WHAT'S ALL THIS ABOUT SCIENCE?

Eugene H. Spafford
Purdue CS
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KNOWLEDGE

- Epistemology is the field of Philosophy devoted to the study of what can be known and the nature of knowledge
- Why do we care about Philosophy?
  - You want to get a PhD – Doctor of Philosophy!
- Computer Science is similar: the study of what can be computed, and the bounds and methods of those computations

WHAT DO YOU KNOW?

- Does the world really exist?
  - No (solipsism)
  - If I think it, it does (idealism)
  - Yes (materialism)
- Do we have a shared reality?
- What really exists? (metaphysics)

SCIENCE

- Our view of science derives from Kant: reality is that which we can observe.
- Science is a systematic method of obtaining *propositional knowledge* about reality. Science can be:
  - *Natural* -- knowledge of reality
  - *Social* -- knowledge of people and their behaviors

  } Empirical sciences, based on observation

  - *Formal* or *Synthetic* -- knowledge about abstractions and artifacts — A Priori
- Religion/mysticism address knowledge about what we cannot observe.

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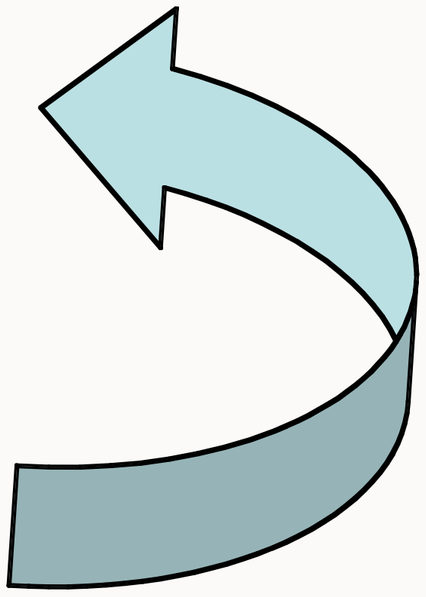
SCIENTIFIC METHOD

- "Ground"
- Hypotheses (or Theses)
- Proof or Refutation
- Presentation
- Theory formation
- Refinement



SCIENTIFIC DISCIPLINE?

- Common terminology
- Common literature
- Shared metrics
- Historical development
- Skepticism, challenge, refinement, refutation
  - *What separates science from pseudoscience and faith*

KEY CONCEPTS

No knowledge is absolute – it is only consistent with observation, experiment, and reasoning. Science does not produce absolute truth.

Every theory and "law" (model based on hypotheses) must be open to refutation!

Any theory for which there is no possible independent refutation is a matter of faith, not science.

TERMS

- *Hypotheses* are confirmed to validate
  - *Theories* which embody
    - *Models* which, with sufficient evidence and testing, derive
      - Scientific *Laws*

But none of these are *truth!* All may be refuted or else they are not science.

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GOOD THEORIES

- Testable/Observable
- Falsifiable
- Minimal/Simple (think “Occam’s Razor” or "Law of Parsimony")
- Predictive
- Explanatory
- Appropriate in scope

MORE PROPERTIES

- Testable
- Refutable
- Simple (parsimonious)
- Pertinent (applies to evidence)
- Reproducible by all others
- Consistent
- Corrigible & Correctable
- Integrative of other theories
- Observed from similar frames of reference

SIR KARL POPPER'S FALSIFIABILITY

- Confirming theories is usually simple
- Confirmation via risky predictions is better
- Refutation must be possible
- Theories that prohibit are better
- Every experiment must be a true test, and only evidence from a true test is valuable
- *Ad hoc* alterations to rescue a theory diminish its value

WHAT IS ENGINEERING?

"The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property." [ABET]

Engineering is artifacts, and science is principles

SCIENCE VS. ENGINEERING

- A scientist will create and operate an artifact to validate a theory.
- An engineer will develop a theory to better understand how to build and operate artifacts.
- A technician will operate artifacts without necessarily understanding the underlying principles or design elements.

METHODS OF CS PROOF

- Analytic (math-style proofs)
- By construction (existence proof)
- By counter-example (not universally accepted)
- By simulation (requires validated model)
- By enumeration (must show completeness)
- Stochastic (must validate metrics; not universally accepted)

Note that the artifacts used in the proof are not the hypothesis!

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GOOD CS THESIS

- Propositional hypothesis in most cases
- Grounded in accessible, existing work
- Advances the state-of-the-art
- Is clearly and succinctly stated (often "It is possible to…")
- Is independent of implementation and timeframe
- Is moderate in scope
- ***Is good science!*** *(see all the preceding)*

BROADENING YOUR HORIZONS

- Philosophy of Science: The Central Issues, edited by Curd and Cover
- The Structure of Scientific Revolutions, by Thomas Kuhn
- Gödel, Escher, Bach: An Eternal Golden Braid, by Douglas Hofstadter
- The Logic of Scientific Discovery, by Karl Popper
- Information at <http://spaf.cerias.purdue.edu/grads.html>