Philosophy of Science

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Philosophy and Science
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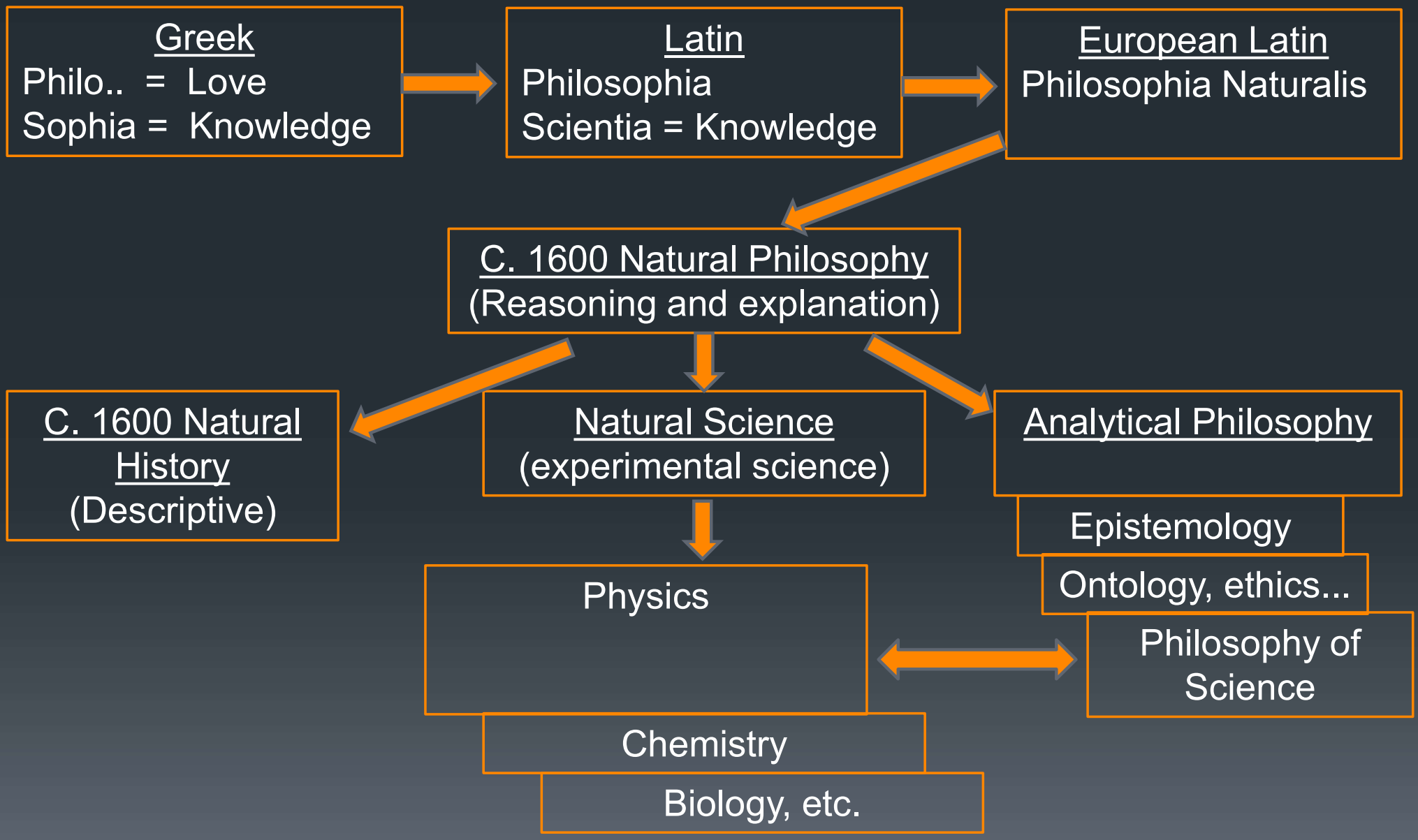


What's it all about?

- What is science?
- Do experiments "prove" anything?
- What makes a scientific theory true?
- What is a scientific explanation?
- Are the 'laws of nature' really laws?
- Do we discover science or invent it?
- How does science progress?

What is science?

- E.g. “An effort to understand, explain and predict the world, using one or more of experimentation, observation and theory-construction”

- So, is creationism a science? (Or astrology…?)

- Concepts (like “science”) rarely have tight definitions.
  They are ‘clusters’ of characteristics,
  and qualify if enough are present.

“Creation Science”

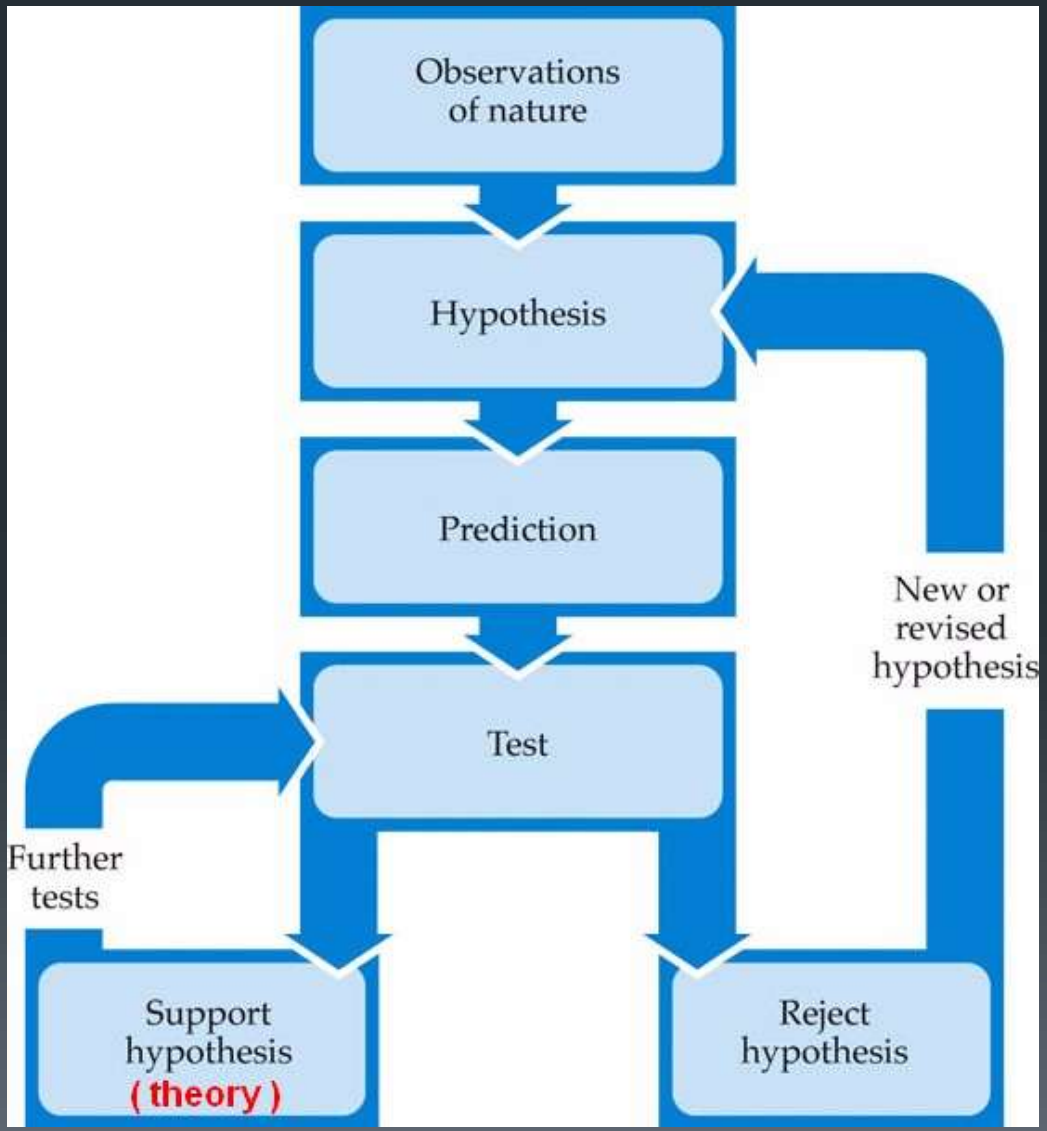
God created the world and all currently-living creatures 4000 years ago.

- In the USA, public schools may not teach religion, although teaching about religion in a secular context is permitted.
- Fundamentalists claimed the Genesis story is science, not religion.
- 1982 Trial to force the teaching of Creation Science, on a par with evolution.
- Judge Overton rejected the creationists. “Science” must be:
  - guided by natural law;
  - explained by reference to natural law;
  - testable against the empirical world;
  - Its conclusions are tentative, i.e., are not necessarily the final word;
  - It is falsifiable.
- Rules out economics, psychology, sociology…?

Pseudoscience

Science	Pseudoscience
Willingness to change with new evidence	Fixed ideas
Ruthless peer review	No peer review
Takes account of all new discoveries	Selects only favourable discoveries
Invites criticism	Sees criticism as conspiracy
Verifiable results	Non-repeatable results
Limits claims of usefulness	Claims of widespread usefulness
Accurate measurement	“Ball-park” measurement

The scientific method



Can experiments prove a theory?

- What is it to deduce the truth of a statement?
- The “gold standard” guarantee of truth is logical entailment:
  - *If all men are mortal and Socrates is a man, then Socrates is mortal.*
  - *2 + 2 = 4*
- These deductions tell us about the meaning of words – nothing about the world.
- Experiments use induction, not deduction.

Sherlock & Mycroft “deducing”!

Story: “The Greek Interpreter” Scene: The Diogenes Club.

The problem with induction

David Hume
(1711 - 1776)

We are “certain” that the sun will rise tomorrow, that grass will still be green, that gravity will still be working.

But Hume pointed out that it is "consistent and conceivable" that nature might stop being regular.

I.e. there is no logical inconsistency in imagining a chaotic universe.

Trust in the uniformity of nature, (including the repeatability of experiments), is an unavoidable *act of faith*, not an act of deductive logic.

It is this instinctive belief in the uniformity of nature which gives rise to our concept of causation. We see only “constant conjunction” - no necessary connection, no logical entailment between cause and effect.

Uniformity and the laws of nature

Sir Isaac Newton
(1642 – 1726)

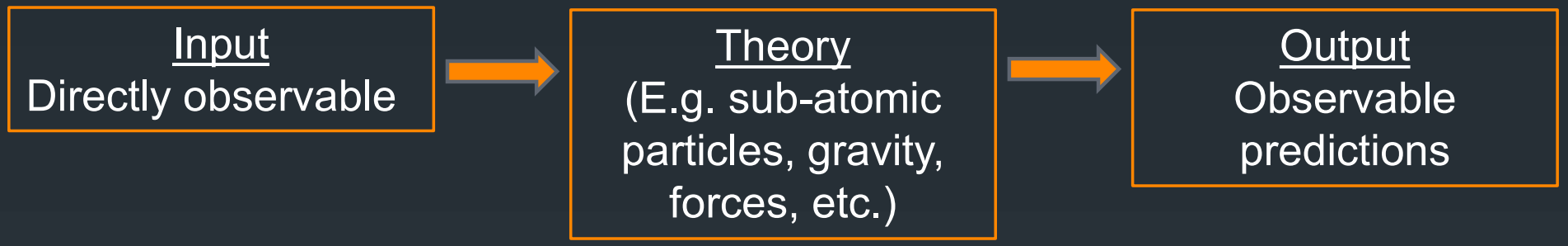
"I have not as yet been able to discover the reason for these properties of gravity from phenomena, and I do not feign hypotheses. …..In this philosophy particular propositions are inferred from the phenomena, and afterwards rendered general by induction."

Philosophiæ Naturalis Principia Mathematica

- No causal necessity > no necessary 'laws'.
- Laws simply describe how nature behaves.
- Should theory attempt to explain why nature behaves that way?

Instrumentalism

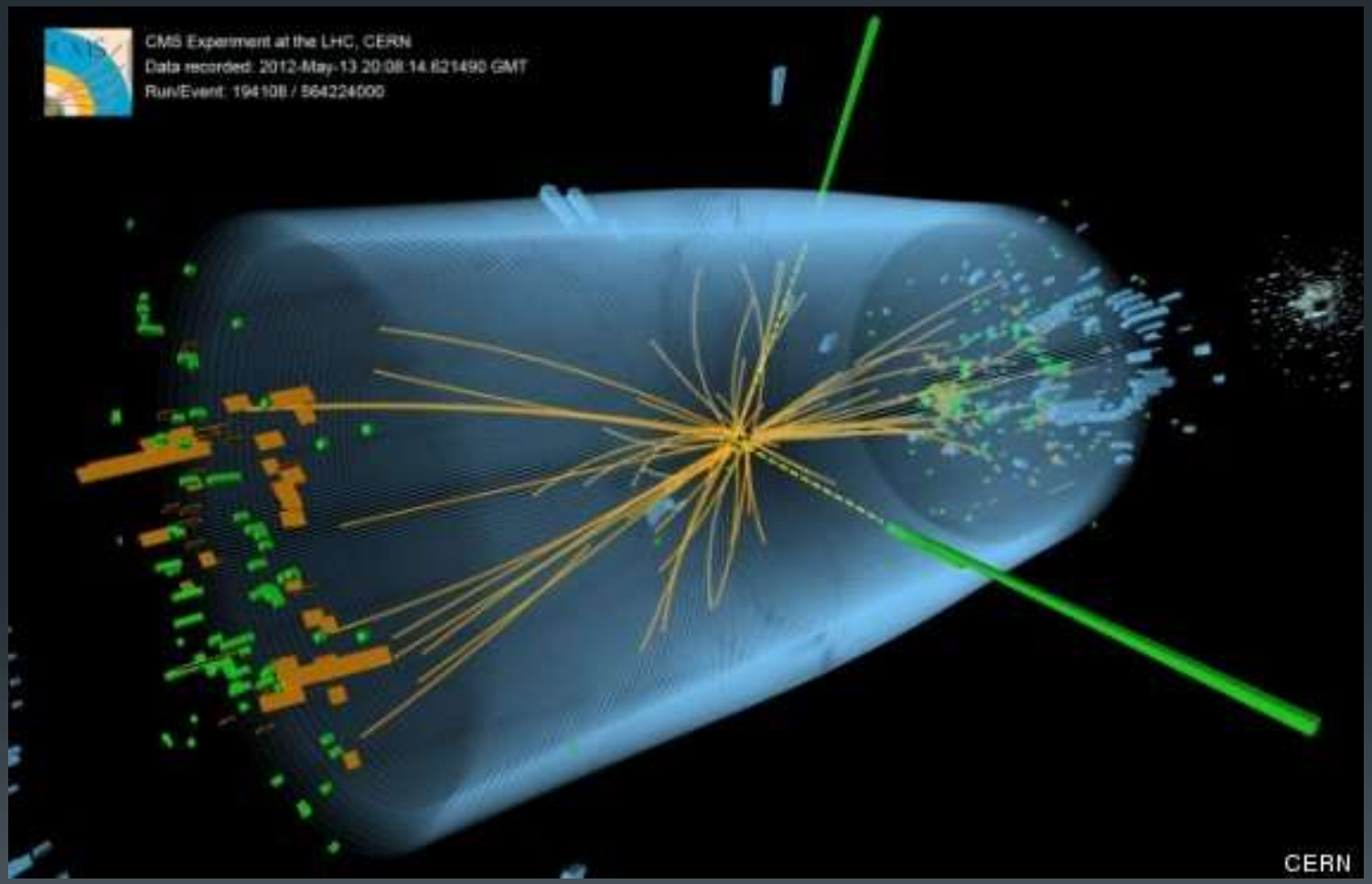
- Scientific theories are instruments to predict directly observable effects – not descriptions of underlying reality.



- But the directly observable shades to indirect indications.
- So instrumentalism is less convincing for theoretical entities (like particles, dark matter, genes[?] etc.,) than for pure theories.

Higgs Boson discovered

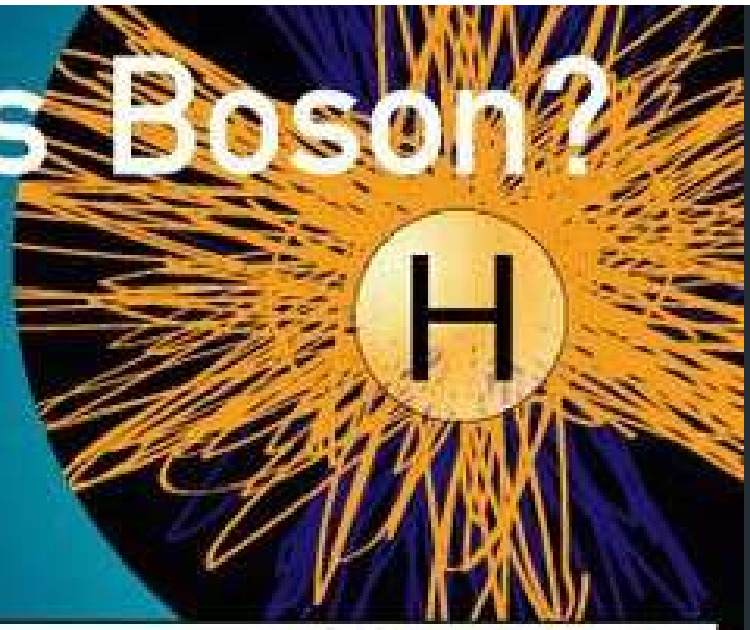
CERN May 2012



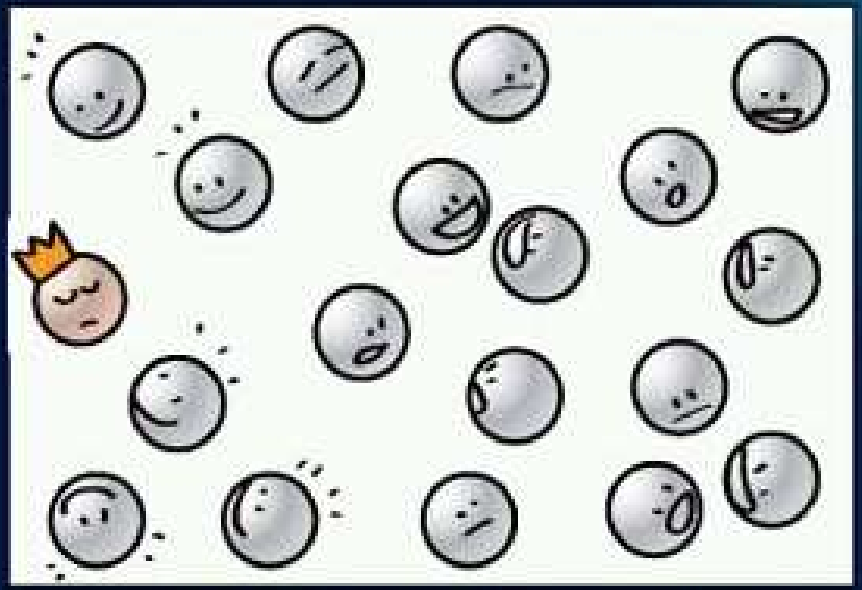
"The picture that proves the God particle." …Really?

What is a Higgs Boson?

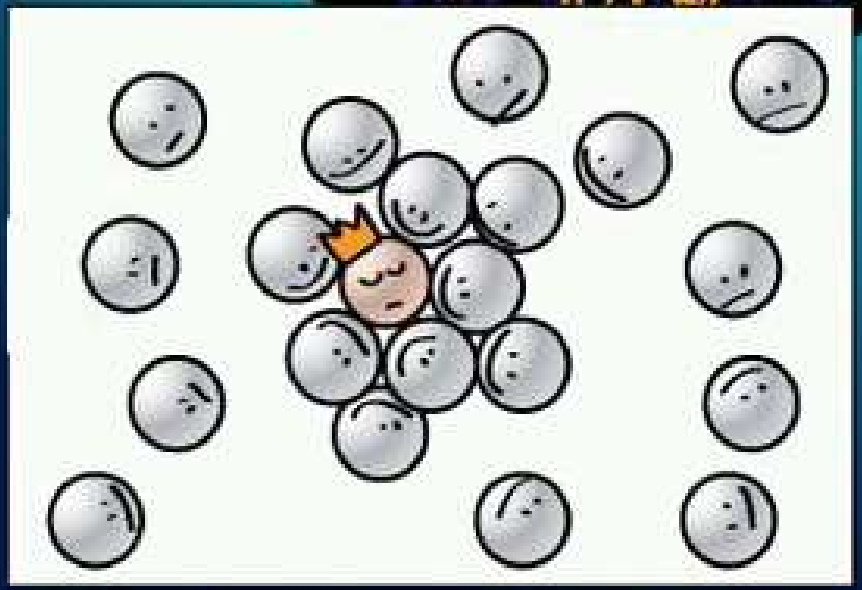
The elusive Higgs boson, if found, would complete the Standard Model of physics. It is thought that matter obtains mass by interacting with the Higgs field. If Higgs did not exist, according to the model, everything in the universe would be massless.



The "cocktail party" analogy



Imagine a party where guests are evenly spaced around the room. The room of guests represents the Higgs field, which is everywhere in the universe. Suddenly a celebrity enters. Guests notice the celebrity and rush in closer to be near her, forming a tight knot.



As the celebrity passes through the room, the concentrated clump of guests surrounding her gives the group additional momentum. The clump is harder to stop than one guest alone would be, and so we can say that the clump has acquired mass.

SOURCE: CERN

Inference to the Best Explanation

Theory attempts to explain why nature behaves the way it does.
But: -

- Observed effects have many possible explanations.
- We cannot deduce which is correct, so we use inference (a form of inductive reasoning) to establish the best explanation.
- "Best" typically means:
  - Simple
  - Consistent with the evidence
  - But potentially falsifiable
  - Yielding testable predictions
  - Consistent with the majority of other accepted theories/"laws".

(Though there is no certainty that the universe is simple!)

Competing concepts
Absolute and Relative space

Newton – the Absolutist

Held that space has a framework independent of objects and their motion. Motion is a change of position within that framework.

Leibniz – the Relativist

Held that space has no existence independent of objects in it. Motion is a change of position of one object relative to others.

How to decide?
Use “thought experiments”

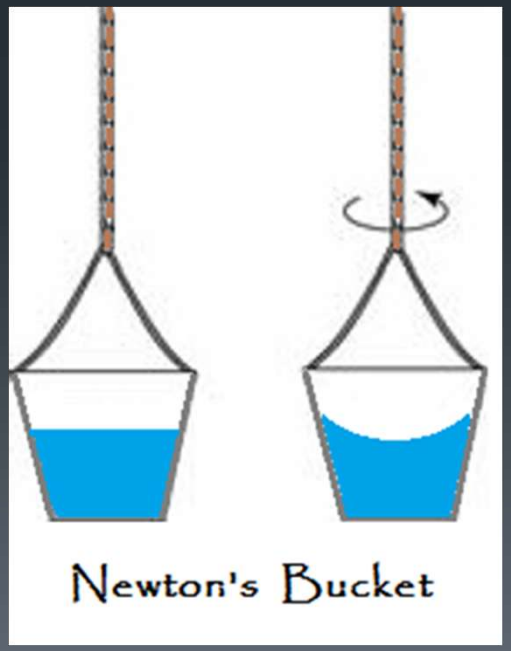
Leibniz:

Imagine a universe containing objects.

Now imagine a 2nd universe like the first, but all objects moved the same distance in the same direction. The two are inseparable. They are the same thing. There is no absolute space.

Newton:

Imagine a bucket of water suspended by a rope. Spin the bucket and wait for the water to achieve the same velocity as the bucket. The water climbs up the sides, although there is no relative motion between bucket and water. Both are spinning relative to absolute space. Therefore absolute space exists.



The theory-ladenness of data

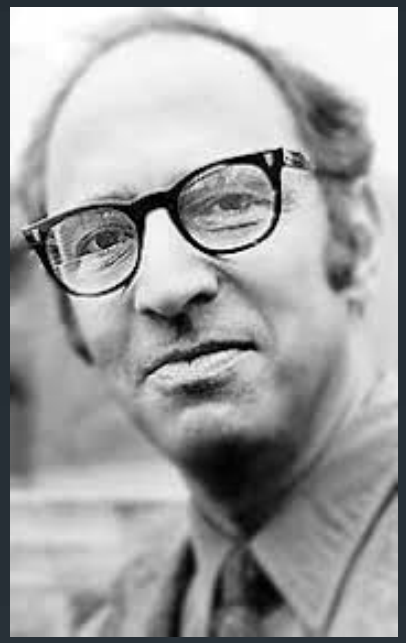
- Particle tracks have to be explained with reference to a huge amount of theory about the experiment.
- “The leaf is green” implies theories about the composition of light, reflectivity, absorption, perception…
- “Pure” theory-free data is a fiction.
- The data which “proves” one theory depends on other theories.

- E.g. An astronomer “observes a neutron star.” He relies on:
  - A theory of stellar evolution
  - A theory of radiotelescopy
  - Plus a whole network of well-entrenched theories about gravity, laws of motion, the materials characteristics of his kit, etc.

Scientific Progress

Thomas Kuhn (1922-96) and paradigm shifts

- Science is not linear, not continuous, not wholly objective.
- Science is a social enterprise, resting on a consensus world-view.
- Scientists work within a paradigm until a ‘paradigm shift’ occurs.
- E.g:
  - From Ptolomey to Copernicus (1542 - heliocentric theory)
  - From Descartes to Newton (1687 - laws of motion)
  - From Genesis/Lamarck to Darwin (1859 - natural selection)
  - From Newton to Einstein (1916 – relativity)
- Typically take a generation to become accepted.
- Evidence builds; the moment of shift is an ‘act of faith’.



My view?

- Trickier than first meets the eye!
- I can't argue my way out of the problem of induction (but I can't do other then accept the uniformity of nature).
- All 'facts' are provisional – though some more core than others.
- "Hard facts" and "proven" theories are those which cohere most widely.
- So coherence is the key to truth, not correspondence with an absolute reality.
- But the "Best Explanation" for the unity of our core theories is that they are shaped by some objective reality! Albeit, we cannot conceive of it or describe it without imposing a human stamp.

Philosophical joke

- Did you hear about the dyslexic agnostic who suffered from insomnia?
- She was awake all night considering the question –

  Is there a dog?