Scientific Methodology and Experimental Evaluation

A short positionning

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with a strong support from Arnaud Legrand and Nadine Mandran

Université Grenoble-Alpes and INRIA
Laboratoire d'Informatique de Grenoble
Team INRIA POLARIS

Master of Computer Science of Grenoble
September 2021

METHODOLOGY FOR SCIENTIFIC RESEARCH

RESEARCH...

An exquisite cadaver

Cadavre Exquis with André Breton, Jacques Hérold, Yves Tanguy, Victor Brauner *Figure* 1934, from MOMA website

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Describe a scientific situation (one big sentence)

- When
- Where
- Who
- How (action, verb)
- What
- Why

Once upon a time, in an ugly swamp, a green giant was fishing big crabs for dinner.

When

Where

Who

How (action, verb)

What

Why

ABOUT SCIENCE...

Définition "Le Robert" (wikipedia)

Ce que l'on sait pour l'avoir appris, ce que l'on tient pour vrai au sens large. L'ensemble de connaissances, d'études d'une valeur universelle, caractérisées par un objet (domaine) et une méthode déterminés, et fondées sur des relations objectives vérifiables [sens restreint]

Définition Trésor de la Langue Française Informatisé

II. Ensemble structuré de connaissances qui se rapportent à des faits obéissant à des lois objectives (ou considérés comme tels) et dont la mise au point exige systématisation et méthode.

Dictionary of science and technology

science noun 1. the study of the physical and natural world and phenomena, especially by using systematic observation and experiment
2. a particular area of study or knowledge of the physical world
3. a systematically organized body of knowledge about a particular subject

New Oxford Dictionary

the intellectual and practical activity encompassing the systematic study of the structure and behavior of the physical and natural world through observation and experiment : the world of science and technology.
1.a particular area of this : veterinary science | the agricultural sciences.
2. a systematically organized body of knowledge on a particular subject : the science of criminology.
3. archaic knowledge of any kind.

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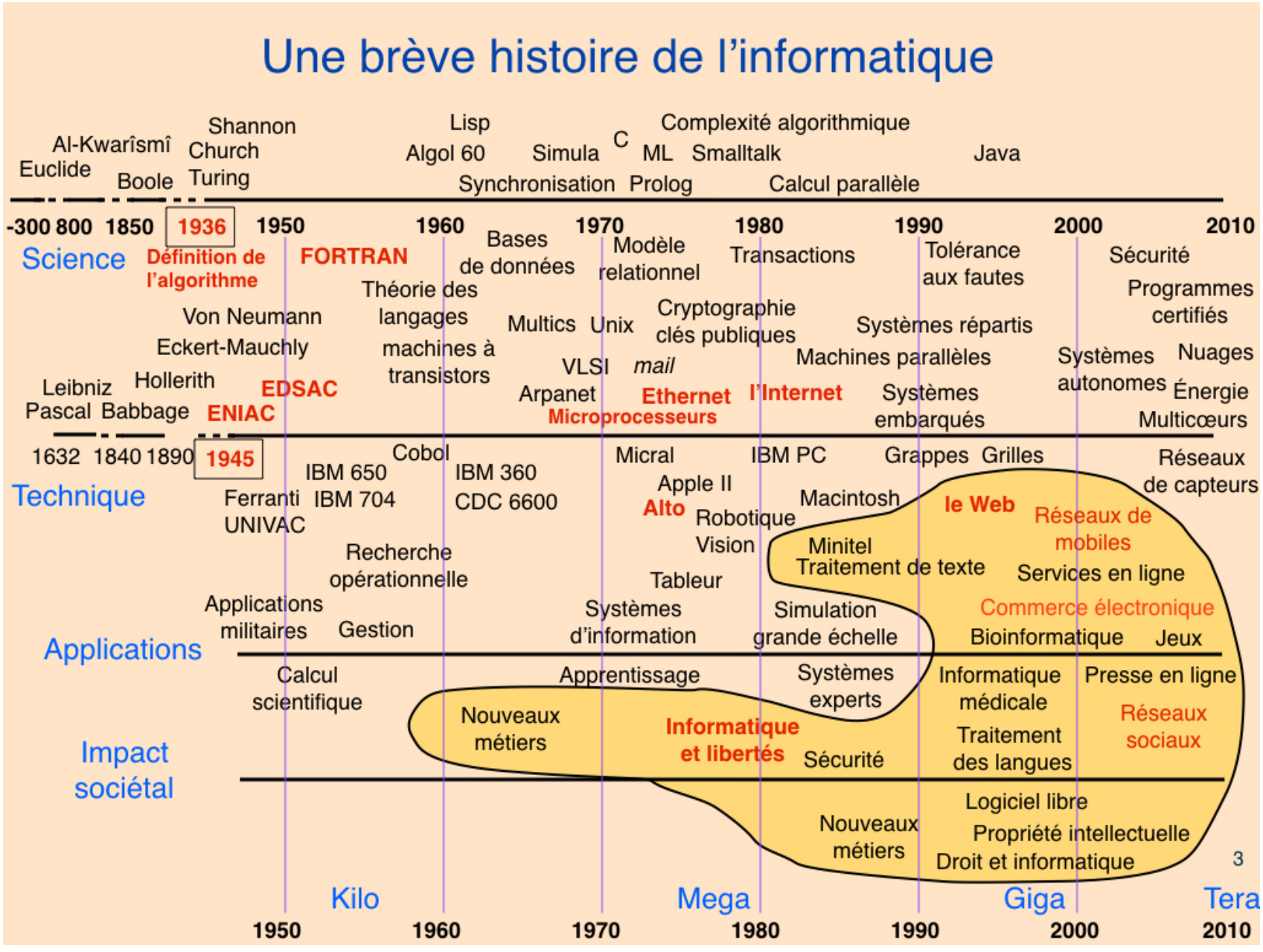
structured knowledge on the "physical world" associated to universal methods (observation/experiment)

METHODOLOGY FOR SCIENTIFIC RESEARCH

COMPUTER SCIENCE

If computer science is a monument, what would she be ?

use one or two keywords to explain why.



(source S. Krakowiak 2016)

COMPUTER SCIENCE

Computing

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  Science of artificial... but not only

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Computer Science

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  Operative process

  Programming **Language**
  link between levels of abstraction

  Architecture (Computing Engine)
  abstraction of the physical world

  Human in the loop

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  Back and forth between theory and experimentation

  Automatic abstraction transform

  Self-generated tools

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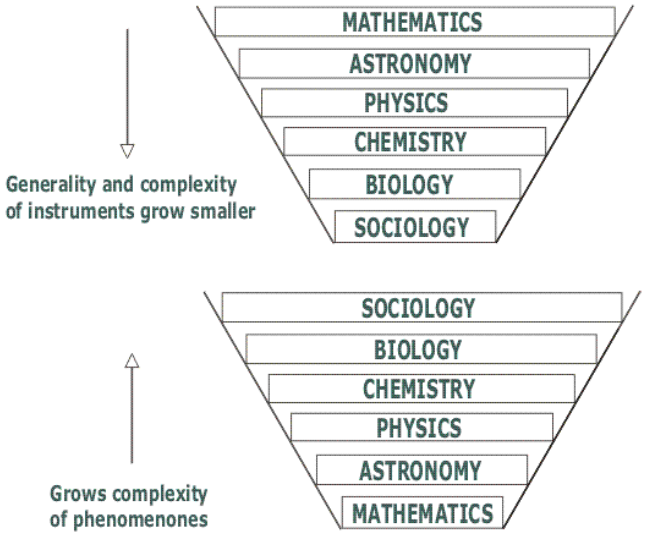
COMPUTER SCIENCE POSITION

Classification of Sciences



Auguste Comte (1798-1857)

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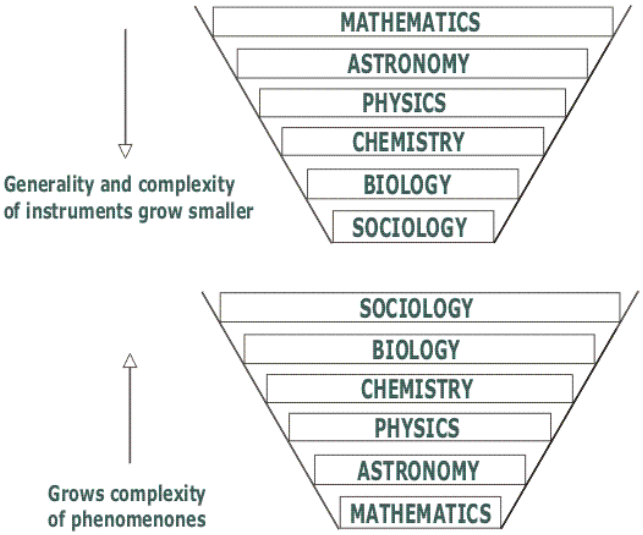

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Analytic / Synthetic

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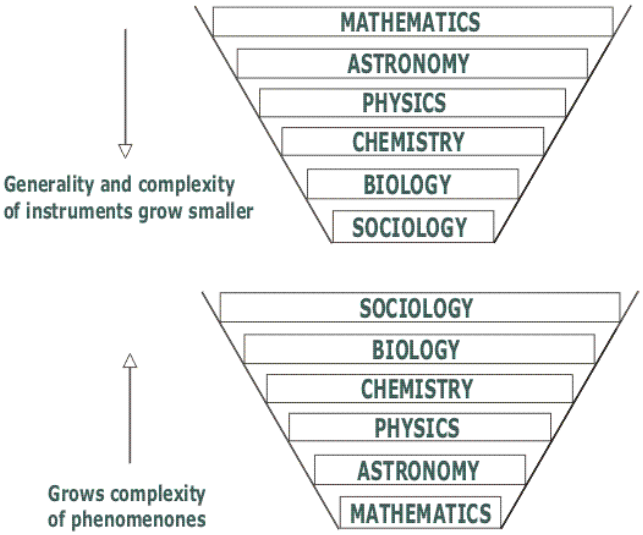

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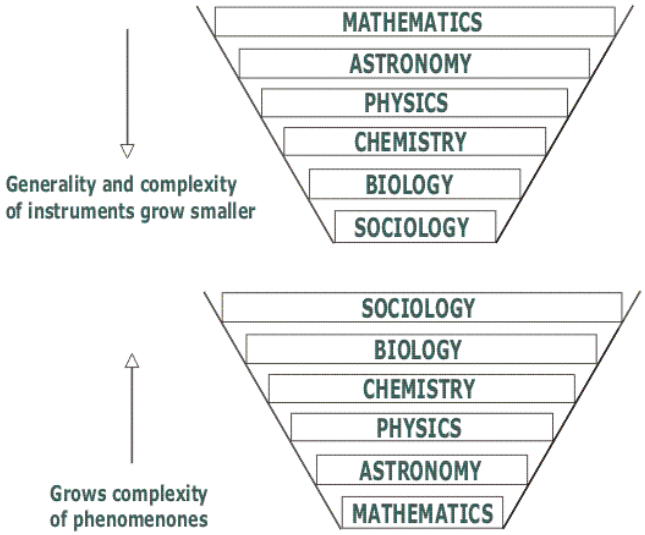

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2nd Int. Conf. on the History and Philosophy of Computing, October 28-31, 2013, Paris, France.

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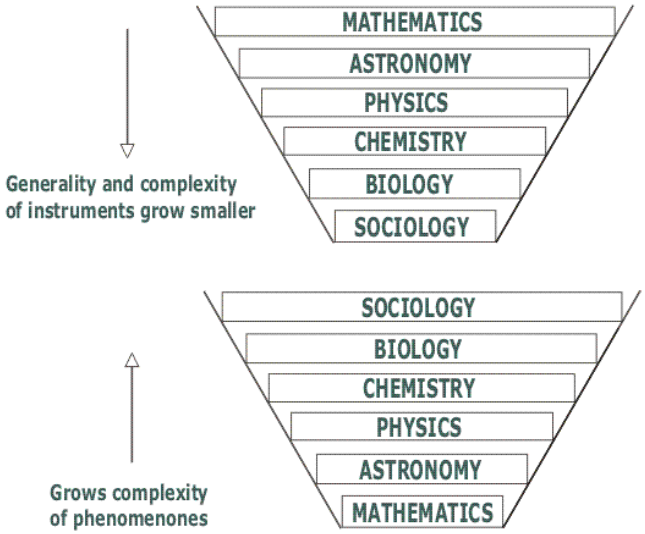

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Thus, not only Informatics requires to extend the usual classifications of sciences to include analytic a posteriori sciences, but it also destabilizes the usual distinction between a priori and a posteriori sciences and the usual classifications of sciences, that attempt to classify sciences alone and not sciences and technologies together. Gilles Dowek (2013)

METHODOLOGY FOR SCIENTIFIC RESEARCH

SCIENTIFIC FACTS

Give one example of a scientific fact and explain why you call it *scientific*

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A scientific fact is an **hypothesis** that have been confirmed by a **specific** experience.

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Step 1

Write in less than 5 lines a scientific hypothesis and propose an experiment to validate it

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Step 2

Switch your hypothesis with your neighbor.
Evaluate the obtained conclusion

CLAUDE BERNARD 1813-1878

The Scientific Method

3 steps (loop) :

1. observation of the reality is possible without premises ;
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3. experimental verification by confrontation of the hypothesis with the reality (which is always true).

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Inductivism

reasoning from the particular case to the general situation :
"The best theory is the one check by the more numbers of facts."

CLAUDE BERNARD 1813-1878

Wikipedia

INTRODUCTION

A L'ÉTUDE DE LA

MÉDECINE EXPÉRIMENTALE

PAR

M. CLAUDE BERNARD

Membre de l'Institut de France (Académie des sciences), et de l'Académie impériale de médecine,

Professeur de médecine au Collége de France, Professeur de physiologie générale à la Faculté des sciences,

Membre de la Société royale de Londres, de l'Académie des sciences de Saint-Pétersbourg et de l'Académie des sciences de Berlin.

PARIS

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LEIPZIG, E. JUNG-TREUTTEL, QUERSTRASSE, 10

1865

Tous droits réservés.

Electronic French version

SCIENCE : CONJECTURE AND REFUTATIONS

Read the text

- identify main keywords (and their definition)
- identify examples and their role in the text (W5H)

KARL POPPER 1902-1994

- Criteria to separate science and non-science :
  Is scientific a theory that could be falsifiable, that could be submitted by empirical falsification = refutable by facts

FromKarl Popper's text

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  - World 2 : the world of mental objects and events
  - World 3 : objective knowledge.

FromKarl Popper's text

In the following text K.R Popper try to answer the questions : "*When a theory get a scientific status ?*" "*Does it exist a criteria to assert the nature or the scientific status of a theory ?*"

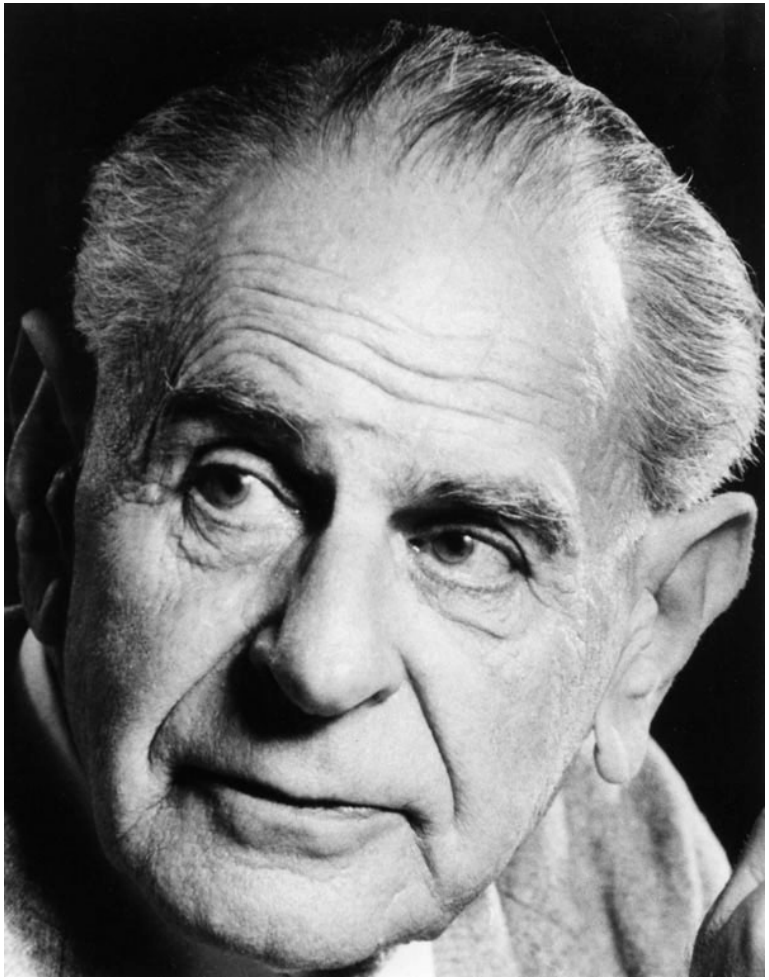
1. It is easy to obtain confirmations, or verifications, for nearly every theory-if we look for confirmations.
2. Confirmations should count only if they are the result of risky predictions ; that is to say, if, unenlightened by the theory in question, we should have expected an event which was incompatible with the theory–an event which would have refuted the theory.
3. Every 'good' scientific theory is a prohibition : it forbids certain things to happen. The more a theory forbids, the better it is.
4. A theory which is not refutable by any conceivable event is nonscientific. Irrefutability is not a virtue of a theory (as people often think) but a vice.
5. Every genuine test of a theory is an attempt to falsify it, or to refute it. Testability is falsifiability ; but there are degrees of testability : some theories are more testable, more exposed to refutation, than others ; they take, as it were, greater risks.

6. Confirming evidence should not count except when it is the result of a genuine test of the theory ; and this means that it can be presented as a serious but unsuccessful attempt to falsify the theory. (I now speak in such cases of 'corroborating evidence'.)
7. Some genuinely testable theories, when found to be false, are still upheld by their admirers–for example by introducing ad hoc some auxiliary assumption, or by re-interpreting the theory ad hoc in such a way that it escapes refutation. Such a procedure is always possible, but it rescues the theory from refutation only at the price of destroying, or at least lowering, its scientific status. (I later described such a rescuing operation as a 'conventionalist twist' or a 'conventionalist stratagem'.)

One can sum up all this by saying that the criterion of the scientific status of a theory is its falsifiability, or refutability, or testability.
K.R. Popper, Conjectures and refutations.

Thanks to C. Grasland

KARL POPPER 1902-1994



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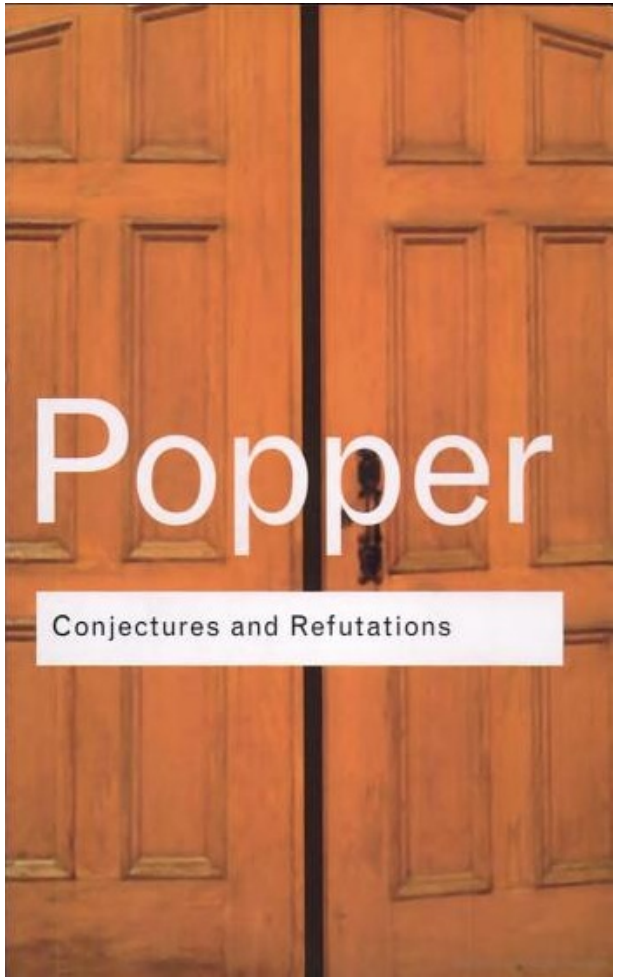

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Scientific principles [J-Y LB]

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- (Dijkstra :) It is when you cannot remove a single piece that your design is complete.
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Science is a Social Phenomena

- collaborative construction of knowledge
- dynamic evolution of knowledge

...now it's your turn ...

RÉFÉRENCES I

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