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Arguments, Laws, and Explanation

I start by way of outlining some of the standard counterexamples to Hempel's account of full explanation. . . .

These counterexamples cluster around two difficulties: (A) irrelevance and (B) symmetry. I do not say that Hempel's account has no resources for replying adequately to *any* of these standard counterexamples, although I do think that this is true in some cases. I indicate where I believe that this is so. The counterexamples purport to show that Hempel's account of explanation, even if necessary, could not be sufficient. However, I argue that in thinking through an adequate response to the counterexamples, we will see that Hempel's requirements are not even necessary for (full) explanation. . . .

■ | The Standard Counterexamples: Irrelevance

The first reason, (A), for holding that Hempel's conditions for explanation could not be sufficient turns on the fact that there can be derivations that meet all of Hempel's requirements for D-N (or I-S) explanation, but whose premises are obviously irrelevant to the explanation of the conclusions of those derivations. In the main, I shall only be concerned in this chapter with the explanation of singular facts . . . , but we might note some counterexamples which concern the explanation of laws as well. Here is one, taken from Ardon Lyon, which concerns the explanation of empirical laws by deductive subsumption.[1]

1 All metals conduct electricity.
2 Whatever conducts electricity is subject to gravitational attraction.

∴ 3 All metals are subject to gravitational attraction.

As Lyon points out, no one would regard the conjunction of (1) and (2) as explaining (3), in spite of the fact that the latter does follow from the former, because (1) and (2) are irrelevant to the truth of (3). 'Metals are not subject to gravitational attraction because they conduct electricity: non-conductors are subject to gravitational attraction to just the same degree' (Lyon 1974: 247). Lyon's counterexample is directed against Hempel's account of the explanation of laws, but it is easy to construct a parallel counterexample to Hempel's account of the explanation of singular facts. The explanandum in question would be that this bit of metal is subject to gravitational attraction, and the explanans will include the fact that this bit of metal conducts electricity.

Another alleged counterexample to Hempel's analysis of the explanation of laws is offered by Baruch Brody.[2]

1 Sodium normally combines with bromine in a ratio of one-to-one.
2 Everything that normally combines with bromine in a ratio of one-to-one normally combines with chlorine in a ratio of one-to-one.

∴ 3 Sodium normally combines with chlorine in a ratio of one-to-one.

Brody claims that this derivation has no explanatory power whatever, and I agree with him. But even if the reader were to insist that it has some such power, it doesn't have much, and Hempel's analysis does not offer us the materials for saying why that should be so. Although Brody does not say so, one could say that the problem here too is one of explanatory irrelevance. The ratio in which bromine and chlorine combine is surely irrelevant for explaining (but not necessarily irrelevant in other ways) the ratio in which sodium and chlorine combine, even though the two ratios *are* related in a lawlike manner. As with Lyon's counterexample, it is simple to convert Brody's counterexample to one concerning the explanation of a singular fact: the fact that this bit of sodium combined with this bit of chlorine in a one-one ratio.

Two further counterexamples which I wish to mention are specifically directed to irrelevance in the case of the explanation of singular facts. The first example is adapted from Peter Achinstein.[3] Suppose that poor Jones (he is so often ill) eats at least a pound of arsenic and dies within twenty-four hours, and that eating at least a pound of arsenic inevitably leads to death within twenty-four hours. Does it follow that the argument below is an explanation of Jones's death?

1 Jones ate at least a pound of arsenic at time t.
2 (x) (x eats at least 1 lb arsenic at t 5 ⊃ x dies within 24 hours after t).

∴ 3 Jones dies within 24 hours of t.

Suppose, consistently with the above suppositions, that Jones was run over by a bus and died soon after ingesting the arsenic. In this case, the deduction will not be explanatory, since Jones, although he would have died from the arsenic had he not been run over by a bus soon after eating the poison, was actually killed by the bus. It is the bus, and not the arsenic, which explains his death, in spite of the argument given above meeting all of Hempel's conditions.

One can generalize Achinstein's example, to any case in which there is causal pre-emption. Suppose some event, e, has two potential causes c and d, in the sense that c occurs and causes e, and that d also occurs and does not cause e, but would have caused e if c had not occurred. d is a potential alternative cause of e, but is pre-empted by the actual cause c. In any such case, there will be an Achinstein-style counterexample to the D-N account of the explanation of singular facts, since there will be a derivation (with all true premises, etc.) to the explanandum via a premiss set which includes a premiss about the pre-empted cause but not one about the actual cause, and hence no explanation of the explanandum so derived. The pre-empted cause is explanatorily irrelevant to the explanandum thus derived.

I do take the lesson of this counterexample to be important, so it will be worth dwelling on it. Is there a way of meeting this alleged counterexample from the existing resources of Hempel's theory? One might think that it can be met by the introduction of a *ceteris paribus* ["other things being equal"] clause in the statement of the law, (2), and the addition of a further premiss (which will in this case be false) that says that other conditions are in fact equal.[5] So the 'irrelevant explanation', since it includes a false premiss, will fail to be an explanation on Hempel's own account. After all, the rejoinder goes, no one can die who is already dead; the arsenic will be what kills Jones only if he hasn't already died from some other cause. The arsenic ingestion is relevant, only if the *ceteris paribus* clause in the law is met, and the clause will exclude the case in which an alternative cause operates.

I fail to see how the *ceteris paribus* clause response will meet the difficulty at hand. A *ceteris paribus* clause is inserted in a law, as a means of saving an *apparently* falsified law from real falsification: other things are not equal, so the law is true after all. However, in the counterexample, Jones's being run over by a bus does not *even apparently* falsify the law that whoever eats at least a pound of arsenic dies within twenty-four hours. After all, after eating the arsenic, Jones *did die* within the required time

period. So how could Jones's bus-related death present any kind of even apparent difficulty for the law about what happens to people after they ingest at least a pound of arsenic? Any difficulty for that law must involve someone's failure to die in some circumstances or other, and poor, dead Jones is no example of that.

In general, when c (the bus hitting Jones) causes e (the death of Jones), there is no argument from this fact to the falsity of the law that whenever a D (an ingestion of at least a pound of arsenic), then an E (a death). In particular, one does not need to rephrase the law as: Whenever a D, then an E, unless there is some alternative cause that operates to bring about an E. It is *true* that whoever eats a pound of arsenic at t dies within twenty-four hours, even when sometimes death of arsenic ingestors is actually brought about by buses or something else.

One further reply to this counterexample might dispute that (2) correctly expresses the intended law. Suppose we interpret the law as itself *including* a causal claim: eating a pound of arsenic *causes* death within twenty-four hours. If laws are universally quantified generalizations (remember that we are assuming throughout that this is so), how should we represent 'eating 1 lb arsenic at t *causes* death within 24 hours', in such a way that it would retain an explicit causal claim? Perhaps in this way: (x) (x eats at least 1 lb arsenic at t ⊃ x's eating at least 1 lb arsenic at t causes x's death within 24 hours). There may be some other way in which to capture the causal claim in an explicit way within the universally quantified generalization, but I cannot see what it might be.

This generalization *is* falsified by the case in which Jones eats the arsenic but the bus causes his death, so a *ceteris paribus* clause would have to be inserted into it after all. If this is the law, it surely intends to assert that one's eating that much arsenic will cause death, *unless* something else causes it instead. The qualification, 'unless something else causes it instead', would be included in the *ceteris paribus* clause. The law should therefore be expressed as: (2') (x) (x eats at least 1 lb arsenic at t & *ceteris paribus* ⊃ x's eating at least 1 lb arsenic at t causes x's death within 24 hours). The explanatory argument which uses (2') would have to include an additional premiss: (2'') Other things are equal. If the bus and not the arsenic kills Jones, (2'') would be false, and so the argument would fail to be explanatory, on Hempel's own account. Can we conclude then that, on this view of what the law is, the *ceteris paribus* strategy could handle the arsenic-and-bus counterexample to Hempel's account after all?

I think not, for two reasons. First, this strategy is simply not available to Hempel. No supporter (like Hempel) of the orthodox view of laws would accept (2') as giving the correct form for a causal law. Second, there are additional problems about what the explanandum would be which (2') would help to explain; the explanandum certainly would not be as given by (3), 'Jones dies within 24 hours of t'. The explanandum explained by (2') could only be: (3') 'eating at least 1 lb arsenic caused

Jones's death within 24 hours of t'. One might wrongly suppose that this will present no difficulty for Hempel, since (3) follows from (3'). If one explains (3'), and (3) follows from (3'), hasn't one explained (3) as well?

As Peter Lipton has pointed out,[6] this assumption is not available to Hempel. Hempel's D-N model of explanation is itself not closed under logical entailment. Suppose conclusion c is derived from, and explained by, law L and initial conditions i. The disjunction, i or c, logically follows from c. But the explanation of c by the conjunction of L and i cannot, on Hempel's account, be an explanation of i or c, because L is not essential to the derivation of i or c from the conjunction of L and i.

I have no doubt there is *some* way to handle the arsenic-and-bus case, but the introduction of a *ceteris paribus* clause into the law is simply not it. Nor do I think that there are any resources available in Hempel's account as it stands for satisfactorily dealing with it.

The arsenic-and-bus counterexample is interesting for another reason. It provides an additional example of the asymmetry between explanation and prediction. Someone who produces the above argument, (1)–(3), cannot be said to have explained Jones's death, but he certainly will have been able to predict it successfully. He predicts that Jones will die, and his prediction is correct. Moreover, he has offered excellent grounds for his prediction. Given that Jones drank the arsenic, the predictor could be certain that Jones would die. One can predict via a pre-empted cause, even though one cannot explain via one. Any rejoinder which wishes to claim that the above argument yields neither a successful prediction nor a successful explanation will owe us a fuller account of successful prediction than has been, thus far at any rate, provided.

A second example of explanatory irrelevance which constitutes a counterexample to Hempel's analysis of explanation of singular facts is one taken from Wesley Salmon.[7]

1 Every man who regularly takes birth control pills avoids pregnancy.
2 John Jones has taken his wife's birth control pills regularly.
∴ 3 John Jones avoided becoming pregnant in the past year.

The same sort of case can be made out for someone 'who explains the dissolving of a piece of sugar by citing the fact that the liquid in which it dissolved is holy water'. A sentence which states the fact that the sugar dissolved in that liquid can be derived from, but hardly explained by, sentences stating the fact that the liquid is holy water and the relevant law connecting water and the dissolution of sugar. The fact that the water is holy water is not relevant to the explanation of the dissolution. If (1) above is rephrased as a stochastic rather than as a deterministic law, it will serve

as an irrelevance counterexample to the Hempelian account of I-S explanation.

A determined advocate of Hempel's models of explanation might try to insist that the inclusion of explanatorily irrelevant material in the explanans in Salmon's counterexamples might make the explanations poor(er), but that they are still explanations none the less. [Elsewhere] I distinguished between cases in which an explanation is bad and cases in which there is no explanation at all, and . . . I applied that distinction specifically to the example of the inclusion of explanatorily irrelevant information in the explanans. . . .* [For example] that someone is a man who takes birth control pills entails that the person is a man, and the person's being a man explains why that person does not become pregnant, but the person's being a man who takes birth control pills does not explain in the least why the person does not become pregnant.

I agree with Salmon about this. . . . The richer information has the explanatorily relevant information buried in it: its being water is included in its being holy water; the person's being a man is included in the person's being a man who takes birth control pills. But the richer information does not explain some explanandum, just in virtue of the fact that the weaker information which it includes and hence entails does explain it. The additional information which makes it richer but which is explanatorily irrelevant overrides and kills the explanatory power of the weaker information when it is added to it. As Salmon said, irrelevance is *fatal* to explanation.

The examples which I group under (A) all teach the same lesson. There can be derivations which meet all of Hempel's conditions for the explanation of a singular fact, but, whereas they are wonderful derivations, they offer no explanation of what is derived. This is because the premises are explanatorily irrelevant to the conclusion, or contain misleading explanatorily irrelevant additional information, even though they do imply the conclusion. . . .

■ | The Standard Counterexamples: Symmetry

The second reason, (B), for holding that Hempel's conditions could not be sufficient for singular explanation has to do with 'explanatory' symmetries. Hempel's account of singular explanation in terms of derivability from true, empirical premises permits intuitively objectionable cases in

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*Ruben argues for the bad explanation–no explanation distinction and the thesis that adding irrelevant information to the premises of an argument can rob it of all explanatory power in chapters 1 and 5, respectively, of his *Explaining Explanation*, from which the present reading is taken.

which (part of) the explanans can be explained by the explanandum, as well as explain it. How can we amend the account, so that such symmetries of 'explanation' will not arise?

Both James Woodward and Peter Achinstein have argued (or implied) that the explanation relation is not an asymmetric relation, as is usually supposed, and that there are or can be bona fide cases of acceptable symmetrical explanation, explanatory mutual dependence between two singular facts.[8] However, both would of course concede that there are some cases in which symmetrical explanation must be ruled out (i.e. in the case of causal explanation). The explanation relation, even if not asymmetric, is surely not symmetric. If not asymmetric, it must be non-symmetric. This is enough for my argument here. All the examples I shall consider in this part of the chapter are cases in which symmetrical explanations are intuitively unacceptable; I do not need to retain the stronger claim that the explanation relation itself is asymmetric. . . .

There are a number of these 'symmetry' counterexamples which challenge Hempel's account of singular explanation, many of which derive from Sylvain Bromberger and Michael Scriven.[9] We have already touched on some of these examples in the discussion of Hempel. There are really two kinds of cases that generate these unacceptable symmetries. First, there are equations which show that the numerical value assumed by some property of a system at time t is a function of the values assumed by other properties of a system at time t or an earlier time, $t - \Delta$ (Ohm's law, Hooke's law, the Boyle-Charles laws for ideal gases, the length and period of a pendulum).

Second, there are laws with biconditionals, which can include cases both of laws of coexistence and of laws of succession. A barometer falls iff [if and only if] a storm is approaching; the light received from the galaxies exhibits a shift towards the red end of the spectrum iff the galaxies are receding from us; and (Aristotle's case) a planet twinkles iff it is not near. To this, we can add Salmon's confused rooster who explains the rising of the sun on the grounds of his regular crowing.[10] These equations or biconditionals will allow the *derivation* of the height of the flagpole from the length of the shadow and the length of the shadow from the height of the flagpole; the length of the pendulum from its period and its period from its length; the approaching storm from the fall in the barometer as well as the fall of the barometer from the approaching storm; the receding of the galaxies from the red shift as well as the red shift from the recession of the galaxies, the rising of the sun from the crowing of the cock as well as the crowing of the cock from the rising of the sun.

But, in each of these pairs, the first derivation would be nonexplanatory; the second, explanatory. Equations and biconditionals permit symmetric derivations; but since at least these examples do not provide symmetric explanations, there must be more to singular explanation than what Hempel's theory thus far allows.

Hempel, as we saw, 'dealt' with this by suggesting that there may not really be true biconditionals in such cases (he supposed, it will be recalled, that there might be cases of Koplik spots without measles). But what we have to establish is how, given that there may really be true biconditionals or equations of this kind which allow derivations 'in both directions', we are able to distinguish the explanations from the derivations which fail to explain.

■ | A Proposed Cure and Its Problems: The Causal Condition

It is not a novel thought that the cure for the problems of irrelevance and symmetry, (A) and (B), that Hempel's analysis of D-N explanation faces (at least for the explanation of singular facts; explanation of laws would be quite a different matter) is to be found by stipulating that the premises include something about the cause of the event to be explained. This was Aristotle's suggestion . . . for the examples of the [non]twinkling planets and the deciduous vines.* Mill's official theory, which requires that the premises include the statement of a causal law, has similar resources for dealing with the counterexamples. At least some explanations are, on such an account, deductively valid arguments with true premises which have empirical content, one of which is a lawlike generalization (thus far, Aristotle, Mill, and Hempel can agree), but also one of which mentions or specifies in some way the cause of the explanandum event (the final requirement would have to be added to the Hempelian account, but is already explicit in the accounts of the other two).

*Aristotle's two examples of the nontwinkling planets and the deciduous vines can be found in his *Posterior Analytics*, book I, chapter 13, and book II, chapter 16, respectively. Both illustrate Aristotle's distinction between *knowledge of the fact* and *knowledge of the reasoned fact*. Knowledge of the fact occurs when we use a deductive argument with true premises to infer that something is the case. Knowledge of the reasoned fact—*explanatory* knowledge—occurs only when we reason (deductively) from causes to effects, thus yielding knowledge of *why* something is the case. For example, Aristotle believed (falsely, as it turns out) that all and only broad-leaved plants are deciduous. Thus, one could correctly infer that a vine is broad-leaved from the fact that it is deciduous. But knowledge of the reasoned fact occurs only when we infer that a vine is deciduous from the fact that it is broad-leaved. For only in that case, according to Aristotle, would we understand *why* the vine is deciduous. (Aristotle assumes that having broad leaves is what causes a plant to shed its leaves but that shedding of leaves is not what causes a plant to have broad leaves.) In a similar way, Aristotle attributes knowledge of the fact to someone who infers that planets are near the earth from the fact that they do not twinkle, but he attributes knowledge of the reasoned fact to someone who infers that planets do not twinkle from the fact that they are near the earth. (Proximity to the earth causes celestial objects to shine steadily, but their shining steadily does not cause them to be near the earth.)

How would the causal requirement help with the problem of symmetry? Given the angle of the sun's elevation, it is the height of the flagpole that causes the length of the shadow, and not vice versa; the change in atmospheric pressure that causes the rise or fall of the barometer, and not vice versa; the receding of the galaxies that causes the red shift, and not vice versa. The causal requirement will also help with irrelevance. It was the bus but not the arsenic, his being a man but not his taking birth control pills, the substance's being water but not its being holy water, which is causally relevant to the death of Jones, the pregnancy failure, and the dissolution of the sugar. So causation seems a way both to rule out symmetric 'explanations' (anyway, where these are unwelcome) and irrelevant 'explanations'.

One might doubt whether causation will in fact help with irrelevance. Suppose we have a jar in which there is some sugar. We add to the sugar some water appropriately blessed by the local priest. What caused the dissolution of the sugar? In part, its being immersed in the water. But the sample of water just *is* a sample of holy water, so if the immersion in the water caused the dissolution, then the immersion in the holy water caused it. If the immersion in the water not only caused but also explains the sugar's dissolution, doesn't the immersion in the holy water explain it too?

No, for we have distinguished . . . between causation and causal explanation. It is true that the immersion in the water, and hence in the holy water, causes the dissolution of the sugar. But it is the *fact* that it was immersed in the water in the jar that *causally explains* the fact that it dissolved, and even though the water is holy water, the fact that it was immersed in the holy water in the jar is a different fact from the fact that it was immersed in the water in the jar. The fact that it was immersed in the holy water in the jar introduces a feature that the other fact does not introduce. And that additional feature, the water's being holy, is causally irrelevant to the dissolution and hence irrelevant to the explanation of the dissolution. A similar diagnosis will be available in the other cases of explanatory irrelevance we have looked at. The purported explaining facts introduce features which are causally irrelevant to what is being explained.

Many contemporary writers have converged on the necessity of including such a causal requirement. Thus, Salmon, reversing his earlier attempts to explicate explanation on the basis of statistical relations and without mention of causation, says that 'The explanatory significance of statistical relations is indirect. Their fundamental import lies in the fact . . . that they constitute evidence for causal relations', and 'The time has come . . . to put the "cause" back into "because" '.[11] Or, 'To give scientific explanations is to show how events and statistical regularities fit into the causal network of the world' (Salmon 1977: 162). Others, including Baruch Brody, have hit upon the same idea, of supplementing Hempel's account with some sort of causal information.[12]

The difficulty with this otherwise extremely attractive view has been pointed out by Timothy McCarthy.[13] It is easy to construct examples of derivations which meet all of Hempel's conditions, plus the condition that there be a premiss which mentions the actual cause of the event to be explained, but which still fail to be explanatory. McCarthy has given several such examples.

His first example (slightly amended) is this. Let e be any event; let 'D(e)' represent any sentence describing e, and let 'C(e)' be a sentence which describes c, e's actual (and not its pre-empted potential) cause (c is described under its causally relevant description). Let '$(x)(Ax \supset Bx)$' represent any law utterly irrelevant to the occurrence of e. (It won't matter if you want to strengthen the requirement and make the law a causal law). Finally, let o be any object such that Ao. Consider the following derivation:

1 $(x)(Ax \supset Bx)$
2 $C(e)$ & Ao
3 $\sim B(o) \lor \sim C(e) \lor D(e)$
∴ 4 $D(e)$

This derivation of 'D(e)' from premisses (1)–(3) meets all of Hempel's conditions + the suggested causal supplement. e's cause is described by 'C(e)' in premiss (2). Moreover, 'C(e)' is essential to the derivation (as is the law). Yet, no one would say that we have here an explanation of e, because even though c, e's cause, is described in or mentioned by a premiss, it is not made causally and hence explanatorily relevant to e's occurrence. There is still a notion of 'explanatory relevance' that 'derivation + mention of cause of what is to be explained' simply isn't getting at. As McCarthy says,

> One might suppose that the idea is to mirror the causal dependence of e on its cause by the deductive dependence in d [the derivation] of a description of e upon a description of e's cause. That is an interesting idea; immediately, however, we may begin to suspect a gap in the argument. The basic worry may be put in this way: why should it follow, merely because a D-N derivation of a sentence describing e ineliminably involves, in some way or other, a description of e's cause that this description functions in the derivation to show (causally) why e occurs? No obvious reason exists why a D-N derivation of a sentence describing e could not depend on a description of e's cause in some way quite unrelated to the causal dependence of e on that cause. (McCarthy 1977: 161)

McCarthy shows that various attempts to outmanoeuvre this objection will fail. In particular, his argument can be sustained even if an additional

condition due to Kim is imposed.[14] That condition is this: let all the singular sentences in the premisses be put in complete conjunctive normal form.* Then the condition requires that none of those conjuncts is a logical consequence of the explanandum itself. However, the following derivation meets all of Hempel's requirements + the causal requirement + Kim's conjunctive normal form condition. In the derivation below, 'C(o)' describes the cause of o's turning black, which, let us suppose, is o's being immersed in a bucket of black paint.

> 1 All crows are black.
> 2 (x) (y) (x turns the colour of y & y is black $\supset$ x turns black).
> 3 C(o) & Henry is a crow.
> 4 ~C(o)Vo turns the colour of Henry.
> ∴ 5 o turns black.

Even though (1)–(4) meet all of Hempel's requirements + the causal supplement + Kim's condition, no explanation of (5) has been given.

There is surely something right in the demand that 'cause' be put back into 'because'. But what has gone wrong in the above examples? To simplify, in both derivations, call the cause 'c' and the effect to be explained, 'e'. Although it is true that one of the premisses in both of the above derivations says that c occurs, and although it is true that this premiss is essential to the derivation, no premiss asserts, of c, that it is the cause of e. The derivation gets us, as it were, to e's occurrence from c's occurrence, not via the fact that c causes e, but rather via a law irrelevant to c's causing e. There is no connection between c and e other than that of logical derivability of the latter's description from the former's (plus an irrelevant law), and that type of connection simply isn't enough to ensure explanation of the conclusion by the premisses. As McCarthy puts it:

> The reason is precisely that the logical dependence of 'D(e)' on 'C(e)' has nothing at all to do with the causal dependence [and hence the explanatory dependence] of e on the event described by 'C(e)', because the law mediating the deductive relation between 'C(e)' and 'D(e)' is causally irrelevant to the occurrence of e.[15]

* Any truth-functional expression can be reduced to an equivalent expression in conjunctive normal form—that is, to a conjunction of disjunctions where every component of each disjunction is either an atomic proposition or the negation of one. Displaying all the nonlawlike (singular) premisses in this expanded form makes clear whether any part of the content of the explanans is entailed by the explanandum—this being the kind of circularity that Kim's constraint is designed to rule out.

In the note to the preceding sentence, I argue that various further attempts to strengthen the causal requirement, which require that the law not be irrelevant to the occurrence of the effect, will still leave us with non-explanatory derivations.

There is a very simple way to bring the cause and the explanandum event together in the right and relevant way, in order to ensure explanation: not by including as a premiss a singular statement which merely describes or mentions the cause of the explanandum event, e, but rather by including as a premiss a singular statement which asserts, of that cause, that it is the cause of e. *The relevant premiss in McCarthy's arguments would say, for example, not only that c occurs, but also that c is the cause of e.*[16] If this were added, it seems that the derivation would become explanatory. And surely it is this that is lacking in McCarthy's examples, which accounts for the fact that they are not explanatory. This simple and expedient method avoids all the difficulties we have found in trying to capture explanatory dependence or relevance by logical dependence of conclusion on premisses. Explanatory dependence, at least in this example, is captured by an explicit statement of the causal dependence of the effect on the cause. Why just mention the cause in one of the premisses? Why shouldn't a premiss actually assert the causal dependence of explanandum event on explanans event?

I do not think that every such additional premiss must use the word 'cause'. The premiss might assert that e occurs *because* c occurs, or that the *reason* for e is c, or some such.[17] In so far as we are here restricting ourselves to singular causal explanation, all of these will be ways of saying roughly the same thing. The point is this: the premiss under consideration will have to itself assert the dependence of effect on cause, and this dependence cannot be captured by logical dependence. The occurrence of the expression, '. . . is the cause of . . .', although frequently the way in which this is done, is hardly essential (remember that throughout I assume that the descriptions in the causal claim are the ones relevant for explanation); other alternative expressions, like ones which use 'because' or 'is the reason for', and which also capture this sense of non-logical dependence, will do equally well.

However, there are at least two important consequences of this last suggestion that we must note. First, *Hempel's (and Mill's) requirement that there be a lawlike generalization in the premisses which is essential for the derivation is rendered unnecessary.* On the suggestion being canvassed, we have in the argument a premiss that explicitly says: the cause of the explanandum event is such-and-such, and that premiss *by itself* will entail the statement that the explanandum event occurred, without the addition of any further premisses at all. In particular, no premiss stating a universal general fact, no law, will be required for the derivation of the explanandum. So the first consequence is the redundancy of laws in (at least some) explanations.

There is a second important consequence of this suggestion. Why think of explanations as arguments at all? True, we could think of the explanation as an argument with a single premiss:

1 c is the cause of e.

∴ 2 e.

But the derivation of 'e' from 'c is the cause of e' is trivial. It is simpler, and nothing is lost, if we think of this explanation as composed of a singular sentence, 'c is the cause of e' (or, 'e because of c', etc.). Since in fact all of the premisses save this one will be redundant, the explanation really just consists in the one remaining sentence that says that the cause of the event to be explained was such-and-such.

Deductivism and probabilism agreed that *all* full explanations are arguments; if McCarthy's argument and my elaboration of it above are sound, then at least sometimes full explanations are *not* arguments, but sentences. McCarthy's argument, in conjunction with my suggestion for remedying the defect to which it points, does not show that full explanations are *never* arguments; that conclusion would be too strong. But I would go further; *typically*, full explanations are not arguments, but singular sentences, or conjunctions thereof.

Is construing a specific bit of discourse as a sentence rather than an argument simply a matter of personal aesthetic preference on my part? McCarthy's argument and my subsequent remarks were intended to motivate the choice of sentence over argument. The explanation must explicitly include some word like 'because', 'reason', 'causes', etc., and it is just this that the idea of an explanatory argument was meant to avoid, by attempting to capture the dependence which such expressions get at by the idea of deductive or inductive logical dependence of a conclusion on premisses. We have seen how this strategy fails, and have seen that only explicit assertions or statements of the relevant dependence will do. Hence, such explanations typically consist, on my view, of sentences rather than arguments.

Let me mention one not very promising line of reply to this. Is there any *real* difference between an argument theory and a non-argument (or, specifically, a sentence) theory? Isn't the difference between an argument and a sentence theory somewhat superficial? There is, indeed, a way to trivialize the distinction between an argument and a sentence. Any argument can be rewritten as a conditional sentence, with the premisses as the antecedent and the conclusion as consequent. Such a conditional sentence, if true, is necessarily true. The explanatory sentences envisaged by a non-argument theory, if true, are contingently true. Explanations are typically contingently true sentences or conjunctions thereof. The sen-

tence, 'o is G *because* o is F and all F are G', is, if true, contingently true, even though the corresponding assertion of entailment, 'if all F are G and o is F, then o is G', is a necessary truth.

Moreover, any attempt to minimize the difference between an argument theory and a non-argument sentence theory works more to my advantage than to Hempel's. It is a doctrine central to Aristotle's, Mill's, and Hempel's accounts that explanations are arguments. In so far as the distinction between an argument and a sentence is minimized, it is a central doctrine of theirs whose importance is being reduced.

We have, at a sweep, a convincing reason for dismissing any argument theory of explanation, whether deductivist or probabilist. (We still have the choice between certainty, high, and low epistemic probability theories of explanation, the first two being the non-argument analogues of deductivism and probabilism.) In particular, this criticism strikes at the very heart of the Mill-Hempel theory, and the Aristotelian theory of scientific explanation, for all three thinkers held that all full explanations were deductive or inductive arguments. These accounts of explanation not only fail to offer sufficient conditions for full explanation, but more importantly they fail even to provide *necessary* ones. The criticism is not that explanations are not just arguments, but rather arguments plus something more; explanations are, typically, not arguments at all. . . .

If explanations are typically not arguments, what place do laws have in explanation? Can we argue that, since explanations typically are not arguments, therefore explanations typically do not include laws? Although I do believe that many full explanations do not include laws, I do not think that the absence of laws from even some explanations at all follows from the fact that some explanations are not arguments.

The requirement that explanations always include at least one lawlike generalization has been closely bound up with argument theories of explanation. That is to say, if all explanations were deductively valid or inductively good arguments, they would (given the addition of some further uncontroversial assumptions) have to include a lawlike generalization as a premiss.[18] But the inverse is not true; it does not follow from the fact that not all explanations are arguments, that a law is not a part of every full explanation. It only follows that, if laws are a part of full explanations which are not arguments, the idea of their parthood in such cases is not to be cashed out as that of a premiss in an argument. For example, suppose (S) is an explanation of why e happened: (S) 'e occurred because of the fact that c occurred and that whenever a C, an E.' (S) is a sentence, not an argument, and yet it includes the statement of a law.

However, McCarthy's example, in conjunction with my additional remarks about the solution for the difficulty he detects, and Scriven's example below, *also* convincingly show that laws are *not* part of *every* full explanation, in any sense of parthood. The idea that full explanations do

not always include laws (and therefore are not always arguments) is not a novel one. In different ways and from different points of view, Ryle, Scriven, Salmon, and Achinstein (and others too; the list is not intended to be exhaustive) have said this, or similar things, about the role of laws in explanation.[19] For example, in numerous papers, Michael Scriven said things similar to what I would wish to maintain about the role of laws or generalizations in explanation (although I do not need to agree with any of his specific examples). In 'Truisms as the Grounds for Historical Explanations', he defended the view that the following was a perfectly *complete or full* explanation as it stood: the full explanation of why (a) William the Conqueror never invaded Scotland is (b) that 'he had no desire for the lands of the Scottish nobles, and he secured his northern borders by defeating Malcolm, King of Scotland, in battle and exacting homage' (Scriven 1959: 444). The explanation, (b), is a conjunctive statement formed from two singular statements and contains no laws. Explanations which lack laws are 'not incomplete in any sense in which they should be complete, but certainly not including the grounds which we should give if pressed to support them' (p. 446). Notice that Scriven can be taken as making a weaker and a stronger point: (a)'s full explanation, whatever it is, includes or may include no law; (b)—which includes no law—is (a)'s full explanation. I agree with the weaker of Scriven's points; there are some full explanations which do not include laws, and (a)'s full explanation is likely to be such an example. I do not necessarily agree that (b) is (a)'s full explanation. I return to this distinction below.

Scriven's example above is an explanation of a human action. It is sometimes argued in the case of human actions that they are explicable but *anomic* [not governed by laws]. The thought here is rather different. Human actions might be, perhaps must be, nomic, law-governed. The first of Scriven's claims is that although or even if human actions are always nomic, sometimes the laws or 'truisms' which 'cover' them form no part of their full explanation.[20]

Scriven makes it clear that he intends the point as a point about explanation generally, not just as a point about the explanation of human action.

> . . . abandoning the need for laws . . . such laws are not available even in the physical sciences, and, if they were, would not provide explanations of much interest. . . . When scientists were asked to explain the variations in apparent brightness of the orbiting second-stage rocket that launched the first of our artificial satellites, they replied that it was due to its axial rotation and its asymmetry. This explanation . . . contains no laws. (Scriven 1959: 445)

I have been arguing that some full explanations do not include laws. But laws are still important, even to those cases of explanation which do

not include them, in other ways. Indeed, the argument view, by insisting that laws are a part of every full explanation, has tended to neglect the other ways in which laws are important to explanation. Let me add some remarks about how laws are still important for the explanation of the world about us, all consistent with my above claim; the remarks will also permit me to sharpen my view somewhat on the role of laws and generalizations in explanation.

First, to repeat what I mentioned above, I have argued that there are *some* full explanations of which laws form no part, in any sense. But many full explanations do include laws, and this seems to be especially so in the special sciences. Indeed, this is one way in which actual explanations, whether 'ideal' or not, in science and ordinary affairs typically differ. Explanations in science typically include relevant laws, although even when this is so, their inclusion in the explanation will not necessarily be as a major premiss of an argument: 'o is G because o is F and all F are G' is a (contingently true) *sentence* which includes a law, but is not an *argument*.

Second, laws are important for the resolution of many types of puzzlement. Clearly, citation of an appropriate regularity can show that the phenomenon about which I may be perplexed or puzzled is, in any case, not atypical or extraordinary or irregular in any way. Given Mill's view of the epistemic circularity of deduction, it was not easy to see why he thought explanations had to be deductive arguments with at least one lawlike premiss.* One line of response I proposed on his behalf was that what a covering law 'explanation' of, for example, the Duke of Wellington's mortality could do, was to show how the good Duke's mortality fits into a pattern of nature; the deductive 'explanation' places his mortality within the context of a wider generalization, and hence within the context of a uniformity of nature. I believe that Mill was thinking along such lines as these, since explanation for him was always the fitting of facts into ever more general patterns of regularity. But the answer that I gave on his behalf invites the following observation: explaining the Duke's mortality is one thing; fitting his mortality into a more general pattern, however worthy that may be, is something else. To learn that something is not irregular is not the same thing as to explain it. Not all resolutions of puzzlement or perplexity are *ipso facto* explanations.

There is a *third* way in which laws can be important. Does the explanans really fully explain the explanandum? Perhaps it is not adequate to explain it fully; something may be missing. How can I justify my claim that the explanans fully does the job it is meant to do? On Scriven's (1959: 446) view, suppose I claim that the full explanation of e is c. If I am

* In this paragraph, Ruben is referring to his discussion of Mill in chapter 4 of *Explaining Explanation*, from which the present reading is taken.

challenged about the adequacy or completeness of my explanation, I can justify my claim to completeness, and thereby rebuff the challenge, by citing a law (or truism), e.g. that all C are E (c being a C; e being an E). This is what Scriven calls the 'role-justifying grounds' that laws provide, in support of a claim that one has given a full explanation. The law or truism can justify my assertion that c is the full and adequate explanation of e, without being part of that explanation. Although Scriven does not say so, there can be no objection to offering the full explanation and the justification for its fullness in a single assertion, but if this is done, we should be clear that what we have is a full explanation *and* something else, and not just a full explanation.

It is for this reason that I distinguished Scriven's weaker and stronger claims above. I agreed that a full explanation for (a) included no laws, but I did not necessarily agree that (b)—which included no laws—was (a)'s full explanation. The full explanation of o's being G is the fact that o is F, only if it is a law that all F are G, *sans* exception. Suppose the law in question is a more complex law which says: (x) (Fx & Kx & Hx & Jx ⊃ Gx). A full explanation of why o is G would be the fact that o is F&K&H&J. In this way, my view of full explanation is, in at least one way, close to Hempel's, in spite of my rejection of his, or any, argument theory of explanation. Full explanations, on my view as on his, may well be close to ideal things; if almost no one ever gives one, that tells us a lot about the practical circumstances of explanation-giving, but provides no argument whatsoever against such an account of full explanation.

There may be perfectly good pragmatic reasons why we are entitled to give a partial explanation of o's G-ness; it may be that o's being K&H&J is so obvious, that one never needs to say anything more than that o is F. But the law (or 'truism') provides the criterion for what a complete or full explanation is. I do not want to commit myself about the 'fullness' of Scriven's explanation for William's non-invasion of Scotland, since this raises issues about whether there are any laws which 'cover' human actions and which are also expressible in the vocabulary of human action itself, as Aristotle seemed to believe. This would also involve a discussion of how 'truisms', in Scriven's parlance, differ from laws, and I avoid this issue here.[21]

But, to turn to his second example, I am sure that the explanation of the variations in apparent brightness of the orbiting second-stage rocket that launched America's first artificial satellite, in terms only of its axial rotation and asymmetry, cannot be its full explanation. I agree that its full explanation, whatever it is, need not include a law, but since the explanation Scriven offers fails to contain any particular information about, for instance, the source of light that was present, it could not be a full explanation. Scriven's own remarks about the role-justifying grounds that laws provide helps make this very point. The particular explanation Scriven

offers as full can be seen to be only incomplete, not because it does not include a law, but because the law provides the test for fullness which Scriven's explanation fails.

Fourth, on my view, there is still a connection between singular explanation and generality, but not through the presence of a law. Suppose it is argued that the following is a full explanation:[22] (F) object o is G because o is F. It seems to me that someone who insists that this cannot be a full explanation because of the absence of a law has to motivate the thought that (F) could not really be a full explanation, by showing what it is that (F) omits, which is not omitted once a law is added to the explanation. (Recall that we are already assuming that argument theories of explanation have been rejected, so he can't fault the absence of the law on the grounds of non-derivability of explanandum from explanans without it.) He must, I think, say this: the real full explanation is only (FL): object o is G because o is F and (x) (Fx ⊃ Gx).

But can we pinpoint what it is that the law is meant to add to (F)? What has (FL) got that (F) lacks? . . . What matters to explanation are properties.[23] When o's being F fully explains o's being G, it isn't (to put it crudely) that o's being F explains o's being G; there is nothing special about o in any of this. Rather, it is o's *being F* that explains o's *being G*. Explanatory impact is carried by properties and there is generality built into the singular explanation by the properties themselves, without the inclusion of a law. This implicit generality surely implies that other relevantly similar Gs which are F will get the same full explanation that o got.

Of course, there is one obvious sense in which an explanation of o's being G, in terms of o's being F, could be incomplete. The explanation might fail to specify or cite all of the explanatorily relevant properties or characteristics of o. But all of the relevant properties of o can be cited without inclusion of any law generalization.

Suppose, for the sake of argument, that it is an exceptionless law of nature that (x) (Fx ⊃ Gx). In this case, the only property of o, relevant for explaining why o is G, is o's F-ness. In such a case, it seems that o's being G can be fully explained by o's being F. What could the inclusion of the law or generalization add to the explanation that o is G because o is F?

In '(x) (Fx ⊃ Gx)', the only information that could be relevant to the explanation of o's being G is already given by the property linkage between being F and being G which is already expressed by (F). That part of the information in the generalization which is about (actual or possible) Fs other than o which are also G, is simply irrelevant to the explanation of o's being G. In short, everything relevant to the explanation of o's being G is already contained in (F), since that claim already makes the requisite property connection between being F and being G. Assuming that the

generalization can connect properties at all (it is unclear that a generalization can do this, even when strengthened by a necessity operator), what (FL) does that is not done by (F) is to extend the connection to cases other than o. And this can't have any additional explanatory relevance to o's case. The case of temporally and spatially distant F-objects which are G is surely not relevant to o. One might ask about explanation the question Hume asked himself (but believed he could answer) about his constant conjunction theory of causation: 'It may be thought, that what we learn not from one object, we can never learn from a hundred, which are all of the same kind, and are perfectly resembling in every circumstance.'[24]

My view is even more radical than the suggestion . . . that Mill could have considered a type of real explanation, parallel to his account of the fundamental kind of real, non-deductive inference. Such Millian considerations would certainly dispense with the generalization that all F are G, in the explanation of o, which is F, being G. If the manhood of individual persons does not explain their mortality, how could putting all the cases together, as it were, into a generalization, help get explanation off the ground? How could a generalization have some supervenient explanatory power that each instance of the generalization lacks?

Although such a view dispenses with generalizations, it does not dispense with the relevance to o's case of other Fs which are also Gs. This Millian inspired view of explanation would retain, as relevant to the explanation of o's being G, the F-ness and G-ness of other particulars, a, e, i, u, etc. Mill thought that we could (really) infer (and, let us suppose, explain) the Duke's mortality, not from a generalization, but from his resemblance to other individual men who were mortal. Yet, it is hard to see how, if the Duke's manhood cannot explain his mortality, introducing the manhood and mortality of people other than the Duke (whether by a generalization or by the enumeration of other particular instances) could explain it. What is the relevance to the good Duke's mortality of the mortality of men spatially and temporally far distant from him?

On my more radical view, neither the generalization that all Fs are Gs, nor the F-ness and G-ness of other particulars, is required to be any part of the full explanation of o's being G. In the case being supposed, the only fact required for the full explanation of o's being G, is o's being F, even though the generalization, and the explanation of other particulars' G-ness by their F-ness, and so on, are implied or presupposed by the full explanation of o's being G by o's being F. The question Hume asked, quoted above, if it has any bite at all, bites not only against a constant conjunction theory of causation (which brings a generalization into prominence), but even against a weaker theory of causation which makes part of the analysis of an instance of a causal relation information about *any other* individual instances of that causal relation.

■ | Generalizations Get Their Revenge

The above remarks attempt to spell out a number of ways in which laws and generalizations are important for explanation, without necessarily being part of them. There is yet another way, closely connected with the third and fourth ways mentioned above. It is sufficiently important to separate it from the others. . . .

Aristotle, it will be recalled, thought that laws provided the criteria for the selection of the descriptions under which the explanans explains the explanandum. Why did the match light? I struck it, and my striking of the match was, let us suppose, the penultimate thing that ever happened to the match. Or, my striking of the match was the event that caused the match to light. Why, then, can I *explain* the fact that the match lit by the fact that the match was struck, and not by the different facts that the penultimate thing that ever happened to the match occurred, or that the cause of its lighting occurred, even though these three singular facts (the fact that the match was struck, the fact that the cause of the match's lighting occurred, the fact that the penultimate thing that ever happened to the match occurred) are all facts about the same causal event, but differently described? In virtue of which of the features of a cause is the cause fully explanatory of the effect?

Aristotle's reply would be that the explanatory features are the ones linked in a law (whether deterministic or stochastic). To be sure, that strikings of matches are followed by lightings of matches is itself no law, nor any part of a law, of nature. We must therefore extend Aristotle's point, to include not only features linked in a law, but also features nomically connected in the appropriate way in virtue of underlying laws. . . . In virtue of the underlying laws of physics and chemistry, striking and lighting, but not for example being a penultimate occurrence and a lighting, are nomically related. It is not that the laws need be any part of the explanation; rather, the laws provide the criteria for determining under which descriptions one particular explains another (which singular fact explains another). Laws permit selection of the vocabulary appropriate for singular explanation.

The above allows me to make a closely related point about the role of theories in explanation. Scientists often cite theories in explaining a phenomenon. For example: the theory of gravity explains why the moon causes the earth's tides; the law of inertia explains why a projectile continues in motion for some time after being thrown; subatomic particle theory explains why specific paths appear in a Wilson cloud chamber. And theories consist (perhaps *inter alia* [among other things]) of generalizations. But (a) it does not follow that theories are explanatory in virtue of their generality, (b) nor does it follow that the way in which they are explanatory is in all cases by being part of the explanation. I have already

argued for (b). But I now wish to argue for (a). Theories help to explain singular facts, in virtue of supplying a vocabulary for identifying or redescribing the *particular* phenomena or mechanisms at work, which are what explain the explanandum facts.

The examples of 'syllogistic explanation' that I used in my discussion of Mill might have struck the reader as exceedingly artificial: whoever would have thought, the reply might go, that the Duke of Wellington's mortality could be explained by his manhood and the generalization that all men are mortal? And, in admitting that some explanations do include laws (especially in the sciences), I gave this example: 'o is G because o is F and all F are G'. These generalizations are 'flat', in the sense that they are simple generalizations that use the same vocabulary as do the singular explanans and explanandum descriptions. Flat generalizations do not contribute at all to singular explanation.

However, from the fact that flat generalizations are explanatorily useless, it hardly follows that all are. What is needed, so the reply might continue, are generalizations which employ a theoretical vocabulary with greater depth than 'man' and 'mortal'. Perhaps the vocabulary should be in *deeper* terms that refer to the fragility of hydrocarbon-based life forms. To explain why o is G, in terms of o's being F, if a law is to be included, typically a scientific explanation will cite a law with a vocabulary which is different from and deeper than the vocabulary of which 'F' and 'G' are part. Only as such could the generalizations be explanatory.

And such a reply is correct. But it confirms rather than disconfirms my view. If generalizations or laws were always *per se* explanatory, then flat ones ought to help explain (perhaps not as well as deep ones, but they should explain to some extent none the less). The fact that *only* ones that are deep, relative to the vocabulary of the explanans and explanandum singular sentences (in general, theories), will help explain *at all* is an indication that they are explanatory in virtue of offering a deeper vocabulary in which to identify or redescribe mechanisms, but not just in virtue of being generalizations. And even so, to return for a moment to (b), the generalizations that make up the wider or deeper theory may help to explain by offering that alternative vocabulary, and without being part of the explanation itself.

I argued before that often full explanations do not include laws, but that they sometimes do, especially in the special sciences. When laws are included within an explanation, as they sometimes are, the purpose of the inclusion is to introduce a vocabulary different from the one used in the explicit descriptions of the particular explanans and explanandum events. On the one hand, if the less deep vocabulary used to describe the particular phenomena were wholly expendable, the theoretic vocabulary could be explicitly used to describe them, and any mention of the law would be redundant. If on the other hand no deeper vocabulary were available, there would be no purpose for a law to serve. Laws find their honest employ-

ment in singular explanation in situations between the two extremes: when the less deep vocabulary used to describe singular explanans and explanandum is to be retained at that level, but a deeper vocabulary is available, and needs introduction.

One important role that theories play in science is to unify superficially diverse phenomena.[25] In virtue of a unifying theory, what seemed like different phenomena can be brought under one set of deep structural laws:

> By assuming that gases are composed of tiny molecules subject to the laws of Newtonian mechanics we can explain the Boyle-Charles law for a perfect gas. But this is only a small fraction of our total gain. First, we can explain numerous other laws governing the behavior of gases. . . . Second, and even more important, we can integrate the behavior of gases with the behavior of numerous other kinds of objects. . . . In the absence of the theoretical structure supplied by our molecular model, the behavior of gases simply has no connection at all with these other phenomena. Our picture of the world is much less unified. (Friedman 1981: 7)

On my view, there is a difference between unification and explanation. Unification of a phenomenon with other superficially different phenomena, however worthwhile a goal that may be, is no part of the explanation of that phenomenon. If other men's mortality couldn't explain why the good Duke is mortal when his own manhood doesn't, then the fragility of other hydrocarbon-based life forms couldn't explain the Duke's fragility or mortality when his own hydrocarbon constitution doesn't. It doesn't matter, from the point of view of explanation, whether there are any other phenomena which get explained by the deeper vocabulary; the point is that the vocabulary gives a new and more profound insight into the phenomenon at hand, whether or not the vocabulary unifies it with other phenomena.

■ | Notes

1. Ardon Lyon, 'The Relevance of Wisdom's Work for the Philosophy of Science: A Study of the Concept of Scientific Explanation', in *Wisdom: Twelve Essays*, ed. Renford Bambrough, Blackwell, Oxford, 1974, pp. 218–48.

2. Baruch Brody, 'Towards an Aristotelian Theory of Explanation', *Philosophy of Science*, vol. 39, 1972, pp. 20–31.

3. Peter Achinstein, *The Nature of Explanation*, Oxford University Press, New York, 1983. Discussion of this example on pp. 168 and 170–1.

4. The case of causal pre-emption presents some difficulty for any analysis of deterministic and/or nondeterministic causation which makes a cause necessary

in the circumstances for its effect. . . . David Lewis does not think that a nondeterministic cause is necessary in the circumstances for its effect, but he does think that a deterministic cause is. Lewis deals (on p. 191) with the case of pre-emption in 'Causation', reprinted in Ernest Sosa, *Causation and Conditionals*, Oxford University Press, Oxford, 1975, pp. 180–91; his treatment is discussed by William Goosens, 'Causal Chains and Counterfactuals', *Journal of Philosophy*, 1979, pp. 489–95.

5. Michael Redhead suggests this reply in a paper, 'Explanation' (unpublished): '. . . we need to attend to all the relevant circumstances. . . . Again the scientific ideal assumes that all the relevant circumstances are being cited' (p. 5). Redhead's reply to my argument is that I neglect the relevant microphysical circumstances linking the bus, but not the arsenic, with the death. On this sort of view, at best only microphysical explanation will meet Hempel's requirements for explanation.

6. In private discussion.

7. Wesley Salmon, 'A Third Dogma of Empiricism', in *Basic Problems in Methodology and Linguistics*, ed. Robert Butts and Jaakko Hintikka, Reidel, Dordrecht, 1977, pp. 149–66. Readers can learn about the nervous husband and the religious explainer on p. 150. Also section 2 of Wesley Salmon, 'Statistical Explanation', in R. Colodny, ed., *The Nature and Function of Scientific Theories*, University of Pittsburgh Press, Pittsburgh, 1970, pp. 173–231, reprinted in W. Salmon, R. Jeffrey, and J. Greeno, *Statistical Explanation and Statistical Relevance*, University of Pittsburgh Press, Pittsburgh, 1971, pp. 29–88.

8. James Woodward, 'Explanatory Asymmetries', *Philosophy of Science*, vol. 51, 1984, pp. 421–42. See also Evan Jobe, 'A Puzzle Concerning D-N Explanation', *Philosophy of Science*, vol. 43, 1976, pp. 542–9, and Clark Glymour, 'Two Flagpoles are More Paradoxical Than One', *Philosophy of Science*, vol. 45, 1978, pp. 118–19. Peter Achinstein, *op. cit.*, p. 236: 'It is possible to explain the presence of a macro-property by appeal to the presence of an identical micro-property, or vice-versa.' Achinstein does not draw the conclusion explicitly that explanation is not asymmetric, but the conclusion follows from what he does say.

9. Aristotle's example of vines which are deciduous because broad-leaved provides a 'symmetry' counterexample to Hempel's account of the explanation of laws.

10. Wesley Salmon, 'A Third Dogma of Empiricism', p. 150.

11. Wesley Salmon, *Scientific Explanation and the Causal Structure of the World*, Princeton University Press, Princeton, 1984, p. 192, p. 96.

12. Baruch Brody, *op. cit*, pp. 23–4.

13. Timothy McCarthy, 'On an Aristotelian Model of Scientific Explanation', *Philosophy of Science*, vol. 44, 1977, pp. 159–66.

14. Jaegwon Kim 'Discussion: On the Logical Conditions of Deductive Explanation', *Philosophy of Science*, vol. 30, 1963, pp. 286–91. The conjunctive normal form requirement is introduced on p. 288.

15. McCarthy, *op. cit.*, pp. 161–2. Can we strengthen the causal requirements to rule out a McCarthy-style counterexample? In the arguments so far, the law, even though it might be a causal law, is 'irrelevant' to the explanation (although

it is not irrelevant for the derivation). The law may be a causal law, but it does not *join* the cause of the explanandum event with the explanandum event. The law premiss and the description of the explanandum's cause don't mesh together. In McCarthy's example, the law (let's assume that it is an irrelevant *causal* law) was: $(x)(Ax \supset Bx)$, but the description of the explanandum's cause was 'Ce'. As McCarthy says: 'Let "$(x)(Ax \supset Bx)$" represent any law irrelevant to the occurrence of e' (p. 161). In the second example, the law relates blackness and crows, but the cause of o's turning black has nothing to do with the law; the cause of o's turning black is having been immersed in black paint. No law in the derivation related black paint immersion and turning black. Perhaps a bit of tinkering is all that is needed. Can we impose a further requirement, and thereby escape the counterexample to Hempel's theory as supplemented by the causal requirement?

Suppose we impose the additional requirement that not only must there be a premiss essential to the argument which describes C, the particular cause of the event to be explained, but that there also must be a law premiss essential to the argument such that c(o) and the event to be explained, in this case, o's turning black, are covered by *that* law. That is to say, the law itself must not be 'irrelevant'; it must bring together the event to be explained and the cause of that event. Thus, the additional 'relevance' needed can be cashed out as 'the law must be a covering law which covers the token cause and effect mentioned in the explanatory argument'. If there is one law which covers both the token cause and the token effect, the law will be a causal law.

We must not require that the explanandum event and the cause be covered by the *same* law, as the above suggests. This would be too strong, for surely there are occasions on which we can explain an effect by its cause mediately, rather than immediately, via two or more laws. Perhaps we should require that however many laws there are, not only must the premises contain a description of the cause of the event to be explained, but that both the cause and the explanandum event must be covered by relevant laws, which may relate the cause with the effect only mediately, so that the cause and effect can each be covered by a different law. No doubt, at least one of the laws will be a causal law; but it would be too strong to require that all of the 'interconnecting' laws be causal: I can explain the period of a metal pendulum at t' by citing the fact that heat was applied to the pendulum at t, the causal law that heat causes metal to expand, and the (noncausal) law that relates the length and period of a pendulum.

Even this additional condition will not let us deal with McCarthy's third case, which is as follows. I shall first sketch the third example informally, in order to make it fully intuitive. Suppose o's being F causes o to be G. One would imagine that the explanation of o's being G is o's being F, via the *causal* law (for let us suppose that it is a causal law) that whatever is F is G. But, with certain other assumptions about the case, we can construct an argument which meets all of the Mill-Hempel conditions, even supplemented in all the required causal ways I have suggested, but which still fails to explain.

As we have already specified, o's being F causes o to be G. What we are to imagine is a case in which the cause of an event to be explained is also the cause of the prediction of that event: If a machine of type T is brought into contact with an object which is F, the object's being F causes the machine to predict that the object is G, as well as causing the object to be G. Moreover, the machines are to

be of type T, which are 'infallible predictors': if it predicts that an object is G, it follows that the object is G. We can now obtain the following argument, noting that (2) states a causal law:

1 If a machine is of type T and if it predicts that an object is G, it follows that the object is G.

2 If an object is F, and if a machine of type T is in the right relationship with the object, the machine will predict that the object is G.

3 Object o is F.

4 The machine of type T is in the right relationship with object o.
_____
5 Object o is G.

This argument meets all the conditions we have laid down. The premises include essentially a description of the cause of o's being G, namely o's being F. Further, the premises include laws which cover and connect the cause and effect, and at least one of which is a causal law. But still, I believe, the argument is not an explanation of why o is G. The object o is G *because* it is F, and nothing in the derivation reflects this.

16. My suggestion for remedying the difficulty McCarthy points out is taken from, or anyway inspired by, Peter Achinstein, *op. cit.*, pp. 159–62, 188–92.

17. This idea is close to Peter Achinstein's conception of a complete content-giving proposition. I do not believe, though, that any purely grammatical characterization of this idea is possible. See Peter Achinstein, ibid., pp. 28–48, and my review of his book in the *British Journal for the Philosophy of Science*, vol. 37, 1986, pp. 377–84.

18. That there must be a lawlike generalization among the premises in an explanatory argument does not follow simply from the assumption that explanations are arguments, for there are sound arguments with no such premise. But the additional assumptions that would be needed in the case of arguments that are explanations are straightforward and uncontroversial to the question at hand.

19. Gilbert Ryle, ' "If," "So," and "Because" ', in Max Black, ed., *Philosophical Analysis: A Collection of Essays*, Prentice-Hall, Englewood Cliffs, NJ, 1963, pp. 302–18; Michael Scriven, in a series of contributions, but perhaps especially in 'Truisms as the Grounds for Historical Explanations' in *Theories of History*, ed. Patrick Gardiner, Free Press, New York, 1959, pp. 443–75 (see p. 446; page references in the text are to 'Truisms . . .'); Wesley Salmon, 'A Third Dogma of Empiricism', pp. 158–9; Peter Achinstein, *op. cit.*, pp. 81–3, and also in 'The Object of Explanation', in *Explanation*, ed. Stephan Körner, Blackwell, Oxford, 1975, pp. 1–45.

20. See Thomas Nickles, 'Davidson on Explanation', *Philosophical Studies*, vol. 31, 1977, pp. 141–5, where the idea that 'strict' covering laws may be 'non-explanatory' is developed.

21. Scriven's distinction is similar to Donald Davidson's, between homonomic and heteronomic generalizations. See Davidson, 'Mental Events', reprinted in his *Essays on Actions and Events*, Oxford University Press, Oxford, 1980, pp. 207–27; see especially pp. 218–20.

22. Note that I say '. . . that the following is *a* full explanation'. It is no part of my view that there can be at most only one full explanation for a singular fact. To take just one possibility: suppose one wants to explain why o is G. Suppose it is a law that all D are F, and a law that all F are G. The fact that o is G can be fully explained both by the fact that o is F, and the fact that o is D.

23. I do not deny that there can be cases of explanation in which explanatory relevance is borne by names. . . . But I do not deal with these cases here.

24. David Hume, *A Treatise of Human Nature*, ed. L.A. Selby-Bigge, Oxford University Press, Oxford, 1965, p. 88. I think that much of the motivation for the inclusion of a generalization in every full explanation stems from the Humeian analysis of causation.

25. See Michael Friedman, 'Theoretical Explanation', in *Reduction, Time, and Reality*, ed. Richard Healey, Cambridge University Press, Cambridge, 1981, pp. 1–16. See also his 'Explanation and Scientific Understanding', *Journal of Philosophy*, vol. LXXI, 1974, pp. 5–19, and the reply by Philip Kitcher, 'Explanation, Conjunction, and Unification', *Journal of Philosophy*, vol. LXXIII, 1976, pp. 207–12.