

# Lecture 4

Explanations and Causes

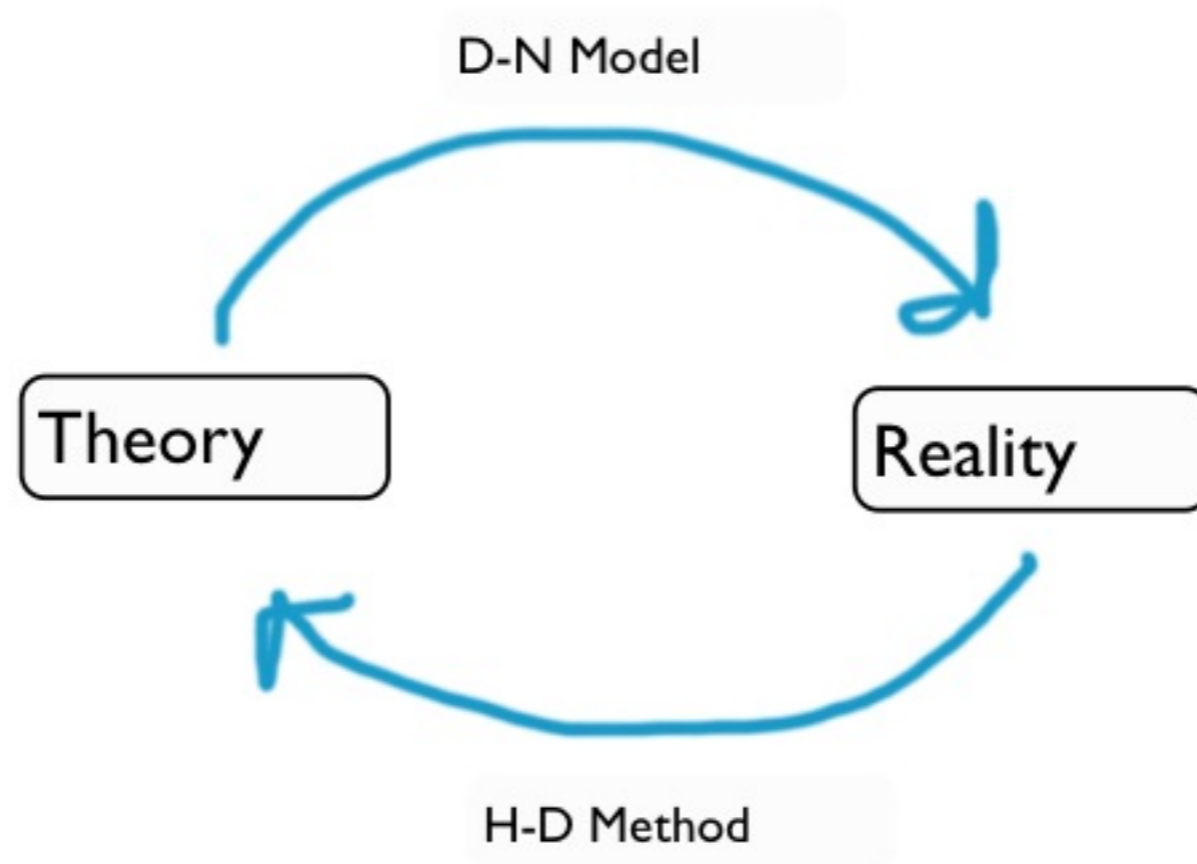
# Why science?

- It seems as if science has 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 Warming.

- A huge majority of scientist agree that Global Warming (GW) is *caused* by human-related release of carbon dioxide (CDR). How is this to be interpreted?
- It could be interpreted as  $CDR \Rightarrow GW$  (where the implication is taken in some informal sense).
- It could be interpreted as  $\text{not } CDR \Rightarrow \text{not } GW$  (which means  $GW \Rightarrow CDR$ ).
- It could be interpreted to mean both things:  $CDR \Leftrightarrow GW$ . Probably (?) this is what is meant.

# Two types of causes

If we have two statements  $A$  and  $B$  they can be causally connected in two ways:

- Sufficient cause.  $A$  is a sufficient cause of  $B$  if  $A \Rightarrow B$ .
- Necessary cause.  $A$  is a necessary cause of  $B$  if  $\text{not } A \Rightarrow \text{not } B$  ( $B \Rightarrow A$ ).
- We will later argue that sufficient cause is what we normally mean by cause.

# The two main topics today

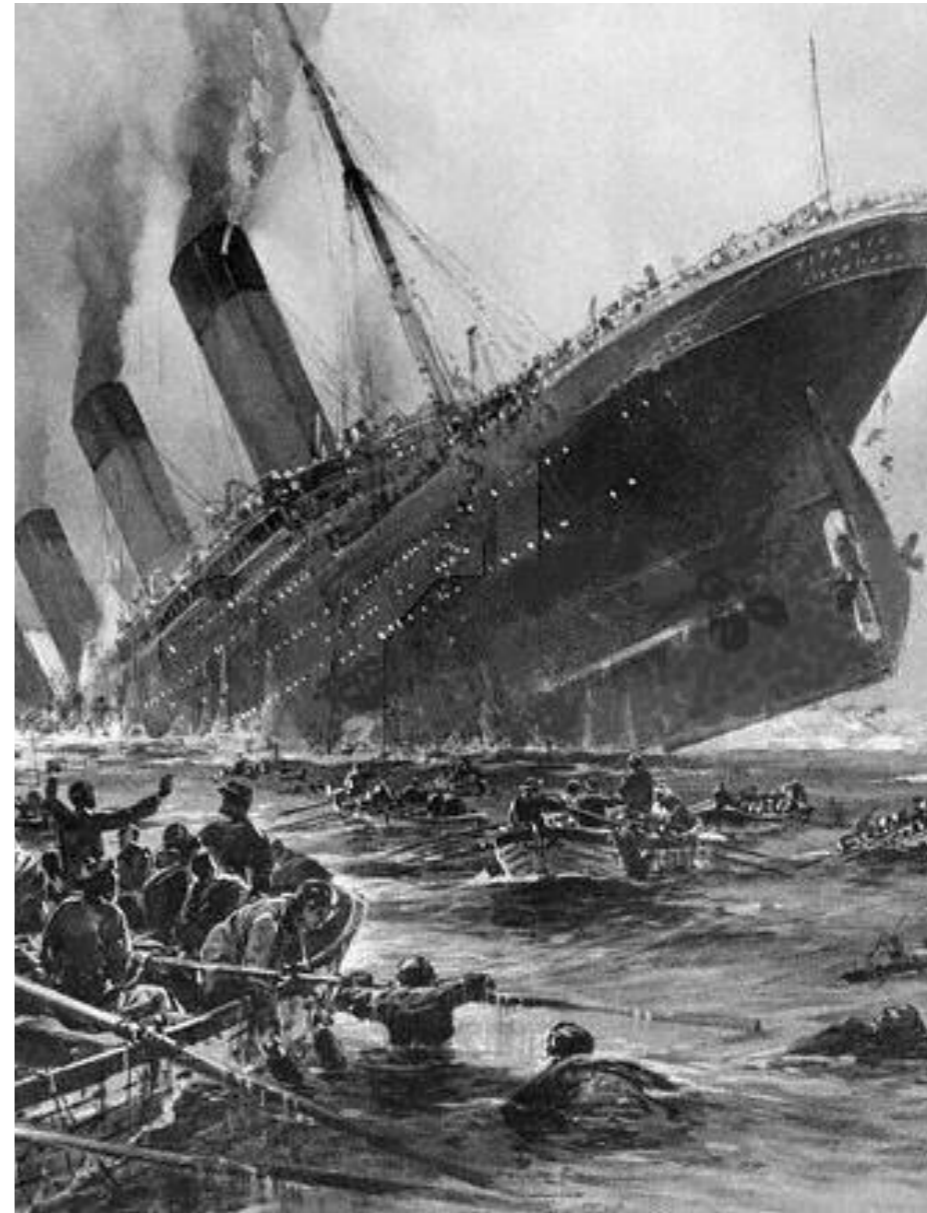
We will discuss

- 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 maybe are not so uncomplicated after all.

# Why did the 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 her 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  $P$ , 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.

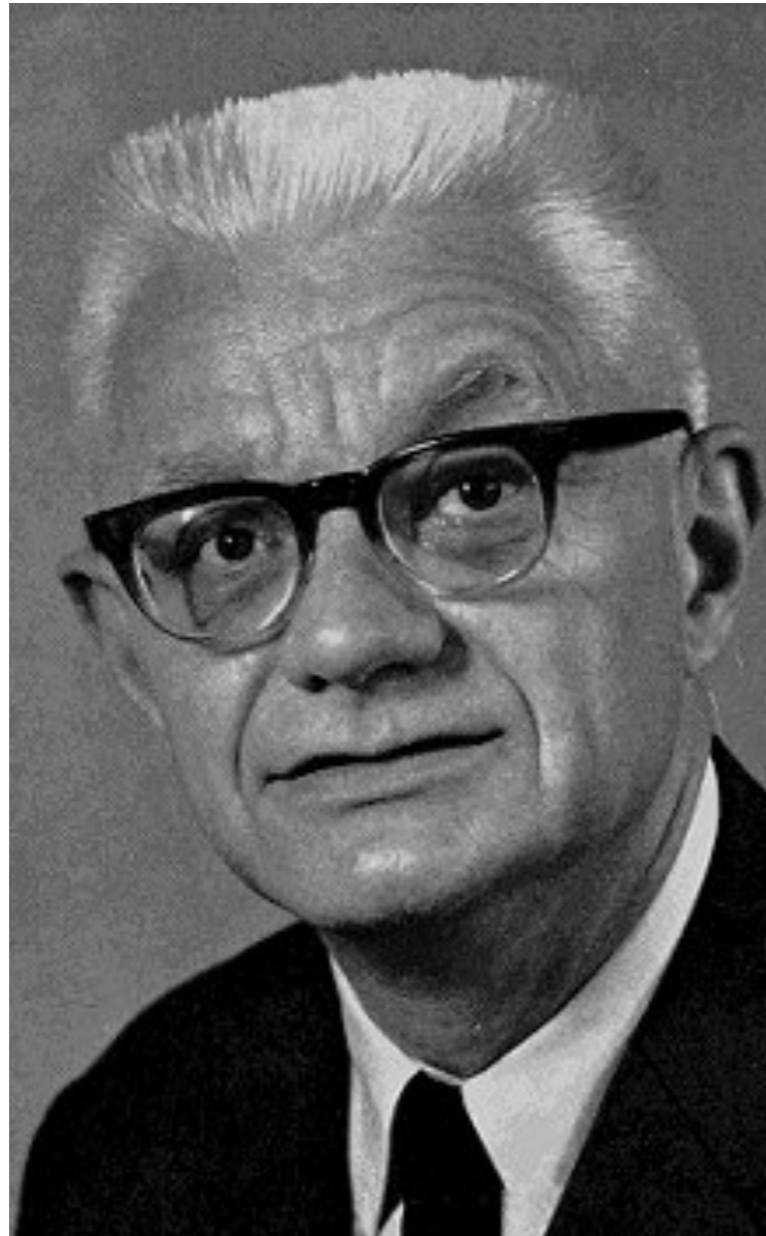
# When are the different types of explanation used?

- 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  $L$ .  
( $I \Rightarrow P$ )
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 of why B is true in S.



# Hempel's statement

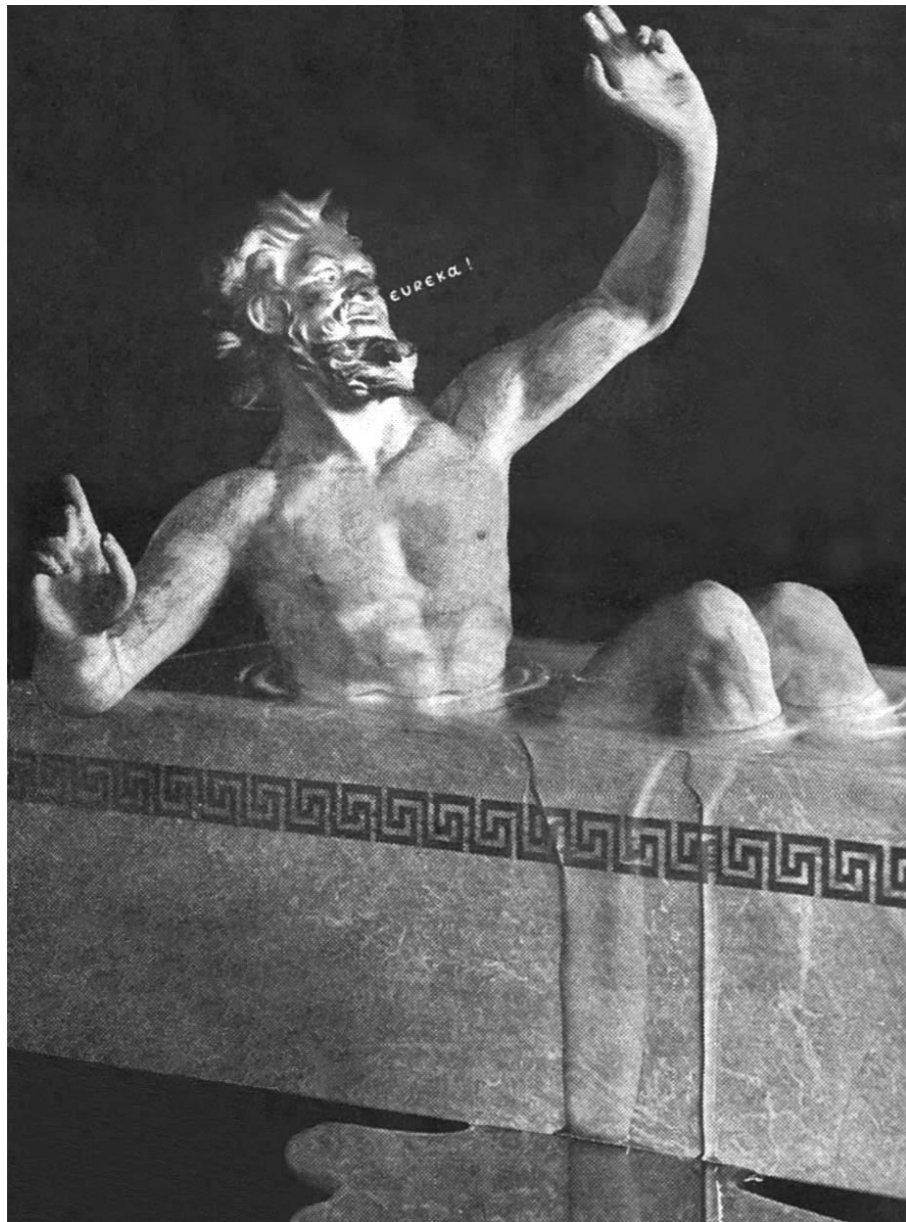
- Hempel said that all scientific explanations have the form indicated in the D-N model.
- The most important part of an explanation is that we have a general law that we "know" is true.
- The conclusion must follow by a *logical deduction* from the law L and the initial condition I.
- The conclusion 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 causes disease.

# A simple example



Archimedes

- Let  $L$  be Archimedes' law:  
If a body has lower 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 this really should be considered a cause.
- And in another sense it could be too *weak*. It can classify something as a cause even if it should not.
- The D-N model is a high-level method for determining causes. It sometimes needs 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 height 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 a lethal disease and just had one month left to live. That would be a scientific explanation of why he is no longer alive.
- But then we are told that the day after his visit to the doctor he was run over by a tram and died.
- The latter 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  $A \Rightarrow B$ .
- 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  $E_1 \& E_2 \& E_3 \& \dots \& E_k \Rightarrow F$ .
- Let us also assume that the implication is no longer true if any of the  $E_i$ :s are excluded.
- We then say that each one of the  $E_i$ :s is a cause of  $F$ .
- But if we want to choose just one cause?
- We can choose 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 isolation.
- $E3$  - The owner turned on the light switch.
- We can then see that  $E1 \& E2 \& E3 \Rightarrow F$ .
- 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.
  
- 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.

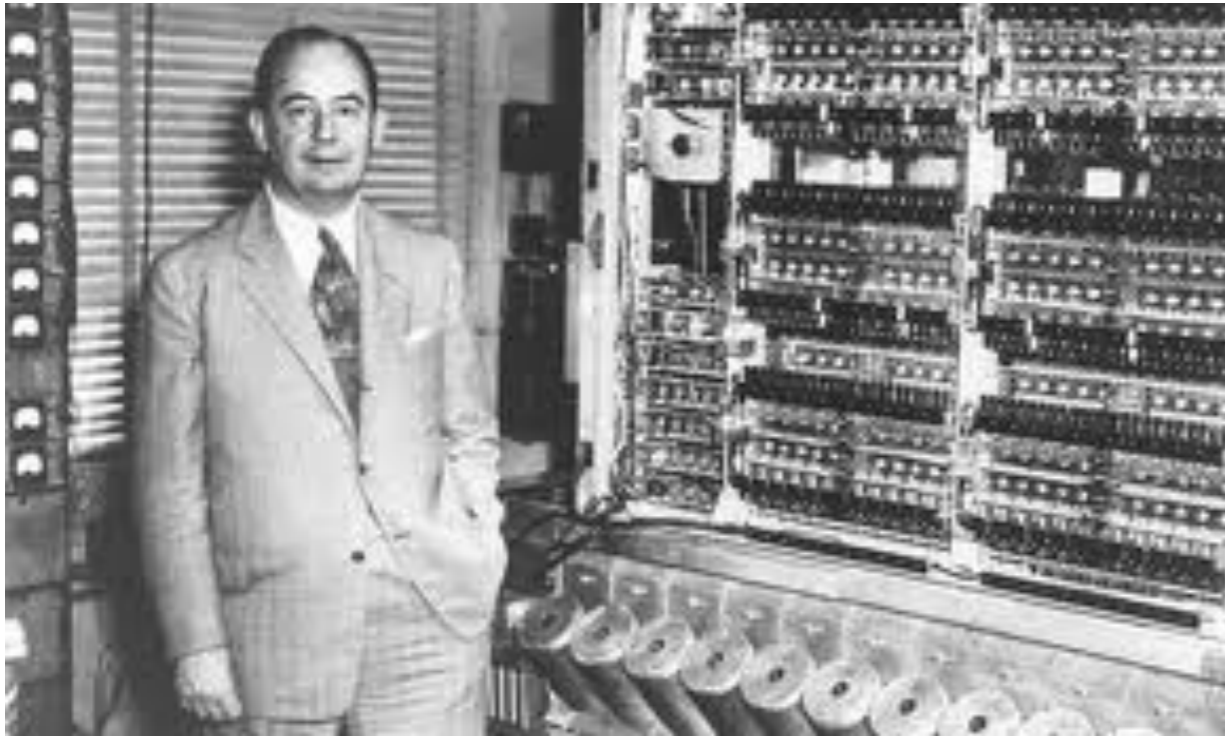
# Explanations by reduction

- 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.

# Explanations by purpose



von Neumann

- Explanation by purpose is a model for explaining human behavior.
- A special model of explanation used in social sciences is *rationality*.
- In this context rationality means that each person acts in order to maximize his or hers *utility*. This model is used in *Game Theory*.

# 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 indicates what the alternatives are:

{Hamlet, Gertrud, Ofelia, The director, ...}

{Kill, Confuse, Kiss, Sue, ...}

{Horatio, Rosencrantz, Guildenstern, 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



- According to most views explanation is a central concept in science.
- Explanations provide a connection between theory and observations.
- If we want a theory of explanation that focuses on deduction and scientific laws, the D-N model seems 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 of 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 things. 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 replace 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!