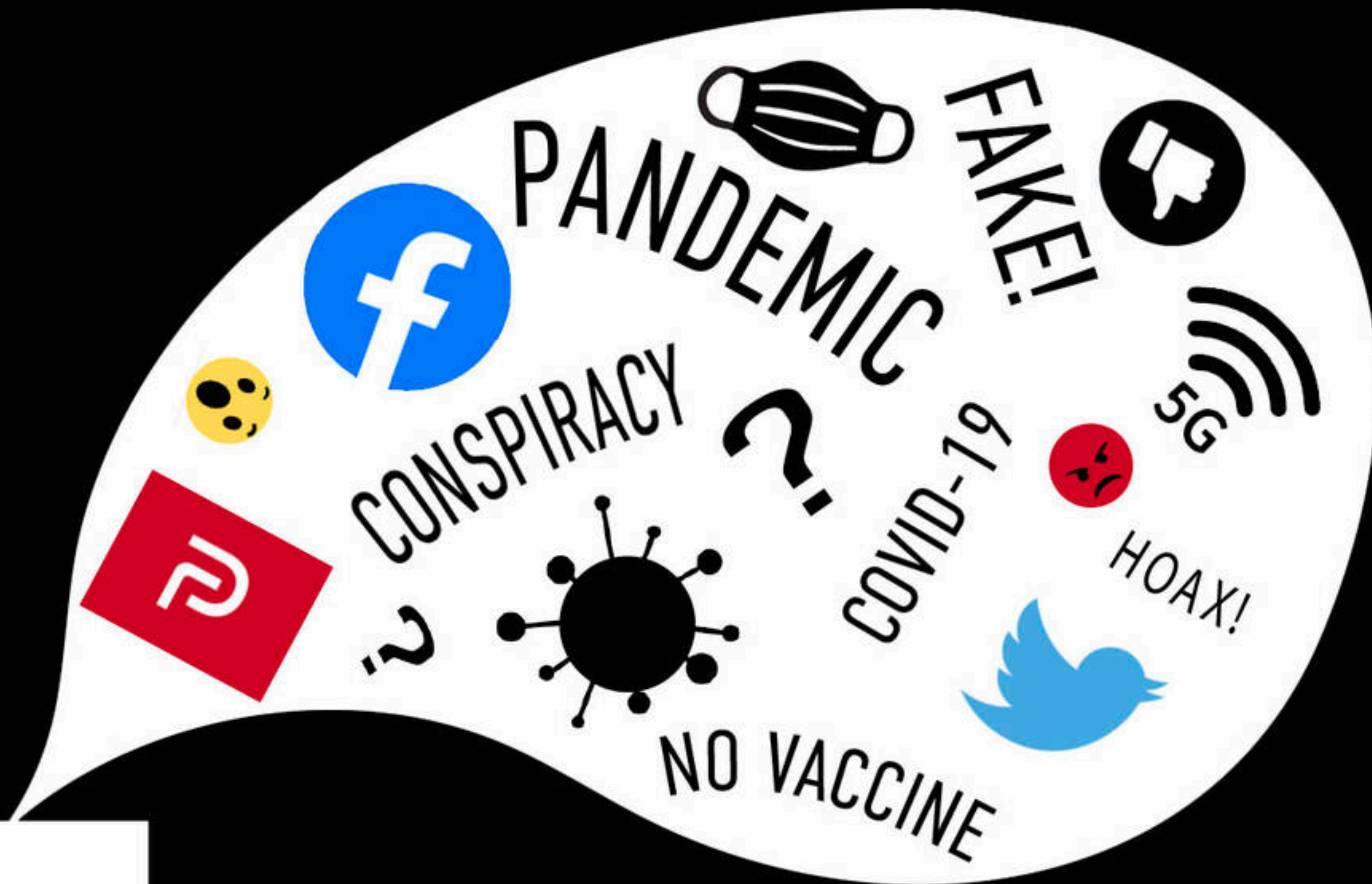
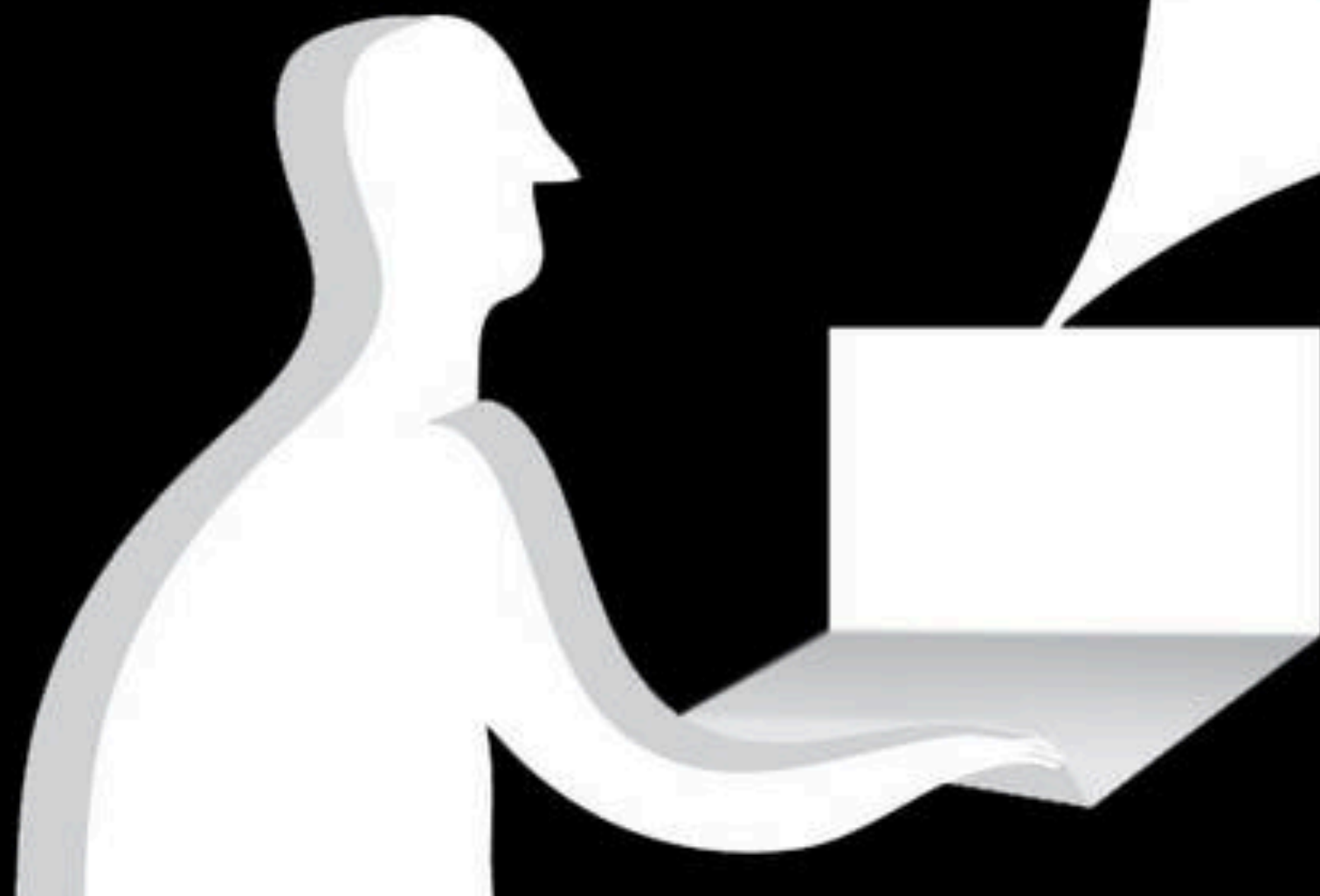
White



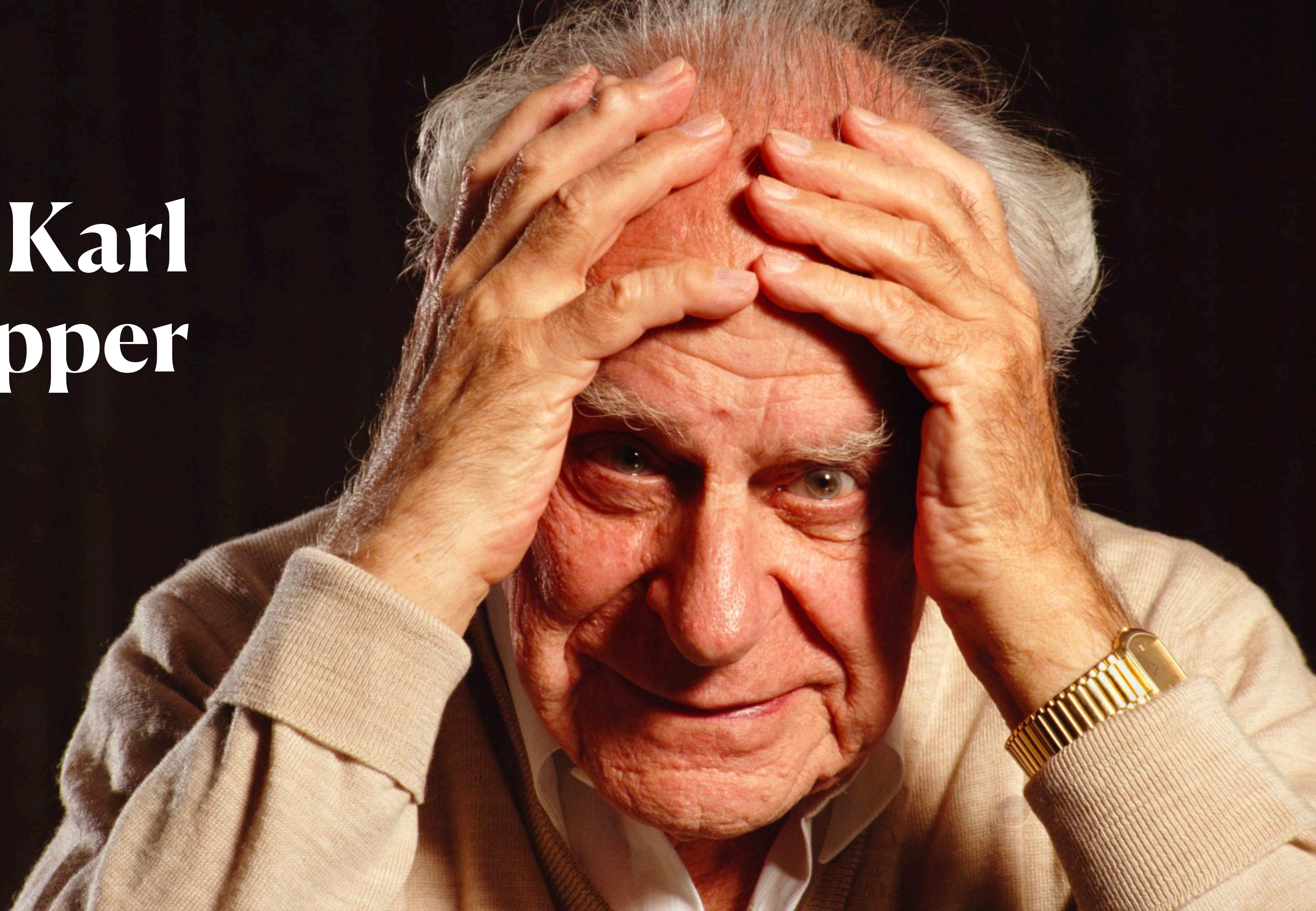
(Nelson
Goodman)



LET'S
GET
WEIRD



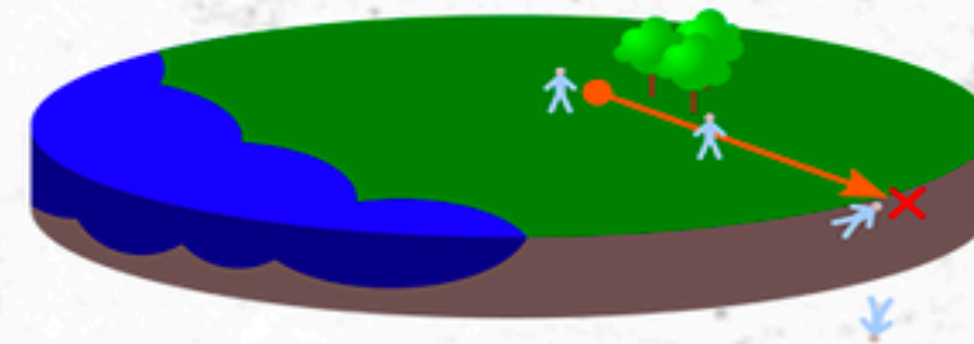
Karl Popper





Science

Pseudoscience

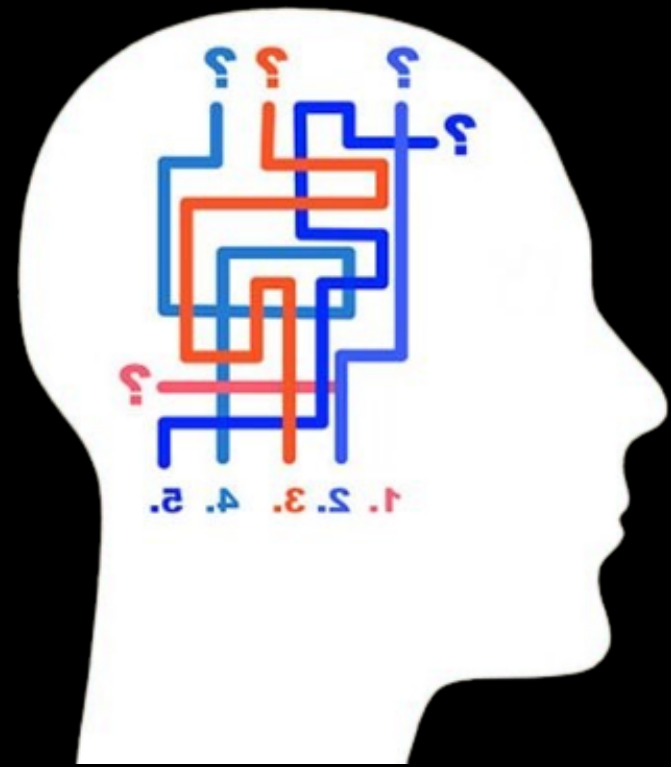


Popper claims that scientists are actually worried about **seeking negative evidence against scientific hypotheses**.

However, his claim was not that scientists should seek strict falsification. He articulated that the best science is characterized by **framing hypotheses that are highly risky**, and therefore easy to test, and when they fail these tests (as eventually they will), then new risky hypotheses should be framed. **Thus, he held that the business of experiment is to seek disconfirmation.**

Popper's claim about falsifiability may be treated as a **description** of the attitudes of scientists or a **prescription** about what attitudes they should have!

Q: Is that the case?



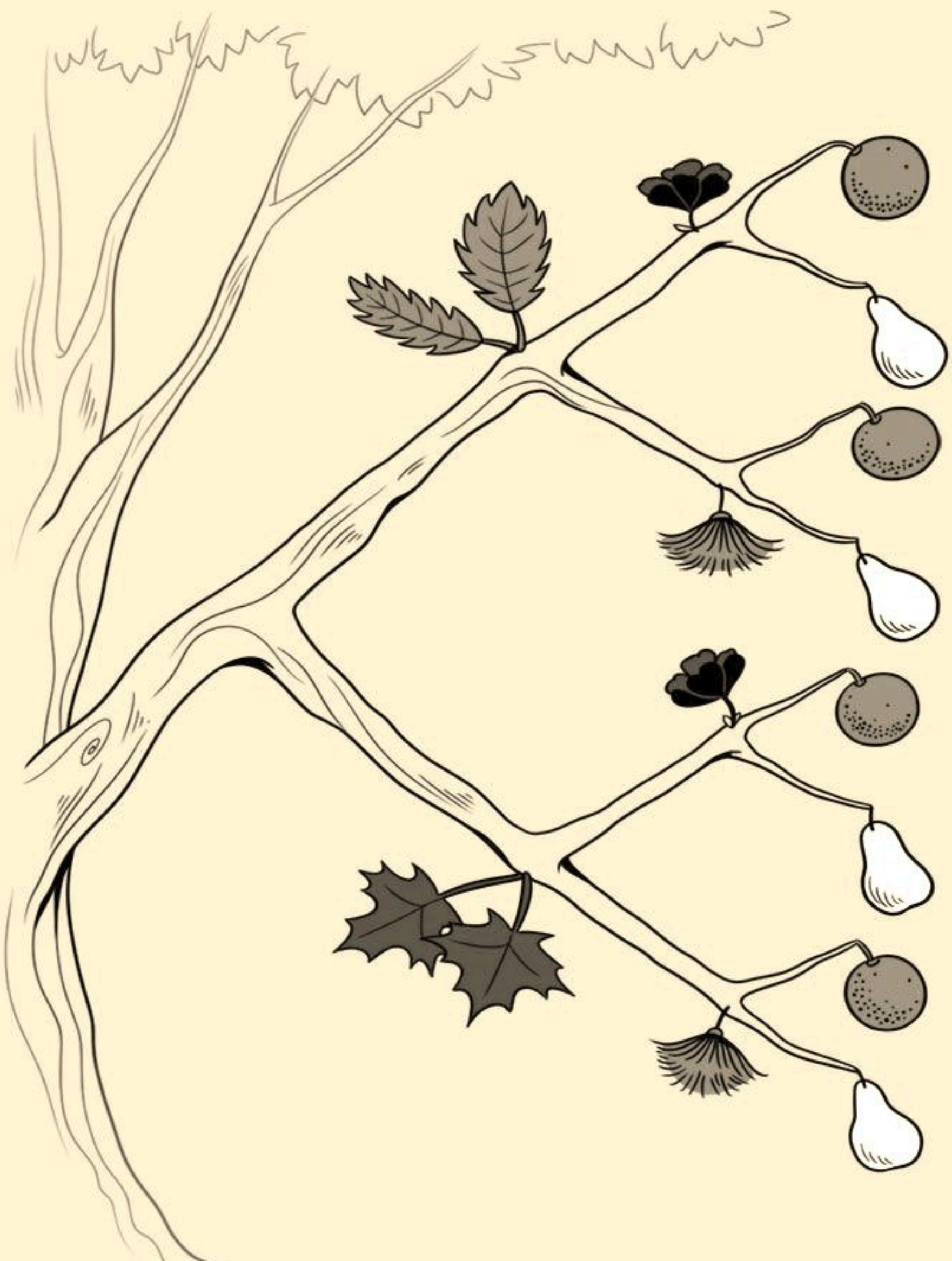
Example: Economics initially relied on the rational agent model, which clashed with real-world human behavior and seemed to defy Popper's falsifiability principle. However, instead of discarding the model, the field evolved to include behavioral economics, which accounts for irrationality.

This adaptability **challenges** the strict application of Popper's falsifiability as the **sole criterion for scientific validity**. Models like the rational agent serve as useful, though imperfect, starting points that can be refined over time, highlighting that **falsifiability is just one tool among many in assessing the utility and validity of scientific theories.**



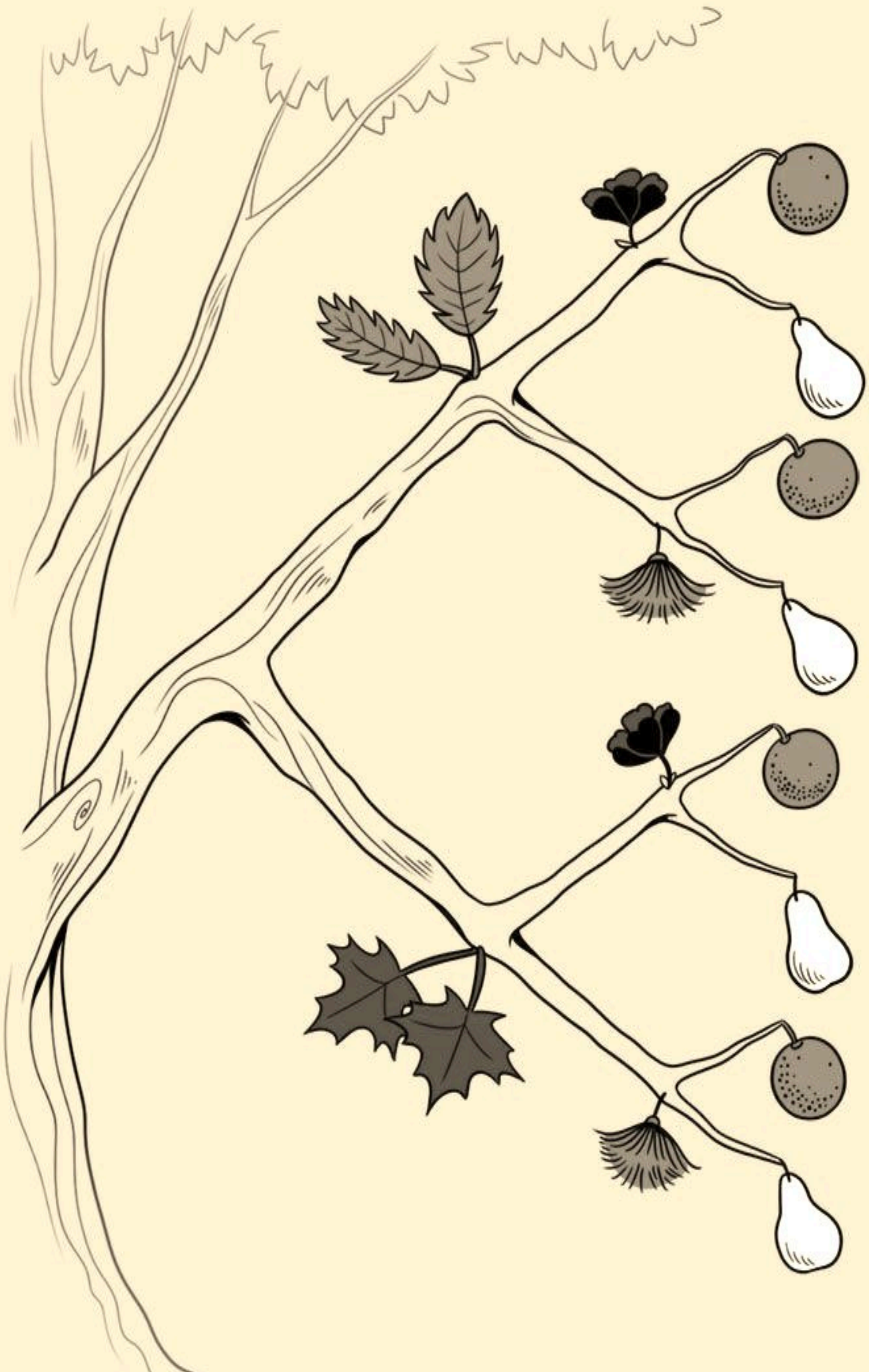


Underdetermination



As negative tests can be due to an auxiliary hypothesis, positive tests might reflect compensating mistakes in two or more hypotheses. Thus, **it seems unavoidable to conclude that there is underdetermination of theory by observation.**

Since typically there is a whole array of hypotheses at play during any empirical test, **any negative result can trigger different scientists to change any possible combination of them to make the framework empirically adequate again.** This seems rather arbitrary and far away from our naïve understanding of science.

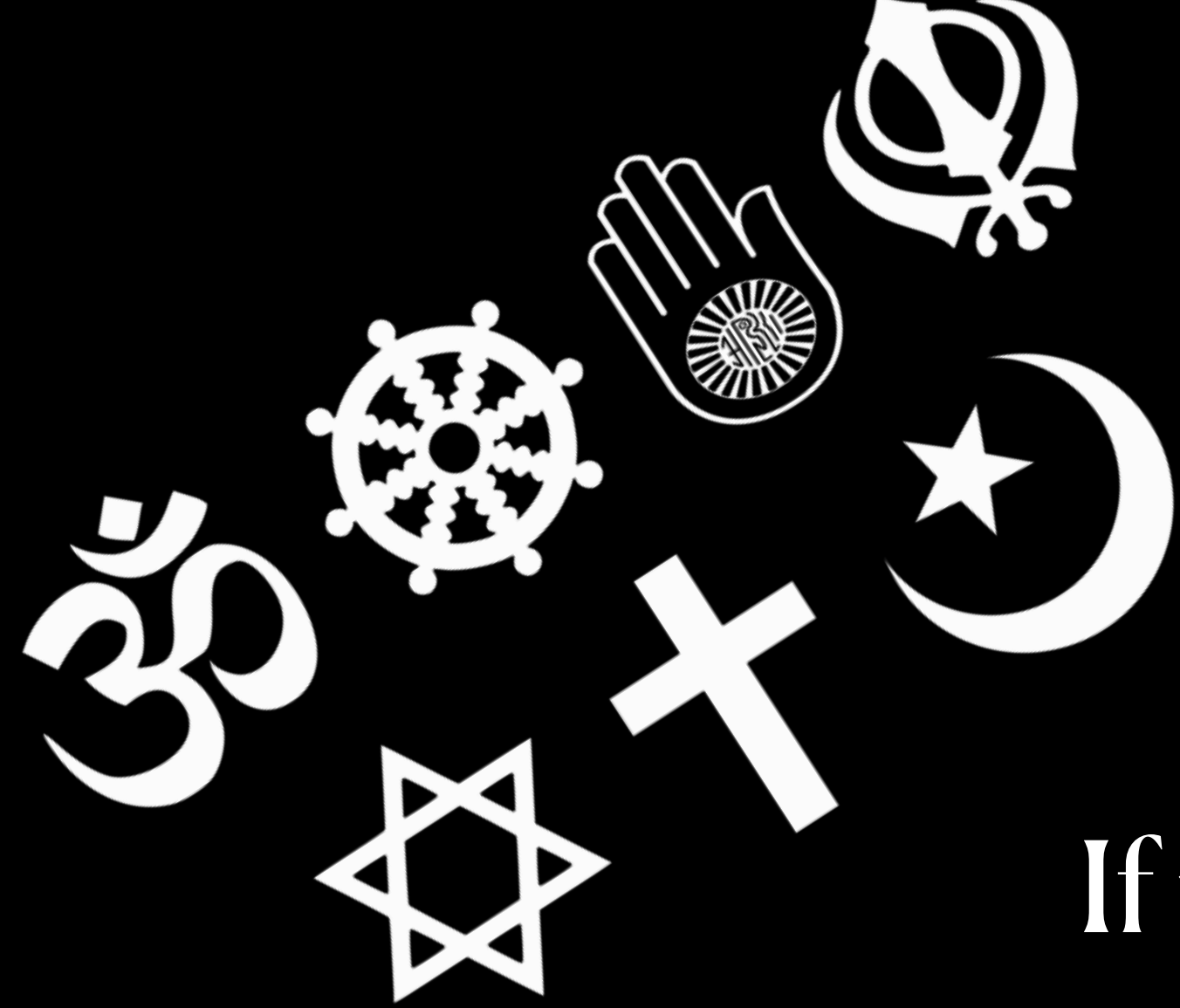


If empirical data alone tests theory, and if it doesn't point to where the theory needs to be changed, then over time **we would expect theories to proliferate**, *but that doesn't seem quite to be the case, especially in the natural sciences.*

The problem of empirically equivalent but logically incompatible theories becomes especially serious as science becomes more theoretical.

Question:

Imagine we have all the data on every subject in,
could there still be two distinct equally simple,
elegant, and empirically adequate theories that are
incompatible with one another?



If it's **not** the test of observation and experiment which is able to collapse the theory landscape into a single candidate, why is it still the case that **scientific communities find consensus** over time?



Next Time (Mar 8th) - Science as a Social Endeavour

- To read (all on Athena):
 - Chapter 12 of Rosenberg & McIntyre
 - Reading exercise on Okruhlik paper “Gender and the Biological Sciences”

Assignment II

2. Prompt

Choose **one** of the following three topics:

- (1) Scientific realism or anti-realism
- (2) Theory testing
- (3) Scientific progress
- (4) Objectivity of science

For the chosen topic, write an assignment that completes the following tasks:

- (a) Explain one philosophical view on this topic in full. In doing so, explain a benefit or argument in support of this view
- (b) Present either a competing view, or an objection against the view you explained in part (a)
- (c) Critically evaluate the theory explained in part (a) by either discussing its strengths and weakness compared to the alternative presented in part (b), or by considering the strength of possible responses to the objection presented in part (b).