

Unit 1: What is Science?

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Foundations of Science

- Curiosity
- Reality
- Order
- Empiricism

The Scientific Method

1. Define the question
2. Gather information and resources
3. Form hypothesis
4. Perform experiment and collect data
5. Analyze data
6. Interpret data and draw conclusions that serve as a starting point for new hypotheses
7. Publish results

Problems with the Scientific Method

- Too procedural
- There really isn't a scientific method.
 - the only principle that does not inhibit progress is: *anything goes.* --Paul Feyerabend
- Deductive (general to specific) instead of inductive (specific to general)
- Experimentation may very well be deductive, but a broad picture of the history and NOS is, IMHO, inductive.

The Four Processes of Science

From Gil Daenzer

1. Observe Nature (Facts)
2. Find Order (Laws)
3. Build Models (Theories)
4. Explain & Predict

This is a conceptual model for science, rather than a procedural one.

The Four Processes of Science

Example

1. I saw a sunrise today (Fact)
2. The sun rises in the east (Law)
3. What's the theory?

The Four Processes of Science

Example

1. Drop a rock: it falls (Fact)
2. Things fall (Law)
3. What's the theory?

Scientific Laws

- An observed regularity
 - Laws are *simple*.
- Scientific laws are descriptive, not prescriptive.
- Scientific laws are discovered, not invented.
- God makes laws, not man.

Some Scientific Laws

- Boyle's Law
- Charles' Law
- Newton's Laws of Motion
- Kepler's Laws of Planetary Motion
- Coulomb's Law
- Hubble's Law
- Ohm's Law
- Maxwell's Equations
- Snell's Law
- Biology: Mendelian Inheritance
- The Laws of Thermodynamics
- The Law of Definite Composition
- The Law of Conservation of Mass/Energy
- Buys-Ballot's law (wind travels counterclockwise around low pressure systems in the Northern Hemisphere)
- Geology: The law of stratigraphic succession

Scientific Theories

- A scientific theory is "a well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses." -- National Academy of Sciences
- Theories are the *conceptual product* of science
- God doesn't make scientific theories, we do.
- One-word synonyms: Model, framework, explanation

Scientific Theories

- Nature abhors a vacuum. So does science. A theory continues to be viewed as authoritative until (and unless) supplanted by another theory. Theories do not purport to describe "truth," but only a model of truth, always tentative – subject to modification, change or a complete discard. -- author unknown
- Science – a search for models that will (1) explain and (2) predict. Not a search for "truth." A scientific theory does not need to be true to be useful. --John W. Burgeson
- Scientists don't consider theories to be true or false in the logical or doctrinal sense that we usually use that word in everyday life.
- Think: strong or weak. Decided how?
- Imre Lakatos: Progressive or Degenerating

Scientific Theories

- Can a theory be proven?
 - Failure to reject
 - Provisional
- How do you tell if a theory is scientific?
 - Karl Popper: Falsifiability
 - Pseudoscience
- Just a Theory
 - From a student essay: "I think that it's OK to teach the theory of evolution with the notion that it is just a theory- it has not been proven."

Some Well-Known Scientific Theories

- Relativity Theory
- Atomic-Molecular Theory
- Kinetic Theory
- Quantum Theory
- String Theory
- Grand Unification Theory
- Germ Theory of Disease
- Plate Tectonics
- Evolutionary Theory
- Evolutionary Psychology
- Music Theory?

Problems with the Scientific Method: The Grade-School Scientific Certainty Myth

Wrong:	Better:
1. Hypothesis	1. Law
2. Theory	2. Theory
3. Law	3. Hypothesis
So a Law is a proven theory!	A theory is never proven.

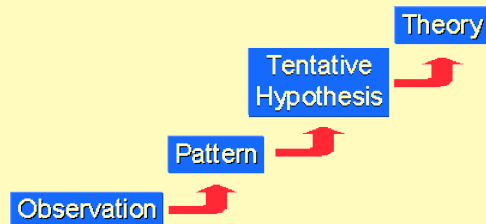
Hypothesis-Theory-Law?

I've seen a number of physics textbooks with philosophical introductions where the story of a hypothesis becoming a theory becoming a law as the evidence improves, gets repeated. The more informative usage is "law" for a well established generalization arrived at by inductive reasoning, and "theory" for the model (arrived at by inspiration or whatever) from which the laws can be predicted by deductive reasoning. Gas "laws" vs kinetic "theory" is an excellent illustration. Of course the categories don't remain clear-cut as you go further into the question, but the distinction is very good for characterizing two distinct modes in which scientists operate.

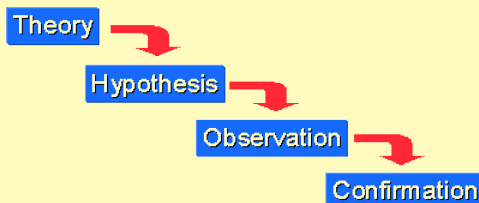
So when people say to me that evolution is a theory, I say yes! A remarkably good one too!

-Mark Sylvester

Induction and Deduction



Induction and Deduction



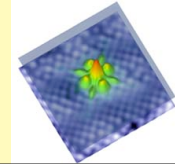
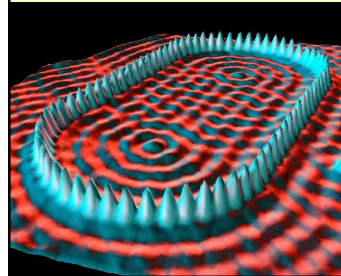
Discussion Activity

- Think of an example of some sort of everyday sequence in which an observable fact leads you to a law of some sort. Then formulate a theory that explains your law. Your law doesn't have to be scientific ("socks disappear in the dryer" would be just as good as "fire burns paper"). In fact, it might be more fun if it's humorous or relevant to everyday life.

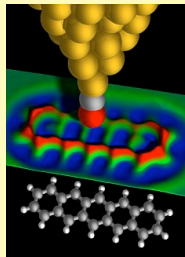
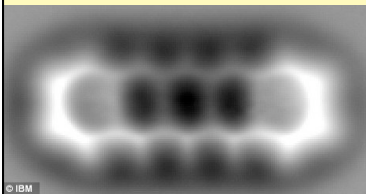
Doing Science

- Do theories ever become laws?
- Problem: All laws rely on induction. Is anything in science certain?
 - Solipsism
- Are there corresponding conceptual processes in religion?

Atomic-Molecular Theory?



Atomic-Molecular Theory?



Science and Truth

Does science find truth?

- Are facts true?
- Are laws true?
- Are theories true?

Ultimate Questions

What is it that breathes fire into the equations and makes a universe for them to govern? ...

Although science may solve the problem of how the universe began, it cannot answer the question:

Why does the universe bother to exist?

--Stephen Hawking,