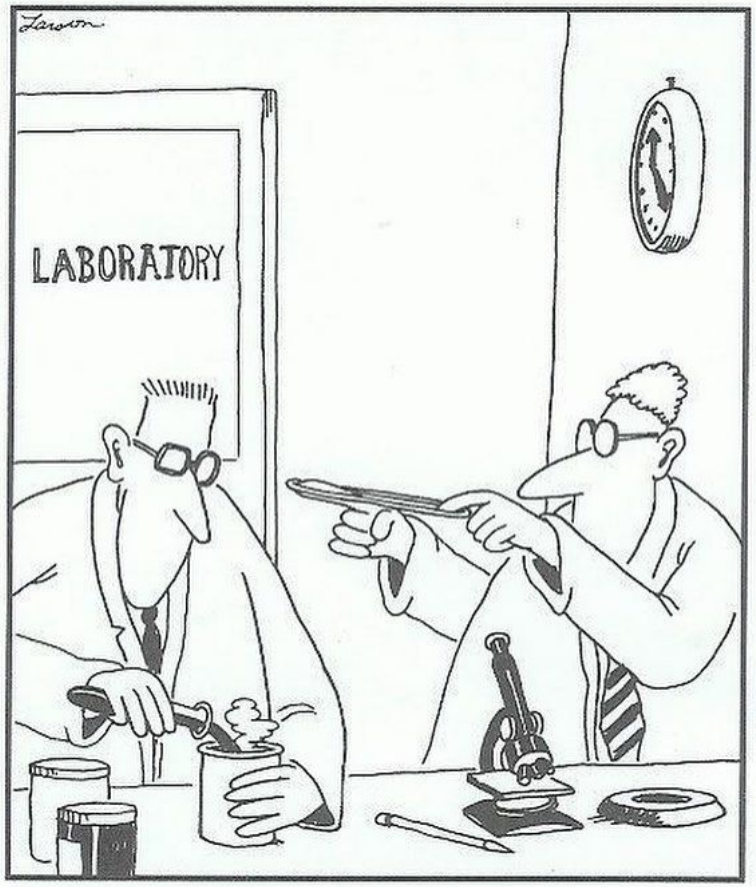
Scientific method

and

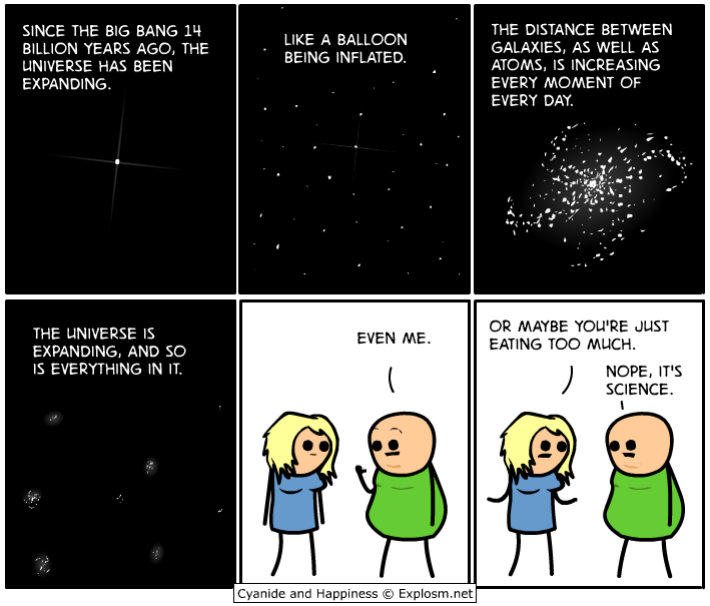
Science vs. Engineering

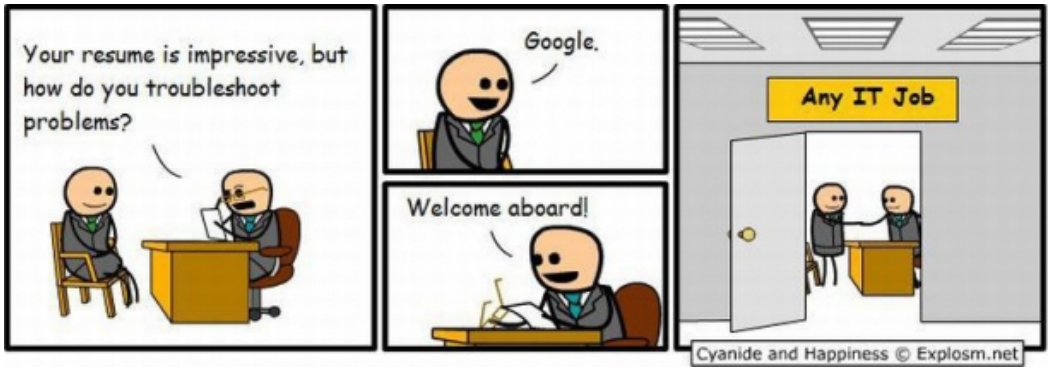


On Oct. 23, 1927, three days after its invention, the first rubber band is tested.

G. Coppin 24 Sept 2021

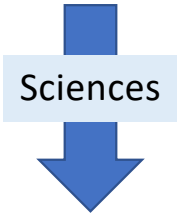
Two different ways





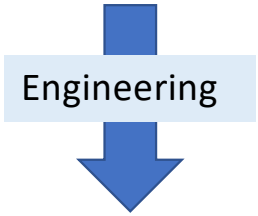
Two different ways

Question



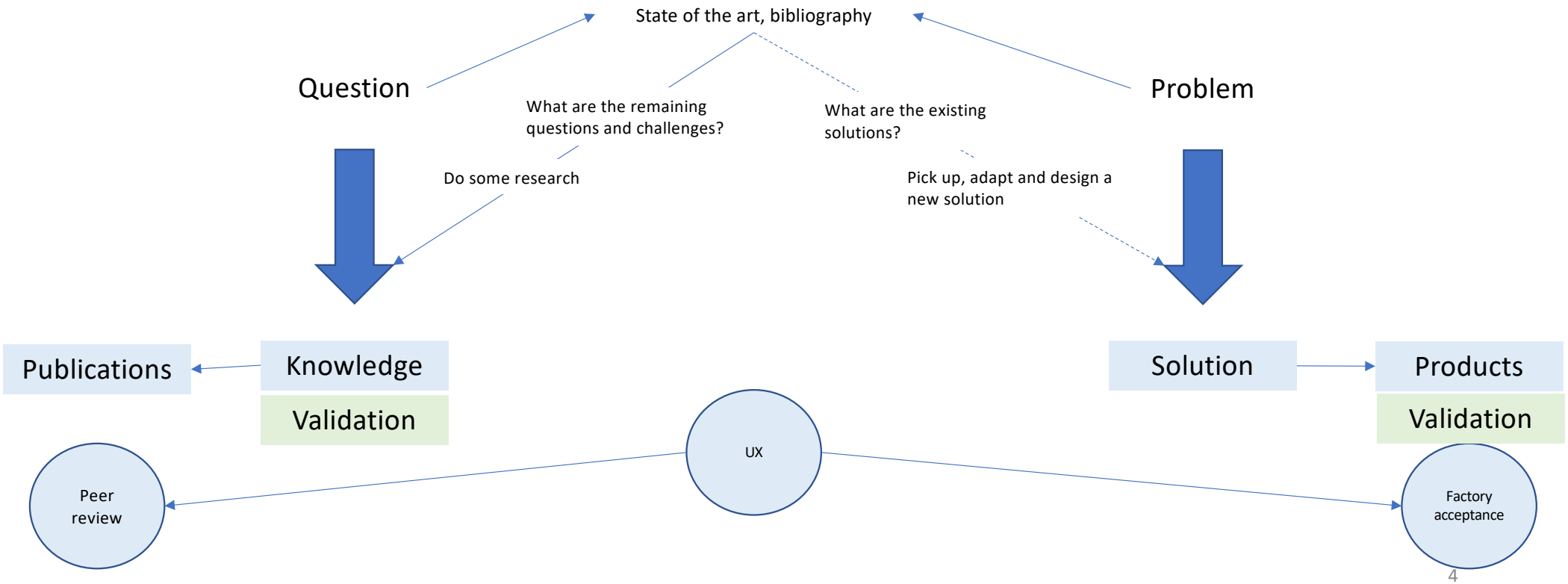
Knowledge

Problem

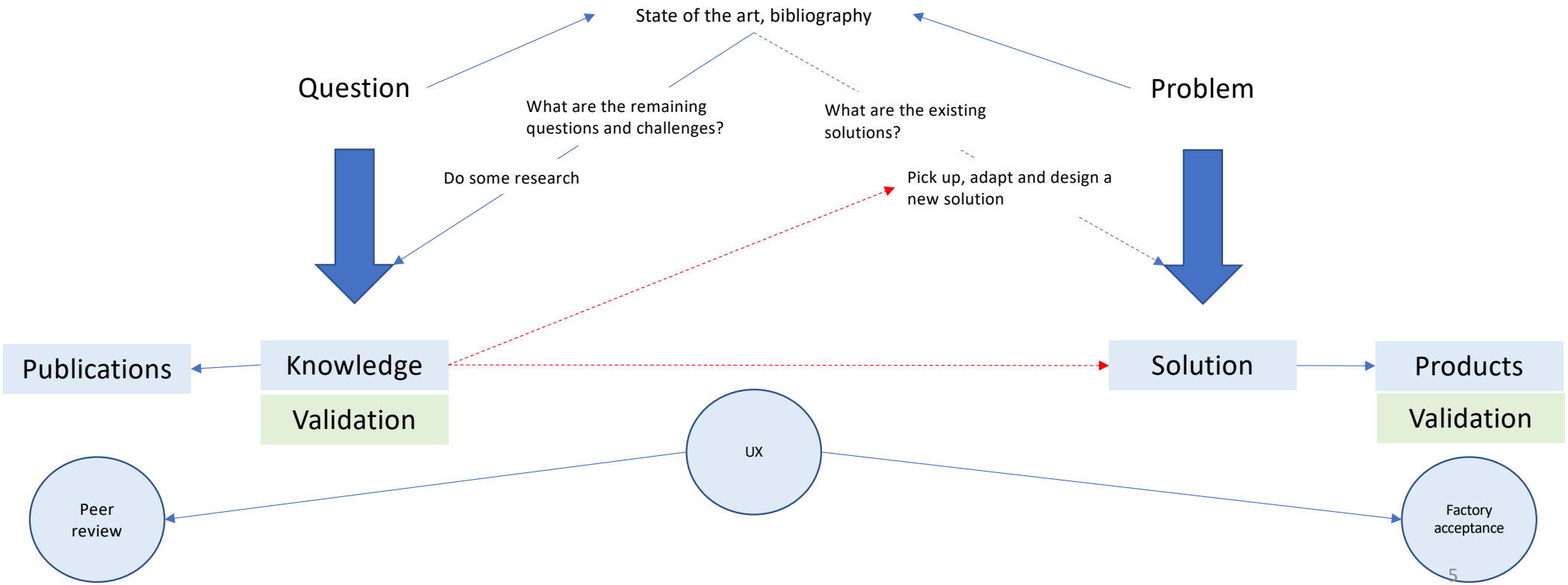


Solution

Two different ways



Two different ways



Scientific method
How to produce science?

Induction vs. Deduction

The deductive approach:

- Consists, on the basis of already existing knowledge in seeking to answer the questions that one or the other will raise because of its inadequacies
- Knowledge is the source of knowledge
- Particularization

The inductive approach:

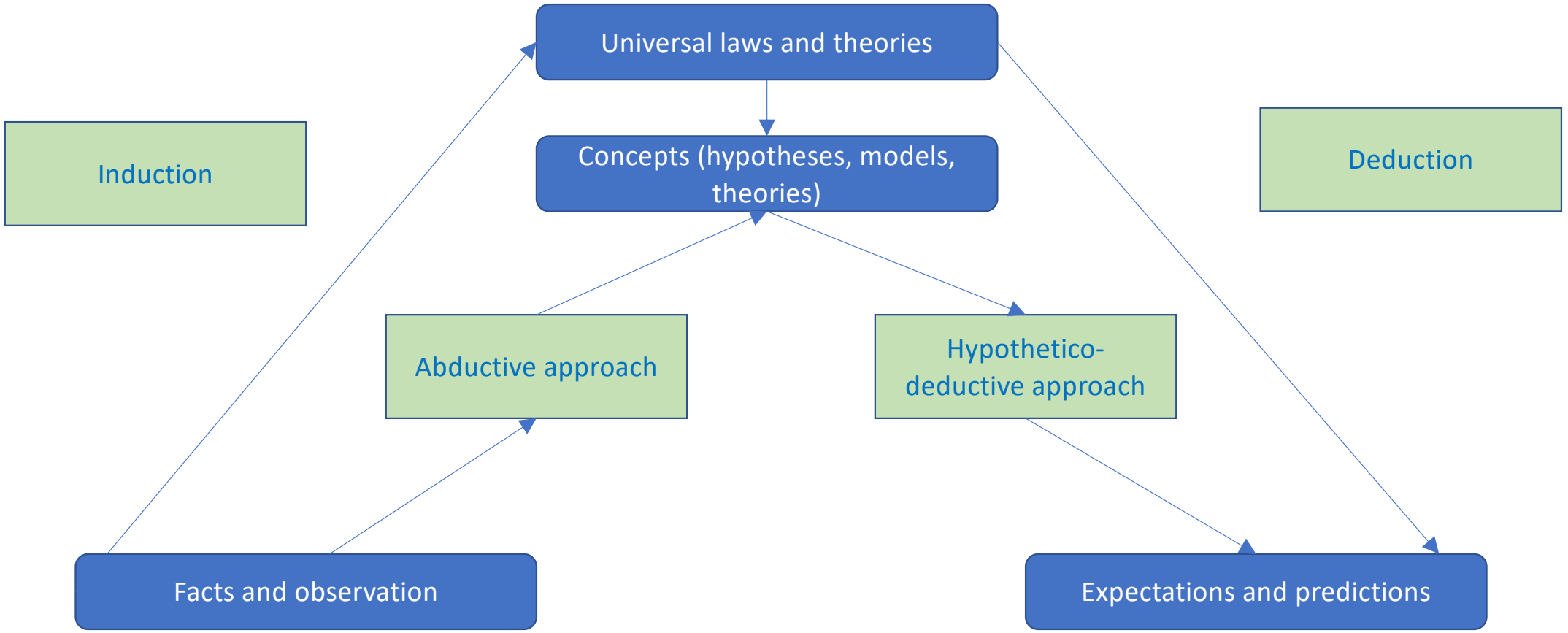
- Involves repetition of observation, and / or experiments
- Approach which implies that the laws which govern reality exist a priori
- Reality is the source of knowledge
- Generalization

Abduction

The abductive approach:

- Serenpidity
- "Most probable" cause
- https://fr.wikipedia.org/wiki/Abduction_(logique)

- Abduction is reasoning governed by the desire to explain a phenomenon. As such, it closely resembles what, in contemporary epistemology, is called "Inference to the best explanation *" (IME), the inference supposed to lead us to the fact that a hypothesis explains phenomena better than its competitors. to the conclusion that it is (probably) true

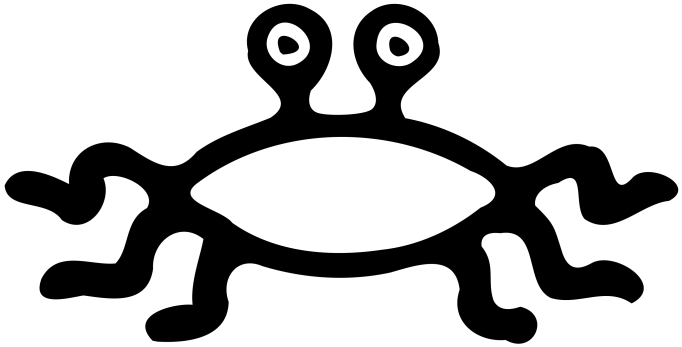

Universal laws and theories
Induction
Concepts (hypotheses, models, theories)
Deduction
Abductive approach
Hypothetico-deductive approach
Facts and observation
Expectations and predictions

The raise of experimental sciences

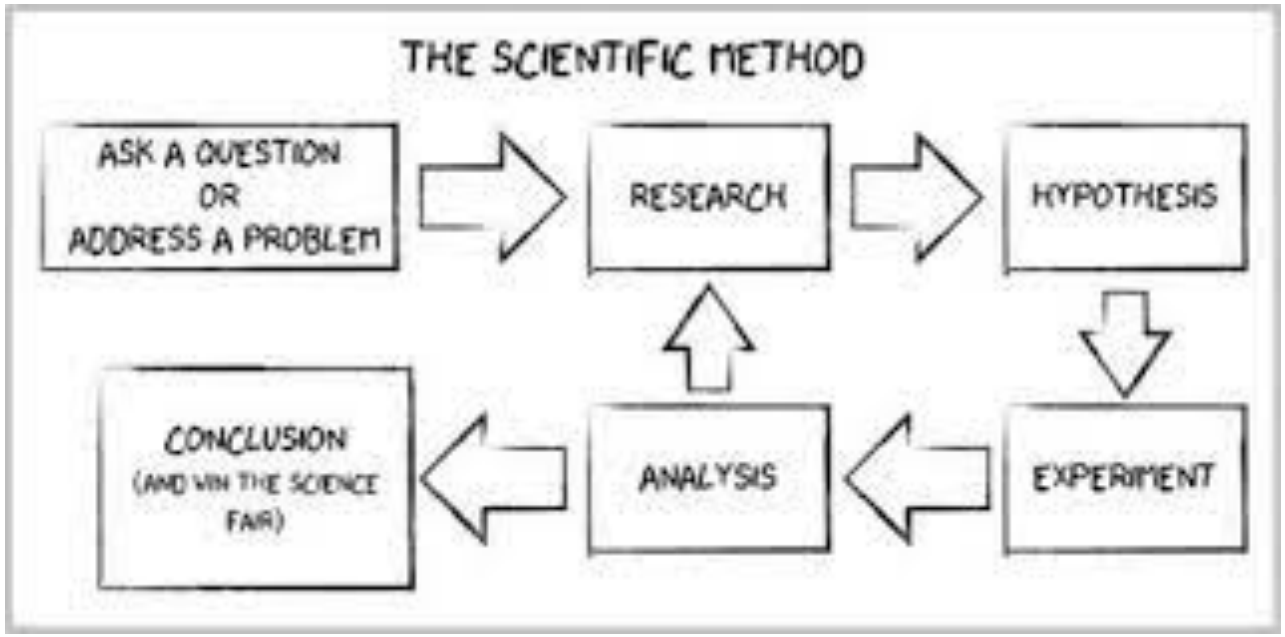
- From 18th Century, sciences have been relying on observables and on experiments
- Deduction -> Induction …. -> Machine Learning

Refutability

- Boundary between science and pseudo-science
- Confirmation bias:
  - People look for hints that confirm the hypotheses they make
- Any scientific theory must be able to potentially be refutable, and therefore not contain its own refutation (K. Popper)
- Pink Invisible Unicorn
- Flying Spaghetti Monster

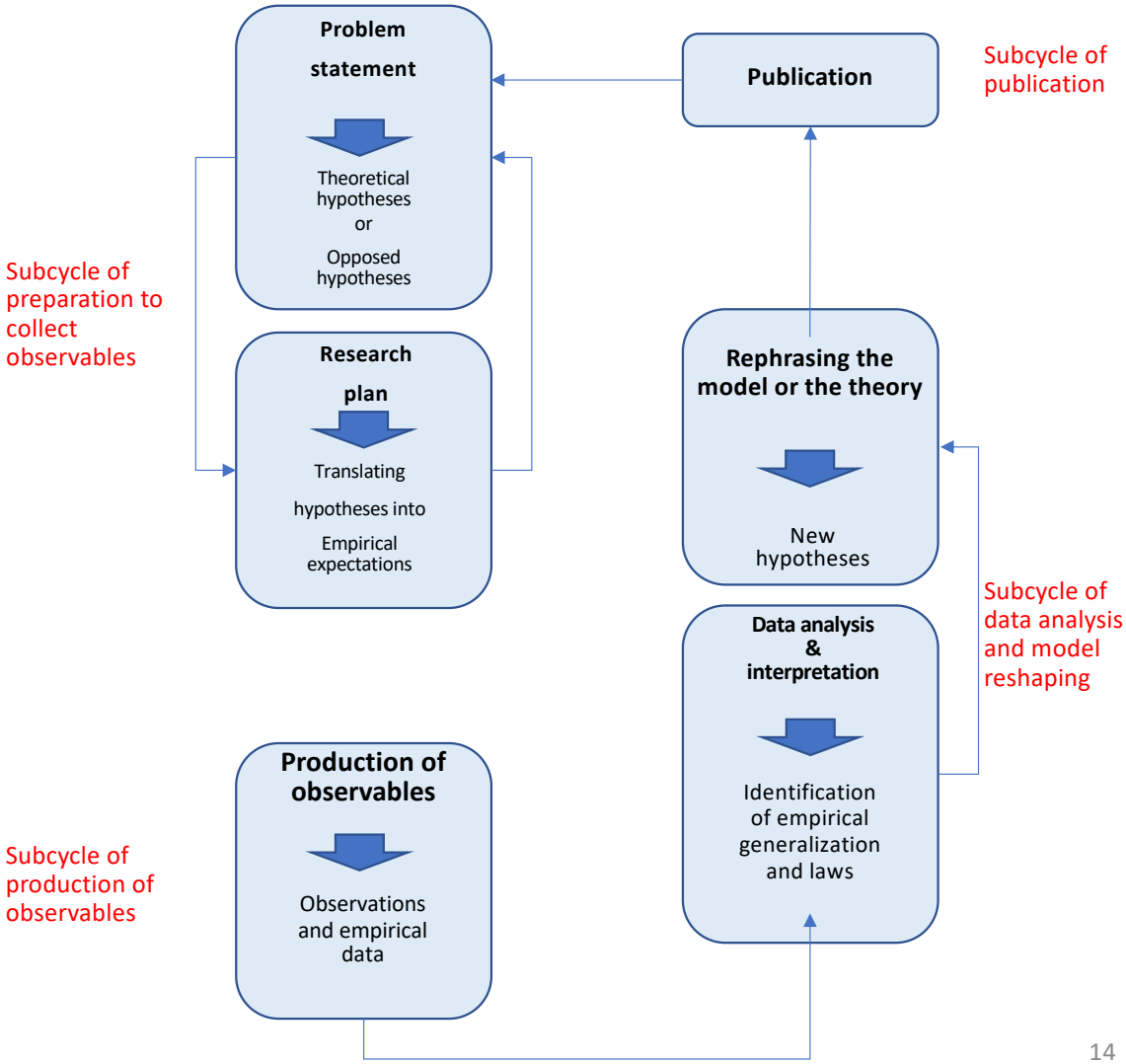


Scientific method



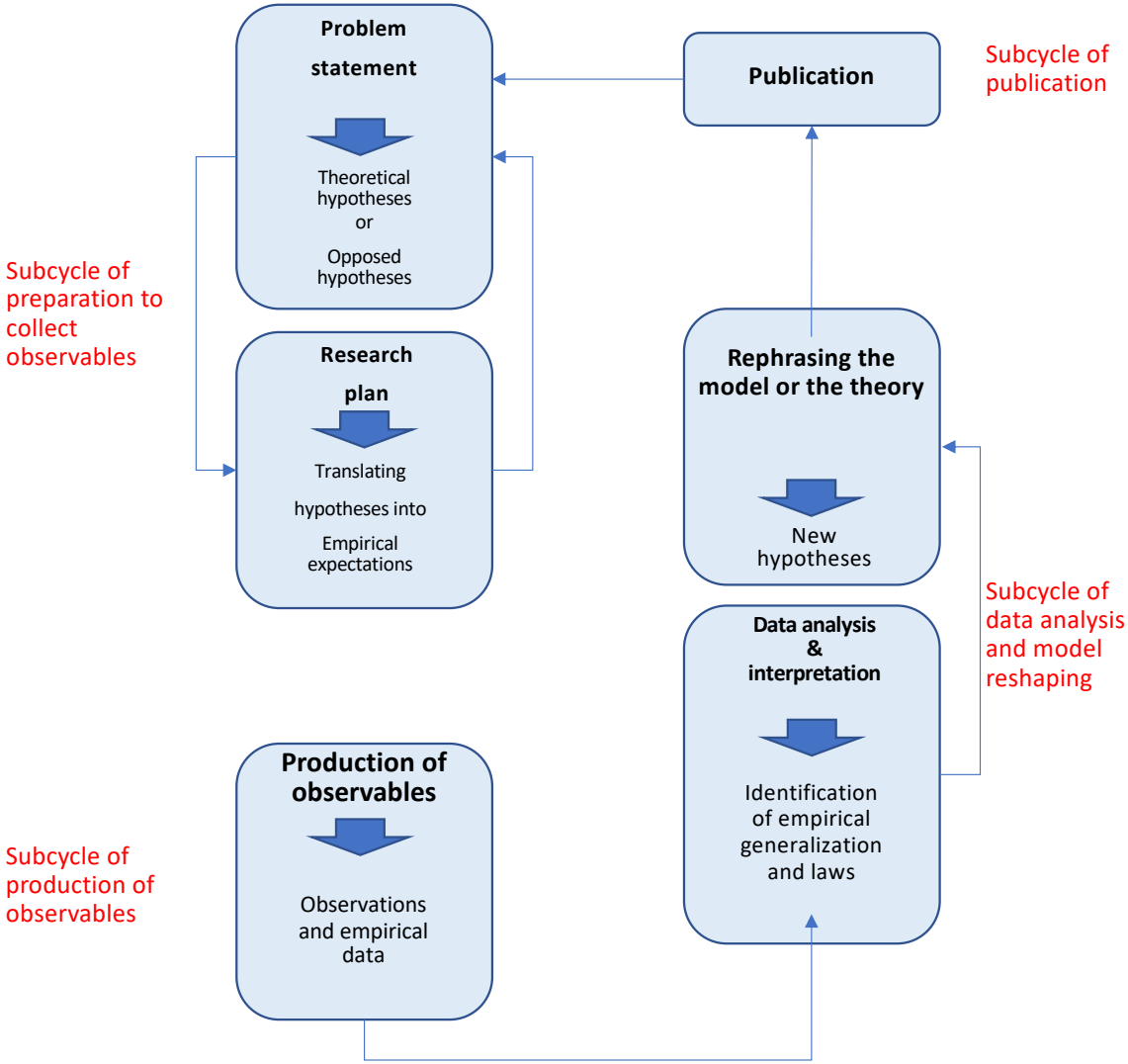
Scientific method (II)

Scientific method (III)



Scientific method (III)

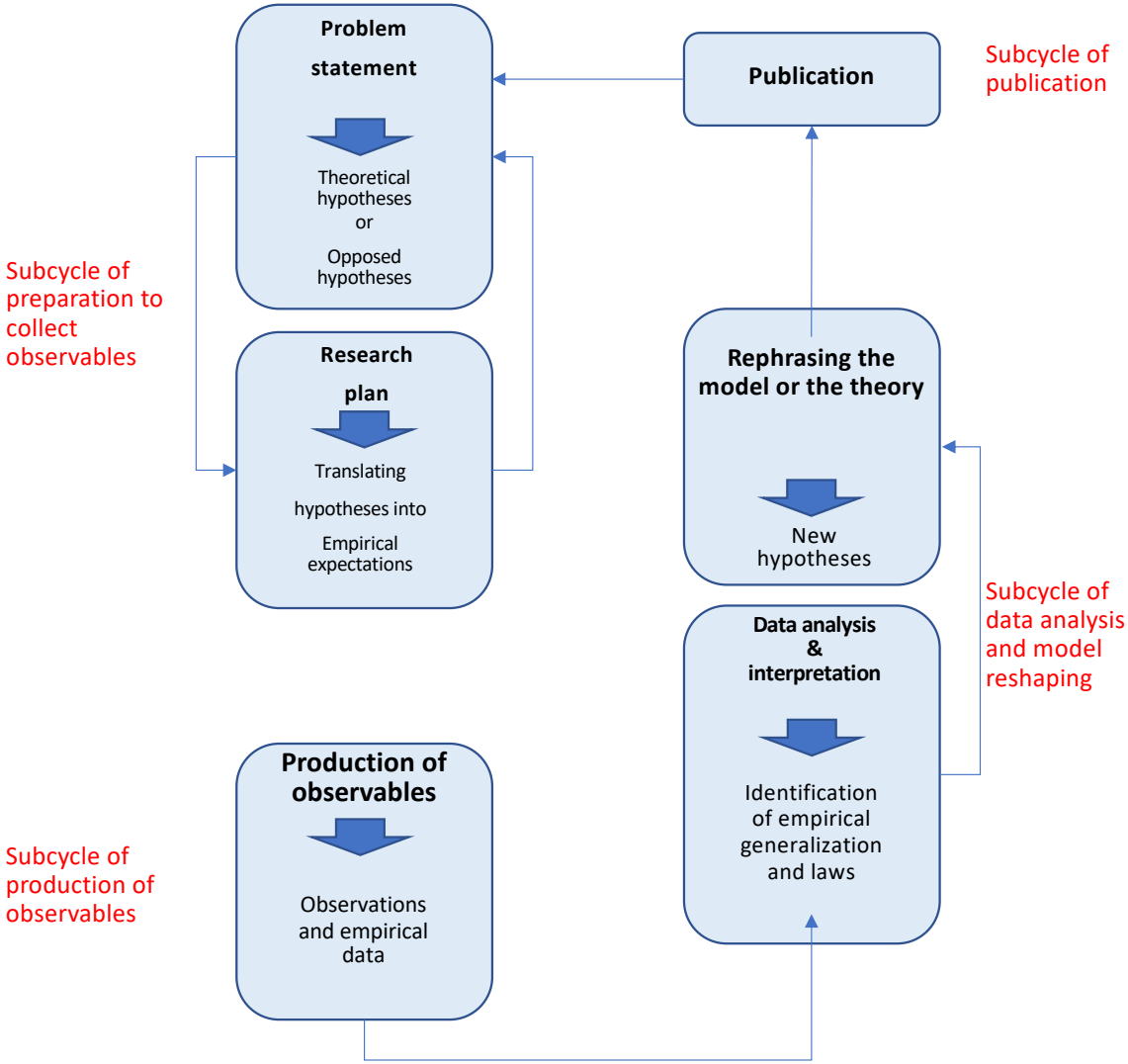
Question: where to start?

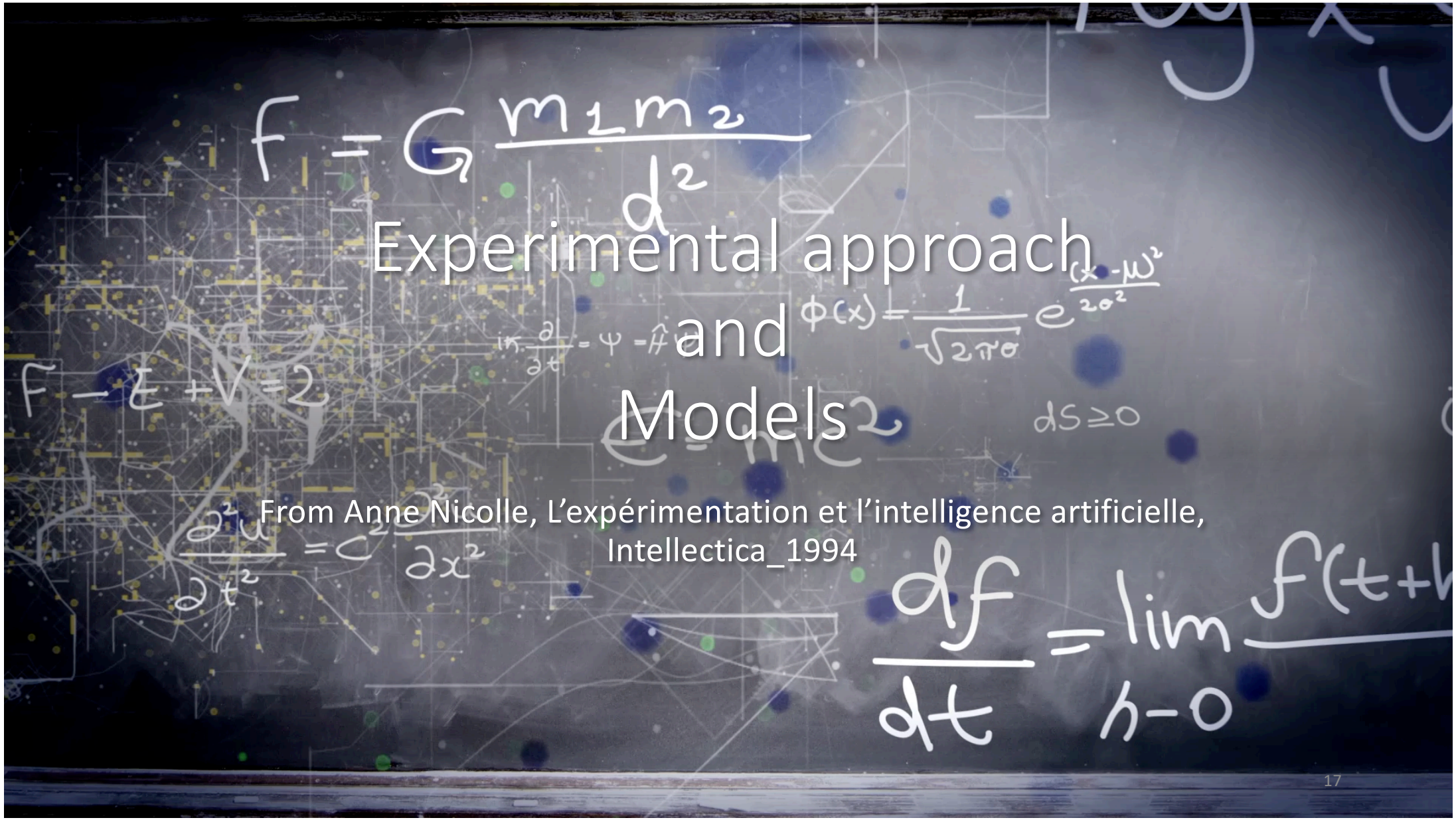


Scientific method (III)

- Karl Popper argues that observation can never be the first step in any knowledge building project, including science. Science never begins with observation, but always with prejudice, hypothesis, theory

- **(K. Popper, Conjectures et réfutations, 1985)**

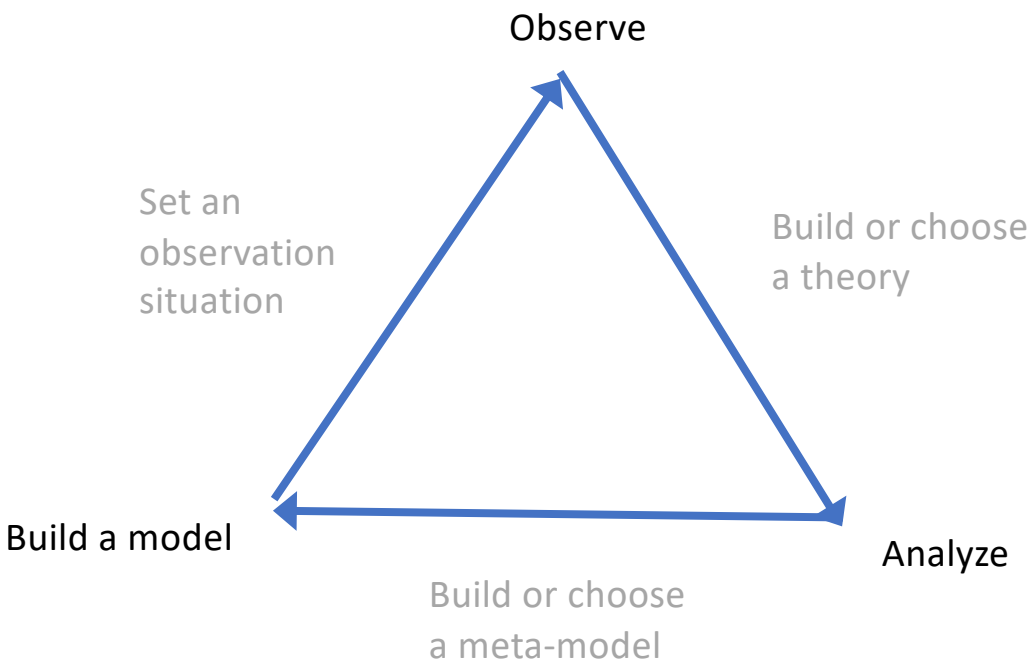




Experimental approach and Models

From Anne Nicolle, L'expérimentation et l'intelligence artificielle, Intellectica_1994

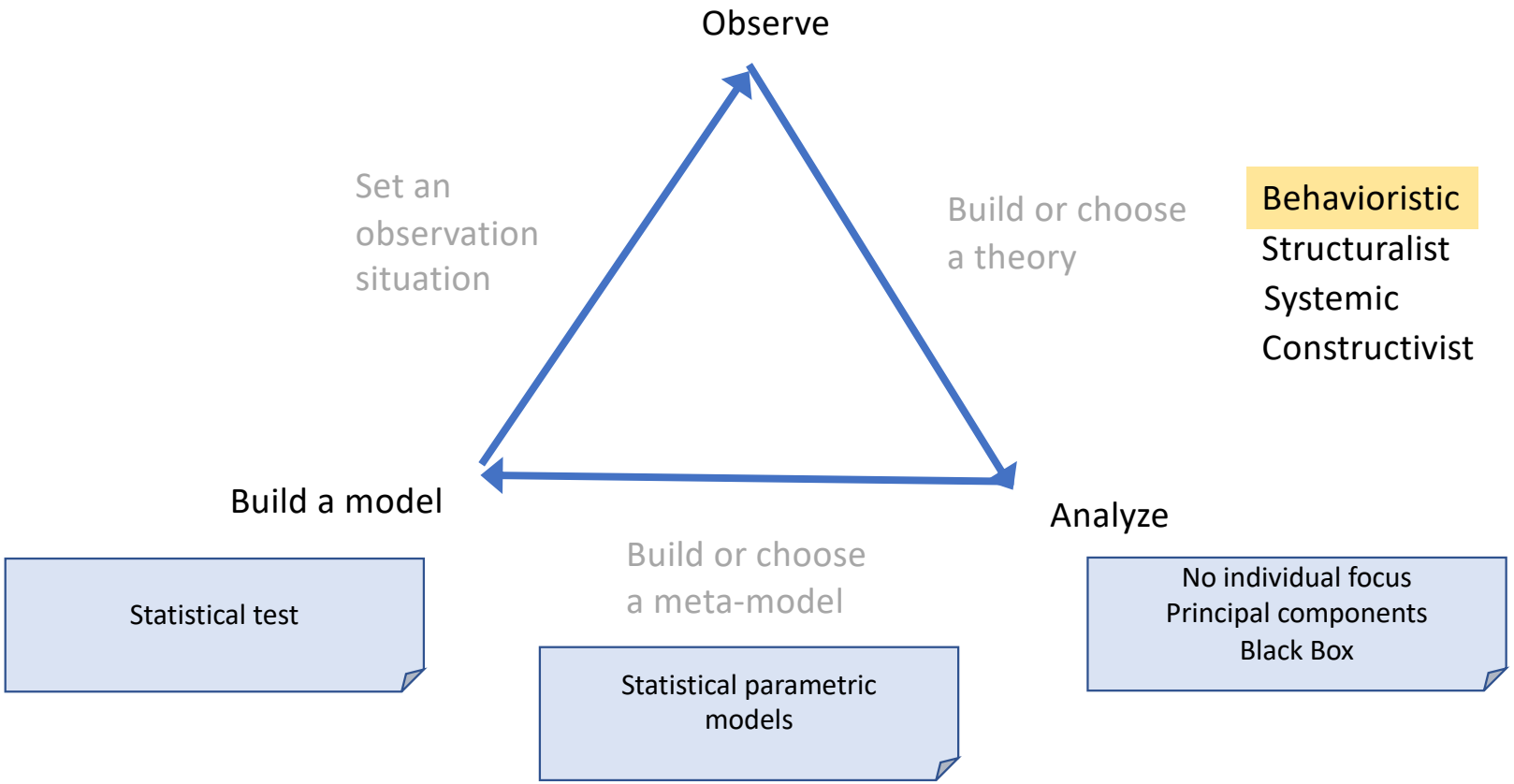
Experimental approach



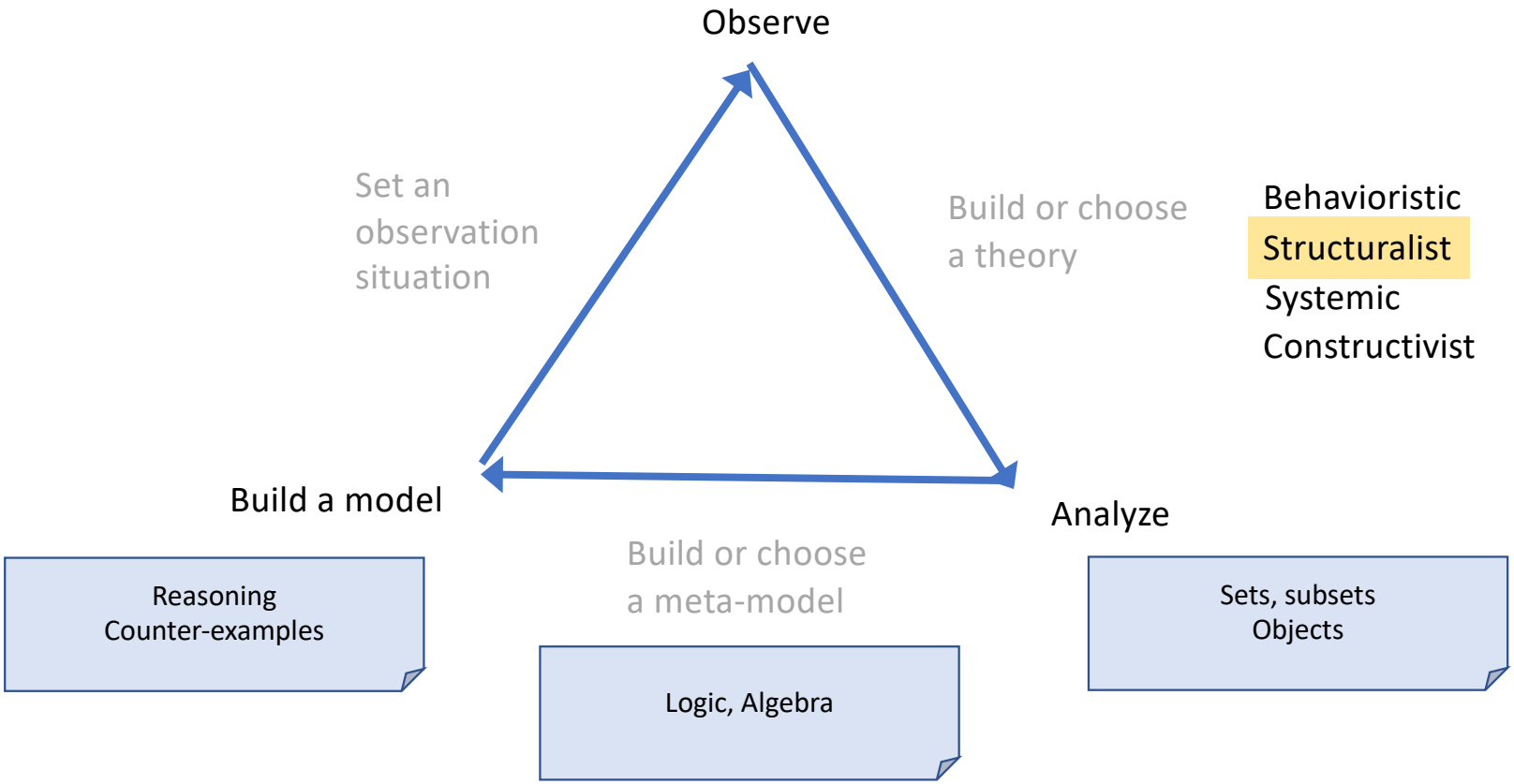
Cognitive Sciences Paradigms

Behavioristic
Structuralist
Systemic
Constructivist

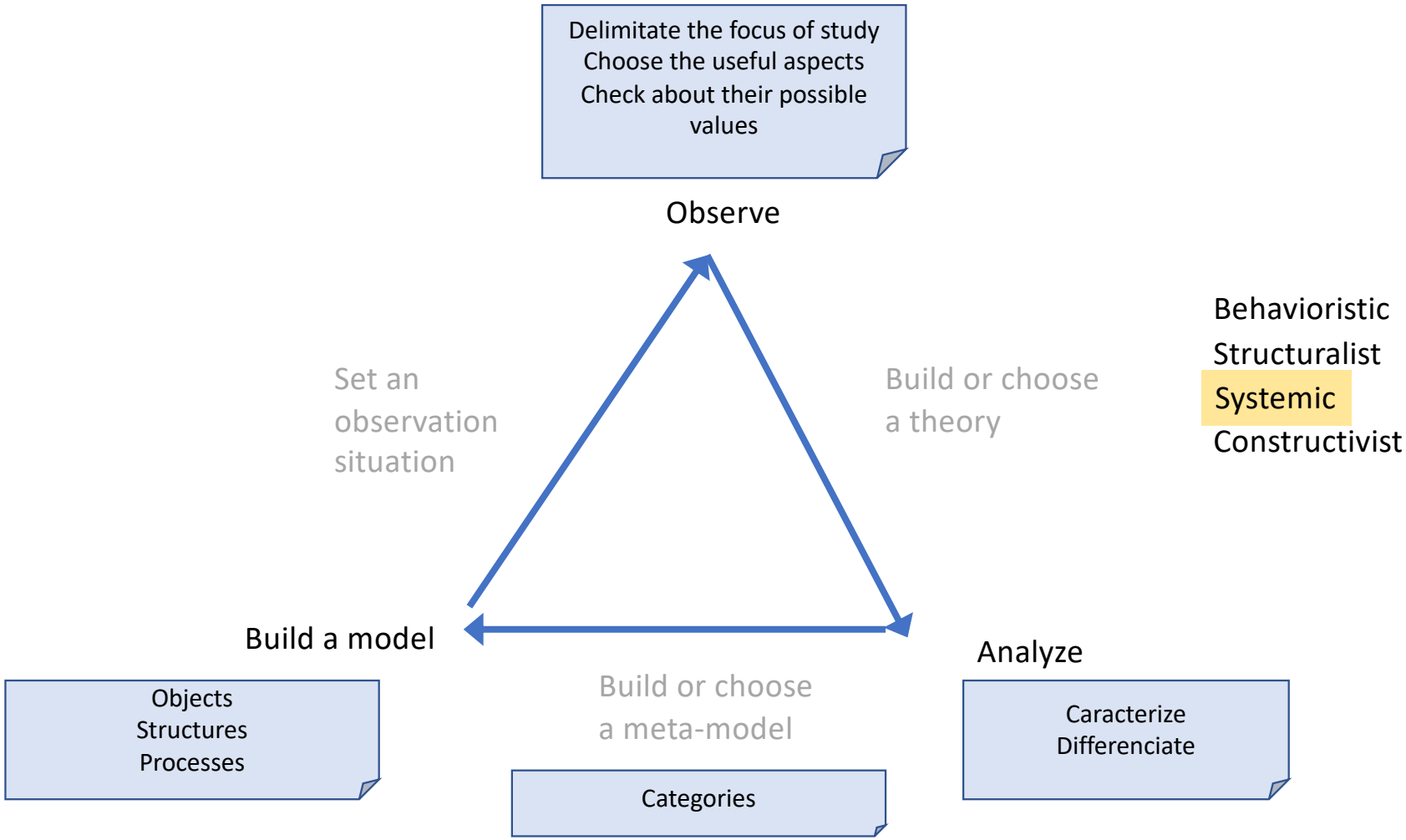
Experimental approach: behavioristic



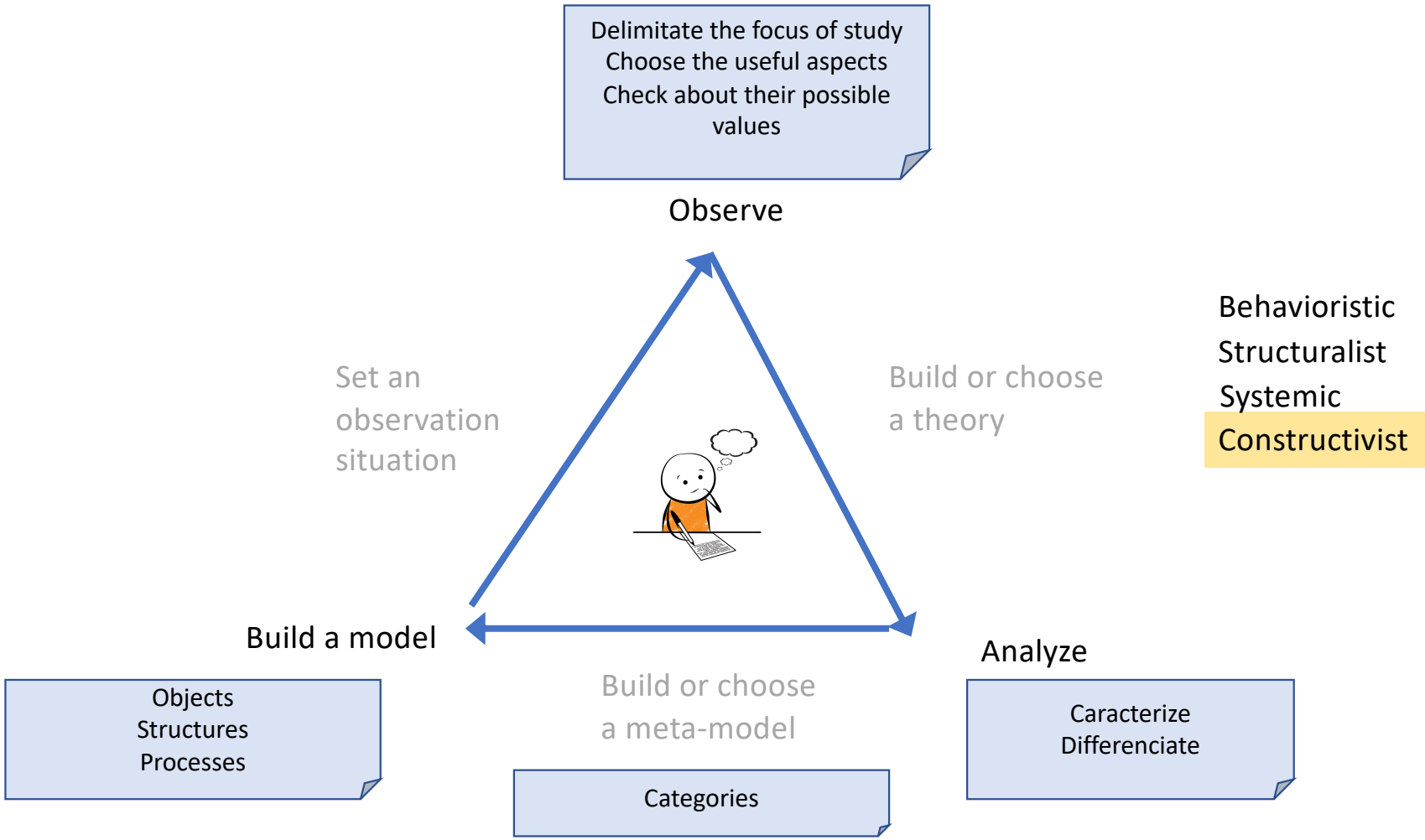
Experimental approach: structuralist



Experimental approach: systemic



Experimental approach: constructivist



Experimental computing
Comparison of methods

Problem:

face recognition, representation of a 3d scene, application architecture, substance detection, data communication, etc.

Hypothesis:

”SN algorithm is better than OP algorithm”

Methodology :

Definition of a benchmark,

Definition of one or more performance measures

Comparison of SN and OP algorithms according to the measurements.

Experimental computing
Acquisition of new fundamental knowledge

Problem:

face recognition, representation of a 3d scene, application architecture, substance detection, data communication, etc.

Hypothesis:

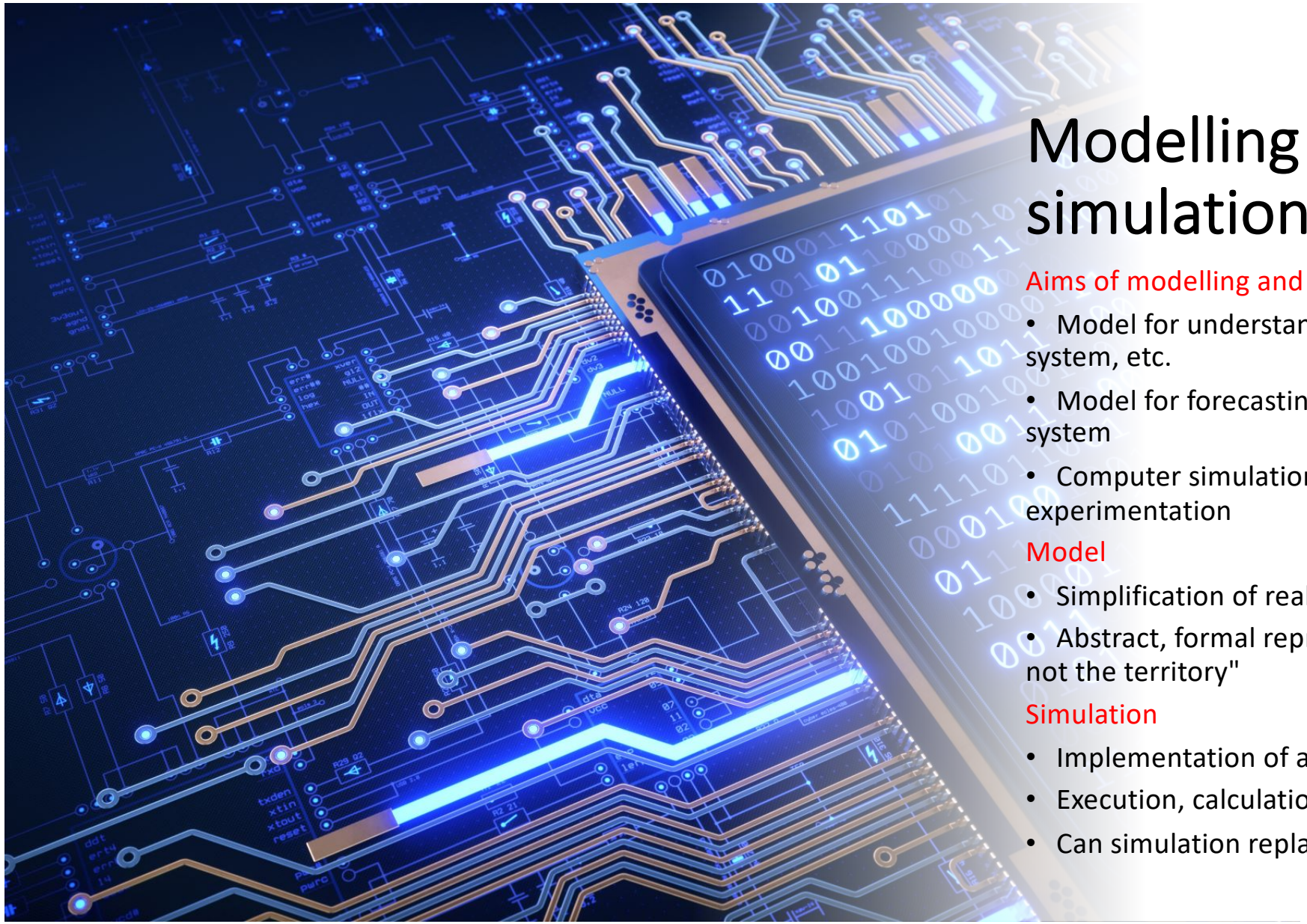
"SN algorithm is better because it takes advantage of the large number of 01"

Methodology :

Definition of a benchmark with and without properties

Definition of one or more performance measures **related to the property**

Comparison of SN and OP algorithms according to the measurements.



Modelling and simulation

Aims of modelling and simulation

- Model for understanding a phenomenon, system, etc.
- Model for forecasting the evolution of a system
- Computer simulation allows exploration, experimentation

Model

- Simplification of reality
- Abstract, formal representation: "The map is not the territory"

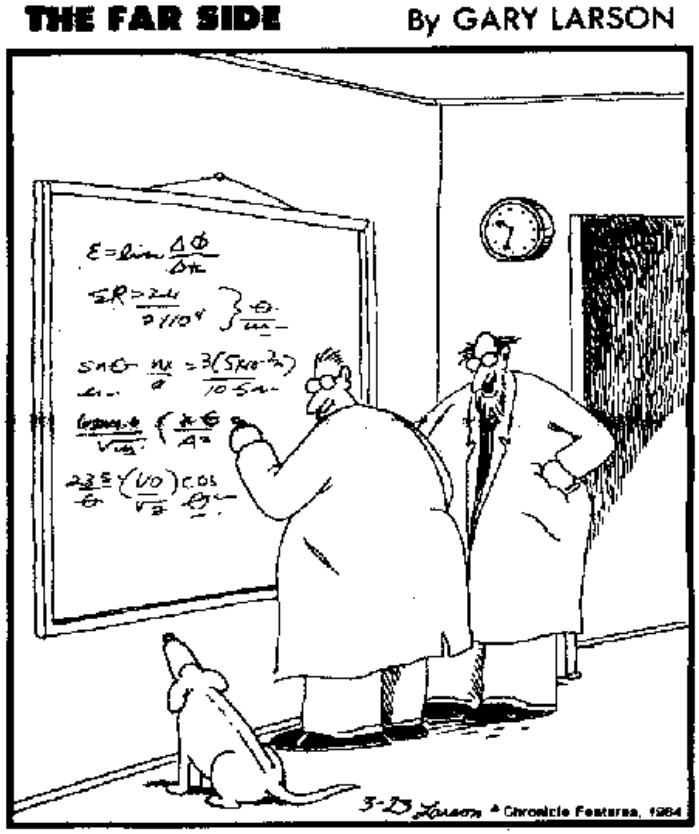
Simulation

- Implementation of a model,
- Execution, calculation of a model.
- Can simulation replace reality ?

Rephrasing the approach from « models »

- Formulation of a scientific question (problem)
- Design of a model (expression of a hypothesis)
- Data production from model simulation
- Validation of the model compared to reality according to the question asked (refutability)
- Adjustment or not of the model (return to step 2)

And now for something completely different



"Ohhhhhhh . . . Look at that, Schuster . . . Dogs are so cute when they try to comprehend quantum mechanics."

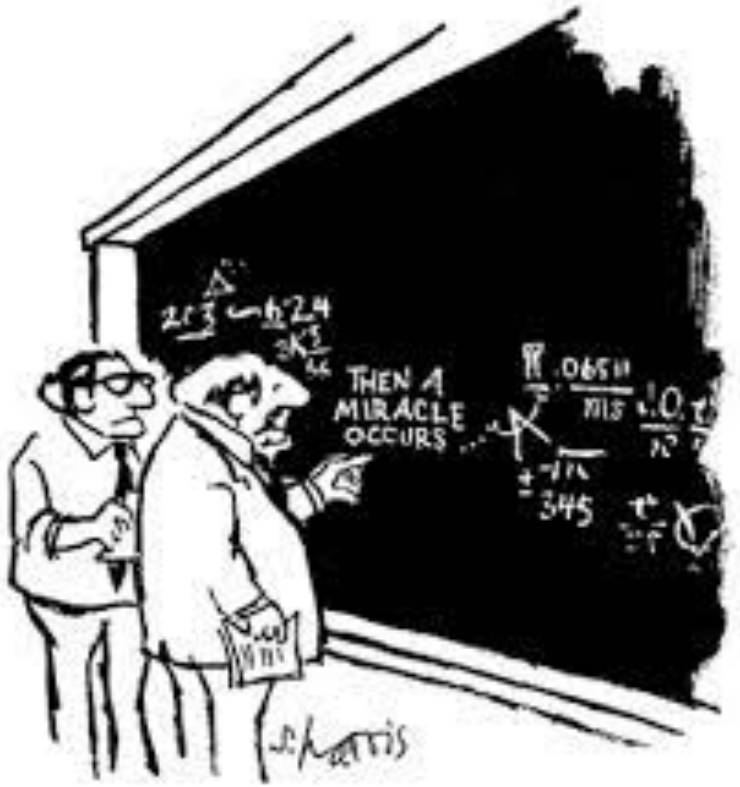
In more "theoretical" computer science, certain properties of algorithms are demonstrated mathematically. It is no longer a purely experimental approach even if we can compare the algorithms in this way (e.g. complexity models)

Thought experiments vs. Data collection

- Pisa tower and Galilée
  - Aristote: the heavier the faster
  - Composite weight should fasten AND slow down the fall
  - Aristote is wrong
- Thought experiment are used
  - For refutation
  - For exploration
- Nota: Albert Einstein was a champion of thought experiments!

Tests and refutability

- It is sometimes very difficult or even impossible to define an “objective” comparison measure
- No absolute “truth”, relating to the tests
- Importance of data (issued from reality, observations, experiments)



“I think you should be more explicit here in step two.”

What does it mean?

When applied to Virtual / Augmented reality

- Please tell me! ☺

When applied to Deep Learning

- Please tell me! ☺

When applied to Human System Interaction

- Please tell me! ☺

What’s next in this course?

- Focus on behavioristic approach
- Statistical models
- Statistical inference
- Hypothesis tests
- Models for prediction

Concrete elements

- Evaluation / getting the credits thru
  - MCQ (Oct ‘21)
  - Critical analysis of science / results production from your project topic (Jan ‘22)
- Classes
  - Cl1 – Reminders in applied stats
  - Cl2 – Statistical inference and tests
  - Cl3 – Correlation, variable independance
  - Cl4 – Linear regression and ANOVA