Lecture 4

Explanations and Causes

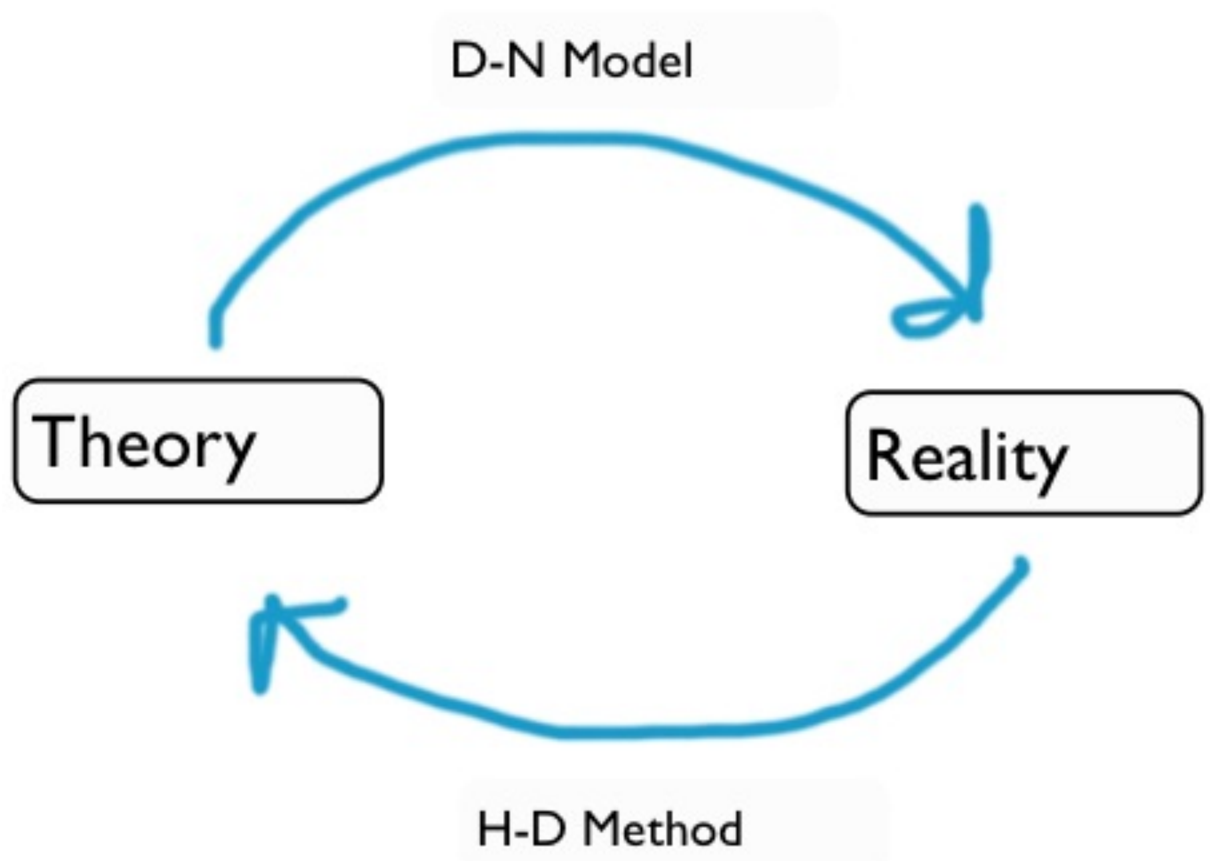
Why science?

- It seems as if science has have two functions:
- Science can make predictions.
- Science can give explanations.
- The first function is of great practical importance.
- But the second function was historically the first.
- And is maybe the most fundamental one.

Theory of science as a scientific theory

- Hempel and his colleagues tried to create a theory of how science should be done.
- This theory has its own logic and formal rules.
- It is a sort of science in its own way.
- It describes the connection between theories and observations.
- One component is the HD Method.
- Another is the so called DN Model that is about causes and explanations.

Connections between the H-D Method and the D-N Model



The somewhat ambiguous concept "cause"

As a short preamble we will discuss Global Heating.

- A huge majority of scientist agree that Global Heating (GH) is *caused* by human-related release of carbon dioxide (RC). How is this to be interpreted?
- It could be interpreted as RC => GH
(where the implication is taken in some informal sense).
- It could be interpreted as not RC => not GH (which means GH => RC).
- It could be interpreted to mean both things: RC <=> GH. Probably (?) this is what is meant.

Two types of causes

If we have to statements A and B they can be casually connected in two ways:

- Sufficient cause. A is a sufficient cause of B if A => B.
- Necessary cause. A is a necessary cause of B if not A => not B (B => A).
- We will later argue that sufficient cause is what we normally mean by cause.

The two main topics today

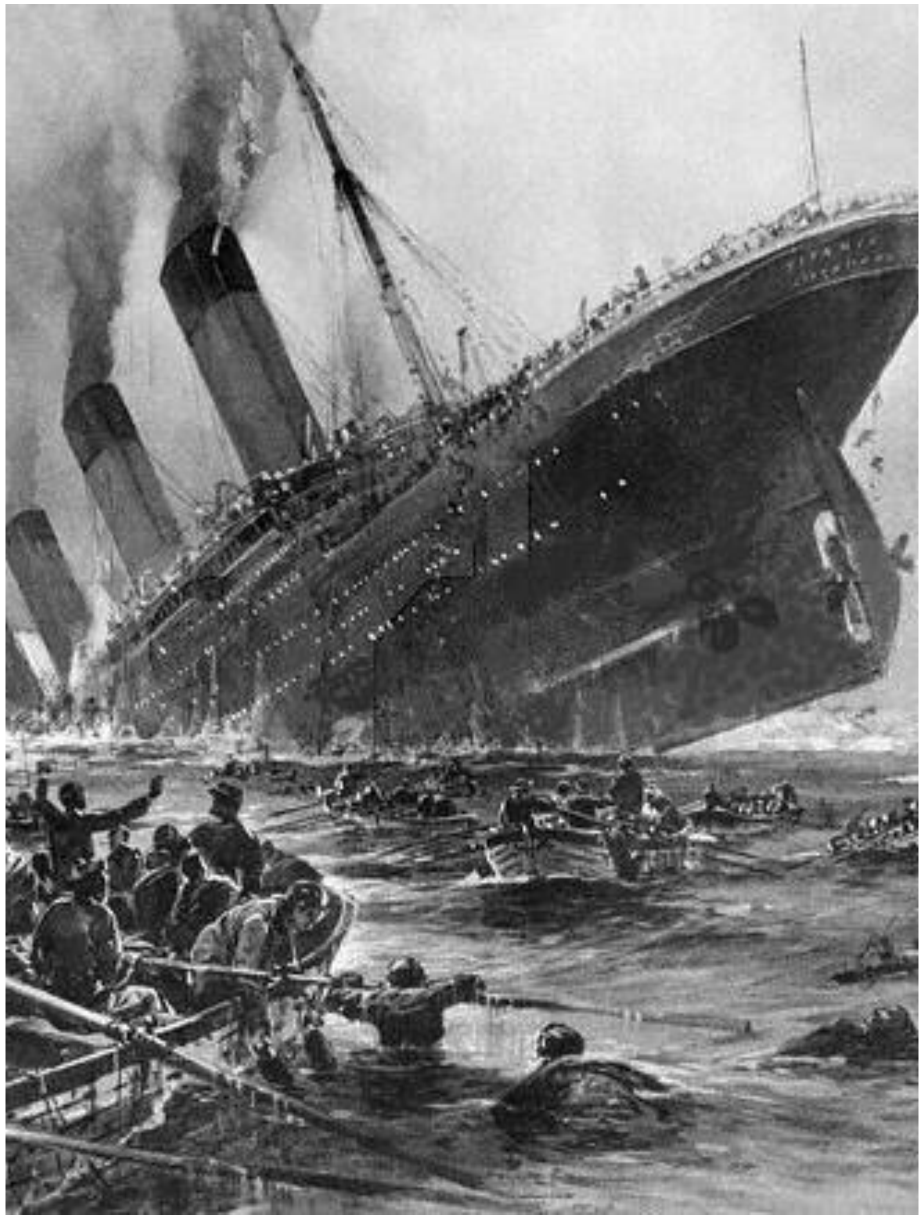
We will discuss

- Scientific explanations.
- Causes described scientifically.

We will look at things from a *philosophical* perspective. This means that sometimes we will see that things we thought were simple to maybe are not so uncomplicated after all.

Why did Titanic sink?

- There are some obvious explanations.
- What about *scientific* explanations?



What is an explanation?

First some examples:

- Kepler's elliptical planet orbits explained observed astronomical data.
- Newton's mechanics explained the elliptical planet orbits.
- Bacteria explained Semmelweis's observations.
- Quantum Mechanics explained the behavior of electrons.

Everyday explanations

- The most common type of explanation occurs when we ask why a person does something. What is his or hers motive?
- In an evolutionary way it is perhaps the primal type of explanation. We can call it an *anthropological* explanation.
- In ancient times we tried to understand Nature in anthropological terms.
- But these explanations have gradually been replaced with other types of explanations.

When do we accept an explanation?

We can say the following:

- An explanation is some form of insight.
- We feel that we have been given an explanation when "we see the whole picture".
- We feel that something is explained when we don't have to ask any more questions.

Can all this be expressed in a scientific way?

Four types of explanations

Let us assume that P calls for an explanation. Here are some ways of doing it:

- Causal explanation: If something causes P, the it also explains P.
- Functional explanation: P has some good function and this fact explains P.
- Explanation by purpose: There is some mind that has wanted P.
- Pragmatic explanation: The explanation is adapted to the type of answer the questioner wants.

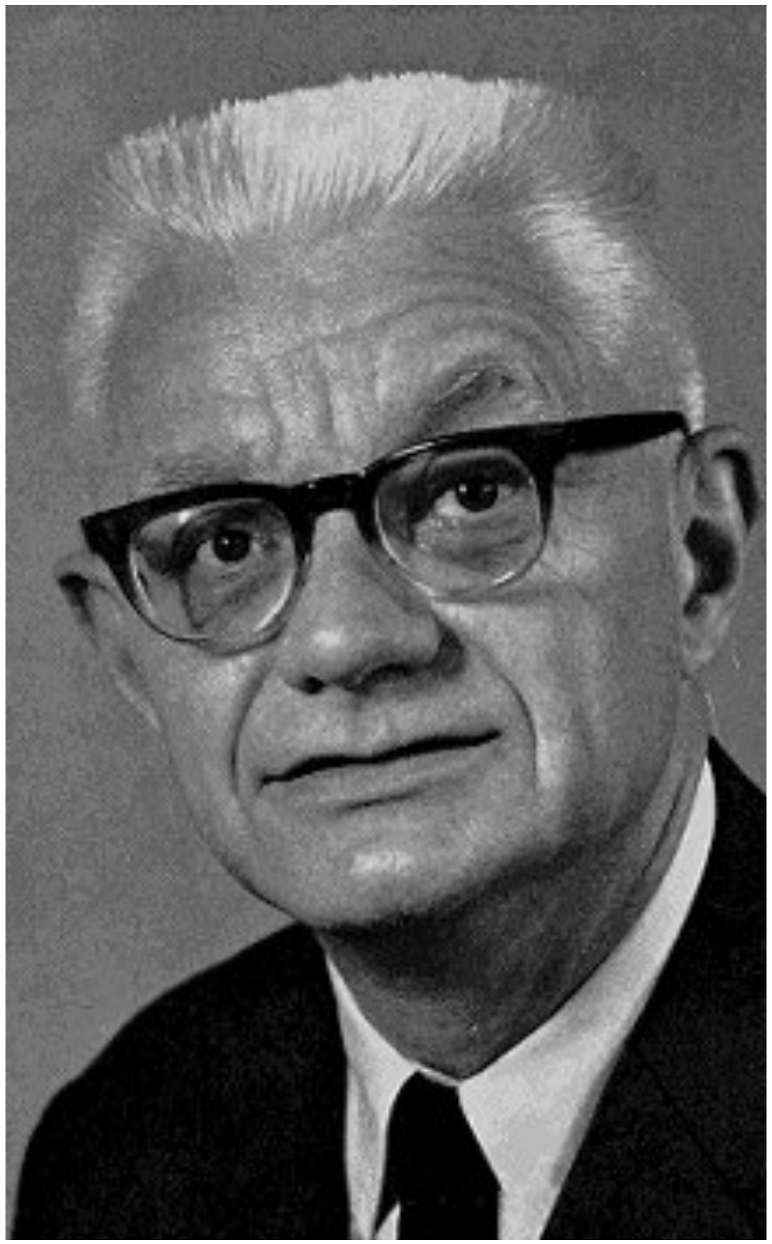
When are the different types of explanation used?

- Physics: Uses explanation by cause.
- Biology: Explanation by cause and by function.
- Social Science: Possibly all types of explanation.
- Mathematics and Computer Science: Mostly explanation by cause and logical explanation (which maybe can be considered a special type of explanation by cause). There could also be functional explanations and explanations by purpose.

Causal explanation

- Is considered the fundamental scientific explanation
- But there are different ideas of what form such an explanation should have.
- The most famous idea was proposed by Carl Hempel: The Deductive - Nomological Model. (D-N Model).
- Nomological means that the model refers to a scientific law.

The D-N Model



Carl Hempel

We have a fact P in a situation S. In the D-N model this fact is explained in the following way:

1. A general scientific law L. (I => P)
2. An initial condition that applies in S.

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3. Conclusion: P

A special form

A special form of the D-N model is the following:

1. General scientific law: In all situations of type A we have that B is true.
2. The situation S is of type A.

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3. Conclusion: B is true in S.

We have in this way got an explanation why B is true in S.

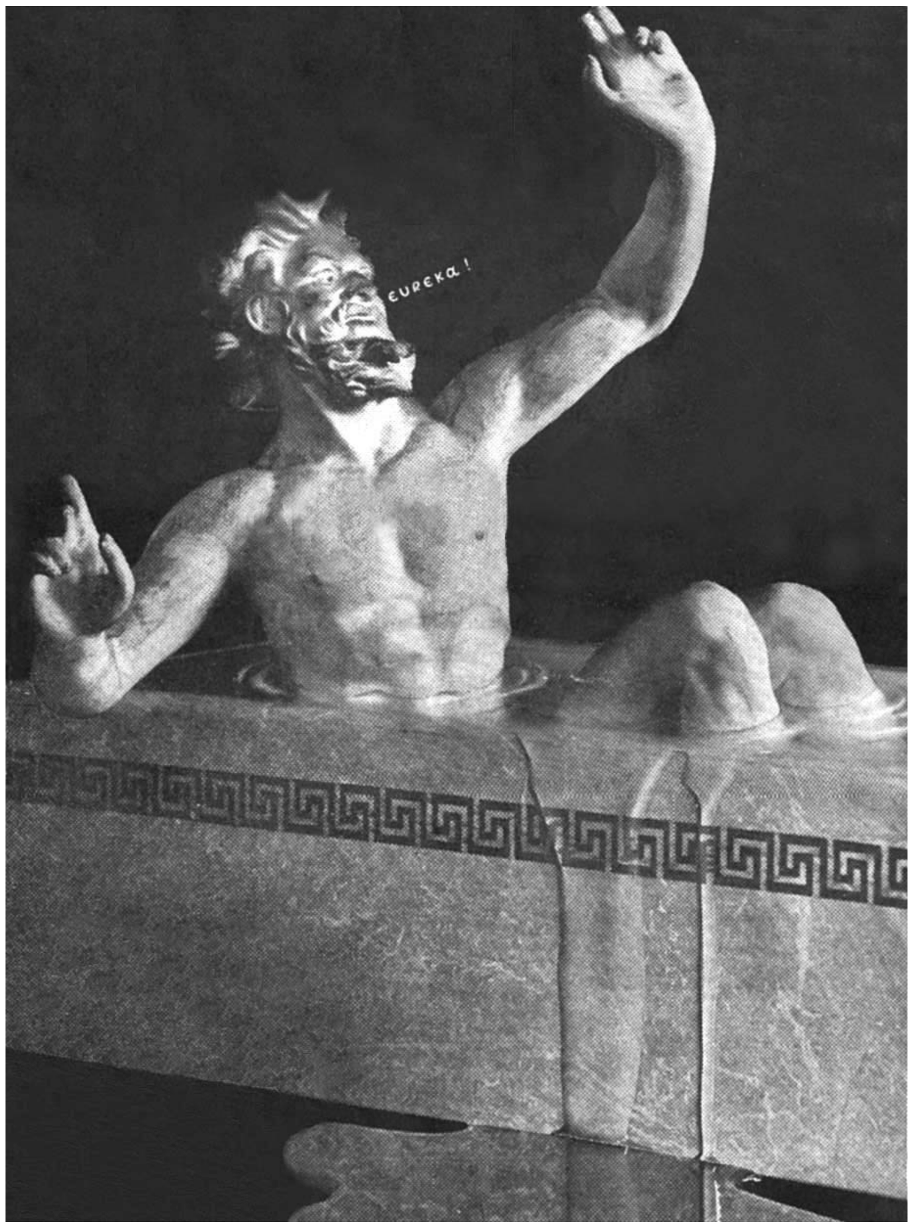
Hempel's statement

- Hempel said that all scientific explanations have the form indicated in the D-N model.
- The most important part of an explanation is that we have a general law that we "know" is true.
- The conclusion must follow by a *logical deduction* from the law L and the initial condition I.
- The conclusion P must be such that it can be empirically verified (observed).
- The initial condition I can be said to be *the cause* of P.

Example

- Semmelweis wondered why so many patients died in maternity ward no.1.
- Following the D-N model we should say that bacteria caused their deaths.
- The scientific law is the fact that bacteria spread diseases.

A simple example



Archimedes

- Let L be Archimedes' law: If a body has smaller density than that of water, it floats.
- Let P be "this piece of wood floats".
- Let I be "This piece of wood has lower density than that of water".
- Then I is an explanation of P.

Why do we need laws?

- Of course, there are "explanations" without reference to laws.
- If I say that I arrived late because there was a stop in the subway I have given an explanation, but not a *scientific* explanation.
- The principle is that for an explanation to be scientific it must refer to scientific laws.

Hempel's principle of symmetry

- There is an interesting symmetry between explanations and predictions.
- Let us assume that we have the statement: "In situation S we have a fact P".
- Then assume that P can be explained by a law L and an initial condition that applies to the situation S.
- But then we can make the prediction that in a situation S where I applies P will occur as a fact.
- And if we can scientifically predict that P will occur in a situation where I applies, we have explained P.
- So, once more: If a theory can explain facts then it also predicts facts and vice versa.

Problems with the D-N Model

- Even if we think that the D-N model is sound and important, we should be aware that there are some problems with it.
- In a sense it could be too *strong.* It can exclude something as a cause even if it really should be considered a cause.
- And in another sense it could be too *weak.* It can classify something as a cause even if should not.
- The D-N model is a high-level method for determining causes. It can sometimes need to be complemented by low-level methods.

Too strong

- We know that Titanic sank because it collided with an iceberg.
- That would be a scientific explanation(?)
- But then, what exactly is the scientific law?
- Perhaps we could state an appropriate scientific law(?)

Too weak

- This is another classic example: There is a flagpole outside the City Hall in Missoula, Montana.
- On this particular day the sun shines so that the sun-rays hit the flagpole at an angle of 37 degrees.
- The shadow is 20 meters long.
- This is the scientific explanation for the fact that the flagpole is 15 meters high!
- Or ... isn't the hight the explanation for the length of the shadow?
- The D-N model cannot decide this question!

What are causes?

- So it seems that sometimes the D-N model can indicate something as a cause even if it really isn't.
- But then, what is a cause? It is hard to define even if we feel that we understand it intuitively.
- Let us look at another example:

And it is a tragic example

- We get to know that a man A is dead. Why did he die?
- We then hear that two months ago he visited his doctor who told him that he had an lethal disease and just had one month left to live. That would be a scientific explanation why he doesn't live anymore.
- But then we are told that the day after his visit to the doctor he was run over by a tram and died.
- The later explanation is obviously the right one(?)

A closer analysis of causes

- A more detailed analysis of what causes are can run like this:
- Assume that we have an implication A => B.
- If we are looking for an explanation of B, we have to describe both A and the implication. The implication should be given by a general law.
- If we are looking for a cause of B we can often be a little more informal about the implication. (It is more philosophy than science.)

A closer analysis of causes II

- We have already talked about necessary and sufficient causes. We will focus on sufficient causes.
- Let us assume that E1&E2&E3&...&Ek => F.
- Let us also assume that the implication is no longer true if any of the Ei:s are excluded.
- We then say that each one of the Ei:s is a cause of F.
- But if we want to chose just one cause?
- We can chose the one that is most unlikely to occur.

A house on fire!

- Let F be the fact that a house has burnt down. What is the cause? We find three facts:
- E1 - The walls in the house were filled with an isolation material that was quite likely to catch fire.
- E2 - The electrical cables in the walls had very bad isolations.
- E3 - The owner turned on the light switch.
- We can then see that E1&E2&E3 => F.
- But is there a cause more relevant than the others? - Maybe E2.

Another way of viewing causes: Temporal connections

- If A is a cause of B, then A should be a *predecessor* of B.
- The simplest way of describing this is that A immediately precedes B in time and there is something in A that makes B occur.
- We can also try to find a chain of simpler causes that connect A to B.
- In physics there are attempts to define such chains by describing transference of energy between bodies.

Another way: Statistical correlations

- We can use probability to decide if A is a possible cause of B.
- If $P(A\&B) > P(A)P(B)$ we say that A and B are (positively) correlated. Then A could be a cause of B.
- The condition is equivalent to $P(B|A)>P(B)$.
- The condition is symmetric in A and B: If A is a possible cause of B, then B is a possible cause of A.
- "Which came first? The hen or the egg."

Reichenbach's principle

This principle says that:

- If A and B are uncorrelated ($P(A\&B) = P(A)P(B)$) no one is the cause of the other.

- If they are positively correlated then either

1. A is the cause of B
2. or B is the cause of A
3. or there is a third factor C that is the cause of both A and B.

Examples of Reichenbach's principle

- An investigation of a school class shows that there is a positive correlation between the children's shoe sizes (A) and how well they perform on tests (B).
- Is A the cause of B or vice versa?
- No, there is a third fact, their age (C), that is a cause of both A and B.

- If Another study shows that there is a positive correlation between someone being a teetotaler (A) and having a very bad liver (B).
- Here B is probably a cause of A.
- Or we could assume that the person has once been an alcoholic (C). Then C is a cause of both A and B.

Other types of explanations

The previous slides have been about causal explanations. We will now briefly review some other types of explanations:

- Explanations with unifying theories.
- Explanations by reduction.
- Functional explanations.
- Explanations by purpose.
- Pragmatic explanations.

Explanations with unifying theories

- The D-N model looks at statements, observations and laws *in isolation.* Another way of viewing explanations is that the statements and laws should be seen in relation to other observations.
- A unifying theory is a theory that explains a lot of observations (almost everything).
- The ideal would be to explain an event P by such a theory.
- Possible examples are Newton's mechanics and Darwin's theory of evolution.

Explanations by reduction

- An attractive way of explaining observations is to reduce them to a basic theory and restate them in the language of the theory.
- A classic example is the attempt to explain *everything* by a reduction to a model of the universe consisting of colliding particles. The model is not longer really relevant, though.
- Another example is the reductions of thoughts and feeling to chemical reactions in the brain.
- And maybe everything can be reduced to Quantum Mechanics? So the only thing we have to learn is QM?!
- We can see that there must be limits for the practical uses of reductions.

Functional explanations

- We want to explain why condition P occurs. We do it by noticing that P has a (good) function.
- Why do we have eyes? So that we can see!
- In biology The Theory of Evolution gives a justification for this way of thinking.
- In Social Science there are perhaps some justifications to. (What about Social Darwinism?)
- A good function doesn't need to be willed by anyone to occur. This is a cornerstone of Darwinism.

Pragmatic explanations

- According to this view, explanations are not that important in science. The important thing is deductions and so on.

- What we mean by an explanation depends on the context.

- What type of answer do you want?

Contrast classes

We look at an example: In Shakespeare's play Hamlet, prince Hamlet kills Polonius. (One of his few physical actions.)

We might ask: "Why does Hamlet kill Polonius?"

Contrast classes II

This question can be read in at least three different ways:

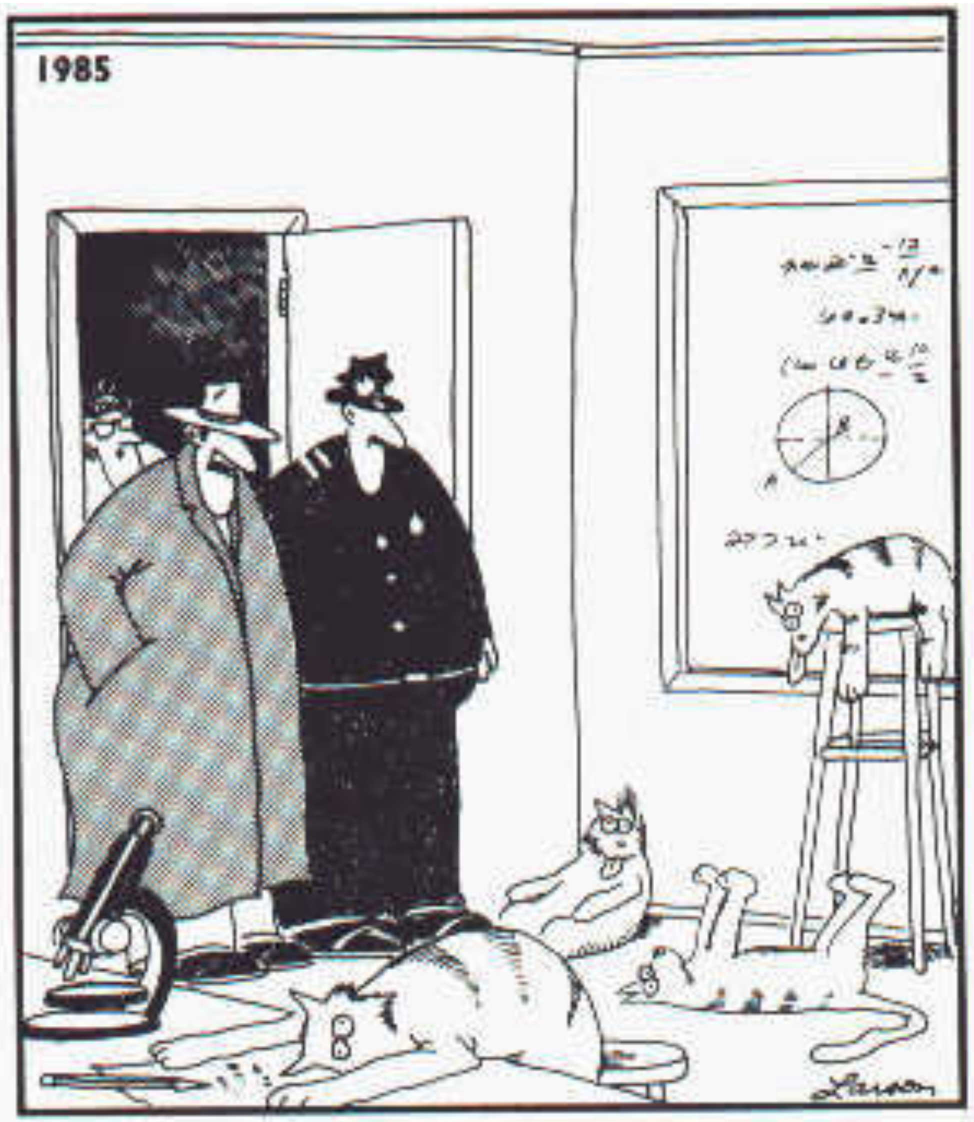
1. Why does *Hamlet* kill Polonius?
2. Why does Hamlet *kill* Polonius?
3. Why does Hamlet kill *Polonius*?

To each reading there is a contrast class that indicate what the alternatives are:

5. {Hamlet, Gertrud, Ofelia, The director, ...}
6. {Kill, Confuse, Kiss, Sue, ...}
7. {Horatio, Rosencrantz, Gyldenstiern, The critic, ...}

An explanation tries to explain why a particular alternative from the relevant contrast class is the one occurring. An explanation must be adapted to the exact form of the question.

Conclusion



"Notice all the computations, theoretical scribblings, and lab equipment, Norm. ... Yes, curiosity killed these cats."

- According to most views explanation is a central concept in science.
- Explanations provides a connection between theory and observations.
- If we want a theory of explanation that focus on deduction and scientific laws, the D-N model seem to be the best alternative.
- But it needs to be complemented with some common sense.

Two other views of science

Kuhn

Feyerabend

Thomas Kuhn

Thomas Kuhn 1922-1996

- American. Doctor in physics at Harvard.
- Became more and more interested in the history and philosophy of science.
- In 1962 he published ”The Structure of Scientific Revolutions”. This is probably the most influential book on the philosophy of science ever published.
- The book introduced the phrase *paradigm shift.*

Kuhn's philosophy

- A paradigm consists of terms, methods, norms and ways of viewing thing. It defines our way of understanding the world (or at least a part of it).
- *Normal science* is science as it is done within the paradigm.
- In *revolutionary science* we reject the old paradigm and replaces it with a new one.

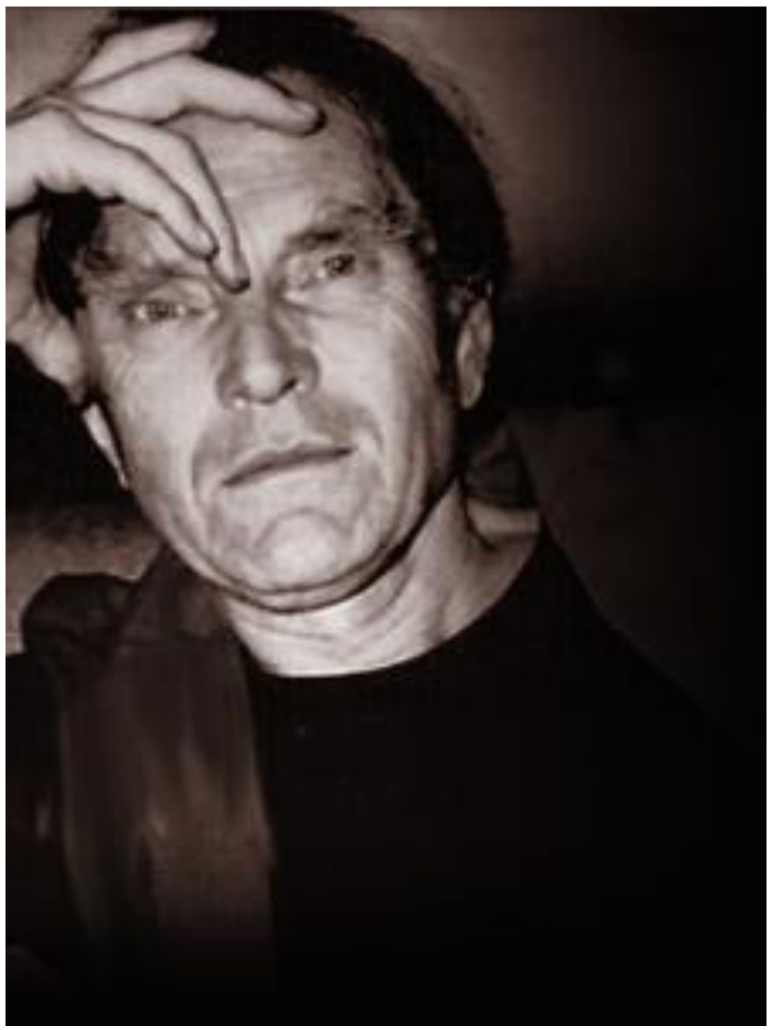
More details

- In normal science we don't put the paradigm on trial. All problems are handled within the paradigm.
- Within the paradigm we are doing ”puzzle-solving”. It is characteristic of real science that there is an established program for such problem solving.
- When a *crisis* occurs, it can lead to a paradigm shift.
- Such a shift is often done for *irrational* reasons.
- Two paradigms are *incommensurable* with each other.

Problems with Kuhn's philosophy

- Is it a recommendation for how science should be done?
- Yes, in a way. The philosophy focuses on the importance of stability in normal science.
- We would like to think that a paradigm shift always leads to a *better* paradigm. How can we tell if this is actually the case?
- Kuhn doesn't provide a clear answer to this question.

Paul Feyerabend



Anything goes!!

There is no scientific method!