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Two cultures of philosophy of science

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PLATO (429–347 B.C.)

Axiomatic science:
"It is not the material world, but the realm of abstract concepts called Forms (or Ideas) that possesses the most fundamental kind of reality".

Deduction **of physical laws from prime principles (axioms):**
top-down approach,
Rationalism

Influenced: Descartes, Newton, Galileo, Hilbert , Einstein, Dirac...

Raphael, "The School of Athens"(1509–1511)

ARISTOTLE (384–322 B.C.)

Empirical science:
Three types of knowledge: ***Epistéme***, or "theoretical know why", ***Techné*** or "technical know how" and ***Phronesis*** as "practical wisdom".

Inductive-deductive **method based on observations:**
bottom-up approach,
Empiricism (partially)

Influenced: Grosseteste, Locke, Hume, Newton, Herschel...

=> Prime principles (P) vs. measurements (A)
(very loosely)

Plato's axiomatic (deductive) science

- Perception ⇔ *constant change*: perceptible entities are unstable, therefore unreliable.
- Forms = reliable sources of knowledge: *abstract concepts*.

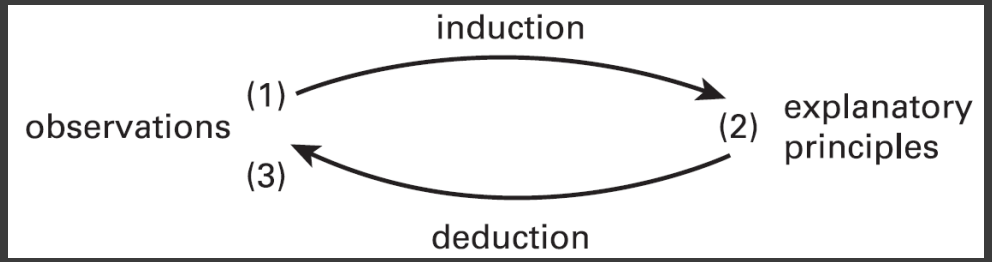
- Therefore, proper scientific reasoning occurs only via *deduction* from Forms (or specifically, "axioms") to something that can be *compared to observations*.

- Following Pythagoras:
  - mathematics is the "world's syntax"

=> reality can be described in purely geometric terms

Aristotle's empirical (inductive-deductive) science

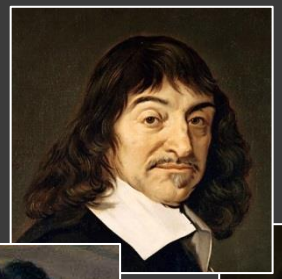
- Proper scientific knowledge is grounded on *perception*.
- Inductive process: extrapolates some property from a set of observations.
- Deductive process: demonstrates how this property applies to *other* observations (=> *predictive*).



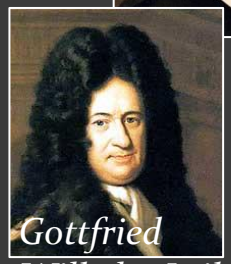
⇒ One starts with induction (from particular to universal): bottom-up approach.

⇒ Formulate the *universal principle*: deduction explains new measurements (top-down).

Early 18th century: Rationalism (P) vs Empiricism (A)

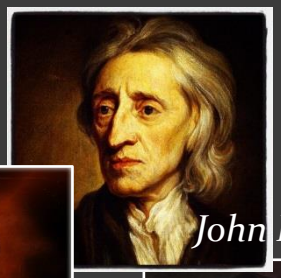

René Descartes

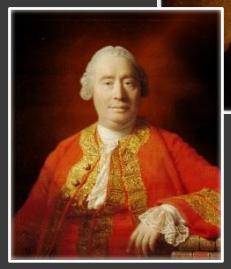

Baruch Spinoza


Gottfried Wilhelm Leibniz

- Sensorial experience is *illusory*: the source of knowledge is in the mind.
- Truth resides in our innate ideas.
- Physical laws and equations can describe reality flawlessly.

=> The world is knowable *a priori*, through logical *deduction*


John Locke

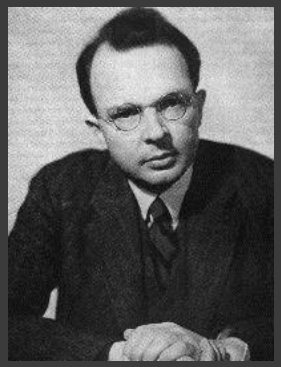

David Hume


George Berkeley

- Knowledge can be attained only (or primarily) from sensorial experience.
- One can only observe, not predict.
- Only induction is scientifically relevant.

=> The world is knowable *a posteriori*, by collection of raw data and *induction*

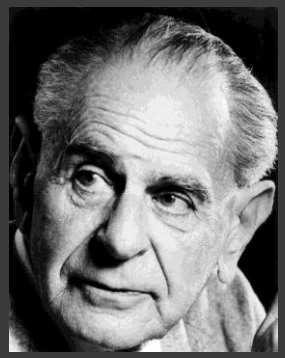
20th Century: Criticism of the scientific method



Rudolf Carnap (1891-1970)

Verifiability principle: only scientific hypotheses subjected to empirical investigations are meaningful.

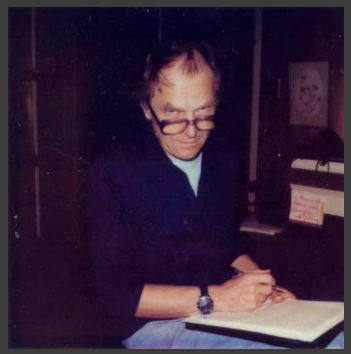
We *verify* hypotheses through observations, via induction.



Karl Popper (1902-1994)

If a theory is falsifiable, then it is scientific.

1. Just *a single exception* to its predictions falsifies a theory.
2. **Induction does not even *exist!*** "The large number of white swans does not imply that *all* the swans are white".



Paul Feyerabend (1924-1994)

There is no scientific method.

The only genuine approach which does not inhibit progress is "anything goes": a principle of **scientific anarchy**.

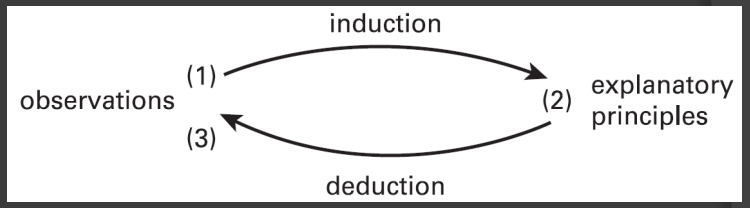
Summary

- Plato & Rankine: deduction from prime principles, ***design***.
- PLATO: mathematics is the "world's syntax".

=> reality can be described in purely geometric terms.

Top-down approach

- Aristotle & Shewhart: induction from measurements, ***production***.
- ARISTOTLE: inductive-deductive scientific method



More bottom-up: start with induction, then explain and *predict* via deduction.

- Empiricists (ONLY induction) vs. Rationalists (ONLY deduction).
  ⇒ **Radical methods at the origin of problems in engineering**
- 20th Century:
  Verificationism vs Falsificationism vs Scientific Anarchy