Belief in Science and Religion
Lecture 2: Scientific Methods

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Belief in Science and Religion
Lecture 2: Scientific Methods

- What science is not like
- What science is like
- What science is
What Is Science Like?

Science is...

- Experimental
- Objective
- Hypotheses – Prove / Refute
- Applicable, Useful
- General,
- Person-independent, shared
- Models
- Predictive
- Dependable
Science is ... Universal

Scientific statements are

- Universal
- Timeless
- Necessary

\[ F = m a \]

- Everywhere
- Always
- For everyone
Science is ... Deductive

Deductive logic: from general to specific.

All swans are white
+ This animal is a swan

\[ \text{This animal is white} \]

Premises

If the premises are true, the conclusions are necessarily true.
Science is ... Certain

“Few philosophers or scientists still think that scientific knowledge is, or can be, proven knowledge...

but few realize that with this the whole classical structure of intellectual values falls in ruins and has to be replaced.”

I. Lakatos *Methodology of Scientific Research Programmes*
Science is ... Not Verifiable

Scientific statements can be falsified, but not verified.

e.g. “All swans are white”

Verified? ❌
Falsified? ✓
Science is ... Not Verifiable
Scientific statements can be falsified, but not verified.
e.g. “Not all swans are white”
Science is ... Not Verifiable

Scientific statements can be falsified, but not verified.

Scientific statements can be falsified
But not verified.
+ The statement
  “Not all swans are white”
  can be verified.

The statement
  “Not all swans are white”
Is not scientific.

Scientific statements are universal, timeless and necessary
Science is ... Not Verifiable

Scientific statements are universal, timeless and necessary

\[ F = m a \]

“It will rain tomorrow”
Science is ... Not Verifiable

Scientific statements are universal, timeless and necessary can be

but can also be specific, temporal, and contingent.

\[ F = m a \]

“It will rain tomorrow”
Science is ... Not Verifiable

Scientific statements are universal, timeless and necessary can be, but do not have to be

WHAT?

YOU CAN JUST REDEFINE "SCIENCE"?
Science is … Falsifiable

State, in advance, what event would constitute a falsifying instance of a particular theory.

If this event occurs, the theory is falsified, and must be rejected.
Science is ... Falsifiable

Falsifying evolution

A perfect example of adaptation to the environment
Science is ... Falsifiable

Falsifying evolution

ARTICLE

Received 20 Aug 2012 | Accepted 17 Jan 2013 | Published 5 Mar 2013

Mid-Pliocene warm-period deposits in the High Arctic yield insight into camel evolution

Natalia Rybczynski¹, John C. Gosse², C. Richard Harington¹, Roy A. Wogelius³, Alan J. Hidy² & Mike Buckley⁴
“We report ... the first evidence of a High Arctic camel... It is likely that modern camels are derived from a lineage that was originally adapted to living in Late Neogene, northern forests, and some traits seen in modern camels may reflect this heritage... specialized traits seen in modern camels may also have served well in an Arctic realm. For example their wide flat feet function well on soft substrates, such as sand or snow. Their iconic hump(s), containing fat, also may have been adaptive. [They] could have been critically important for allowing populations to survive and reproduce in harsh climates characterized by 6-month long, cold, winters.”
Science is ... Falsifiable

Science must be falsifiable
  +
Evolution does not get falsified

Evolution is science
  +
Evolution is not falsifiable

\[ \{ \text{Evolution is not science} \} \]

\[ \{ \text{Science does not have to be falsifiable} \} \]
Science is ... Falsifiable

Falsifying evolution

“New concepts need to be integrated into an expanded evolutionary synthesis.”

Too Many Ways To Be Wrong
Too Many Ways To Be Wrong

This bull is a boy
Too Many Ways To Be Wrong

All dinosaurs are girls
Too Many Ways To Be Wrong

Sexing reptiles

Even if a dinosaur had a penis, you might not see it
Too Many Ways To Be Wrong
Too Many Ways To Be Wrong

“Daddy, my pirate is a dinosaur.”
Too Many Ways To Be Wrong

Duhem Quine hypothesis

“Our statements about the external world face the tribunal of sense experience not individually but only as a corporate body.”

For any finite set of observations or statements there exist an infinite number of theories with which they are entirely consistent.

Scientific statements are not falsifiable
Science is... Reproducible

Standard cosmological model
Science is ... Explanatory
Quantum mechanics: Bohr model

Classical problems:
Quantum answers:
- Why doesn’t the electron fall into the nucleus?
  - Electrons orbit the nucleus without falling in.

- Why do you get narrow emission / absorption lines?
  - Electrons moves between stable states by emitting or absorbing narrow linewidth radiation.

- Why are the absorption lines distinct?
  - The energy levels of the electrons are discrete.
Science is ... Predictive

Quantum mechanics: Bohr model

**Theory:** Bohr
Phil. Mag., 26 (1913) 1-25.

**Experiment:** Lyman
Science is ... Explanatory
Science is ... Predictive
Science is ... Unifying

Quantum mechanics: Bohr model

**Bohr:**
Atomic hydrogen (just about)

**Not Bohr:**
Helium, Lithium,
Molecular hydrogen,
Classical mechanics,
Classical electrodynamics...
Everything except atomic hydrogen.
Science is ... Explanatory
Science is ... Predictive
Science is ... Unifying
Science Makes Progress

Quantum mechanics: Bohr model
Science is ... Predictive
Science is ... Unifying
Science Makes Progress

Quantum mechanics: Bohr model
Science Works
If it is scientific then it works

Having problems with your teeth?
Bruise easily?
Blurred vision?
Bad complexion? Pale? Spotty? Yellow?
Feeling grumpy?
Fever?
At death’s door?
Science Works

If it is scientific then it works
If it works then it is scientific

Having problems with your teeth?
Bruise easily?
Blurred vision?
Bad complexion? Pale? Spotty? Yellow?
Feeling grumpy?
Fever?
At death’s door?

Vitamin C!
Science Works
If it works then it is scientific

Acne,
Alcoholism,
Arthritis,
Dysentery,
Haemorrhagic fever,
Hay fever,
Headaches,
Infertility,
Insomnia,
Lactation deficiency,
Malpositioning of the foetus,
Nicotine addiction,
Obesity,
Sciatica,
Schizophrenia,
Stroke,
Whooping cough,
possibly Coma.

“Acupuncture: review and analysis of reports on controlled clinical trials” World Health Organization (2003)
Science Works
If it works then it is scientific

Sir Isaac Newton:
Gravity,
Optics,
Transmutation.
When Science Won’t Let Go

The universe follows rules
Science is Not Alone

The greatest good is served by the individual maximising profit
Science is Not Alone

God is good
Summary

• “The scientific method” is not well defined.

• At pragmatic root, applied science does whatever works.

• Pure science does whatever is necessary to protect the claim “the universe follows rules”.

• Other subjects also have a “hard core” they protect at all costs.