

A Brief Overview of the Philosophy of Science

NRC 601

Research Concepts in Natural Resources

Department of Natural Resources Conservation
University of Massachusetts Amherst

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Opening premise

“The universe is a place filled with wonderful but deeply mysterious structures and processes - [but] these can be understood as behaving in accord with universal laws.”

- Anonymous

Objectives

- (1) lay a foundation of philosophy and trace the philosophical roots of science.
- (2) become familiar with the names and backgrounds of some key philosophers of science.
- (3) identify some of the ideas and approaches that form the foundations of modern science.

Some terminology

- empiricism --- all knowledge is derived from experience.
- deductivism --- specific observations obtained from generalizations.
- inductivism --- generalizations from facts recorded in experience.
- materialism --- everything that exists is physical.
- metaphysicalism --- related to abstract, intangible, philosophical.
- realism --- there is a knowable external world.
- scepticism --- the world is unknowable; nothing can be established.
- pluralism --- increase alternative H's to max. chance of falsification.

Types of Reasoning

(1) analogical

“Betty should be able to graduate from college because her identical twin did so”

“Black spruce require certain levels of nutrients, therefore white spruce should”

(2) inductive

1,000 apples are red \therefore all apples are red

(3) deductive

“If all men are mortal and Socrates is a man, then Socrates is mortal.”

In Ecology . . .

We study a . . .
sample,

. . . and apply what we learn to . . .
the population.

Thus we commonly use . . .
inductive reasoning,

. . . based on . . .
empirical data.

Sir Francis Bacon (1561-1626)

An English lawyer, statesman, essayist, historian, intellectual, reformer, philosopher, and champion of modern science.

Proposed to:

- (1) Ask questions
- (2) Collect data
- (3) Promote "negative instances"



John Locke (1632-1704)



A British philosopher
Oxford academic and medical examiner
"One of the greatest . . ."

Promoted empiricism – sought to base
knowledge on our senses.

Discussed the crucial notion of probability.

Locke's views on *epistemology* (the study of knowledge) is a prototype of what we believe today.

Locke understood the task of epistemology to be:

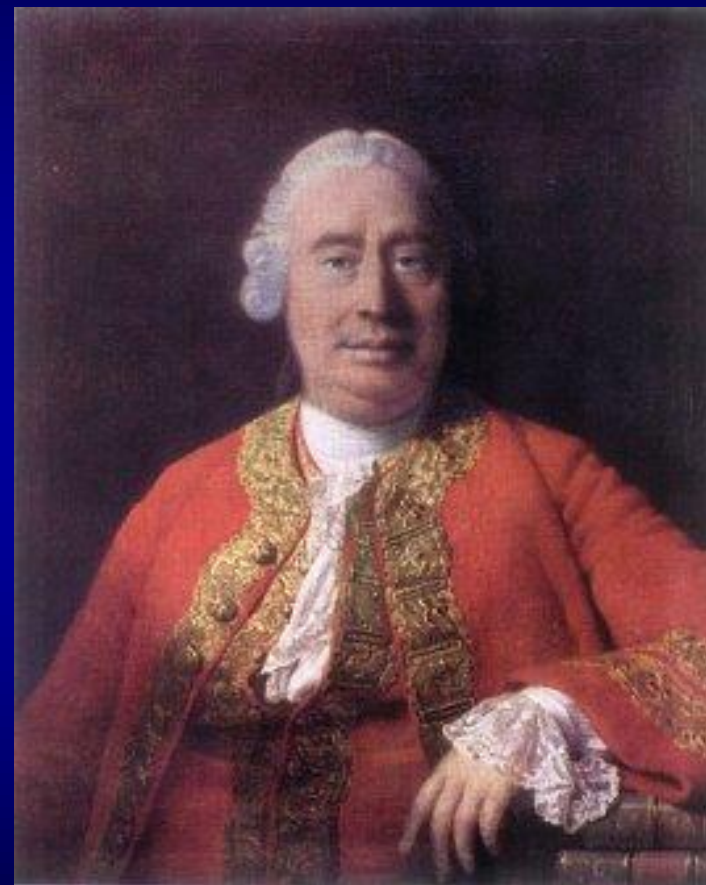
- (1) To understand what knowledge is
- (2) To understand strengths of various kinds of evidence
- (3) To determine how far our knowledge extends
- (4) To show that we do have knowledge, versus the skeptic

David Hume (1711-1776)

A Scottish philosopher and historian
A central influence of Darwin and Huxley
"One of the most important . . ."

Advanced skepticism - almost nothing
can be known.

Believed certainty was impossible -
questioned his own identity - fell into fits
of despair.



Hume's contributions to philosophy are relevant today.

- Problem of Causation - challenged belief in cause-and-effect.

what evidence is there of a causal relationship?

- Problem of Induction - past is not a reliable guide to future.

it worked before, but why should it do so again?

- Utilitarianism - supported countryman Francis Hutcheson.

the greatest good for the greatest number.

- The Design Argument - order & purpose bespeaks divine origin.

design in Nature does not prove the existence of God.

John Stuart Mill (1806-1873)



A British philosopher
Strong empiricist and liberal
"One of the most influential
..."

Held a positive view of the
universe and humans place in it
...

Promoted the progress of human knowledge,
individual freedom, and well-being of people.

Mill's view of science included . . .

- A belief in Induction as the best approach to science . . .

Humans make spontaneous and unscientific observations.

The logic of science is inductive logic, which provides a set of rules that is the best guide for the discovery of new truth.

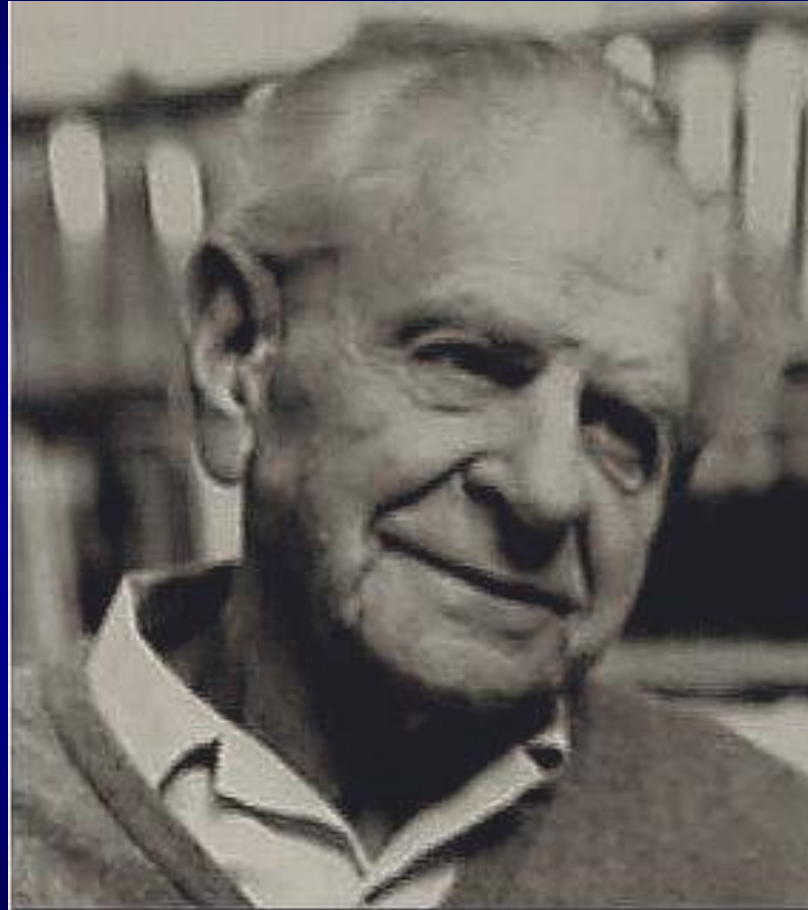
- A recognition of uncertainty . . .

We cannot achieve certainty, and we need to recognize that.

- And a realistic approach . . .

In the absence of infallible knowledge, we ought as reasonable persons be satisfied with fallible knowledge.

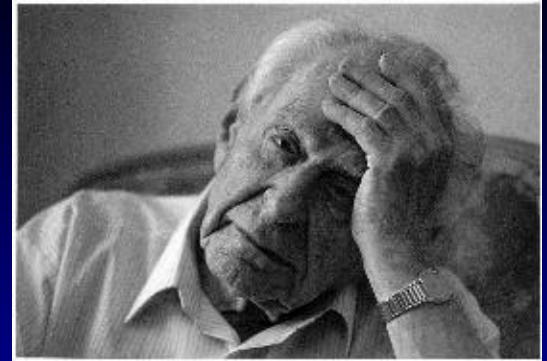
Karl Popper (1902-1994)



Sir Karl Popper (1902-1994)

- regarded as one of the greatest philosophers of the 21st century
- born in Vienna, Austria on 28 July 1902; died on 17 September 1994
- was a cabinet maker and school teacher
- received Ph.D. in philosophy in 1928
 - taught at University of Canterbury in New Zealand in 1937
 - taught at London School of Economics in 1946
 - professor of logic and scientific method at U. London in 1949
 - knighted in 1965

Some important events:



Teenage flirtation with Marxism:

- driven by democratic failure to stem fascism and the nazis

Einstein lecture at University of Vienna during early 1900s:

- Einstein challenged his own theories on the behavior of light
- highly improbable in the face of Newtonian physics
- falsification of any part would falsify the whole theory

Contrasted to Marxism and psychoanalytic theories:

- nothing could be falsified because they were imprecise
- theories were changed to accommodate the facts

These events and factors combined to make Popper arrive at a criterion for demarcating science from non-science:

"Falsification"

Whereas, Marxism was continually modified solely to accommodate recent events and observations,
and,

Psychoanalytic theories were always consistent with all possible observations,

They were considered *unscientific* by Popper.

"The Logic of Scientific Discovery" 1934

The Problem of Demarcation

How to distinguish between science and non-science?

A theory is scientific only if it is possibly refutable by a conceivable event --- every genuine test of the theory is an attempt to refute or falsify it.

In Popper's view:

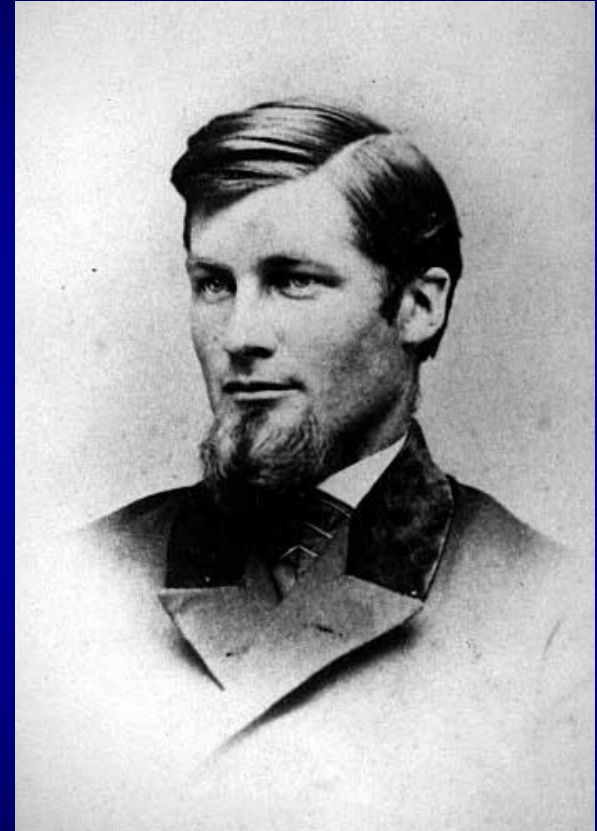
- science starts with *problems* rather than observations, and scientists are largely *problem solvers*
- special emphasis is placed on *independent creative imagination* in the formulation of theory
- promote a *critical ethos* where the give and take of debate is highly esteemed

Thomas Chrowder Chamberlin (1843-1928)

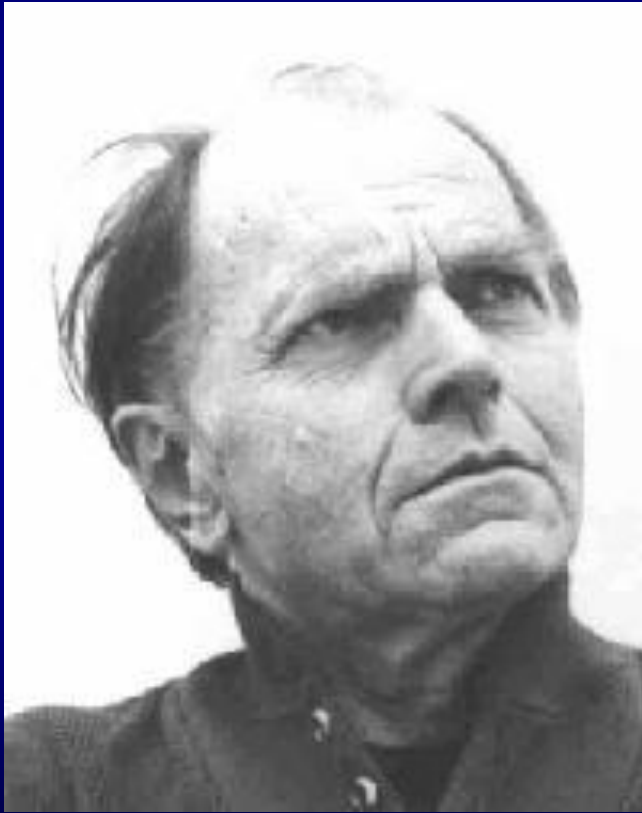
Born in Illinois; influential geologist
and science educator.
Founding editor of the *Journal of
Geology*.

*"The Method of
Multiple Working
Hypotheses"*

Science (old series) 1890
Journal of Geology 1897



Paul Feyerabend (1924-1994)



Pronounced "fire aaa-bin"

Born in Vienna; studied science
and philosophy

Professor of philosophy at UCal-Berkeley
One of the most controversial . . .

Met Karl Popper in 1948

Was an admirer, later a critic of
Popper

Finally a critic of philosophy of science
Described as "brilliant" and
"irresponsible"

Was at first a Popperian falsificationist . . . but later rejected Popper's views as too simplistic . . .

Believed in inductivism . . . that science proceeds through generalization from facts recorded in experience . . .

In 1970 he published an article, expanded into a book in 1975, called:

"AGAINST METHOD"

He was now dissatisfied with any methodology . . . the history of science is so complex that no general method applies . . . and in fact, would only inhibit progress . . .

The only rule he was satisfied with was

"Anything goes."

Feyerabend received strong critical reaction to *Against Method* and was criticized as being aggressive and nasty.

He was shocked and surprised, and responded with an essay entitled "*Conversations with Illiterates.*"

". . . Science is much closer to myth than a scientific philosophy is prepared to admit. It is one of the many forms of thought that have been developed by man, and not necessarily the best."

Science prevails only because modern science has overpowered its opponents, it did not convince them.

Only believed in the separation of science and state, and that so-called scientific experts should be controlled by juries of laypeople.



Thomas Kuhn (1922-1996)

Born in Cincinnati, Ohio
Ph.D. in physics from Harvard
Later positions at Harvard,
Berkeley, Princeton, and MIT

Of five books and countless articles,
his most renowned work is the book is

"The Structure of Scientific Revolutions"

Published in 1962 when he was a grad student
Sold >1 million copies in 16 languages

Science is not a steady cumulative acquisition of knowledge.

Rather, it is a series of peaceful interludes punctuated by intellectually violent revolutions ----- the tradition-shattering complements to the tradition-bound activity of normal science.

The typical pattern is the successive transition from one paradigm (a collection of beliefs) to another through a process of revolution.

Such scientific revolutions come only after long periods of tradition-bound normal science.

"Novelty emerges only with difficulty, manifested by resistance, against a background provided by expectation."

Mileva Maric Einstein and Albert Einstein, 1903

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е томе знаменитых
Einstein-Magity
первой жены). Все



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$$E = \frac{mc^2}{\sqrt{1 - \frac{v^2}{c^2}}}$$

"One should be nice and modest and keep one's mouth shut, that is my advice to you." -- Albert to Mileva, 1925

Rosalind Franklin (1920-1958)

Best known for her work on DNA and X-ray diffraction photographs.

Maurice Wilkens gave her photos of DNA to Watson and Crick without her permission.

Watson, Crick, and Wilkens received the Nobel prize in 1962.



“The view has been expressed that her contribution to the discovery was comparable to those who did receive the award.”

Lynn Margulis

Distinguished Professor, Biology Dept.,
University of Massachusetts Amherst.

Noted work on symbiosis and evolution.

Best known for developing the theory
that cells with nuclei evolved from the
merger of two bacterial cells.



Has written extensively on biological interconnectedness,
the inter-relationships of life, and the Gaia Hypothesis.

Margulis . . .

has been called “one of the most creative scientific thinkers of our day.”

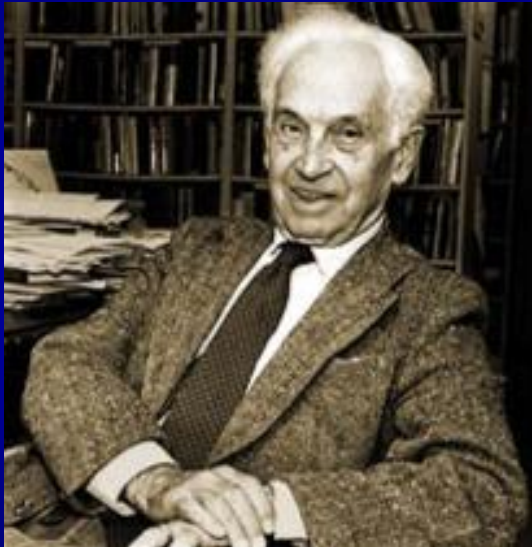
. . . “one of those rare scientists whose research fundamentally altered the way we view the world . . .”

*E. Goldscheider, “On Wisconsin”
alumni magazine, 2009*

“Man is the consummate egotist. It may come as a blow to our collective ego, but we are not masters of life perched on the top rung of an evolutionary ladder.”

*L. Margulis, “On Wisconsin”
alumni magazine, 2009*

Ernst Mayr (1904-2005)



Has written extensively on evolution
and many aspects of ecology

*"This is Biology,
the Science of the Living World"*

Mayr . . .

“From the Scientific Revolution in the seventeenth century until well after World War II, science for most people meant the “exact” sciences – physics, chemistry, mechanics, astronomy – all of which relied heavily on mathematics and emphasized the role of universal laws.”

“By comparison, the study of the living world was considered an inferior endeavor.”

“ . . . the duality of causation in organisms . . . ”
(universal physical laws and genetic programming)