Models of Explanation

Hempel

Kitcher

Van Fraassen

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Two main conceptions

- Epistemic conceptions (Hempel, Kitcher)
  - Explanations are arguments that show that the fact to be explained has to be expected, predicted
- Ontic conceptions (Hillel-Ruben, Salmon, Railton, Woodward)
  - Explanations are not arguments; they identify the (causal) mechanics (or the like)
- Pragmatic conceptions (van Fraassen)
  - there are lots of different types of explanation

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Motivations for finding a good theory of explanation

- Intuitively: One of the things science is supposed to do is provide *explanations* of the way the world works.
  - But it is not entirely obvious what we *mean* by 'explanation'.
  - If we don't know what we mean by 'explanation', then
    - we don't know what we want from science;
    - we can't coherently discuss why (or whether) such explanation-seeking is a *valuable* activity.

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Motivations for finding a good theory of explanation

- One of the ways we justify beliefs seems to be via 'inference to the best explanation'.
  - Examples:
    - Newtonians criticized Aristotelian "natural tendencies" for (allegedly) not being *explanatory*.
    - Those who support the theory of evolution over creation-science often argue that creation-science *doesn't explain anything* (or: doesn't provide *good* explanations), and that therefore there's no (or: not enough) reason to believe it.
- If we don't know what an explanation is at all, then we can't know what makes an explanation a good one, so we can't know how to adjudicate disputes like these.

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Motivations for finding a good theory of explanation

- Pierre Duhem, Ernst Mach and others:
  - Science does not explain
  - To explain = to strip bare
  - If science is intended as explanatory then it is hopelessly subordinate to metaphysics (and this is BAD):
    - Metaphysical claims cannot be confirmed or refuted
    - Postulate unobservable entities whose existence cannot be tested

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Motivations for finding a good theory of explanation

- Rudolf Carnap and Hans Reichenbach:
- science does explain
  - (only if theories involve testable laws)
- Against Hans Driesch's entelechies:
  - Vital, non material, force possessed by every living organism responsible for:
    - Maintaining the organs' integrity
    - Directing the organ's development
    - Regenerating lost parts

- Carnap and Reichenbach: entelechies do not explain anything

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Motivations for finding a good theory of explanation

- Carnap and Reichenbach:
  - entelechies do not explain anything
- Driesch's response:
  - It's just like when physicists postulate the existence of the magnetic fields to explain the behaviour of certain materials:
    - Observable only indirectly
- Carnap's reply:
  - Physicists postulated the (unobservable) magnetic field, AND empirical laws that it has to obey
  - These laws can be used to make predictions, which can be tested
  - In contrast, entelechies lack predictive power

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The 'covering law' model of explanation

- → explanation must involve at least one empirical law
- The best-known systematic attempt to say what an 'explanation' is along these lines is Hempel's 'covering-law' model

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The covering law model of explanation

- According to the covering law model, there are two types of explanation for facts:
  - deductive-nomological (D-N) - 1948
  - inductive-statistical (I-S) - 1962
  - (explanations of special laws in terms of general laws: see later)

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The D-N (deductive-nomological) model

- The deductive-nomological (DN) model
  - Basic idea: to explain S is to deduce S, by a valid argument, from the relevant laws + background facts.
  - 'DN':
    - *deductive* because a DN explanation is a deductively valid argument
    - *nomological* because 'nomological' means 'pertaining to laws,' and a DN explanation has one or more laws of nature among its premises

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The D-N (deductive-nomological) model

$C_1, C_2, \ldots, C_k$ particular facts and initial conditions

$L_1, L_2, \ldots, L_k$ general law

Explanans

E fact to be explained (**Explanandum**)

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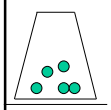
The D-N (deductive-nomological) model

- An example of an explanation:
  - Q: "Why did soap bubbles ooze out from under the tumbler?"
  - A: "When the tumbler was placed **upside-down** on the plate, the air inside the tumbler was trapped there. And the tumbler had just **come out of hot water**, so it was hotter than the air. So the trapped air started to **heat up**. And if you heat up some air at constant volume, its **pressure increases**. So the air pressure inside the tumbler got to be higher than the air pressure outside the tumbler. Also, there was a **layer of soapy water** on the plate, so, there was a small gap between the tumbler and the plate, spanned by a soapy film. And if you have a film like that with higher pressure on one side than the other, the film will **bulge outwards towards the low-pressure side**. That's what **created the bubbles**."



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The D-N (deductive-nomological) model

- Hempel's observations:
  - This looks a lot like an *argument*.
  - The explanation involves an appeal to laws – e.g. the law that if air is heated at constant volume, its pressure increases – and that appeal to laws seems to be an essential part of what makes the story an *explanation*.
  - Hempel's project is to use observations like these to build a general theory of what explanation *is*.

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The D-N (deductive-nomological) model

- In our example:
  - **Particular facts**:
    - F1: The tumbler was placed upside-down on the plate, trapping air (i.e. forcing the air inside to stay at constant volume).
    - F2: The tumbler had just come out of hot water that was at higher temperature than the air.
    - F3: There was a layer of soapy water on the plate.

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The D-N (deductive-nomological) model

- In our example:
  - **Laws:**
    - L1: If air is placed in contact with an object at higher temperature than the air, the air will heat up.
    - L2: If you heat up some air at constant volume, its pressure increases.
    - L3: If a film has higher pressure on one side than the other, the film will bulge outwards towards the low-pressure side.
  - **Explanandum:**
    - E: The film bulged out towards the outside of the glass (i.e. bubbles formed).

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Criteria of adequacy for the DN model

- **Definition:** A DN explanation of an explanandum E is an argument with E as its conclusion, where:
  - (logical conditions)
  - 1-The argument is deductively valid
  - 2-The deduction makes essential use of general laws
  - 3-The explanans have empirical content
  - (empirical condition)
  - 4-The sentences in the explanans are all true

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The D-N (deductive-nomological) model

- Why each of these conditions is necessary:
  - 1 is necessary because an *invalid* argument wouldn't explain its conclusion
  - 2 is necessary because without relating the phenomenon to *laws*, we wouldn't have a *scientific* explanation
  - 3 (empirical content of explanans) is actually redundant (it's entailed by (1) and the fact that the explanandum has empirical content); it's unclear why Hempel lists it separately
  - 4 is necessary because deducing something from *false* premises doesn't count as *explaining* it at all

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The D-N (deductive-nomological) model

- Examples of scientific explanations that seem to fit the D-N model
- 1-Explaining the `bent spoon' effect
  - Q: Why does a spoon look bent, if you put it in a glass of water so that half the spoon is underwater?
  - A: The law of refraction tells us that light bends when it moves from water to air. If light from a straight object bends between the object and our eye, then that object will look bent. The spoon is straight. Therefore, when it is put half into water, it will look bent.

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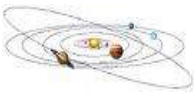
The D-N (deductive-nomological) model

- 2-Explaining the orbits of the planets
  - Q: Why do the planets go round the sun?
  - A: Newton's laws tell us that F=ma, and that $F=GmM/r^2$. The initial conditions (initial positions and velocities of the planets and sun) are given by I. From these laws and initial conditions, we can deduce, mathematically, what the orbits will be. It turns out they will be (approximately) ellipses around the sun.



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The D-N (deductive-nomological) model

- Why D-N explanations are worth having
  - 1-Unification:
  - Some D-N explanations 'unify' parts of our knowledge.
    - E.g., by having D-N explanations of both free-fall on the Earth's surface and the orbits of the planets by appealing to the same set of laws in each case - Newton's laws - we have 'unified' our understanding of terrestrial and celestial physics. And unification counts as an improvement in the state of our knowledge (...right?).

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The D-N (deductive-nomological) model

- Why D-N explanations are worth having
  - 2-Correction:
  - Sometimes, a D-N explanation will show that the explanandum is only approximately true, and will provide the correction.
    - E.g. when we give a D-N explanation for Kepler's laws using Newton's, we find that Kepler's laws are not exactly true, since objects that are very far away (e.g. the 'fixed stars') exert gravitational forces on the planets too. But we also understand why Kepler's laws are *very nearly* true (the 'fixed stars' are very far away, and things that are very far away exert only very small gravitational forces).

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Elliptic Explanations

- Explanations that scientist usually give are not exactly of the kind described by the DN model
  - *Elliptic* explanation: Some of the premises (because it is assumed that the questioner already knows them).
    - Examples:
      - "Why does the spoon look bent?" "Because light bends when it goes from water to air"
      - Virtually every explanation we give!

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Partial Explanations

- Partial explanation: the explanandum does not follow from the premises (what follows is something more general)
  - Example:
    - Q: why some kind of apples turn from green to red when they ripen?
    - The answer we give would explain why all apples change colour when they ripe, not -strictly speaking- that that particular kind does

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Elliptic/Partial Explanations

- Hempel:
- NO, these explanations are OK:
  - The laws that are left out are accepted by everyone and therefore are redundant
  - This deviation from the DN model is justified and justified on pragmatic grounds

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Partial Explanations

- Example: Freud's slip of the pen
  - Q: Why did Freud write "October 20th" in the September entry of his diary?
  - A: Freud subconsciously wanted his patient to arrive sooner than she was in fact going to arrive. Subconscious desires tend to lead to acts that somehow express the fulfilment of those desires. Freud's slip of the pen expressed fulfilment of his wish for the patient to arrive sooner than she was actually going to arrive.

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Partial Explanations

- Hempel:
  - it's not an explanation of the particular fact it wanted to explain --
    - The conclusion is: "Freud will perform some act that expresses the fulfilment of his wish"
    - Rather than "Freud will write "October 20th" in the September entry of his diary"

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The D-N (deductive-nomological) model

- Hempel's claim is that the vast majority of scientific explanations are *essentially* of covering-law form, even if they are elliptic and/or partial (and so don't look like D-N explanations at first sight).

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The thesis of structural identity (aka, symmetry thesis)

- There is symmetry between prediction and explanation (of events):
  - 1-every adequate explanation (of events) is potentially a prediction
    - and
  - 2-every adequate prediction is potentially an explanation
    - (prediction=predictive argument; not a statement without any supporting argument)

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The thesis of structural identity (aka, symmetry thesis)

- The difference between predictions and explanations is ONLY a matter of pragmatic factors:
  - Why the explanation/prediction was proposed?
- Predictions are proposed prior to the fact to be explained to test the theory
  - We make predictions to anticipate the future
- Explanations are proposed after the fact to be explained in order to have theoretical understanding
  - We make explanations to understand the past

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Inductive statistical explanation

- Inductive statistical explanation: the I-S model
- Explanation of single events that fall under a statistical law
  - they cannot be a conclusion of a deductive argument since their occurrence is not certain
  - But they can be conclusion of a strong inductive argument
    - Inductive strength: numerical value of the probability given by the statistical law in the explanans

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Inductive statistical explanation

- Schematically:

P(G/F)=0.95 statistical law } Explanans
Fa particular fact }
----------[0.95]
Therefore Ga Explanandum

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Inductive statistical explanation

- ex:
  - Brian has a streptococcal infection, and is given penicillin
  - Almost all patients recover from streptococcal infection if given penicillin (probability P)
  - Therefore Brian recovers from his streptococcal infection
    - when P is close to 1

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Inductive statistical explanation

- Remarks:
- 1- we have to have a strong inductive argument to have an explanation; so we can explain only events that are likely to occur
- 2-Hempel denies that the DN model is a limiting case of the IS model (when P=1)
  - They are essentially different because IS must be relativized to a particular "knowledge situation"
    - Epistemic relativity coming from RMS (requirement of maximal specificity introduced by Hemel to solve the problem of ambiguity, see later)

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Inductive statistical explanation

- A problem:
  - inductive arguments are not monotonic: adding premises will affect the strength of the conclusion, for example, it can make the argument very weak
  - ex:
    - Brian has a streptococcal infection, and is given penicillin
    - Almost all patients recover from streptococcal infection if given penicillin (probability P)
    - Brian is allergic to penicillin, Brian has a penicillin resistant streptococcal infection (R)
    - Therefore Brian recovers from his streptococcal infection
    - (where R is close to 0)

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Inductive statistical explanation

- A problem:
- or we could give two arguments that give equal weight to logically contradictory conclusions (Brian will recover, Brian will not)
- Hempel added the requirement of maximal specificity: we must include all information relevant to the explanandum event, or we should consider Brian as a member of the narrowest reference class

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Inductive statistical explanation

- → The problem of ambiguity:
- Given an IS explanation, (A), with true premises for some Ga, there will often be another IS explanation, (B), with true premises for ~Ga:
  - Ex: (A) P(G/F)=0.95; Fa; Therefore Ga
  - (B) P(~G/H)=0.96; Ha; Therefore ~Ga
    - This is because there may be different reference classes to which we could assign the explanandum; each choice will present us with different statistical laws; and these laws (often) will have different probabilities

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Inductive statistical explanation

- Hempel's example:
  - Explanandum: Wn, where n= November 27 in Stanford; W: it is warm and sunny
  - Reference class 1: N= the set of November days in Stanford
    - (A) P(W/N)=0.95; Nn; therefore Wn → we can explain Wn
  - Reference class 2: S= the set of immediate successors of cold and rainy days
    - Assuming Nov 26 was cold and rainy: n belongs to S also
    - (B) P(~W/S)=0.8; Sn; therefore ~Wn → we have also explained ~Wn !!!!

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Inductive statistical explanation

- A possible way out:
  - we look for explanations after the fact has already happened, so we are never confronted with two arguments
- Hempel did not like this:
  - if the essence of explanation is nomic expectability (=predictability based on laws), the one cannot accept that (B) would be just as god as (A) in the counterfactual situation
    - Hempel is committed to this because of the thesis of structural identity

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Inductive statistical explanation

- The current body of knowledge, K, contains both the premises of (A) and of (B), so we are equally justified in predicting Wn and ~Wn
- (A) and (B) generate an inductive inconsistency
- Thus we need to restrict inductive inferences
- → Requirement of maximal specificity (RMS): we should assign the explanandum to the **most specific** reference class (the maximally specific reference class to which it is known to belong)
  - We must provide all the information potentially relevant to the explanandum

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Inductive statistical explanation

- K= the current body of knowledge
- S= the conjunction of the premises in a I-S explanation
  - P(G/F)=r; Fb; therefore Gb
- If S&K implies F_1b (where F_1 is a subclass of F), then S&K must imply $P(G/F_1)=r_1$, where r_1 must be equal to r

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Inductive statistical explanation

- Ex:
  - (A) P(W/N)=0.95; Nn; therefore Wn
  - (B) P(~W/S)=0.8; Sn; therefore ~Wn
  - The premises of both (A) and (B) are in K
  - N belongs to N&S, which is a subclass of N
- Does the conjunction of the arguments' premises and K imply the probability of W in N&S?
  - If P(W/N&S) is not given, then RMS is not satisfied, and neither argument is a satisfactory I-S explanation
  - If P(W/N&S)=r1, then
    - If r1=r=P(W/N) the S is irrelevant to W and satisfies RMS; if there is no more specific class to which it belongs, then (A) is an acceptable I-S explanation
    - If r1 is not r; then not

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Inductive statistical explanation

- Epistemic relativity of I-S explanations:
  - K will contain some false statements and K will change over time
  - Thus, there is no such thing as an objective, correct inductive explanation independent of scientific context

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Criteria of adequacy for I-S model

- (1) Strong inductive argument
- (2) Explanans must contain statistical law(s).
- (3) Explanans must have empirical content.
- (4) Explanans must be true.
- (5) Explanans must satisfy the Requirement of Maximal Specificity (RMS).
  - RMS: All relevant information must be present in the explanans that would have an effect on the explanandum.

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D-N/I-S Adequacy conditions

- (1) Must be either a valid-deductive argument, or a strong inductive argument.
- (2) Explanans must contain a law(s) (universal or statistical).
- (3) Explanans must have empirical content.
- (4) Explanans must be true.
- (5) Explanans must satisfy the Requirement of Maximal Specificity (RMS).
- The DN/IS Adequacy Conditions are necessary and sufficient conditions for scientific explanations of particular facts.

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Deductive statistical explanation

- Statistical generalizations can be derived from statistical laws as a conclusion of a deductive argument
- ex
  - every C-14 atom has a probability of 1/3 of disintegrating within every period of 5730 years
  - Therefore in a large collection of C-14 approximately ¾ will probably decay in 11460 year

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Problems for the symmetry thesis

- **The symmetry objection:**
- According to the D-N model, two events could each explain the other (because their *logical* dependencies are symmetric)
- but intuitively this does not seem correct (because *explanation* is an *asymmetric* relation)

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Problems for the symmetry thesis

- Michael Scriven
- The Syphilitic Major: an explanation that is not a prediction
  - Q: how did Jones contract paresis?
  - A: (paresis is a form of paralysis that affects only those who have had untreated syphilis for many years) Jones had untreated syphilis + the only cause of paresis is syphilis

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Problems for the symmetry thesis

- This is the explanation for Jones' paresis
- But since only 15% of untreated syphilitics go on to develop paresis, Jones' syphilis could not have been used to predict that he will have syphilis (we would have predicted exactly the opposite)

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Problems for the symmetry thesis

- Hempel's reply:
- No satisfactory explanation has been provided
  - It's just a necessary (but not sufficient) condition for the occurrence of the event

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Problems for the symmetry thesis

- Hempel's examples:
  - ex1:
    - all people who die have been oxygen breathers when they were alive
    - but we do not explain the death of someone pointing out that they were oxygen breathers
  - ex2:
    - a person have won the Irish sweepstakes
    - But we do not explain why they won pointing to the fact that that person has bought the ticket...

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Problems for the symmetry thesis

- This reply could be thought as being unsatisfactory:
- in the mayor example, we know no other factor that could cause paresis

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Problems for the symmetry thesis

- Evolutionary theory: an explanation that is not a prediction
  - Darwin explained the origin of species using this theory of natural selection working on random variations
  - Scientists accept that D's theory offers genuine explanation
  - yet no scientist has been able to use D's theory to predict the coming-into-existence of any new species.
  - Thus, evolutionary theory explains but does not predict

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Problems for the symmetry thesis

- Hempel's reply:
  - evolutionary theory does not really explain what it cannot predict
  - Story (= narrative describing the sequence of species that have arisen and become extinct) vs theory (that employs generalizations about heredity, mutation and selection plus detailed assumptions about the environmental conditions) of evolution
  - The story has no explanatory import
  - The theory can provide at best partial, statistical explanations

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Problems for the symmetry thesis

- Scriven's collapsed bridge: an explanation that is not a prediction
  - A bridge has collapsed
  - Explanation: metal fatigue occurred
  - but the fact that the fact occurred tells us also that it was serious enough to make the bridge collapse
  - We could not have predicted the collapse, even if we can explain it

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Problems for the symmetry thesis

- Similar cases:
  - the man who killed the wife for jealousy
  - the man who got skin cancer after sunburn
- we could not have predicted the relevant events but we can nevertheless explain them after they have happened
  - we have explanations that are not predictions

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Problems for the symmetry thesis

- Hempel's reply:
- There is a conditional:
  - **if** all the information in the explanans had been known and taken into account before the occurrence of the explanandum event, **then** the event could have been predicted
- Scriven has shown that in some cases the antecedent is not satisfied, but not that the conditional is false

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Problems for the symmetry thesis

- Hempel concedes that there seem to be adequate predictions that are not explanations
- Koplik spots=spots inside one's cheek a week before a case of measles
  - One can predict that a patient with Koplik spots will get measles in a week
  - Still this does not explain why she will develop measles after a week

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Problems for the symmetry thesis

- To some people, H's model is vulnerable to this kind of examples because the model does not mention causation
  - the K-spots fail to explain because they do not cause measles
  - Both measles and k-spots have a common cause: the measles virus

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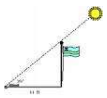
Problems for the symmetry thesis

- We can predict and explain S, the length of the shadow cast by a flagpole of height H:



  - A flagpole of height H casts a shadow of length L
  - Light travels in straight lines
  - The sun is α degrees above the horizon
  - C. The length of the shadow is $L=H \sin \alpha / \cos \alpha$
- Prediction and explanation

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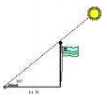
Problems for the symmetry thesis

- But equally well we could predict and explain (???) why the flagpole has height H given its shadow has length S:



  - 'Explaining' why the flagpole is 60 feet high
    - A flagpole of height H casts a shadow of length L
    - Light travels in straight lines
    - The sun is α degrees above the horizon
    - C. The height of the flagpole $H=L \cos \alpha / \sin \alpha$
  - This is a fine prediction but not a good explanation

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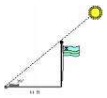
Problems for the symmetry thesis

- This is also an example which is supposed to show that the conditions of adequacy are not sufficient:



According to the DN model we can explain the length of the flagpole by the length of the shadow but this seems wrong.

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Problems for the symmetry thesis

- Examples:
  - A: Explaining why the pressure of the gas rose
    - P1. A gas is sealed in a container of fixed volume and heated strongly.
    - P2. If the volume of a gas is kept constant then its temperature is directly proportional to its pressure.
    - C. The pressure of the gas rose

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Problems for the symmetry thesis

- B: 'Explaining' why the temperature of the gas rose
  - P1. A gas is sealed in a container of fixed volume and its pressure.
  - P2. If the volume of a gas is kept constant then its temperature is directly proportional to its pressure.
  - C. The temperature of the gas rose.
- Intuitively, Argument 2 does not seem to be a genuine *explanation*.

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Problems for the symmetry thesis

- Other examples:
  - The storm approaching → predicts and explains the barometer readings; not the other way round
  - The length of the pendulum → predicts and explains the period of the pendulum; not the other way around

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Problems for the symmetry thesis

- Many people think that what's missing from the D-N account is the condition that the explanans must cause the explanandum.
- two sets of counterexamples:
  - first set concerns explanation of laws
  - second set explanations of events
- we will focus on the second set

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Problems with the D-N model

- **The irrelevance objection**: an "explanation" which is not an explanation
- Peter Achinstein -The arsenic eater
  - P1. Everyone who eats a pound of arsenic dies within 24 hours.
  - P2. Jones ate a pound of arsenic.
  - C. Jones died within 24 hours.
  - (He was actually run over by a car)

- The premises of the DN argument are IRRELEVANT to the explanandum

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Problems with the D-N model

- **The arsenic eater: an example of causal pre-emption**
  - an argument that meets all the conditions of the covering law model, but is not a genuine explanation because the factors cited in the argument were actually pre-empted by some other cause of the explanandum.

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Problems with the D-N model

- Causal pre-emption:
- Suppose that some event E has **two potential causes** C1 and C2:
  - either C1 or C2 would be enough to cause E.
- Suppose that in fact, **both C1 and C2 occur**.
- Suppose that **C1 actually causes E**; C2 does not (although it would have, if C1 had not occurred).
- Then, we say that **C2 was a potential cause** of E, but that it **was pre-empted by the actual cause C1**.
- Ex: Suzy and Billy both throwing rocks at a window

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Problems with the D-N model

- How to use causal pre-emption to create arguments that fit the D-N model, but that are not explanations: give an argument that involves C2 (the pre-empted cause) and not C1 (the actual cause).
  - Example:
  - P1. Everyone who eats a pound of arsenic dies within 24 hours.
  - P2. Jones ate a pound of arsenic.
  - C. Jones died within 24 hours.
  - (He was actually run over by a car)

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Problems with the D-N model

- Wesley Salmon- the birth control pills: an "explanation" which is not an explanation

- Why did Jones not become pregnant?
  - P1. All people who take birth control pills do not get pregnant
  - P2. Jones took the birth control pill
  - C. Jones did not become pregnant
  - (This is not an explanation of why Jones didn't become pregnant. He did not because he is a man)
- The premises of the DN argument are IRRELEVANT to the explanandum

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Problems with the D-N model

- **The birth control pill: a case of over-determination**
  - an argument that meets all the conditions of the D-N model, but that is not an explanation because it uses the wrong one of two or more factors that *overdetermined* the explanandum.

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Problems with the D-N model

- Why did Jones not become pregnant?
  - Argument 1:
    - P1. All people who do not have sex do not get pregnant
    - P2. Jones did not have sex
    - C. Jones did not become pregnant.
  - Argument 2:
    - P1: All men do not get pregnant
    - P2. Jones is a man
    - C. Jones did not become pregnant.

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Problems with the D-N model

- Both arguments fit the D-N model, but only argument 2 is an explanation
- We say that Jones's not becoming pregnant is *overdetermined* by the fact that he is a man and the fact that he took the BCP
- 'Overdetermination' (definition): We say that X is overdetermined by A and B iff either A or B separately would have been enough to ensure that X occurred, but in fact both A and B occurred.

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Problems with the D-N model

- **The ink stain:** an explanation which is not a D-N explanation
- Explanation for why there is an ink stain in the carpet in Tom's office:
  - Because Tom knocked over a bottle of ink.
- This explains the ink stain without being a D-N explanation: it refers to its immediate cause
- Causal explanations that do not appeal to laws seem to be legitimate scientific explanations

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Problems with the I-S model

- Examples that attempt to demonstrate that the I-S conditions are neither necessary nor sufficient for scientific explanations of particular facts.
  - Irrelevance:
  - (A)-The hexed salt example
    - P1: John treats some salt with a 'dissolving spell' – now it is a sample of hexed salt
    - P2: All hexed salts have high probability of dissolving when stirred into cold water for 5 minutes (because all salt is like that)
    - C: This piece of hexed salt dissolves in water
  - The premises of the I-S argument are IRRELEVANT to the explanandum

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Problems with the I-S model

- Irrelevance:
- (B) - Vitamin C and the Common Cold
  - (1) 85% of people with common colds who take massive doses of Vitamin C recover quickly.
  - (2) Mike is a person with a cold who took massive doses of Vitamin C. [0.85]
  - Therefore Mike recovered quickly.

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Problems with the I-S model

- An I-S explanation which fails to be an explanation:
  - Fails to take into consideration that people tend to recover quickly from colds regardless of whether or not they take massive doses of Vitamin C.
- Moral: The argument thesis plus RMS still allows irrelevant information to be included in the premises of an IS explanation.

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Problems with the I-S model

- 2- explanations that an not I-S explanations
- Syphilis and Paresis:
  - (1) 15% of all victims of untreated latent syphilis develop paresis
  - (2) The only way to get paresis is if you had untreated latent syphilis
  - (3) Jones had untreated latent syphilis [.15]
  - Therefore Jones developed paresis

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Problems with the I-S model

- Legitimate scientific explanation of why Jones developed paresis.
- But It's not a strong inductive argument: The premises give a very low probability to the conclusion.

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A possible cure for the symmetry and irrelevance problems

- What went wrong in these cases was that the law failed to identify the cause of the explanadum

- An adequate explanation of a fact must include the cause of the fact
- Maybe Hempel's model can be saved adding an empirical causal condition (Baruch Brody):
  - One of the premises should contain a description of the cause of the explanadum

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A possible cure for the symmetry and irrelevance problems

- Problem of symmetry:
  - It is the flagpole that caused the shadow, not the other way round
- Problem of irrelevance:
  - It was the bus that caused Jones to die, not the arsenic

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A possible cure for the symmetry and irrelevance problems

- Unfortunately, this will not work: the causal condition does not guarantee that the resulting argument will be explanatory
- ex (Timothy McCarthy): why the forest caught fire [De]

  - 1-All metals are conductors [irrelevant law, (x)(Ax>Bx)]
  - 2-the forest was struck by lightning [actual cause, Ce] and this screw is metallic [instance of the law, Ao]
  - 3-either this screw is not a conductor, or the forest was not struck by lightning, or the forest caught fire [~Bo v ~Ce v De]
  - C: the forest caught fire [De]

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A possible cure for the symmetry and irrelevance problems

- This argument fails to explain why the forest caught fire because it is circular:
  - in order for premise 3 to be true [~Bo v ~Ce v De] at least one of the disjuncts must be true;
  - From Premise 1 and 2 we know that the first two are false;
  - so to know that premise 3 is true we must know that the third disjunct is true
  - But this is simply a re-statement of the conclusion

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A possible cure for the symmetry and irrelevance problems

- Jaegwon Kim tried to avoid the circularity:

  - we must add another condition: the explanandum (the conclusion) not entail any of the conjuncts in the premises when they are written in conjunctive normal form (=it is equivalent to a conjunction of disjunctions where every component of each disjunction is either an atomic proposition or the negation of one)
- Premise 3 of the argument above is written in conjunctive normal form and it is entailed by the explanandum
- But McCarthy have provided other arguments...

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A possible cure for the symmetry and irrelevance problems

- The cause of the crow turning black is that it was immersed in black paint [Co]
  - 1- all crows are black
  - 2-(x),(y)(x turns the colour of y & y is black > x turns black)
  - 3- o was immersed in black paint [Co] & Henry is a crow
  - 4- o was not immersed in black paint [~Co] v o turns in the colour of Henry
  - 5- Therefore o turns black
- Satisfies all the conditions but it is not an explanation

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Hillel-Ruben's causal view of explanation

- What's wrong in all these cases?
  - It was not mentioned that c was explicitly the cause of e
  - We arrived to the conclusion not via the fact that c caused e but via some irrelevant law
    - There is no connection beyond logical derivability, and logical dependence has nothing to do with causal dependence
    - We need to tighten the connection between explanans and explanadum so that their relation exists in virtue of some actual cause

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Hillel-Ruben's causal view of explanation

- David Hillel-Ruben's single statement proposal:
  - all explanations of particular events would reduce to something like this:
    - c is the cause of e
    - therefore e
- Explanation is not an argument, it is a statement
- No laws are mentioned

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Hillel-Ruben's causal view of explanation

- R agrees with H that if explanations are arguments then explanations must include laws
- But R thinks that explanations aren't arguments
- Some explanations (especially those in the physical sciences) include laws but the role they play is not that of a premise of an argument
- Other explanations can be complete even if they do not mention laws
- laws are relevant because they reveal properties and because they provide scientist with the language in which they phrase their explanations

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Salmon's causal theory(ies) of explanation

- According to Wesley Salmon (1978 "Why ask 'why?'"), the concept of explanation has two parts:
  - 1-(we won't do that) SR account
  - 2- causal account
- He says that there are two main intuitions about explanations:
  - Scientists: a phenomenon is explained because it follows form a scientific law
    - →Hempel
  - Laymen: a phenomenon is explained in terms of its causes
    - → Salmon

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Salmon's causal theory(ies) of explanation

- Statistical relevance is not the same as causal relevance (SR often only indicates symptoms):
  - Ex: since most swans are white, being a swan is SR for being white
  - Is being a swan causally relevant for being white?
    - Unclear:
    - If yes, then we can explain why a certain bird is white by saying that it is because it is a swan
    - If no, we're not explaining anything

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Salmon's causal theory(ies) of explanation

- Statistical relevance is not the same as causal relevance (SR often only indicates symptoms):
  - Ex: the dropping in level of the mercury column of a barometer is statistically relevant to the weather's turning foul
  - Is it causally relevant?
  - NO: because the change in mercury level does not cause changes in the weather
    - Therefore we cannot explain the change in weather in terms of barometric level

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Salmon's causal theory(ies) of explanation

- Symptoms can be used to predict, but not to explain:
  - Only understanding the causal mechanics yield explanations
  - That's why the SR model is just a first step

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Salmon's causal theory(ies) of explanation

- Many times we use laws in explanations
- According to Salmon this is not because they are merely laws, but because they are causal laws
  - Noncausal laws, like PV=const, have no explanatory power and they cry out for an explanations themselves
- Therefore, we need an account of what causes are

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Salmon's causal theory(ies) of explanation

- Hume:
  - There are no necessary connections between causes and effects
  - Causes are just constant conjunctions:
  - "a cause is an object, followed by another, and where all the objects similar to the first are followed by objects similar to the second"

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Salmon's causal theory(ies) of explanation

- Unsatisfactory!
  - 1- some objects regularly follow one another but they are not in a cause and effect relation:
    - Ex: Nights follow days regularly but nights do not cause days!
  - 2- some causes and effects are not regularly conjoined:
    - A moving billiard ball A hits a stationary ball B, so that A causes B to move, but events of type A do not always follow events of type B:
      - Ball B may have been glued to the table

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Salmon's causal theory(ies) of explanation

- Salmon's notion of causal process:
  - A causal process is a continuous process in space and time …
  - Not all continuous process are causal:
    - Ex: your shadow moving across the lawn as you walk by is not causal because the earlier part of your shadow did not cause the later part of it: what contributes to the making of the later part is your body
      - Pseudo-process

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Salmon's causal theory(ies) of explanation

- Causal processes (and not pseudo-processes) can transmit markers:
  - Pseudo-process:
    - should your earlier shadow be distorted by a rock lying on the lawn as the shadow moved across its surface this distortion would not be transmitted to the later shadow
      - The distortion in the shadow is a **mark**
  - Causal process:
    - A stone flying across the lawn carries its mark with it: if it should cross the path of a water sprinkler and hence get wet, the stone will carry the wetness with it as well

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Salmon's causal theory(ies) of explanation

- From causal processes to causes:
  - Causal process: a continuous process in space and time which is able to transmit marks
  - Causal interaction: "when two causal processes intersect and both are modified in such ways that the changes in one are correlated with changes in the other"
  - Causes: together with effects, they are the events in the casual interactions

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Salmon's causal theory(ies) of explanation

- Salmon's account does not have the problem of symmetry:
  - The flagpole causes the shadow, not the other way round, and that is why the flagpole's length explains the shadow's length and not the other way round

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Salmon's causal theory(ies) of explanation

- According to Salmon's account, theoretical explanations are causal explanations:
  - A claps her hands, B hear a sound
  - Causal explanation:
    - We can explain why B hear a sound in terms of A's clapping hands because the latter causes the former
  - Theoretical explanation:
    - Scientists in addition postulates some invisible things, namely sound waves, which take the vibrations from A to B

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Salmon's causal theory(ies) of explanation

- Why should we go to theoretical explanations?
- According to Salmon, the ultimate explanation of the universe is to produce a causal network linking all the events in terms of causal processes
  - Theoretical explanations provide the causal mechanism: discontinuous processes cannot really explain
    - Causal-mechanical theory of explanation

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Objections

- Salmon's intent is to provide an empiricist account of causation
- Does he succeed?
  - Probably not: Objections to the model
  - Marks: we may perceive them
    - A light ray passing through a red filter will acquire a mark by becoming red and transmit it
    - Redness can be observed:
      - When acquired at A
      - At the endpoint Z when the light strikes a white wall

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Objections

- But:
- (1) why is the redness in A labelled a mark?
  - Because it is given to the ray by the filter (the filter marks the ray)
    - What does 'given' mean?
      - Does it 'caused by'? → bad news: the account is circular!!!!
      - Does it mean something else? What exactly?

Objections

- (2) what does it mean that redness is transmitted to Z?
  - The redness at A causes the redness at B, which causes the redness at C,… , that cases the redness at Z
    - Circular again!

General problems with causal views

- 1) Problem of the nature of causality:
- How are legitimate causal explanations distinguished from illegitimate explanations based on mere statistical correlations?

General problems with causal views

- 2) Problem of purely theoretical explanations: Some theoretical explanations do not explicitly refer to causes.
  - Ex: Why can't you fit a left-handed glove on your right hand?
    - Theoretical explanation: Due to the topological properties of the left-handed glove and the right hand.
    - Causal explanation: Due to the resistance of the inner surface of the left-handed glove with your right hand.
- Purely theoretical explanations count as legitimate scientific explanations. So the causal account cannot be a complete account of scientific explanation.

General problems with causal views

- 3) Problem of irreducible probabilistic explanations:
- To provide causal explanations of irreducibly probabilistic events, we need a theory of probabilistic causation (and a theory of simple causation is hard to come by).

The Unification Account

- The Unification Account
  - Michael Friedman (1974) "Explanation and Scientific Understanding"
  - Philip Kitcher (1981) "Explanatory Unification"

Stannford

Columbia

The Unification Account

- A scientific explanation of a fact (particular or general) is a demonstration of how the fact can be derived from a unifying set of argument patterns.
- Set of argument patterns = basic principles (axioms, theorems, etc) that (may) underlie a theory

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The Unification Account

- Unifying power: a set of argument patterns T is unifying if it scores high on the following properties:
  - (1) Scope: The greater the scope of T, the greater the number of conclusions that can be drawn from T.
  - (2) Simplicity: The greater the simplicity of T, the smaller the number of argument patterns in T.
  - (3) Stringency: The greater the stringency of T, the smaller the range of applicability of T
- General Idea: To scientifically explain a fact, you have to demonstrate how it can be embedded in a unifying theory. This explains the fact by showing how it is related to other facts.

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The Unification Account

- Ex.
- General relativity can be thought of as a unifying set of argument patterns that can be used to describe a certain class of phenomena. Arguably, the set has great scope, great simplicity, and great stringency (it only applies to certain phenomena; namely, phenomena that experience the gravitational force; and it prescribes the behavior of such phenomenon in very restricted ways).
- Astrology, on the other hand, is not stringent: you can apply its descriptions to almost any phenomenon you experience. (Any event you experience in the course of a day is bound to have been "predicted" by your daily horoscope, given a flexible enough interpretation.)

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The Unification Account

- Deducibility
  - Hempel's DN model :The premises of a valid deductive argument are able to explain the conclusion
  - Kitcher: deduction alone explains ONLY if it is an instance of an argument pattern

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The Unification Account

- Intuitively:
  - P: a collection of phenomena
  - S: a collection of argument patterns, made up of a number of schematic premises and conclusions
    - Unification happens when the members of S are less than the member of P
    - Ex:
      - we can deduce 5,000 phenomena (P) from 3 arguments patterns (S)

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The Unification Account

- This account does not have the problem of symmetry (flagpole and shadow):
  - To explain the flagpole's length (or any other dimension of an artifact) we use this argument pattern:
    - origin-and-development pattern (OD-schema): we start with the intentions of the designer, we conclude that the object has remained the same as the time of origin
  - We could try to explain the flagpole's length in terms of the shadow's length, and in this case we'd use a different type of argument pattern:
    - the Shadow pattern (S-schema): …

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The Unification Account

- In explaining the length of artifacts it is more unifying (=simpler) to use the OD schema:
  - It can explain the dimension of all artifacts, while the S-schema cannot
    - some artifacts may be transparent and thus would not cast shadows
    - To explain the length of artifacts one would have to use the S-schema if they have a shadow, the OD-schema if they do not have a shadow

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The Unification Account

- This account does not have the problem of irrelevance (hexed salt):
  - P1. Sample S is salt
  - P2. S has been hexed
  - P3. S has been put in water
  - P4. All hexed salt dissolves when placed in water (law)
  - C. S dissolves in water
- Is not an explanation because it is simpler to explain both he hexed and un-hexed salt in terms of the same argument pattern, that is in terms of the same law that salt dissolves in water

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The Unification Account

- Four Characteristics:
- (1) Unification explanations are derivations.
  - A derivation = A sequence of justified steps; each step being explicitly shown to follow from the preceding ones.

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The Unification Account

- (2) The unification account is committed to an Expectibility Thesis:
  - A unifying explanation must show how the explanandum is to be expected from the explanans.
  - Note: This is not necessarily nomic expectibility, as with DN. In comparison to DN, one might say that unification replaces "law" with "unifying systematization" (i.e., "theory").

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The Unification Account

- (3) Unifying explanations are not necessarily reductionistic.
  - One might think that to provide a unifying explanation of a fact is to show how that fact can be reduced to the fundamental facts that underlie the ultimate grand-unifying theory of everything.
  - In particular, to provide a unifying explanation of a biological fact, you have to show how it can be reduced to facts in chemistry, say, or physics.

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The Unification Account

- But:
- The unification account is compatible with the possibility that biology, say, ultimately can never be reduced to physics.
- If this is so, you can still construct unifying explanations of biological facts: they'll just refer to unifying theories in biology and make no reference to physics.

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The Unification Account

- (4) The unification account is global:
- A unifying explanation embeds a local fact in a larger, global theory.

Problems with the Unification Account

- 1) Problem of subjective standards:
  - How are we to judge which explanations are more unifying than others?

Problems with the Unification Account

- (2) Problem of probabilistic explanations:
- Some legitimate explanations give a low probability to their explananda, hence their explananda are not expected from their explanans (recall the syphilis and paresis example).
- Since the unification account is committed to an Expectability Thesis, it faces this problem.

Problems with the Unification Account

- One response:
- "Deductive Chauvinism": Claim that there are no legitimate explanations of inherently probabilistic facts.

Problems with the Unification Account

- To see how this folds out, consider the following distinction:
- Two Types of Probabilistic Explanations:
  - (a) reducible: Given enough information, these reduce to explanations in which the explanandum can be logically deduced from the explanans.
  - (b) irreducible: The explanandum **cannot** be logically deduced from the explanans, regardless of how much further information is provided.

Problems with the Unification Account

- Deductive chauvinism claims:
  - All probabilistic explanations can be reduced to "deductive" explanations. There are no legitimate irreducible probabilistic explanations.
  - In other words: While there may be inherently probabilistic events, Deductive Chauvinism claims such events cannot be explained (to the extent that inherently probabilistic events cannot be predicted with certainty).

Problems with the Unification Account

- Ex1:
  - Suppose an electron beam impinges on a potential barrier (think of a beam of electrons focused on a wall).
  - The Schrödinger equation in quantum mechanics gives the probability for each electron in the beam to be reflected or to tunnel through. Suppose a given electron, e1, tunnels through the barrier. We can ask: Why did e1 tunnel through the barrier?

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Problems with the Unification Account

- We cannot construct a derivation with the conclusion "e1 tunneled through the barrier".
  - All the Schrödinger equation gives us is the probability that e1 will tunnel through (say it's 0.80). The Schrödinger equation does not predict with certainty whether e1 will or will not tunnel through.
- What this means: We cannot construct a unifying explanation of why e1 tunneled through.

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Problems with the Unification Account

- But: The unificationist who is also a Deductive Chauvinist will respond that this is fine, since there are no legitimate explanations of inherently probabilistic events, and the actual event of e1 tunneling through the barrier is just such an inherently probabilistic event.

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Problems with the Unification Account

- So: A unificationist can claim that there are no explanations of inherently probabilistic events.
- A physicist might be satisfied with the claim that there is no explanation for why a particular electron tunnelled through a barrier.
- But: Does this work for explanations in the social sciences?

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Problems with the Unification Account

- Suppose an anthropologist studying the Yanomami indians of Brazil seeks an explanation of why the Yanomami attacked village A. The anthropologist has determined the following:
  - (a) The Yanomami tend to attack when resources are scarce;
  - (b) The Yanommami tend to attack when the military advantage is theirs; and
  - (c) The Yanomami tend to attack when their social influence is threatened.

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Problems with the Unification Account

- Note: There are no factors that determine with certainty when the Yanomami will attack.
- So: The event of such an attack is an inherently probabilistic event.
- So: A unificationist who is a deductive chauvinist must claim that there is no explanation for why the Yanomami did in fact attack village A.

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Problems with the Unification Account

- But: The anthropologist certainly will not be satisfied with this and will indeed claim that some form of explanation for the attack can be constructed.
- Moral:
  - Deductive chauvinism is a high price to pay as a response to the problem of probabilistic explanations.
  - But if the unificationist does not adopt it, she is faced with the same sorts of problems that afflict the IS account.

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Problems with the Unification Account

- The account of the symmetry objection criticized: Predictive vs retrodiuctive derivations:
  - Ex:
    - Predictive: state of motion of a planet derived from initial velocity, position...
    - Retrodictive: state of motion of a planet derived from future velocity, position...
  - We think retrodictive derivations are not really **explanatory** but the pattern associated with them look exactly as unifying as the pattern containing predictive ones

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Problems with the Unification Account

- Heterogeneity of Unification
- Different types of unifications:
  - Common scheme/vocabulary (classifications)
    - Linnaeus' biological classification
  - Common mathematical framework
    - Langrangian-Hamitonian formulation of NM
  - Common set of mechanisms/causes
- Only the third is genuine physical unification and seems connected with explanation

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Problems with the Unification Account

- Can K's account sufficiently discriminate between these types of unification?
- The worry is that it cannot:
  - Many classificatory and formal unification seem to fit the scheme
  - Ex: "X are mammals" to derive a lot of properties (they have backbones, hearts, their young are born alive,...)
  - They are merely descriptive, not explanatory

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Problems with the Unification Account

- The "winner-take-all" conception of explanatory unification
  - NM cannot explain why the rocket arrived on the Moon because NM is not the best unification we have and only the most unificatory theory is explanatory
    - The unificationist seems to have to maintain that otherwise she will not solve the problems of irrelevance and symmetry

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Problems with the Unification Account

- We seldom seem to go thought the process of comparing the alternatives in order to find the most unifying one

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The contextual theory of explanation

- Bas van Fraassen (1980) "The Scientific Image"
  - He thinks that an explanation is just the answer to a why-question, and that, since there are lots of different types of why-questions, there are lots of different types of explanation.
  - He thinks that what counts as 'the' explanation in a given situation depends on aspects of the conversational context.
    - Pragmatic or contextual theory of explanation

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The contextual theory of explanation

- Ex:
- The question "Why did Adam eat the apple?" will be responded to in different ways, depending on how it is interpreted:
  - (a) Why did Adam eat the **apple**? (As opposed to a grape or an orange.)
  - (b) Why did **Adam** eat the apple? (As opposed to Eve or the snake.)
  - (c) Why did Adam **eat** the apple? (As opposed to throwing it at the snake, etc.)

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The contextual theory of explanation

- The question is ambiguous:
  - they have the same topic, but they do not ask the same question
- In every question there is an implicit contrast class:
  - Ex: **apple** as opposed to a grape or an orange
- We rely on the context to pick out the relevant question which is asked

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The contextual theory of explanation

- vF:
  - there is NO such thing as an adequate explanation in itself
  - An explanation is adequate only if it is what the questioner is asking for
- What counts as an explanation depends on the explanatory relevance:
  - What the explanation-seeker is looking for
  - What the explanation-seeker's background knowledge and interests are

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The contextual theory of explanation

- Example:
- "why does the blood circulate into the body?"
  - Possible acceptable answers, depending on who is asking
    - (a) because the hearth pumps the blood through the arteries
    - (b) to bring oxygen to every part of the body tissue

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The contextual theory of explanation

- Ex: "why did the plane crash?"
  - Suppose a congressional committee is seeking an explanation for a plane crash in order to modify existing safety regulations.
  - It will be more interested in explanations that refer to the procedures the crew went through (or failed to go through), as opposed to explanations that refer to principles in Newtonian dynamics

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The contextual theory of explanation

- How to solve the symmetry problem:
- For van Fraassen there is no asymmetry at all between the shadow and the flagpole's length:
  - Both can be adequate explanations, it all depends on what the questioner wants

The contextual theory of explanation

- Summary:
  - An explanation is an answer to a why question
  - There is nothing special about scientific explanations
  - Every explanation has a topic, a contrast class and a relevance relation
  - Both the relevant relation and the contrast class are indicated by the context

The contextual theory of explanation - objections

- Salmon's objections to van Fraassen
- (1) not all why-questions call for explanations
  - Ex: in a time of grief: "why did my father die?"
- (2) not all explanations are sought by why-questions
  - 2a-How-possibly questions:
    - "How is it possible for chained-up Houdini to escape from a locked strongbox totally submerged underwater, and in such a short time too?"
  - 2b-How-actually questions:
    - "How did there come to be mammals (other than bats) in New Zealand, since NZ is a group of two islands in the South Pacific far away from any land mass?"

The contextual theory of explanation - objections

- Other objections
- (3) this account is not relevant to scientific methodology since it does not help in answering any of these questions:
  - What role does explanation play in science?
  - What sort of things require an explanation?
  - What form should explanations take, and why?
  - How many forms of explanation should science adopt?
  - How is explanation related to other aims of science?