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The Truth Doesn't Explain Much

Nancy Cartwright

INTRODUCTION

Scientific theories must tell us both what is true in nature, and how we are to explain it. I shall argue that these are entirely different functions and should be kept distinct. Usually the two are conflated. The second is commonly seen as a by-product of the first. Scientific theories are thought to explain by dint of the descriptions they give of reality. Once the job of describing is done, science can shut down. That is all there is to do. To describe nature—to tell its laws, the values of its fundamental constants, its mass distributions—is *ipso facto* to lay down how we are to explain it.

This is a mistake, I shall argue; a mistake that is fostered by the covering-law model of explanation. The covering law model supposes that all we need to know are the laws of nature—and a little logic, perhaps a little probability theory—and then we know which factors can explain which others. For example, in the simplest deductive-nomological [D-N] version,[1] the covering law model says that one factor explains another just in case the occurrence of the second can be deduced from the occurrence of the first given the laws of nature.

But the D-N model is just an example. In the sense which is relevant to my claims here, most models of explanation offered recently in the philosophy of science are covering law models. This includes not only Hempel's own inductive-statistical model,[2] but also Patrick Suppes's probabilistic model of causation,[3] Wesley Salmon's statistical relevance model,[4] and even Bengt Hanson's contextualistic model.[5] All these accounts rely on the laws of nature, and just the laws of nature, to pick out which factors we can use in explanation.

A good deal of criticism has been aimed at Hempel's original covering-law models. Much of the criticism objects that these models let in too much. On Hempel's account it seems we can explain Henry's failure to get pregnant by his taking birth control pills, and we can explain the storm by the falling barometer. My objection is quite the opposite. Covering law models let in too little. With a covering law model we can explain hardly anything, even the things of which we are most proud—like the role of DNA in the inheritance of genetic characteristics, or the formation of rainbows when sunlight is refracted through raindrops. We cannot explain these phenomena with a covering law model, I shall argue, because we do not have laws that cover them. Covering laws are scarce.

Many phenomena which have perfectly good scientific explanations are not covered by any laws. No true laws, that is. They are at best covered by *ceteris paribus* generalizations—generalizations that hold only under special conditions, usually ideal conditions. The literal translation is "other things being equal"; but it would be more apt to read "*ceteris paribus*" as "other things being *right*."

Sometimes we act as if this does not matter. We have in the back of our minds an "understudy" picture of *ceteris paribus* laws: *ceteris paribus* laws are real laws; they can stand in when the laws we would like to see are not available and they can perform all the same functions, only not quite so well. But this will not do. *Ceteris paribus* generalizations, read literally without the "*ceteris paribus*" modifier, are false. They are not only false, but held by us to be false; and there is no ground in the covering law picture for false laws to explain anything. On the other hand, with the modifier the *ceteris paribus* generalizations may be true, but they cover only those few cases where the conditions are right. For most cases, either we have a law that purports to cover, but cannot explain because it is acknowledged to be false, or we have a law that does not cover. Either way, it is bad for the covering-law picture.

1. CETERIS PARIBUS LAWS

When I first started talking about the scarcity of covering laws, I tried to summarize my view by saying "There are no exceptionless generalizations." Then a friend asked, "How about 'All men are mortal'?" She was right. I had been focusing too much on the equations of physics. A more plausible claim would have been that there are no exceptionless quantitative laws in physics. Indeed not only are there no exceptionless laws, but in fact our best candidates are known to fail. This is something like the Popperian thesis that *every theory is born refuted.* Every theory we have proposed in physics, even at the time when it was most

firmly entrenched, was known to be deficient in specific and detailed ways. I think this is also true for every precise quantitative law within a physics theory.

But this is not the point I had wanted to make. Some laws are treated, at least for the time being, as if they were exceptionless, whereas others are not, even though they remain "on the books." Snell's law (about the angle of incidence and the angle of refraction for a ray of light) is a good example of this latter kind. In the optics text I use for reference (Miles V. Klein, *Optics*),[6] it first appears on page 21, and without qualification:

Snell's Law: At an interface between dielectric media, there is (also) a *refracted* ray in the second medium, lying in the plane of incidence, making an angle θ_t with the normal, and obeying Snell's law:

$$\sin \theta / \sin \theta_t = n_2 / n_1$$

where v_1 and v_2 are the velocities of propagation in the two media, and $n_1 = (c/v_1)$, $n_2 = (c/v_2)$ are the indices of refraction.

It is only some 500 pages later, when the law is derived from the "full electromagnetic theory of light," that we learn that Snell's law as stated on page 21 is true only for media whose optical properties are *isotropic.* (In anisotropic media, "there will generally be *two* transmitted waves.") So what is deemed true is not really Snell's law as stated on page 21, but rather a refinement of Snell's law:

Refined Snell's Law: For any two media which are optically isotropic, at an interface between dielectrics there is a refracted ray in the second medium, lying in the plane of incidence, making an angle θ_t with the normal, such that:

$$sin\ \theta/sin\ \theta_t = n_2/n_1$$

The Snell's law of page 21 in Klein's book is an example of a *ceteris paribus* law, a law that holds only in special circumstances—in this case when the media are both isotropic. Klein's statement on page 21 is clearly not to be taken literally. Charitably, we are inclined to put the modifier "*ceteris paribus*" in front to hedge it. But what does this *ceteris paribus* modifier do? With an eye to statistical versions of the covering law model (Hempel's I-S picture, or Salmon's statistical relevance model, or Suppes's probabilistic model of causation) we may suppose that the unrefined Snell's law is not intended to be a universal law, as literally stated, but rather some kind of statistical law: *for the most part,* at an interface between dielectric media there is *a* refracted ray. . . . But this will not do. For *most* media are optically anisotropic, and in an anisotropic medium there are *two* rays. I think there are no more satisfactory alternatives. If *ceteris paribus* laws are to be true laws, there are no statistical laws with which they can generally be identified.

2. WHEN LAWS ARE SCARCE

Why do we keep Snell's law on the books when we both

know it to be false and have a more accurate refinement available? There are obvious pedagogic reasons. But are there serious scientific ones? I think there are, and these reasons have to do with the task of explaining. Specifying which factors are explanatorily relevant to which others is a job done by science over and above the job of laying out the laws of nature. Once the laws of nature are known, we still have to decide what kinds of factors can be cited in explanation.

One thing that *ceteris paribus* laws do is to express our explanatory commitments. They tell what kinds of explanations are permitted. We know from the refined Snell's law that in any isotropic medium, the angle of refraction can be explained by the angle of incidence, according to the equation $sin\ \theta/sin\ \theta_t = n_2/n_1$. To leave the unrefined Snell's law on the books is to signal that the same kind of explanation can be given even for some anisotropic media. The pattern of explanation derived from the ideal situation is employed even where the conditions are less then ideal; and we assume that we can understand what happens in *nearly* isotropic media by rehearsing how light rays behave in pure isotropic cases.

This assumption is a delicate one. It fits far better with the simulacrum account of explanation . . . than it does with any covering law model. For the moment I intend only to point out that it *is* an assumption, and an assumption which (prior to the "full electromagnetic theory") goes well beyond our knowledge of the facts of nature. We *know* that in isotropic media, the angle of refraction is due to the angle of incidence under the equation $sin\ \theta/sin\ \theta_t = n_2/n_1$. We *decide* for the two refracted rays in anisotropic media in the same manner. We may have good reasons for the decision; in this

case if the media are nearly isotropic, the two rays will be very close together, and close to the angle predicted by Snell's law; or we believe in continuity of physical processes. But still this decision is not forced by our knowledge of the laws of nature.

Obviously this decision could not be taken if we also had on the books a second refinement of Snell's law, implying that in any anisotropic media the angles are quite different from those given by Snell's law. But laws are scarce, and often we have no law at all about what happens in conditions that are less than ideal.

Covering law theorists will tell a different story about the use of *ceteris paribus* laws in explanation. From their point of view, *ceteris paribus* explanations are elliptical for genuine covering law explanations from true laws which we do not yet know. When we use a *ceteris paribus* "law" which we know to be false, the covering law theorist supposes us to be making a bet about what form the true law takes. For example, to retain Snell's unquali- fied law would be to bet that the (at the time unknown) law for anisotropic media will entail values "close enough" to those derived from the original Snell law.

I have two difficulties with this story. The first arises from an extreme metaphysical possibility, in which I in fact believe. Covering law theorists tend to think that nature is well-regulated; in the extreme, that there is a law to cover every case. I do not. I imagine that natural objects are much like people in societies. Their behavior is constrained by some specific laws and by a handful of general principles, but it is not determined in detail, even statistically. What happens on most occasions is dictated by no law at all. This is not a

metaphysical picture that I urge. My claim is that this picture is as plausible as the alternative. God may have written just a few laws and grown tired. We do not know whether we are in a tidy universe or a untidy one. Whichever universe we are in, the ordinary commonplace activity of giving explanations ought to make sense.

The second difficulty for the ellipsis version of the covering-law account is more pedestrian. Elliptical explanations are not explanations: they are at best assurances that explanations are to be had. The law that is supposed to appear in the complete, correct D-N explanation is not a law we have in our theory, not a law that we can state, let alone test. There may be covering law explanations in these cases. But those explanations are not our explanations; and those unknown laws cannot be our grounds for saying of a nearly isotropic medium, "$\sin \theta_t \backsim k\ (n_2/n_1)$ because $\sin \theta = k$."

What then are our grounds? I assert only what they are not: they are not the laws of nature. The laws of nature that we know at any time are not enough to tell us what kinds of explanations can be given at that time. That requires a decision; and it is just this decision that covering law theorists make when they wager about the existence of unknown laws. We may believe in these unknown laws, but we do so on no ordinary grounds: they have not been tested, nor are they derived from a higher level theory. Our grounds for believing in them are only as good as our reasons for adopting the corresponding explanatory strategy, and no better.

3. WHEN LAWS CONFLICT

I have been maintaining that there are not enough covering laws to go around. Why? The view depends on the picture of science that I mentioned earlier. Science is broken into various distinct domains: hydrodynamics, genetics, laser theory, . . . We have many detailed and sophisticated theories about what happens within the various domains. But we have little theory about what happens in the intersection of domains.

Diagrammatically, we have laws like

$$\text{\textit{ceteris paribus,} } (x)\ (S(x) \subset_{\rightarrow} I(x))$$

and

$$\text{\textit{ceteris paribus,} } (x)\ (A\ (x) \subset_{\rightarrow} \neg I(x)).$$

For example, (*ceteris paribus*) adding salt to water decreases the cooking time of potatoes; taking the water to higher altitudes increases it. Refining, if we speak more carefully we might say instead, "Adding salt to water while keeping the altitude constant decreases the cooking time; whereas increasing the altitude while keeping the saline content fixed increases it"; or

$$(x)(S(x)\ \&\ \neg A(x) \subset_{\rightarrow} I(x))$$

and

$$(x)(A(x)\ \&\ \neg S(x) \subset_{\rightarrow} \neg I(x))$$

But neither of these tells what happens when we both add salt to the water and move to higher attitudes.

Here we think that probably there is a precise answer about what would happen, even though it is not part of our common folk wisdom. But this is not always the case. . . . Most real life cases involve some combination of causes; and general laws that describe what happens in these complex cases are not always available. Although both quantum theory and relativity are highly developed, detailed, and sophisticated, there is no satisfactory theory of relativistic quantum mechanics. . . . The general lesson is this: where theories intersect, laws are usually hard to come by.

4. WHEN EXPLANATIONS CAN BE GIVEN ANYWAY

So far, I have only argued that covering laws are scarce, and that *ceteris paribus* laws are not true laws. It remains to argue that, nevertheless, *ceteris paribus* laws have a fundamental explanatory role. But this is easy, for most of our explanations are explanations from *ceteris paribus* laws.

Let me illustrate with a humdrum example. Last year I planted camellias in my garden. I know that camellias like rich soil, so I planted them in composted manure. On the other hand, the manure was still warm, and I also know that camellia roots cannot take high temperatures. So I did not know what to expect. But when many of my camellias died, despite otherwise perfect care, I knew what went wrong. The camellias died because they were planted in hot soil.

This is surely the right explanation to give. Of course, I cannot be absolutely certain that this explanation is the correct one. Some other factor may have been responsible, nitrogen deficiency or some genetic defect in the plants, a factor that I did not notice or may not even have known to be relevant. But this uncertainty is not peculiar to cases of explanation. It is just the uncertainty that besets all of our judgments about matters of fact. We must allow for oversight; still, since I made a reasonable effort to eliminate other menaces to my camellias, we may have some confidence that this is the right explanation.

So we have an explanation for the death of my camellias. But it is not an explanation from any true covering law. There is no law that says that camellias just like mine, planted in soil which is both hot and rich, die. To the contrary, they do not all die. Some thrive; and probably those that do, do so *because* of the richness of the soil they are planted in. We may insist that there must be some differentiating factor which brings the case under a covering law: in soil which is rich and hot, camellias of one kind die; those of another thrive. I will not deny that there may be such a covering law, I merely repeat that our ability to give this humdrum explanation precedes our knowledge of that law. On the Day of Judgment, when all laws are known, these may suffice to explain all phenomena. But in the meantime we do give explanations; and it is the job of science to tell us what kinds of explanations are admissible.

In fact I want to urge a stronger thesis. If, as is possible, the world is not a tidy deterministic system, this job of telling how we are to explain will be a job which is still set

when the descriptive task of science is complete. Imagine for example (what I suppose actually to be the case) that the facts about camellias are irreducibly statistical. Then it is possible to know all the general nomological facts about camellias which there are to know—for example, that 62 percent of all camellias in just the circumstances of my camellias die, and 38 percent survive.[7] But one would not thereby know how to explain what happened in my garden. You would still have to look to the *Sunset Garden Book* to learn that the *heat* of the soil explains the perishing, and the *richness* explains the plants that thrive.

5. CONCLUSION

Most scientific explanations use *ceteris paribus* laws. These laws, read literally as descriptive statements, are false, not only false but deemed false even in the context of use. This is no surprise: we want laws that unify; but what happens may well be varied and diverse. We are lucky that we can organize phenomena at all. There is no reason to think that the principles that best organize will be true, nor that the principles that are true will organize much.

NOTES

1. See C. G. Hempel, "Scientific Explanation," in C. G. Hempel (ed.), *Aspects of Scientific Explanation* (New York: Free Press, 1965).
2. See C. G. Hempel, "Scientific Explanation," ibid.
3. See Patrick Suppes, *A Probabilistic Theory of Causality*

(Amsterdam: North-Holland Publishing Co., 1970).

4. See Wesley Salmon, "Statistical Explanation," in Wesley Salmon (ed.), *Statistical Explanation and Statistical Relevance* (Pittsburgh: University of Pittsburgh Press. 1971).

5. See Bengt Hanson, "Explanations—Of What?" (mimeograph, Stanford University, 1974).

6. Miles V. Klein, *Optics* (New York: John Wiley & Sons, 1970), p. 21, italics added. θ is the angle of incidence.

7. Various writers, especially Suppes (footnote 3) and Salmon (footnote 4), have urged that knowledge of more sophisticated statistical facts will suffice to determine what factors can be used in explanation. I do not believe that this claim can be carried out. . . .