# Popper and falsificationism

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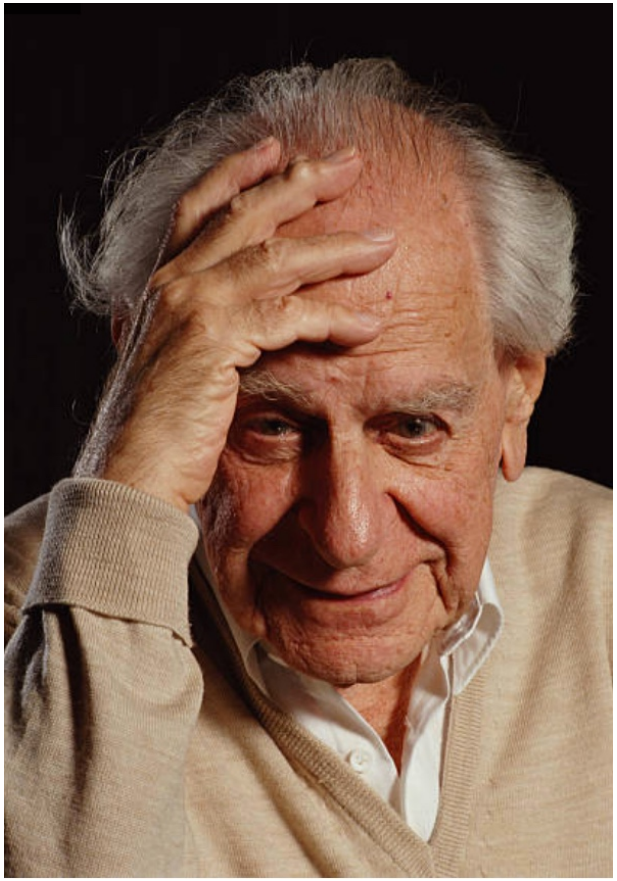
# Sir Karl Popper (1902-1994)



- born in Vienna, educated at U of Vienna
- 1928 PhD, 1930-1936 secondary school teacher
- 1934 *Logik der Forschung* (translated to English in 1959 as 'The Logic of Scientific Discovery' (!)))
- 1937 emigration to NZ, lecturer at Canterbury U College of NZ
- 1946 emigrated to UK, position at LSE
- 1963 *Conjectures and Refutations*
- popular in science; 'Popperazzi'

# Popper's theory of science in a nutshell

- problem of induction $\Rightarrow$ forget about induction altogether
- theory of deductive method of testing instead
- 'deductivism' (as opposed to inductivism)
- explicitly acknowledges Duhem as forerunner of deductivism
- rejected logical positivist demarcation criterion of verifiability (or confirmability)

- instead proposed as demarcation criterion 'falsifiability'
- There's no logic of scientific discovery, but of 'scientific justification'.
- Scientific progress results from the continued cycles of conjectures and refutations.
- We can never be completely sure that a theory is true; nor can we reasonably increase our confidence in the truth of a theory when it is 'corroborated'.
- thesis of falsificationism
- intended as descriptive and prescriptive

# Asymmetry between verification and falsification

The verification of hypotheses by their empirical consequences:

(1) $h \rightarrow e$
(2) $e$

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(3) *Therefore* $h$

deductively invalid (affirmation of consequent)

Falsification:

(1) $h \rightarrow e$
(2) $\neg e$

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(3) *Therefore* $\neg h$

deductively valid (modus tollens)

# Falsification

**Examples of falsifiable statements:**

(1) It never rains on Thursdays.

(2) All bodies expand when heated.

(3) Heavy objects dropped close to the Earth's surface fall downwards if there is nothing to hold them back.

(4) When a ray of light is reflected from a plane mirror, the angle of incidence is equal to the angle of reflection.

- (1), (2): falsifiable and false
- (3), (4): true, but falsifiable
- (3): It is logically possible that the next brick dropped will not fall, even if there is nothing to hold it back.

# Falsification

**Definition (Falsification)**

*A statement is falsifiable iff (if and only if) there is at least one logically possible observation statement that contradicts it.*

**Examples of non-falsifiable statements:**

(5) 'It rains or it doesn't rain': a logical tautology, $p \vee \neg p$

(6) 'All points on a Euclidean circle are equidistant from the centre': true by definition

(7) 'Mercury contains a feminine principle' (alchemy): unintelligible

# Degree of falsifiability: generality

Different degrees of falisifiability:

**Example: which statement is more falsifiable?**

(1) Mars moves around the Sun in an ellipse.

(2) All the planets move around the Sun in ellipses.

Falsifiability: (2) > (1)

[Proof: all statements which falsify (1) also falsify (2), the the inverse is not true. Thus, there are more statements which falsify (2) than (1).]

# Degree of falsifiability: precision

Different degrees of falisifiability:

**Example: which statement is more falsifiable?**

(1) All the planets move around the Sun in ellipses.

(2) All the planets move around the Sun on closed curves.

Falsifiability: (1) > (2)

[Proof: all statements which falsify (2) also falsify (1), the the inverse is not true. Thus, there are more statements which falsify (1) than (2).]

# Falsifiability as criterion of demarcation

**Example: Adler's psychology**

'All human actions are motivated by feelings of inferiority.'

- This principle applies to any behaviour and, consequently, accepting it has no consequences.

# Falsificationism

## Thesis (Falsificationism)

*Falsifiability is the criterion by which science is demarcated from non-science: a hypothesis is scientific iff it has the potential to be disproved by some possible observation.*

$\Rightarrow$ Scientific theories are characterised by an elevated empirical content.

- empirical content: degree of falsifibility

## Positive examples (according to Popper):

Newtonian physics (falsified), theory of relativity (not yet falsified), quantum mechanics (not yet falsified), Marxist economic theory (falsified)

## Negative examples (according to Popper):

Adler's and Freud's psychology, astrology, Goethe's philosophy of nature, metaphysics in the spirit of Heidegger

# Falsificationism

- simplistic slogan: the more easily a hypothesis can be falsified, the better, i.e., the more scientific it is!
- Scientific theories are daring conjectures. Containing highly falsifiable statements, they run a high risk of being false.
- If a theory runs no risk of being false, it is not scientific.

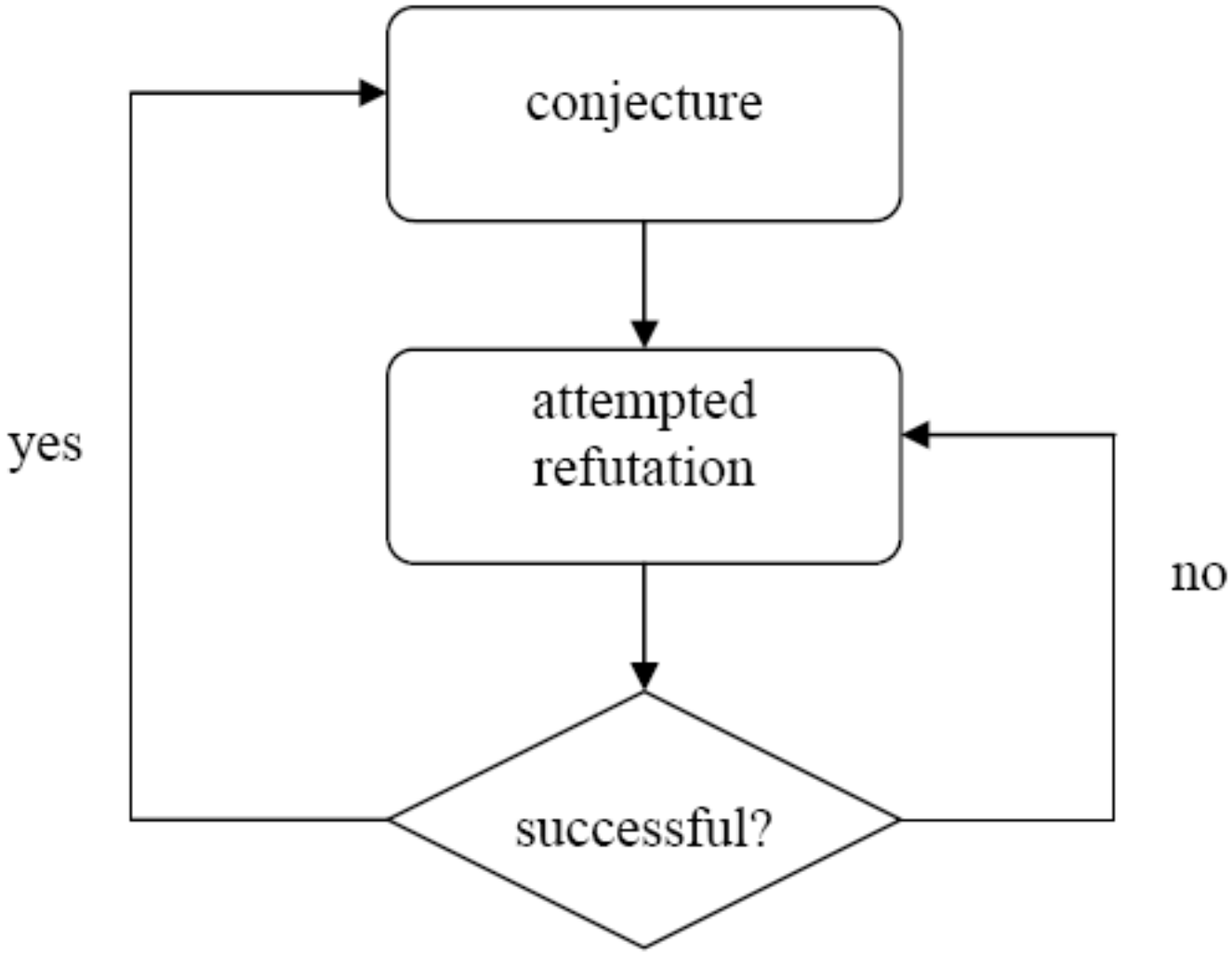
# Falsificationism

- There is an asymmetry between verification and falsification:
  (a) An observation that contradicts the prediction leads to a clear falsification (and rejection) of the theory under consideration.
  (b) No amount of corroboration can verify a theory; confirmation is a myth.
- We should adopt a cautious attitude towards scientific theories, i.e., take account of the provisional nature of theories.
- Science is the search for truth, but we can never know whether we have reached it!

# Conjectures and refutations

- Theories are conjectures freely created by the mind in order to solve problems posed by previous theories.
- Although they can be interpreted literally as representations of objective reality, it is not possible to verify theories (because this would only be possible by means of induction, which is not justifiable).
- But it is possible to falsify them by particular statements (observation or experiment). So science must test speculative theories rigorously and ruthlessly by confronting them with experience.
- If the theory passes an empirical test, we must persevere in trying to falsify it. If it fails, we have to invent a new theory (taking into account the problems of the previous theory).
- So science progresses by trial and error.

# Scientific change: conjectures and refutations



# Problems with falsificationism

# (1) The problem of observation statements

- In order to disprove a theory, the observational statements (or protocol statements) must be true. But the philosophy of perception questions the possibility of justifying statements directly through sensory experience (cf. Wilfried Sellars, 'Myth of the given').
- Are there any methodological rules that provide conditions for the acceptance of observation statements?
- Popper: No. It is not possible to justify all the statements that form the empirical basis of a theory or science. Observational statements are conventional. We accept them as they are (because it's simply not possible to have a scientific practice if we don't believe in anything).
- The empirical basis is a marsh, rather than granite.

# (2) The problem of holism and the immunisation of theories

Holism about testing: an isolated hypothesis cannot be falsified individually.

(P1) $h \& a \rightarrow e$

(P2) $\neg e$

(C) Thus, $\neg h$ or $\neg a$

## Example

- Let $h$ = Newtonian mechanics
- $a$ = positions and masses of the planets known before 1846 (discovery of Neptune)
- $e$ = orbit of Uranus as predicted based on $h$ and $a$
- $\neg e$ is observed – Is the error in $h$ or in $a$?
- Before 1846, it was not possible to locate the error. Although it was identified in 1846 (by the discovery of Neptune), it is always possible that there are false auxiliary hypotheses, so an isolated statement can never be refuted.

# The problem of holism

Where is the error?

- The falsity of *h* can only be inferred if *a* is true. Falsification without true auxiliary statements is not possible.
- Popper: The auxiliaries must be independently testable. But is this always possible?
- In general, it is not possible.
- Popper was aware of the fact that logic itself does not force a scientist to reject a particular hypothesis because of data that contradicts that hypothesis.
- But he thought that a good scientist would never do that.
- N.B. Duhem's problem (the problem of holism) attenuates the logical asymmetry of falsification and verification.

# Implication: immunisation strategy

- The falsification process is therefore based on decisions about the observation report and about the auxiliary hypotheses, decisions that can be called into question.
- Popper insisted that making these decisions about observations and the reliability of measuring devices is different from making decisions about theories themselves.
- But: a hypothesis can be retained despite apparent falsification if one is only prepared to make certain decisions.

$\Rightarrow$ Scientific theories can be 'immunised' against falsification.

Question: Can Popper really maintain that science is rational and objectively progressive when it ultimately depends on purely conventional and arbitrary decisions?

# (3) More trouble: demarcation criteria

## Peter Godfrey-Smith (2021, 96)

> *[I]t is a mistake to try to work out whether theories such as Marxism or Freudianism are themselves 'scientific' or not, as Popper did. A big idea like Marxism or Freudianism will have scientific and unscientific versions... Scientific versions of Marxism and Freudianism are produced when the main principles are connected with other ideas in a way that exposes these principles to testing. To scientifically handle the basic principles of Marxism is to try to work out what difference it would make to things we can observe if Marxist principles were true.*

Peter Godfrey-Smith ($^{2}$2021). *Theory and Reality: An Introduction to the Philosophy of Science*. University of Chicago Press.

# (4) More trouble: probabilistic hypotheses

- What about a probabilistic hypothesis, which prohibits no particular observation and therefore takes no risk?
- Examples of probabilistic hypotheses: coin toss, measurement postulates in quantum mechanics, etc.
- Popper: logically speaking, such hypotheses are not scientific, but 'in practice' falsifiable.

$\Rightarrow$ Falsification can take place 'in practice' without being supported by a deductive relation between observation and theory.

# (5) The problem of scientific progress

- Even assuming falsificationism, how can one rationally prefer a highly corroborated' theory to a new theory?
- If corroboration differs from confirmation in that it is only 'backward-looking', how can it be rationally justified?
- Wesley Salmon (1981): if there is no confirmation, then no policy is more rational than choosing the untested theory (in fact, it is just as rational).

# Popper's replies

Popper was well aware of these problems, and he tackled them...

# Ad hoc hypotheses and immunisation

## (2) The problem of holism and the immunisation of theories

Are we allowed to modify a theory to protect it against falsification?

### Example: phlogiston theory (18th century)

- Phlogiston: a theoretical principle postulated to explain combustion and the chemical transformation of ores into metals
- Combustible substance $\rightarrow$ ash $+$ phlogiston
- Ore $+$ phlogiston $\rightarrow$ metal
- Anomaly: Many substances gain weight through combustion, and ores lose weight as they turn into metal.
- Ad hoc hypothesis: phlogiston has a negative weight.

# Ad hoc hypotheses and immunisation

## (2) The problem of holism and the immunisation of theories

- According to Popper, it is not permissible to immunise a theory against falsifying examples by ad hoc hypotheses (see his criticism of the Adlerians and Freudians).
- But ad hoc hypotheses are also proposed by physicists from time to time!
- You have to take into account their practice, which is entirely justified in certain cases.

**Example: Neptune**

The postulate of a new planet (Neptune) to explain the perturbation of the orbit of Uranus protected the Newtonian theory.

# Ad hoc hypotheses and immunisation

## (2) The problem of holism and the immunisation of theories

- The principle of increase in empirical content allows us to specify the conditions under which ad hoc hypotheses are permitted: An ad hoc hypothesis must add additional empirical content to a theory.
- In other words, an ad hoc hypothesis must serve not only to protect a theory but also to deduce new predictions.
- This was the case in the Neptune example, but not in the phlogiston example.

# Falsificationism and scientific progress

(5) The problem of scientific progress

## Example: Newtonian physics

- For more than 200 years (1687 - ca. 1900), Newton's theory had (almost) passed the most rigorous tests. It even led to the discovery of a new planet (Neptune).
- Falsification at the end of the 19th century by:
  1. the variable mass of high-speed electrons in discharge tubes,
  2. the advancement of the perihelion of the planet Mercury.
- These two phenomena were correctly predicted by the new theories proposed by Albert Einstein in 1905 (special relativity) and in 1915 (general relativity).
- Furthermore, Einstein's theories correctly predicted all the phenomena predicted by Newtonian theory.
- Last but not least, general relativity predicts new phenomena, such as the deflection of starlight near a massive body like the sun (observed in 1919 by Arthur Eddington during a solar eclipse in Brazil), and gravitational waves (observed in 2015).

# Falsificationism and scientific progress

## (5) The problem of scientific progress

- So although the Einsteinian theory cannot be said to be true (according to Popper), it should be noted that, in addition to reproducing all the successes of the Newtonian theory, it
  1. succeeds where the old theory fails, and
  2. predicts new phenomena.
- N.B. Einstein did not simply modify the old theory by adapting it to known anomalies. This would not be acceptable according to Popper's methodology [why?].
- It is crucial that the new theory not only solves the empirical problems of the old theory but also provides new predictions.

In other words, the new theory delivers an increase in empirical content compared to the old theory.

# Falsificationism and scientific progress

## (5) The problem of scientific progress

- For Popperians, scientific progress consists essentially in the growth of empirical content (understood as the degree of falsifiability) in the historical development of a science. For a science to progress, its theories must become increasingly falsifiable.

# Life without induction reconsidered

## (5) The problem of scientific progress

- Let $t_1$ be a falsifiable theory that has passed one rigorous test, and $t_2$ be a falsifiable theory that has passed 100 rigorous tests. Is there any reason to believe that $t_1$ and $t_2$ will pass another test? Is there more reason to expect $t_2$ to pass another test than $t_1$? Inductive interference!
- Popper: $t_2$ is more corroborated than $t_1$.
- What is the point of corroboration if we have no reason to expect that $t_2$ can pass other tests?
- Popper suggested that we might need "a whiff of induction".

$\Rightarrow$ So Popper himself didn't really believe that life without induction was possible!