Lecture 2

Definition of Science

Today

- Some history
- More modern philosophy of science
- Popper
- Discussion of Intelligent design
- Logical empiricism

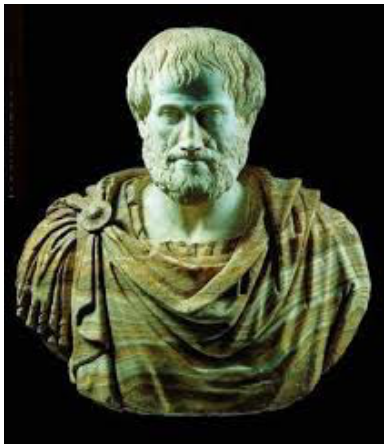
Logic and Experiments

- In the beginning science was all about logical reasoning. Scientists/philosophers tried to find theories about nature.
- What is a theory? In logic a theory is a set of axioms and all consequences following from them by deductions.
- The foremost requirement on a theory is that it is *consistent,* i.e. that no contradictions follow from it.
- But then we have the requirement that the theory should describe reality correctly. We must confront the theory with experiments. (Or must we?)

The connection between theories and observations

- We will spend some time on analyzing the positivistic theories and some questions related to them.
- Can we use observations and form a theory from them?
- Can we first form a theory and then check it against observations?

Aristotle



One of the first scientists

What Aristotle did

- He gave a description of causes in nature. There are four kinds of causes:

A. Material causes
B. Efficient causes
C. Formal causes
D. Final causes

- He gave a primitive description of physics
- He constructed the first formal logic in the form of *syllogisms.*

For Aristotle, science seems to be about classifying things.

Euclid

The creator of formal mathematics

What Euclid did

- He axiomatised geometry and established a new standard for strict reasoning
- He listed a set of undeniable truths (axiom) and showed how theorems can be deduced from the axioms in a rigorous way
- He showed how we can reach insights by just using our minds
- This set a standard for reasoning that is still an essential part of science

The scientific revolution

Galilei

Descartes

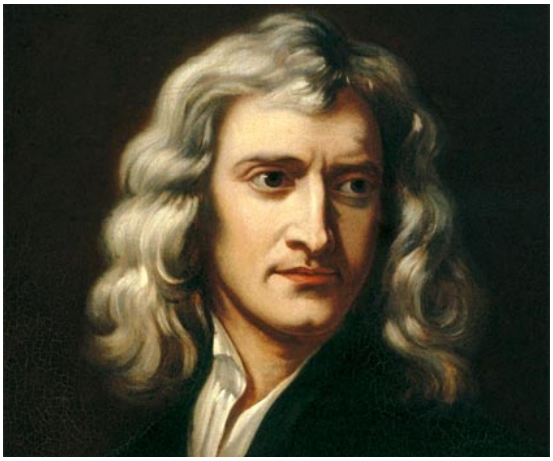
The scientific revolution

- Galileo Galilei makes experiments.
- He discovers a law for the movements of pendulums.
- Bodies with different weights fall equally fast.
- He constructs telescopes. He discovers mountains on the surface of the moon...
- ...and moons circling around Jupiter...
- ...and rings around Saturn.
- He becomes convinced by Copernicus' model.
- He gets punished by the church.

The scientific revolution II

- Descartes: ”Cogito, ergo sum" (I think, therefore I am)
- He creates a program for how research should be done.
- He presents a totally mechanistic worldview: Everything can be explained by interactions between physical bodies.
- He invents analytical geometry.

Newton



The greatest scientist ever?

Newton's mechanics

- At the age of 23 Newton formulates three mechanical laws and the law of gravitation.
- He develops the Calculus (Differential-and Integral Calculus).
- The calculus and his mechanics form the cornerstone in the first modern science.
- At the end of the 17th century Newton's mechanics is internationally recognized.
- Newton is perhaps the first really socially esteemed scientist.

Science established

- The Royal Society is established in England.
- Experiments are performed.
- Research on astronomy, gases and animals. Microscopes are used.
- Newton is at several times in conflict with the other scientists.
- Newton's optics.
- Conflict with Leibniz.

Kant

The greatest philosopher ever?

What Kant did

- He had a theory about the way we view everything around us that can ”explain” science
- He said that we have certain *categories* through which we understand what we see
- We cannot say that the world is ”really” three-dimensional but we are forced to see it that way
- We cannot tell if time really exists but we are forced to experience it
- We don’t know if causes exist but we are forced to believe that they do
- Science is built from our categories, the way we are forced to see things

- Kant thought about his theory as a ”Copernican revolution” in philosophy and science
- It does give strong support to the view that deductions are the road to knowledge (as deductions are, so to say, inside us)
- He also made very important contributions to ethics
- Many regard Kant as the most important philosopher of all times
- However, his view of science is now often seen as dated and incorrect (at least by scientists)

A modern philosophy of science

- At the end of the 19th century a new philosophy of science started to form
- It was build on an analysis of the connections between theories and observations
- What comes first: Theory or observation?
- Can we use observations and form a theory from them?
- Can we first form theory and then check it against observations?
- The new philosophy was very much about questions like this

Observations depend on theories and expectations

- ”We see what we believe”.
- Rosenthal's experiment: A group of medicine students was divided in two groups. They were supposed to make an intelligence test on mice. They are each given a set of mice.
- Group A is told that their mice are the most intelligent. Group B didn't get to know anything.
- Group A found that their mice performed better in the test than the mice in the other group.
- But A and B were given mice of the same type!
- It seems as if the expectations in group A influence the result.
- For reasons like this it is recommended that one should perform double blind tests.

Some attempts to define science

- There are other possible ways to define what is science and what is not
- How about astrology? Is it science or not?
- If you say no - why is that so?
- Perhaps it could be because astrology lacks a central theory and methodology
- Or is it because it lacks possible research programs?
- We will look at another controversial ”theory”: Intelligent design

Creationism and Intelligent Design

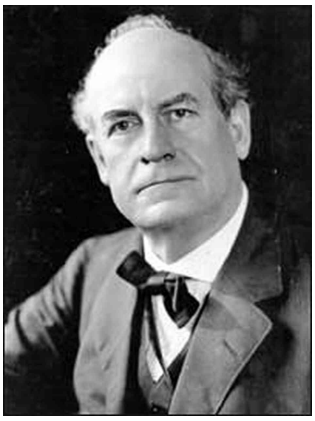
Creationism is the belief that the world and all living things in whole or in part is the result of divine intervention or supernatural means. Creationism is consistent with classical Christianity but may also allow other interpretations of semi-religious character.

Intelligent design is the notion that life on Earth is too complex to have arisen and developed exclusively by random variation and natural selection as biology's theory of evolution says. It is customary to give examples of organs that are irreducibly complex.

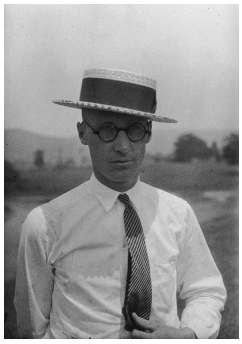
This would indicate an element of deliberate, intelligent design at various times during the evolution of life.

They forward the thesis that there are certain phenomena in the universe and among living things that can best be explained with reference to an intelligent cause, not with reference to undirected natural processes such as natural selection.

A cut out of American history



- In the 1920s, John Scopes, a schoolteacher in Tennessee, was sentenced for teaching evolution.
- The trial became famous and known as "The Monkey Trial".
- The law that prohibited the teaching of evolution was lifted only in 1967.
- Meanwhile, it is also forbidden to teach religion in the United States.



John Thomas Scopes

- 1981 the state of Arkansas enacts a law requiring schools to devote equal time to the teaching of creation-science as of evolution.
- 1982 the law was condemned as unconstitutional in a famous trial. Creation-science is deemed unscientific in a famous ruling by Judge Overton.

How to define a scientific theory

To be more specific, he used these five points to describe the difference between a scientific theory and a pseudo-scientific theory. A scientific theory must fulfill this:

- It is guided by natural law.
- It has to be explained by reference to natural law.
- It is testable against the empirical world.
- Its conclusions are tentative, i.e., are not necessarily the final word.
- It is falsifiable.

Reflections

- Is the requirement that science should refer to natural laws reasonable? Could we not, by that criterion, have to reject several well-established theories?
- Is it really true that creation-science cannot be falsified?
- A natural objection to creation-science is that it is not constructive. It just attacks the theory of evolution.

The idea of Empiricism

- Logical Positivism aka. Logical Empiricism is a philosophy of science that was particularly influential in the first half of the 20th century.
- One of the principles of LP is demands we must put on a statement S in order for it to be *meaningful.*
- Let S be any statement put in a form that indicates that it should be true or false. It is meaningful if either:
- it in principle can be proved or disproved using logical methods
- there are some observations that would confirm or disconfirm the statement
- All other statements are *meaningless.*
- It is now generally thought that this demand is too strong, but it is still a good guiding principle.

On example of a ”meaningless” statement

”Reason is substance, as well as infinite power, its own infinite material underlying all natural and spiritual life; as also the infinite form, that which sets the material in motion. Reason is the substance from which all thing derive their being”

The idea with logical positivism is to ask the question: What kind of test would we perform to see if this statement is true?

A special line of thought

One of the most influential philosophers of science in modern times was Karl Popper.

He is normally very highly regarded amongst scientist since he to a large extent thought that philosophy should be subordinated science.

He tried to find a way to characterize science. His method is called falsificationism.

Falsificationism

- The theory is first presented in *Logik der Forschung* 1934
- A theory should be *falsifiable.*
- If we have a theory T, we try to find a testable consequence K of T.
- If K turns out t be false, then T is falsified.
- Then we must reject T.
- Only theories that are falsifiable in this manner can be considered scientific.

Falsificationism II

- A theory that cannot be falsified cannot predict anything.
- A scientist should always formulate theories in a way so that they can be falsified
- and then try to falsify the theory (!)
- We can never be certain that a theory is true. We can only know that it has not been falsified this far.
- The ”bigger risks” a theory takes, the better it is.

Criticism of falsificationism

- The theory doesn't seem to agree well with how science is done in real life.
- Scientist don't always (perhaps never) try to falsify their theories.
- Well established theories have more than once been temporarily falsified.
- But what are relevant falsifications of a theory?

The HD-Method

Is there a general scientific method?

A suggestion: It could be the Hypothetico-Deductive Method. It combines deductions with observations.

It is certainly used in physics and chemistry.

In a specialized sense it is used in mathematics.

It seems as if it is used sometimes in Social Sciences.

The HD Method used for falsification

- We have a hypothesis and want to show that it is false.
- We have a set of observations E1, E2, …, En.
- Assume that there is an observation Ei such that H => not Ei.
- Then Ei falsifies H.

Observations that confirm

- We have H and E1, E2, ..., En.
- Assume that they are all rather improbable.
- Assume that we have a hypothesis A that we already believe is true and that H&A => E1&E2&…&En.
- Then the observations confirm H.

What is Truth?

- In an obvious way science is about finding truths. But what is truth? There is at least two different types of truth:
- Correspondence Truth - A statement is true if what it says is a fact existing in reality
- Coherence Truth - A statement is true if it is a part of a consistent system of statements
- The two types of truth are related to two ways of finding truths:
- Check observations of reality.
- Prove statements with logical methods.

”Subjective” truth

- Besides these two essentially objective definitions of truth there are other more subjective (but still important) ways of thinking about truth:

- Intuitive truth - Something is true if there is no way we can believe it is false (strong conviction)
- Pragmatic truth - If we cannot prove that something is true or false we can choose to believe it is true if that choice has good consequences for us