

Scientific Methodology Workshop

AISSE Option

{**Jean-Marc Vincent**¹, Nadine Mandran², Andrej Duda³ }@imag.fr

LIG Laboratory

¹Université Joseph Fourier
Équipe-Projet MESCAL

²CNRS
Marvelig

³Grenoble INP
Équipe DRAKKAR



METHODOLOGY FOR SCIENTIFIC RESEARCH

1 ORGANIZATION : Scientific Methodology Workshop

2 SCIENCE : What is this thing called Science ?

3 SCHOOLS OF THOUGHT

- Claude Bernard and the scientific method
- Karl Popper and falsifiability
- Thomas Kuhn and the dynamicity of science
- Imre Lakatos and concentric sciences

4 SYNTHESIS

5 REFERENCES

SCHEDULING

- ① November, 13 14h00-17h00 **Methodology for Scientific Research (1)** JMV
- ② November, 13 15h30-17h00 **Methodology for Scientific Research (2)** NM
Homework : about the scientific method, readings + questions
- ③ November, 20 14h00-15h30 **Elements for experimentation (1) reproducibility, replicability, design of experiments** JMV
- ④ November, 27 14h00-15h30 **Elements for experimentation (2) data analysis process, descriptive statistics, data visualization** NM
Homework : R and R-studio : characterization of a program/algorithm
- ⑤ December, 04 14h00-15h30 **Statistical Analysis (1) probability models, estimation** JMV
- ⑥ December, 11 14h00-15h30 **Statistical Analysis (2) confidence intervals, test and decision** JMV
Homework : comparison of two alternatives : ranking programs
- ⑦ December, 14 14h00-15h30 **Qualitative Approach (1)** NM
- ⑧ December, 18 14h00-15h30 **Qualitative Approach (2)** NM
Homework : project on the qualitative approach
- ⑨ January, 8 14h00-15h30 **Scientific Communication (1) scientific presentation** JMV
- ⑩ January, 15 14h00-15h30 **Scientific Communication (2) writing scientific article** AD (tbc)
Homework : Bibliography and Plagiarism

Follow ADE for the classroom usually H101 (except Nov 20 in D211)

<http://mescal.imag.fr/membres/jean-marc.vincent/index.html>

[Workshop-on-Scientific-Methodology.html](#)



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RESEARCH IN COMPUTER SCIENCE...

Brainstorming n°1

Who is computer science if she was a famous person and why?

and if she was an object?

ABOUT SCIENCE...

Question n°1

In less than 5 lines give a definition of "Science".

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.

RESEARCH IN COMPUTER SCIENCE

Brainstorming n°2

Give 5 examples of scientific facts in computer science

Give 5 examples of non scientific facts

ABOUT SCIENCE...

Question n°2

In less than 5 lines give the definition of a scientific fact.

SCIENTIFIC FACT

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

ABOUT SCIENCE...

Question n°2

Step 1

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

ABOUT SCIENCE...

Question n°2

Step 1

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

Step 2

Switch your hypothesis with your neighbor.
Propose an experiment to invalidate the hypothesis.

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CLAUDE BERNARD 1813-1878

3 steps of the scientific method :

- ① observation of the reality is possible without premises ;
- ② formulation of an hypothesis (theory) from scientist creativity ;
- ③ experimental verification by confrontation of the hypothesis with the reality (which is always true).

Inductivism (reasoning from the particular case to the general situation) : "The best theory is the one checked 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 Collège 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-Petersbourg
et de l'Académie des sciences de Berlin.

PARIS

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LONDON, 6, FINE COURT, QUEENSTREET, 10		

1855

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[Electronic French version](#)

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
- ▶ Asymmetry between verification and falsification. It is an epistemology logical and normative. Theories should be clearly formulated, as precisely as possible, can't be suppressed without a 'good reason' (falsification, or theory with "superior degree of falsifiability"), can't be immunized.
- ▶ The non-ended play of science.
 - World 1 : the world of physical objects and events, including biological entities
 - World 2 : the world of mental objects and events
 - World 3 : objective knowledge.

Karl 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.

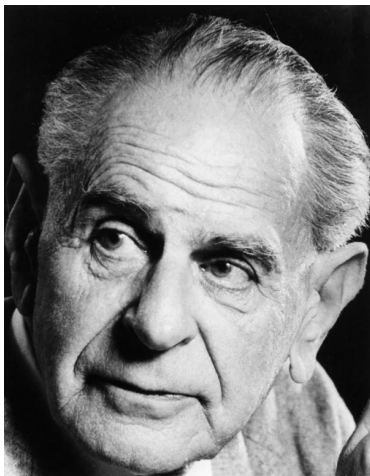
- ⑥ Confirming evidence should not count except when it is the result of a genuine test of the theory ; and this means that it can be presented as a serious but unsuccessful attempt to falsify the theory. (I now speak in such cases of 'corroborating evidence'.)
- ⑦ Some genuinely testable theories, when 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.

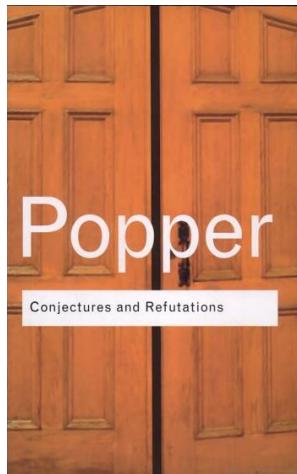
K.R. Popper, Conjectures and refutations.

Thanks to C. Grasland

KARL POPPER 1902-1994



[Wikipedia](#)



[Electronic version](#)

THOMAS KUHN 1922-1996

Pre-science

- 1 debate on the bases ;
- 2 no selection of facts ;
- 3 no scientific domain.

Normal Science

existence of a paradigm, a matrix for the domain :

- 1 common language for the "tribe"
- 2 shared believes (ontologies, metaphors and analogies) ;
- 3 shared values (values, methodological, epistemological norms) ;
- 4 socialization examples. Normal science check that the paradigm is right, never contradictory facts

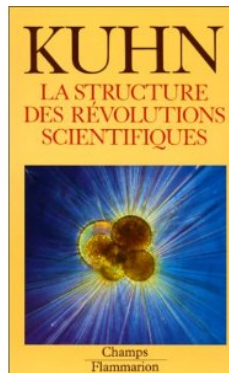
Scientific revolution

strong anomalies : fundamental questioning of the basic paradigms at a psychological, sociological, political level. Incommensurability between the old and the new paradigm.

THOMAS KUHN 1922-1996



Paradigms



Electronic version

IMRE LAKATOS 1922-1974

Research Program : hard core values et fundamental believes fondamentales ontologic and methodologic (ideology of the group), never questioned ("negative heuristic").

Protecting belt : theories confirming observed facts and protecting the hard core from critics. We falsify at the protecting belt level, never at the hard core level. We evaluate series of theories rather than falsifying a particular one (as Popper did).

Main Science : characterized by several concurrent research programs concurrents.

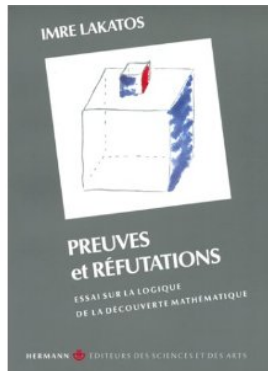
Progressive Program : progress at the theoretical level (increase coherence) and at the empirical level (new facts).

Degenerated Program : no progress at the theoretical (no improvements) / empirical (no unpredictable facts) level

IMRE LAKATOS 1922-1974



[Wikipedia](#)



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SYNTHESIS

Scientific Method

Falsifiability is the logical possibility that an assertion can be shown false by an observation or a physical experiment. [Popper 1930]

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Modeling principles [J-Y LB]

- ▶ (Occam :) if two models explain some observations equally well, the simplest one is preferable
- ▶ (Dijkstra :) It is when you cannot remove a single piece that your design is complete.
- ▶ (Common Sense :) Use the adequate level of sophistication.

SYNTHESIS

Scientific Method

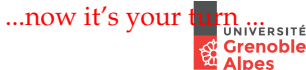
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Science is a Social Phenomena

- ▶ collaborative construction of knowledge
- ▶ dynamic evolution of knowledge



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