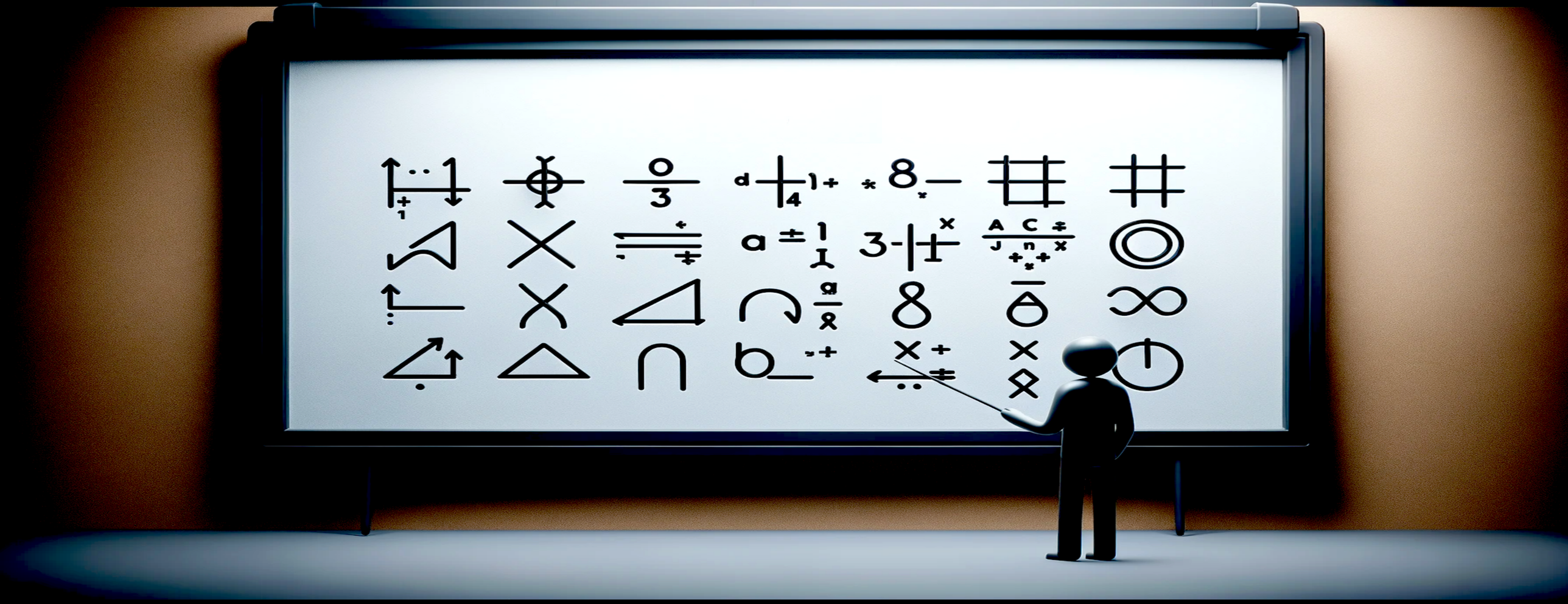
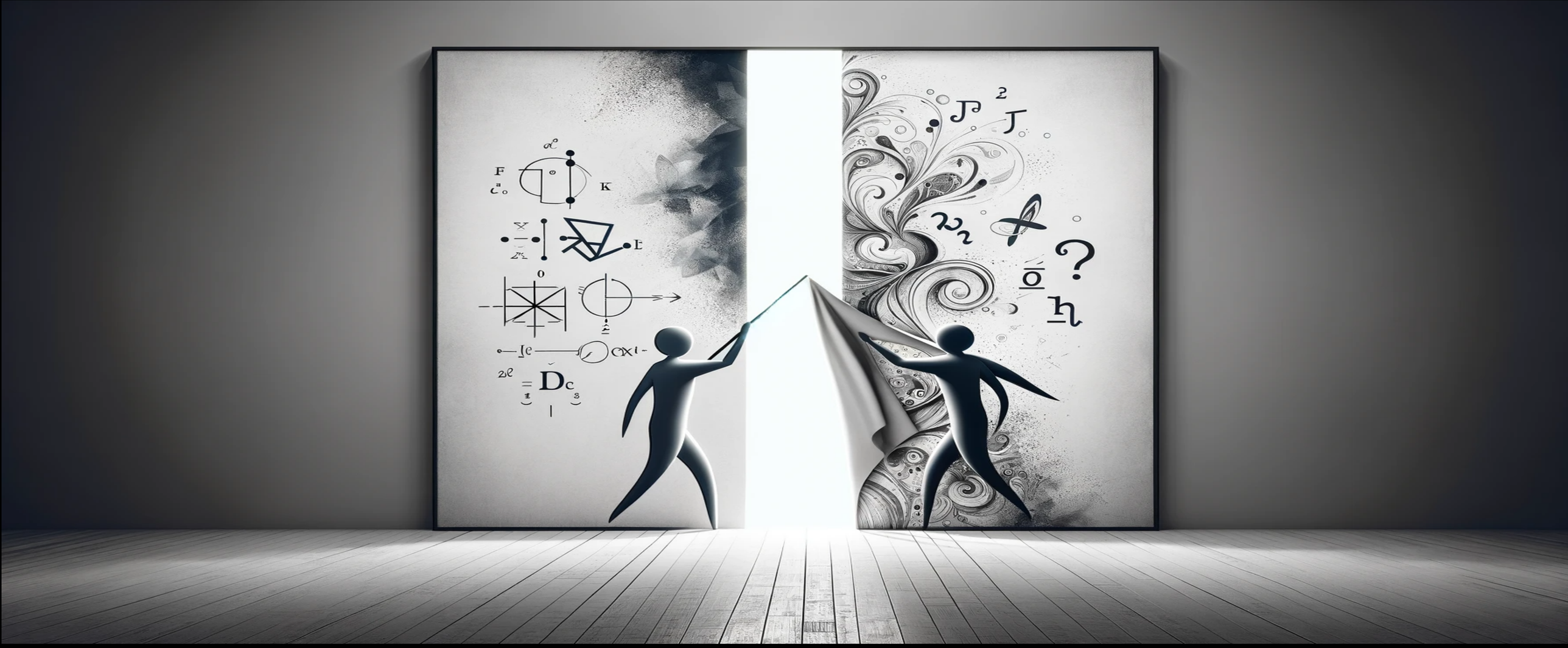
Philosophy of Science I

February 2nd 2024

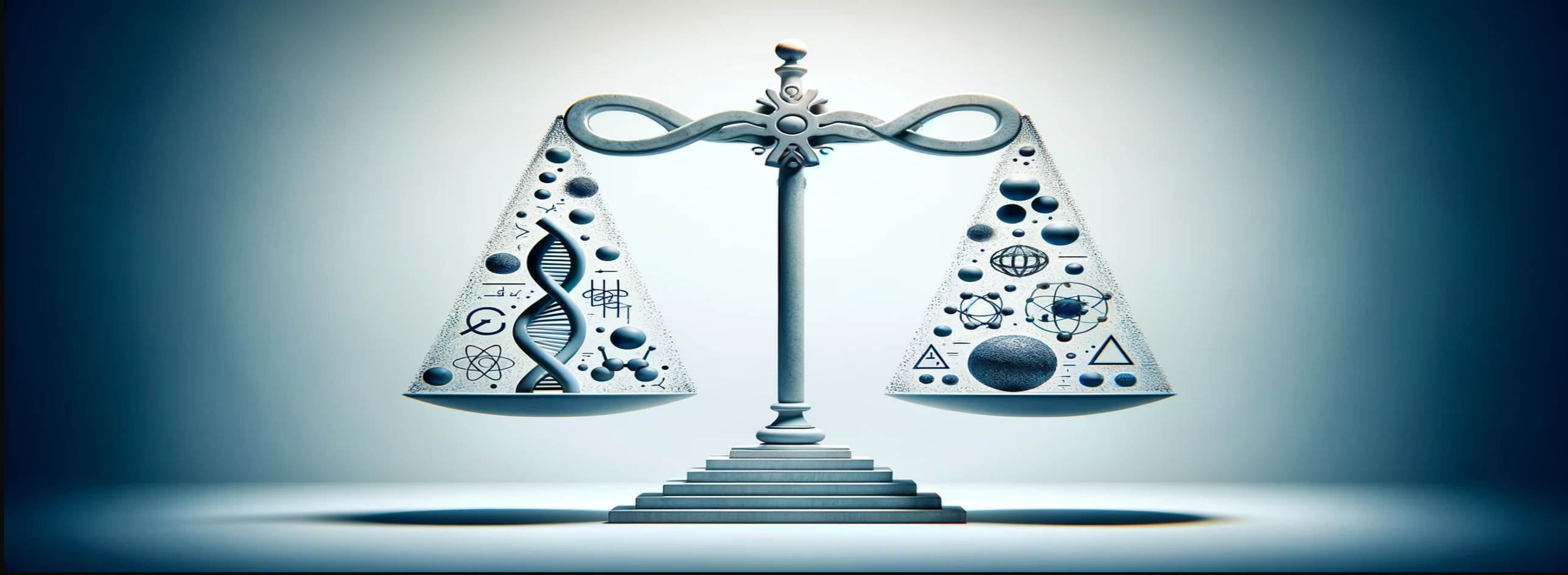
Session 2 - Scientific Explanations



What does it mean to explain?



Are these explanations discoveries or something we create?

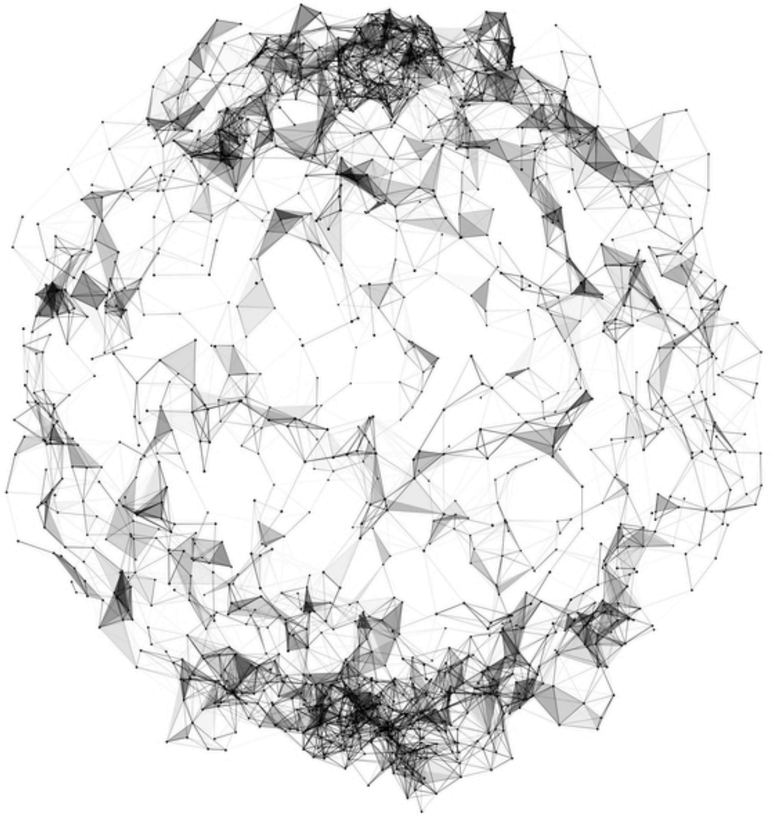


Is there a standard to what we call a scientific explanation?

What is a Scientific Explanation?

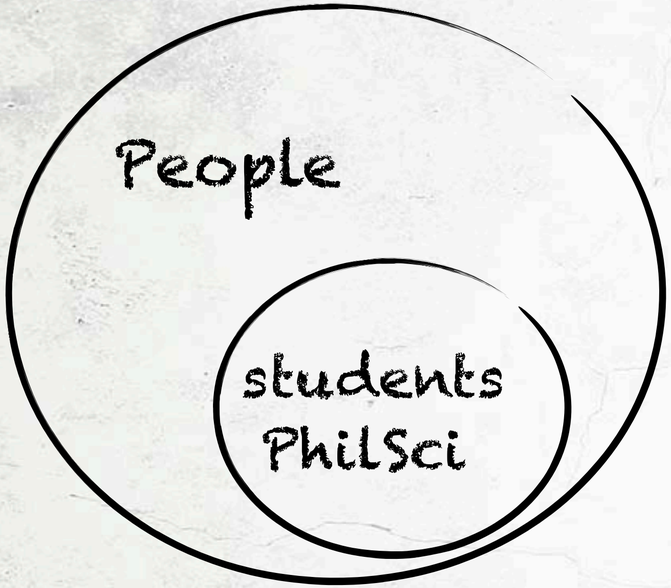
The *rational reconstruction* of logical positivists sought to provide an explicit definition of scientific explanations encompassing **necessary and sufficient** conditions.

Thus, they would establish a prescription, a *litmus test,* to know whether an explanation is or not scientific. Their strategy was inspired after the development of mathematical logic, and a similar rigor was attempted in science.



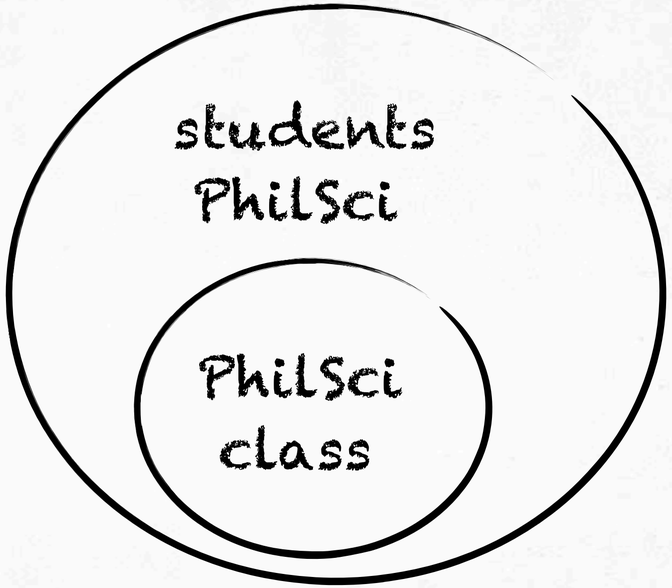
NOTE

Necessity v. Sufficiency



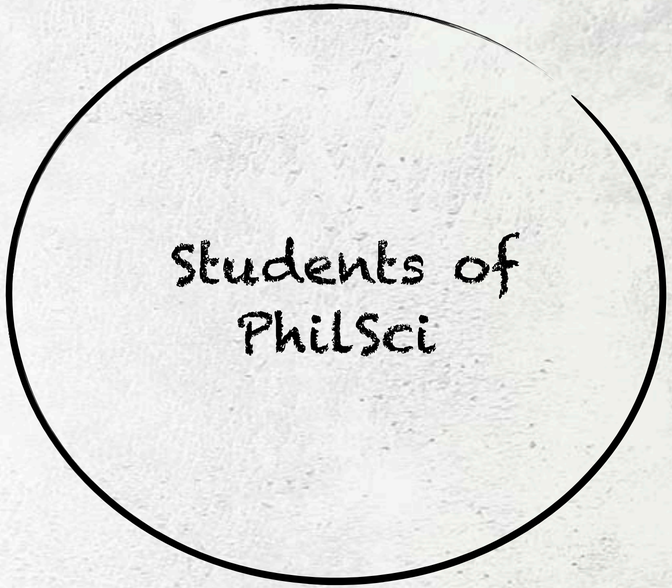
Students of PhilSci are people.

Necessity



People taking this class are students of PhilSci.

Sufficiency



People taking PhilSci are students of PhilSci.

Definition

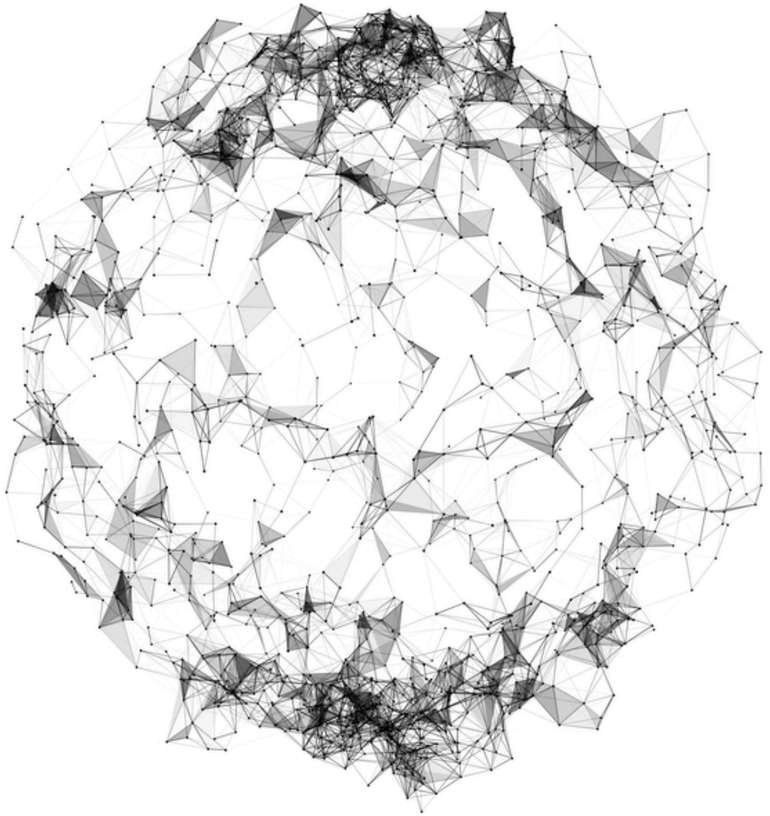
Try yourself!

Break the room in groups of 4.
Provide the definition of a circle v.
definition of a class.

What is a Scientific Explanation?

The *rational reconstruction* of logical positivists sought to provide an explicit definition of scientific explanations encompassing **necessary and sufficient** conditions.

Thus, they would establish a prescription, a *litmus test,* to know whether an explanation is or not scientific. Their strategy was inspired after the development of mathematical logic, and a similar rigor was attempted in science.



Q: What do you think about their strategy?

How scientific explanations work?

E.g.: Water boils at a lower temperature at higher elevations than it does at sea level.

i) The boiling point of a liquid is the temperature at which its vapor pressure equals the external pressure surrounding the liquid. This is a fundamental principle in thermodynamics.

ii) As elevation increases, the atmospheric pressure decreases. This relationship is part of the scientific law governing the behavior of gases in Earth's atmosphere.

iii) The exact altitude determines the atmospheric pressure.

Q: What makes the explanation above scientific?

How scientific explanations work?

Explanandum

E.g.: Water boils at a lower temperature at higher elevations than it does at sea level.

Explanans

i) The boiling point of a liquid is the temperature at which its vapor pressure equals the external pressure surrounding the liquid. This is a fundamental principle in thermodynamics.

ii) As elevation increases, the atmospheric pressure decreases. This relationship is part of the scientific law governing the behavior of gases in Earth's atmosphere.

Boundary/Initial Conditions

iii) The exact altitude determines theatmospheric pressure.

Q: When does the model above seem to fail?

The role of scientific explanations

But why do we need laws for a scientific explanation?

One possibility is that scientific explanations are **causal** - they establish a **relationship** of **cause** and **effect** between the **initial conditions** and the **explanandum** through the **explanans**.

According to a theory of causation going back to David Hume, the relation of cause and effect obtains only when one or more laws cover the events in questions as cases or instances of the operation of laws.

Q: How satisfying is this account?

Q: Why does causation imply laws?

Questions?

Problem 1:
laws but no cause/effect?

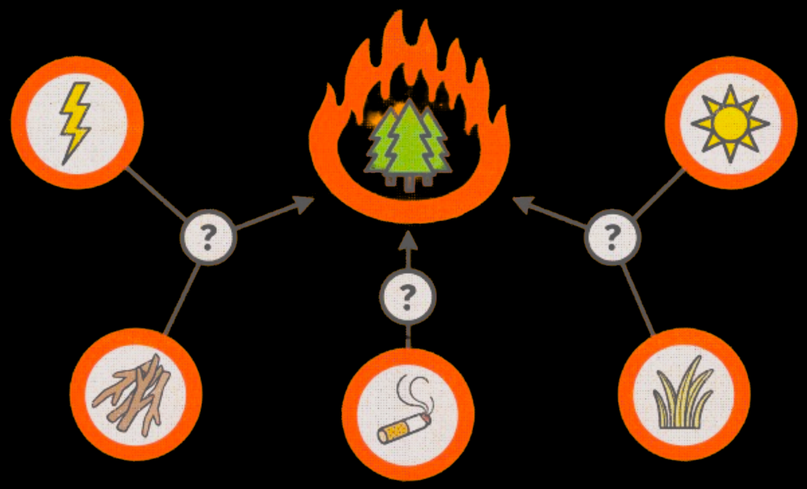
E.g.: the ideal gas law, $PV = nRT$, relates the temperature of a gas at equilibrium with its pressure and volume. But do they cause the temperature?

According to the book, no, as they all vary instantaneously, so no notion of first vary volume, say, and then temperature varies at a later time.

Problem 2:
the nature of causation

E.g.: A thunder always succeeds a lightning. Does the lightning cause the thunder?

No, as both are caused by the electrical discharge between the clouds and the earth. So, clearly causation requires more than mere regularity.

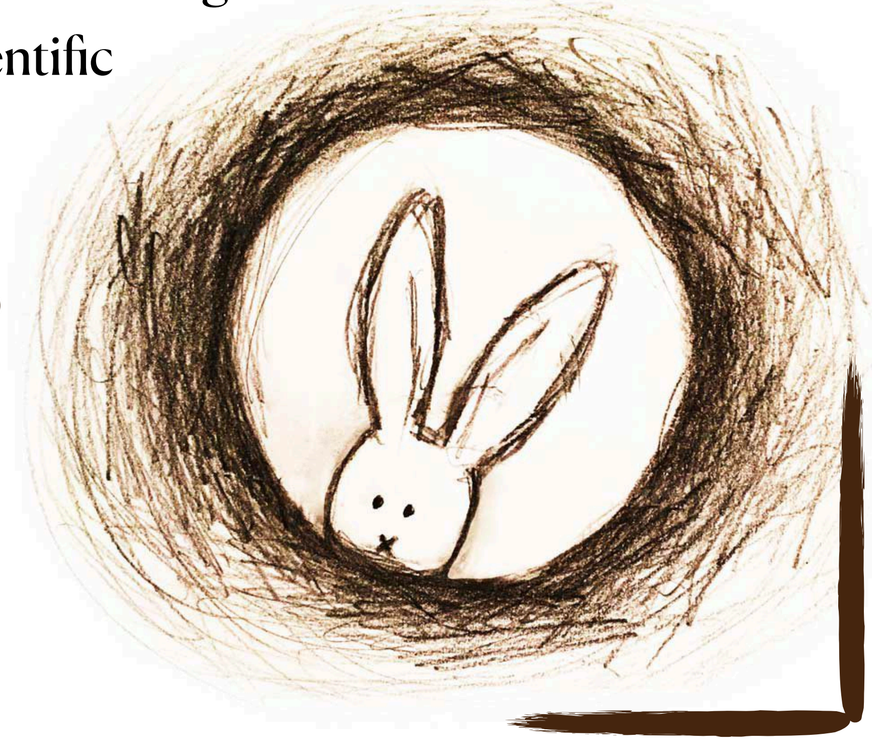


Q: What would that be?

Most philosophers: causes somehow ***necessitate*** their effects. However, some would argue "*that the notion of causation was an obsolete anthropomorphic one*" - based on our unavoidable interventionist agent-like approach to the world.

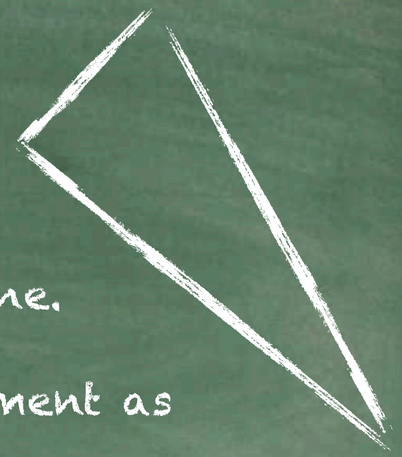
Needless to say, the logical positivists really wanted to avoid this metaphysical rabbit hole about the existence and nature of causal necessity. Therefore, the logical positivists sought a different line of reasoning to invoke and justify laws as a fundamental part of their scientific explanations. Their philosophy of science could be summarized as:

A scientific explanation should establish an **objective** relationship between the explanadum and explanans. **Like a mathematical proof**, it would obtain regardless of whether anyone recognizes it and it would be sufficiently precise without margin for doubt.



Mathematical Proof - $\sum$ $\triangle$'s angles = 180°

Example: Euclid's postulates:



1. A straight line segment can be drawn joining any two points.
2. Any straight line segment can be extended indefinitely in a straight line.
3. Given any straight line segment, a circle can be drawn having the segment as radius and one endpoint as center.
4. All right angles are congruent.
5. If two lines are drawn which intersect a third in such a way that the sum of the inner angles on one side is less than two right angles, then the two lines inevitably must intersect each other on that side if extended far enough.

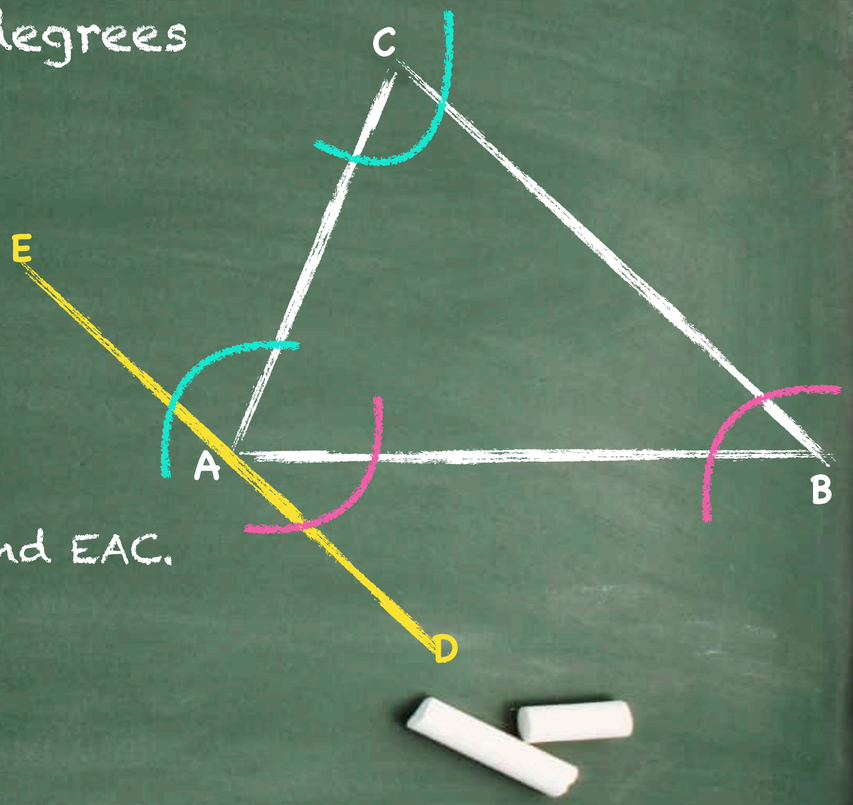
(This postulate is equivalent to what is known as the parallel postulate.)

Mathematical Proof - $\sum \triangle$'s angles = 180°

Theorem: the sum of angles in a triangle is 180 degrees

1. Given a triangle ABC.
2. Draw a line DE parallel to BC, passing through A.
3. Since DE is parallel to BC, the angle DAB is equal to ABC
4. Similarly, the angle EAC is equal to ACB.
5. The sum of angles in a triangle is the sum of DAB, BAC, and EAC.
6. But DAB + BAC + EAC = a straight line, which is 180°.

Therefore, the sum of angles in a triangle ABC is 180°.



We already knew that the sum of angles in a triangle in flat space is 180°, but we now see that that information was implicitly contained in the postulates.

Thus, what they sought was that the explanandum is an unavoidable consequence of the initial conditions together with the explanans - it should logically follow from them!

This logical implication carries two important properties:

- Truth-preserving: if the premises of a deductively valid argument are true, the conclusion is also true
- Whether the premises imply the conclusion is an objective matter of fact which can be computationally decided (not subjective)

By having these properties, we approach the ideal goal that logical positivists had for scientific explanations. This analysis of scientific explanation is mostly associated with Carl Hempel and is called deductive-nomological (D-N) model,
Or the covering law model.

Questions?

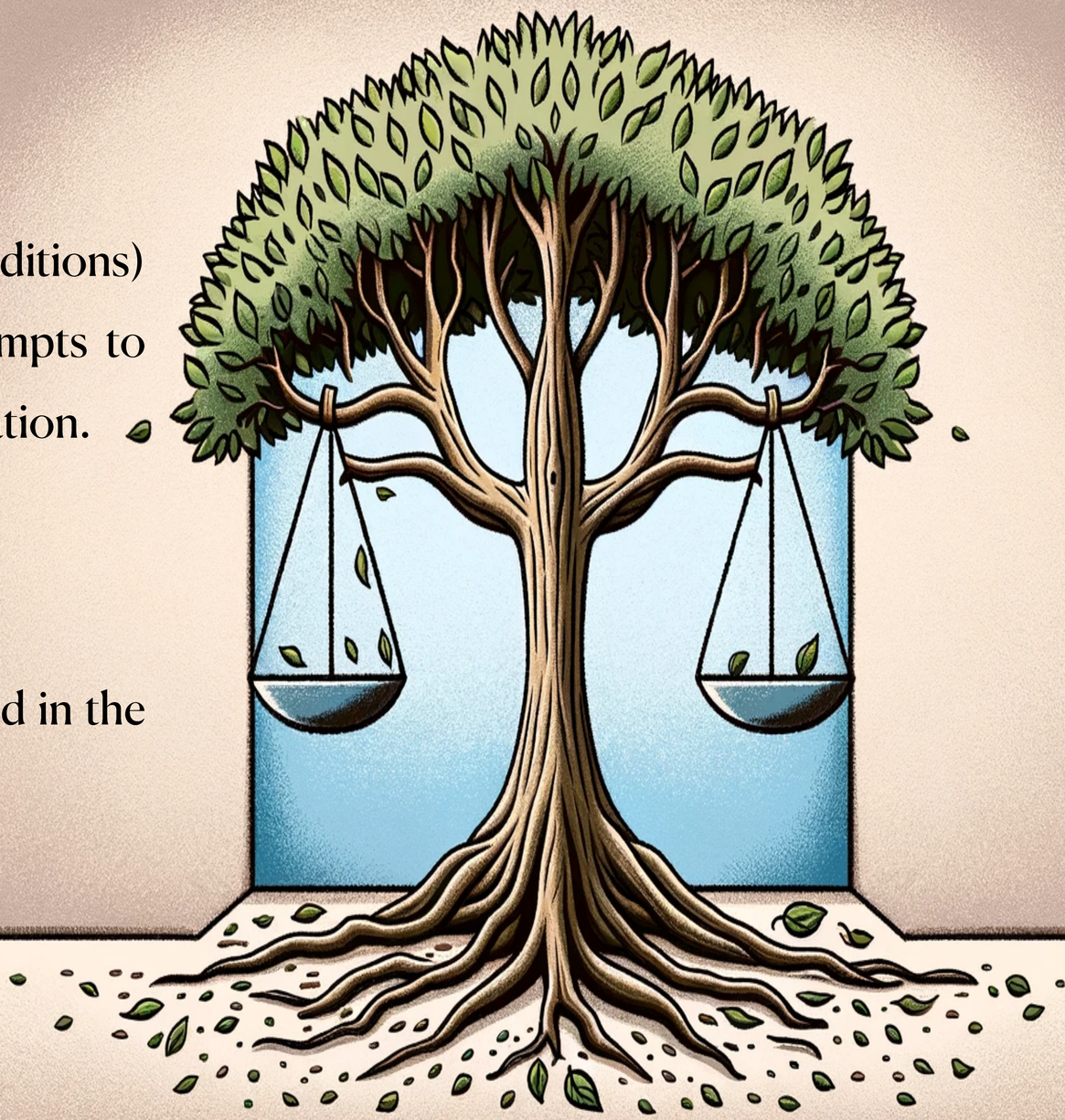
The Deductive-Nomological Model

It attempts to provide a **definition** (necessary and sufficient conditions) of scientific explanation. The definition is **normative** as it attempts to provide the conditions for a successful (or 'good') scientific explanation.

The **requirements** are:

1. The explanation must be a **valid deductive argument**
2. The explanans must contain at **least one natural law** used in the deduction
3. The explanans must be **empirically testable**
4. The sentences in the explanans must be **true**

Q: Criticize it?



Counterexample 1:

1. Heat flow from hotter to colder objects
2. I went climbing on Monday
3. I went climbing on Monday.

Counterexample 2:

1. All students in this class take PhilSci
2. You are in this class
3. You take PhilSci.

Counterexample 3:

1. Birth control pills prevents pregnancy
2. Gut takes birth control pills
3. Gut is not pregnant.

Counterexample 4:

1. The coffee mug is on the desk
2. My feet hit the desk
3. The coffee mug tipped over.

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Law usage/nothing explains itself

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Counterexample 3:

Relevance

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Counterexample 4:

[redacted]

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Counterexample 4:

Singular Events

1. The coffee mug is on the desk
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Counterexample 5:

1. If God wants anything, then it is
2. God wants the sky to be blue
3. The sky is blue.

Counterexample 5:

Testability

1. If God wants anything, then it is
2. God wants the sky to be blue
3. The sky is blue.

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Counterexample 2:

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1. All students in this class take PhilSci
2. You are in this class
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Given the **strong requirement implicated for natural laws**, it's unclear that any of our scientific laws hold the status of a **universal, true natural law**, thus we have good reason that none of our scientific explanations actually hold the standards required by the covering law model.

Q: Can we avoid this problem?

We could weaken requirement 4) to invoke our best scientific theory at a given time instead of a law.

But that undermines the D-N model's claims to precision in explication! In fact, the idea of a "law" is invoked multiple times in the model because there is consensus that the explanatory power of an explanation is borne by the law – it is what makes explanatory the connection between the particular facts mentioned in the initial conditions of the explanans, and the particular facts mentioned in the explanandum.

We will have to think harder about natural laws!

Questions?

More problems!

Recall that the DN model attempts to provide **necessary and sufficient conditions** for a good scientific explanation. So, there are at least two ways of challenging this account:

- Provide examples of good scientific explanations that do not meet at least one of the conditions (counter the necessity claim)
- Provide examples that meet all of the conditions, but which are not good scientific explanations (counter the sufficiency claim)

Let's see some other counter-examples that do seem to explain but fail the requirements (**arguably all current scientific explanations)** and, more worrying, examples that actually fulfill all the requirements but no one takes them to be a scientific explanation.

Counterexample 6:

[redacted]

1. Hammas attacked Israel on Oct 7th
2. Israel declared war on Hammas
3. Israel invaded Gaza.

Sounds reasonable, but [redacted]

Counterexample 6:

No natural laws/singular events

1. Hammas attacked Israel on Oct 7th
2. Israel declared war on Hammas
3. Israel invaded Gaza.

Sounds reasonable, but no natural laws raised.

Even if historically we say, *Whenever Israel is attacked, it retaliates,* still fall short of the universality of a law.

However, D-N aficionados will claim that this is nonetheless **an explanation sketch** and that, **in the case of natural sciences, it eventually can be turn into an explanation following their model.**

Example: The Challenger space shuttle disaster in 1986 occurred because of a problem with rubber used in the shuttle's boosters. **- sounds convincing to a naïve listener, but no laws.**

However, it implicitly summarizes a D-N type of explanation:

General Law: In this case, the general laws involve physics and engineering principles. One relevant law is that certain materials, like the rubber O-rings used in the shuttle's solid rocket boosters, lose elasticity and become brittle in cold temperatures.

Initial Conditions: The Challenger launch took place on a particularly cold morning, with temperatures much lower than those for previous shuttle launches. The O-rings were not designed to function optimally in such cold conditions.

Deduction of the Event: Combining the general law with the initial conditions, we can deduce why the disaster happened. The cold temperature caused the O-rings to fail to seal properly. This failure allowed hot gases to escape from the solid rocket booster and damage the external fuel tank, leading to the shuttle's explosion.

Counterexample 7: flag-pole's shadow

D-N approved, but not explaining

Explanandum: The flag-pole at Stockholm's City Hall is 30 meters high

Explanation:

1. Light travels in straight lines (a law)
2. The sun is emitting light at a 45 degree angle to the ground where the flag-pole is located, perpendicular to the ground (boundary condition)
3. The shadow cast by the flag-pole is 30 meters long (boundary condition)
4. A triangle with two equal angles is isosceles (mathematical truth)

Therefore,

5. The flag-pole is 30 meters high.

Q: What's the issue?

Counterexample 7: flag-pole's shadow

D-N approved, but not explaining

Explanandum: The flag-pole at Stockholm's City Hall is 20 meters high

Explanation:

1. Light travels in straight lines (a law)
2. The sun is emitting light at a 45 degree angle to the ground where the flag-pole is located, perpendicular to the ground (boundary condition)
3. The shadow cast by the flag-pole is 30 meters long (boundary condition)
4. A triangle with two equal angles is isosceles (mathematical truth)

Therefore,

5. The flag-pole is 30 meters high.

Caused by the conclusion!

Q: What's the issue?

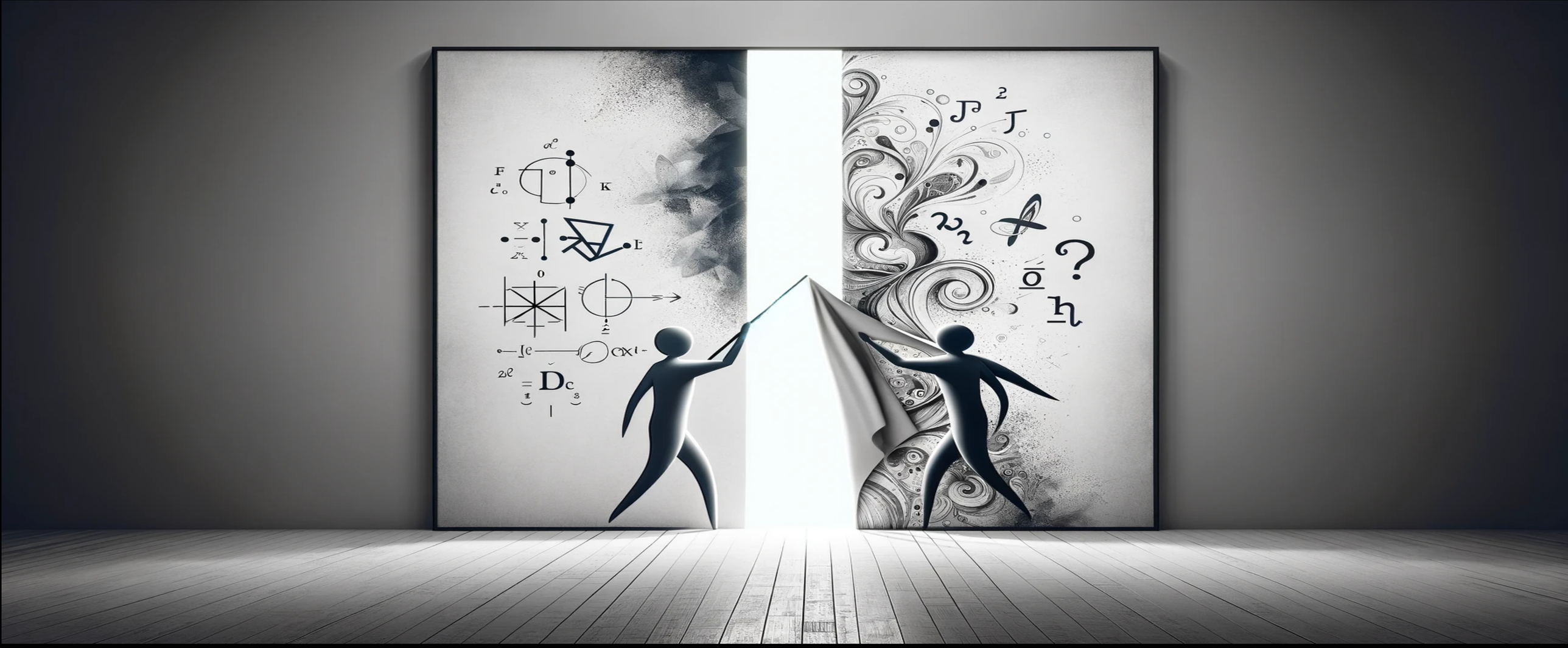
One would expect that the D-N model should be causal, and therefore the premises could not be forward in time than the conclusion (the choice for the height of the pole precedes its having a shadow of any height). However, imposing such a requirement would lead to problems to other scientific explanations, such as the one using the ideal gas law where we see simultaneous changes in temperature, pressure and volume - they do not cause one another.

Some would argue that one can actually still find an explanation of this sort where the premise (3) is actually considered part of the explanation, simply by **adding human intentions to the model**, thus rejecting seeking a completely objective explanatory relation between statements about facts in the world as independent of human contexts.

This argument also highlights **the pragmatics of language**, the context it implicitly carries. Had someone known the context behind the question, for instance the human intentions underlying the situation, then the explanation could have suffice. This sort of context is usually better appreciated in yes/no questions:

E.g.: Are you still a robber? - *it assumes that you were a robber in first place.*

More often than not, questions impose a framework of thought.



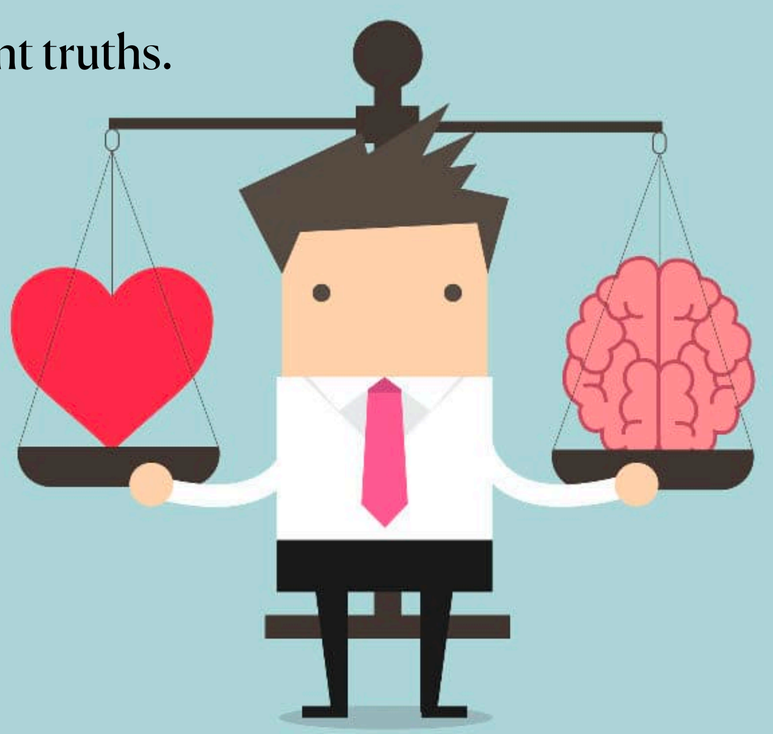
Are these explanations discoveries or something we create?

The Pragmatic Approach

Similarly to the question surrounding the nature of mathematics as being invented or discovered, different attitudes towards philosophy of science are oriented accordingly to the answer to this question.

The logical positivists, in their belief on mathematical truth corresponding to objective discoveries, attempted to strip the scientific endeavour from anything subjective while establishing relations between different truths.

However, a very different attitude can be taken by believing that the scientific enterprise is intrinsically a human institution. On this view, scientific laws do not have a life of their own independent of humans, but rather they comprise beliefs that we use to get around in the world.

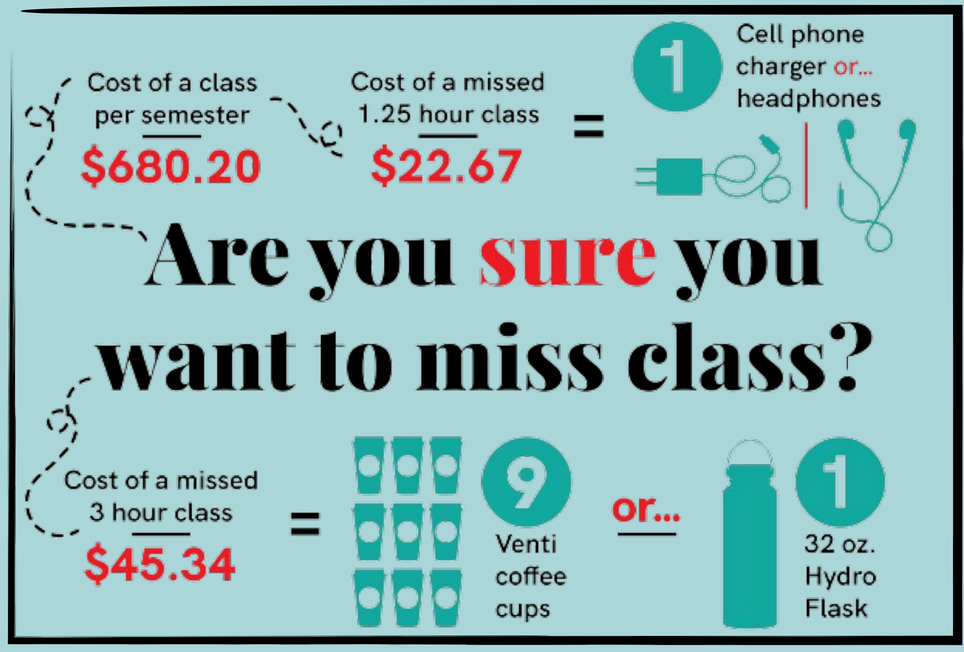


The counterexamples we've seen so far invite us to analyze more closely the way that scientific explanations are used in practice instead of stipulating standards that might be unreachable based on prejudices that might not be warranted,.

To show the role pragmatics play in language, let's consider syntactically and semantically identical clauses, but with different emphasis:

- Why did **you** miss the class?
- Why did you **miss** the class?
- Why did you miss **the class**?

Q: What's being asked in each question?



Each question refers to a different **contrast class** according to van Fraassen: a) students; b) actions; c) courses.

In the pragmatic account, a question Q has three components <P, X, R>:

- P is the **topic** (the explanandum)
- X is the **contrast class** (other possible answers to Q *relevant* in the context)
- R is the ***relevance relation*** (the standards of a correct answer to the question in context)

An answer to Q is of the form:

P in contrast to the rest of X because of A(nswer), where A meets the standard required by R, and A favours P over the rest of X.

Example:

Q: Why did Ms. R kill Mr. R?

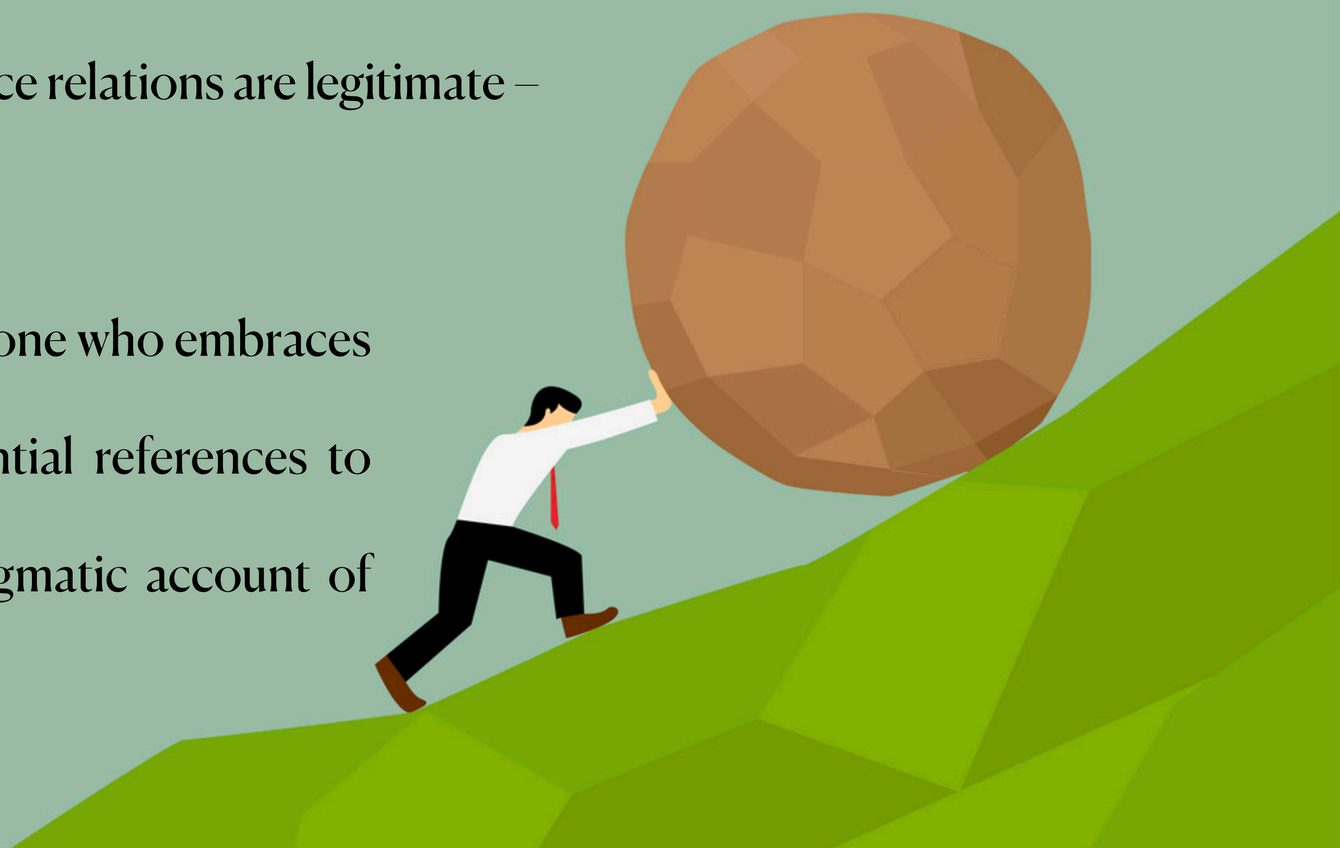
- P: Ms. R killed Mr. R
- X: Ms. R killed the cook; Ms. R killed the butcher, etc
- R: knowledge Ms. R's monetary issues, Mr. R's will and so on.

An answer: Ms. R killed Mr. R rather than anyone else, because she wanted to inherit his money.

Relevance Relations

The ”relevance relation” R is doing a lot of work for the pragmatic account. **But what does it mean to be relevant?** One needs to place restrictions on which relevance relations are legitimate – perhaps only those that are ‘true’, ‘scientific’, or ‘objective’?

But this invites the question: to what extent can someone who embraces the pragmatic aspect of explanation (which makes essential references to beliefs and context) appeal to these notions in their pragmatic account of explanation?

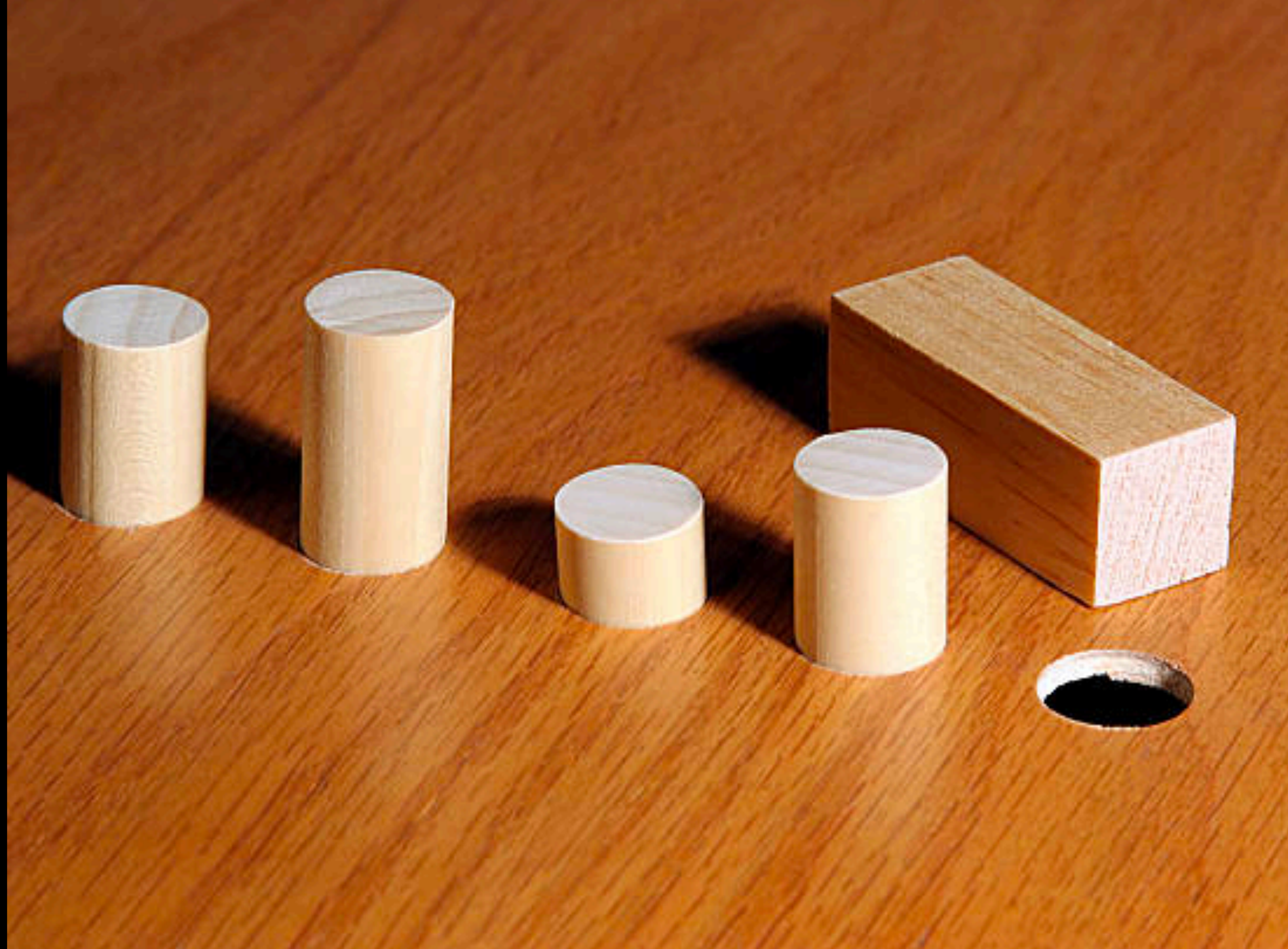


"Explanatory factors are to be chosen from a range of factors which are objectively relevant in certain special ways... **To sum up: no factor is explanatorily relevant unless it is scientifically relevant**; and among the scientifically relevant factors, context determines explanatorily relevant ones.

(van Fraassen, 1980, 126)

Lloyd/Anderson point out that there are **two levels of delimitation**: first, the background of accepted scientific theories at a given time; and within those limits, which ones to be considered for a given question.

Why does it not fit?



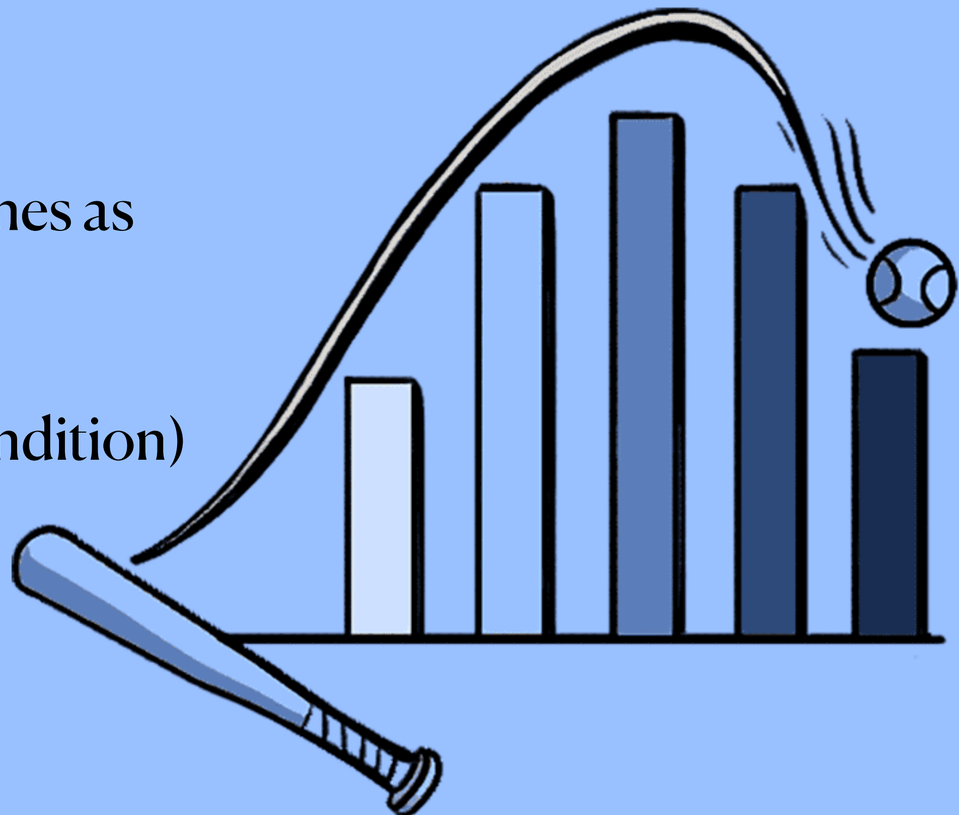
by Frits Ahlefeldt

Inductive-statistical explanation

Explanandum: Rachel votes for the left-wing block

Explanans:

- 80% of voters vote for along the same political spectrum lines as their parents (statistical law)
- Rachel's parents vote for the left-wing block (boundary condition)

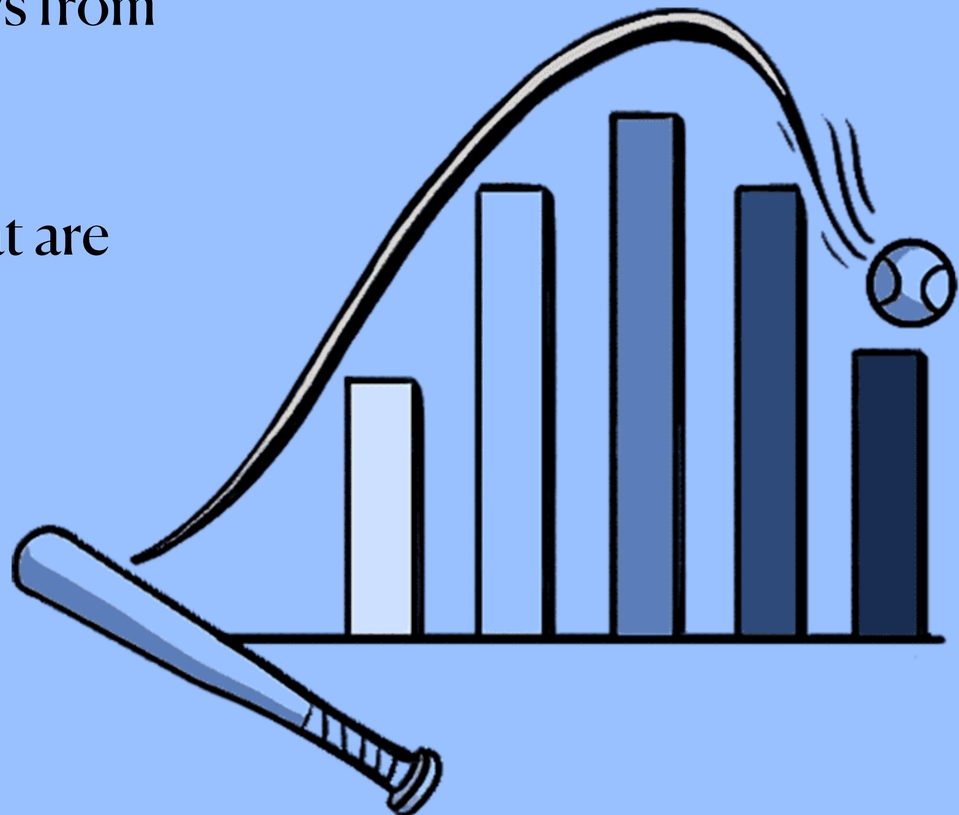


Inductive-statistical explanation

X is an IS scientific explanation IF and ONLY IF

- X is an inductive argument where the explanandum follows from the explanans with **high probability**
- The premises of X **include statistical laws of nature** that are crucial for high inductive validity of the argument
- The premises of the argument are **empirically testable**
- The premises of the argument are **true**

Q: Why else?



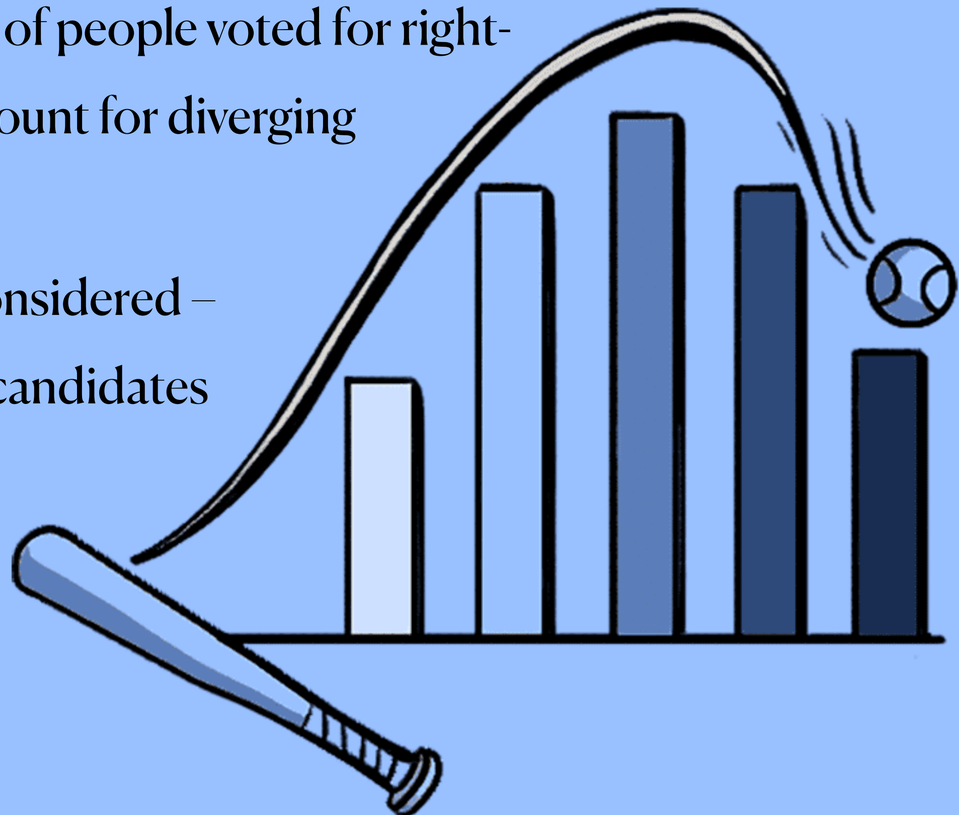
Not without issues!

The main issue with I-S explanations is that **other percentages might play a bigger role than the ones already present in the explanans.**

For instance, perhaps Rachel is in an affluent neighborhood where 90% of people voted for right-wing candidates, thus undermining the explanation above. How can we account for diverging percentiles?

One needs to find the most relevant intersection between the classes considered – here, the fact that Rachel is both a woman and her mom voted for left-wing candidates together with her being in such a neighborhood.

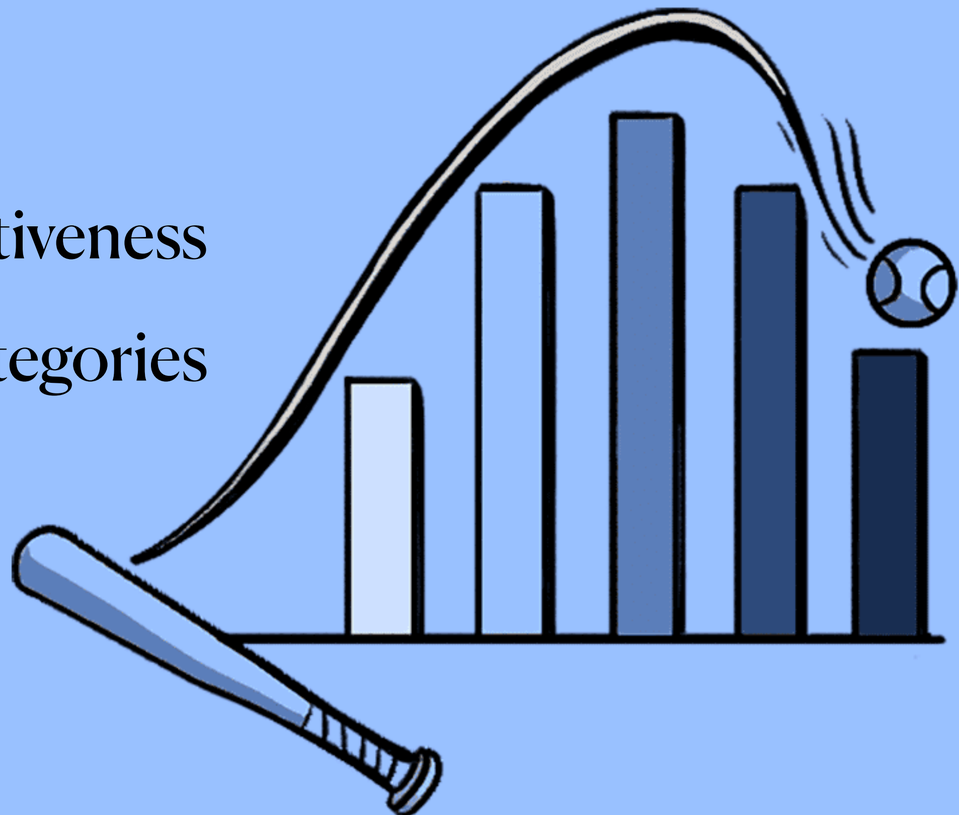
If for this group, the overall percentage of people that voted for left-wing candidates is, say, 70%, then this will now count as an I-S explanation.



Thus, we could imagine an addendum to the D-N explanation:

The explanation must give the probability value for the intersection of all the believed relevant groups.

But then suddenly we are back into the realm of subjectiveness as different people might disagree over the relevant categories one should invoke to explain a given fact!



Next Time (Feb 9th) - Laws of Nature

To read (all on Athena):

- Rosenberg & McIntyre) – Chapter 4
- Cartwright – “The truth doesn’t explain much”