

Science and Ways of Knowing

How Do We Come to Know the World?

- Subjective · Our personal experience
- Objective · Our collective experience, consensus

How do we know?

How Do We Come to Know the World?

- Epistemology** · The *philosophy* of knowing
- Methodology** · An *approach* to knowing

How do we know?

Science and Common Sense

- Science often refutes common sense.
- However, both science and common sense knowing work in similar ways.

How do we know?

Common Sense and Science

Common sense: • Unless we decide not to, we usually observe inaccurately.

Science: • We consciously decide what and how to observe.

How do we know?

Common Sense and Science

Common sense: • We usually generalize from only a few cases.

Science: • We explicitly sample for generalizing.

How do we know?

Common Sense and Science

Common sense: • We observe selectively to see what we're looking for.

Science: • We consciously decide what and how to observe.

How do we know?

Common Sense and Science

Common sense: • We make things up to fill in the gaps.

Science: • We base conclusions only on the evidence.

How do we know?

Common Sense and Science

Common sense: • We believe in luck (streaks and slumps).

Science: • We have to document and back up conclusions about performance.

How do we know?

Common Sense and Science

Common sense: • We get personally and emotionally involved.

Science: • We have to respect scientific norms regardless of opinions.

How do we know?

Common Sense and Science

Common sense: • We form our views prematurely with little or no revision.

Science: • We can constantly revise views.

How do we know?

Common Sense and Science

Common sense: • Some things we just can't know; they're spiritual or mystical.

Science: • We can't rule out any area as unknowable (for example, ESP).

How do we know?

Common Sense and Science

Science is

- More *conscious* than most common sense knowing
- More *careful* than most common sense knowing

How do we know?

Contrast Between Common Sense Problem Solving and Scientific Problem Solving

- Casual versus persistent curiosity
- Casual versus systematic observation
- Casual versus systematic experimentation

How do we know?

Methods of Acquiring Knowledge

- **Tenacity**—ideas are valid knowledge because the ideas have been accepted for so long or repeated so often (similar to *tradition*)
- **Intuition**—direct access knowledge, a feeling (e.g., extrasensory perception, knowledge received directly from God)
- **Authority**—idea is valid because some respected source (e.g., religious writings, military, parents) claims it is valid
- **Rationalism**—knowledge developed through reasoning and logic (e.g. deductive syllogism) but premises must be true as determined by some other evidence
- **Empiricism**—knowledge gained through observation of real events, by experiencing through our senses.

How do we know?

A Typology of Knowledge

Ordinary knowledge—gather from day-to-day experience

wisdom—handed down from the past

skill—the knowledge of specific techniques

craft—combination of skill and wisdom

Extra-ordinary—not everyone has access

magic—knowledge about the power of an object—isolated in individuals

tradition—knowledge that is powerful because it came from the past

faith—belief in a higher power or authority

Scientific—reserved for a few; based on scientific method—
if something can't be tested, it is not science

How do we know?

What is science?

Science is

- A process of inquiry, a way of knowing
- Systematic process of asking and answering questions
- Driven by active curiosity, creativity, natural skepticism, and tolerance for ambiguity
- Serendipity is a part of science, but requires “prepared mind”

How do we know?

Process of Science (Kuhn)

Pre-science—wisdom, magic, tradition

Normal Science—theory perpetuated by a “school of scholars”, professionalization, rigidity, restriction of the scientist’s vision, resistance to paradigm change

- focused on puzzle-solving
- highly cumulative by extending the scope and precision of scientific knowledge
- not does not aim at novelties of fact or theory
- leads to a detail of information and to a precision of the observation-theory match that could be achieved no other way
- discovery commences with the awareness of anomaly

Crisis and Emergence of Scientific Theories

- discoveries are a source of deconstructive-constructive paradigm changes
- far larger shifts result from the invention of new theories
- breakdown of normal technical puzzle-solving activity
- so long as the tools a paradigm supplies continue to prove capable of solving the problems it defines, science moves fastest and penetrates most deeply through confident employment of those tools

How do we know?

Process of Science (cont’d)

Revolution

--the decision to reject one paradigm is always simultaneously the decision to accept another

--the new paradigm must be ready to take its place

--almost always the men who achieve the fundamental inventions of a new paradigm have been either very young or very new to the field whose paradigm they change

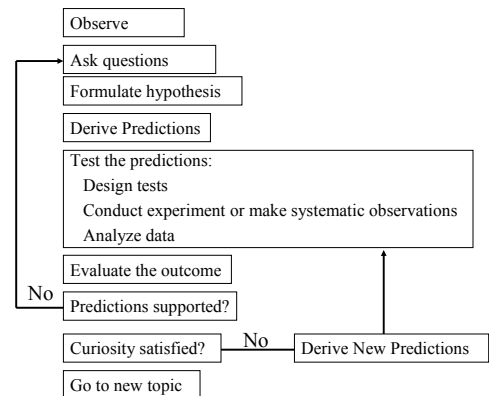
--not generally viewed as revolutions but as additions to scientific knowledge (revolutions are invisible)

New Normal Science

New crisis

How do we know?

The Scientific Method



How do we know?

Key Elements of Scientific Method

- **Driving Curiosity**—formulation of meaningful questions that are out-of-reach of common sense problem-solving
- **Systematic observation**—involving repeated, magnified examinations aimed at reducing uncertainty about cause and effect (antecedents and consequences)
- **Systematic experimentation**—testing different antecedents (causes) to see which one, or combination, produces a given consequence (effects)

How do we know?

Assumptions of Scientific Method

- world is knowable and real
- uniformity in nature
- postulate of natural kinds—everything is not different
- postulate of constancy—constant conditions exist, some phenomena change slow

How do we know?