CHAPTER 3

Eight Other Questions about Explanation

Angela Potochnik

1. Introduction

Philosophical accounts of scientific explanation are by and large categorized as law-based, unification, causal, mechanistic, etc. This type of categorization emphasizes one particular element of explanatory practices, namely, the type of dependence that is supposed to do the explaining. This question about scientific explanations is: in order for *A* to explain *B*, in what way must *A* account for *B*? Various philosophers have answered this question with the suggestion that, to explain, *A* must account for *B* according to natural law, or by reduction to an accepted phenomenon, or in virtue of causal dependence, or by mechanistic production, etc. Accordingly, students of philosophy of science are introduced to the deductive-nomological account, the unification account, various causal accounts, the mechanistic account, etc.[1] In recent years, causal accounts and

[1] This categorization is of course not exhaustive, and it conceals a great deal of variety, for instance in how causes are to be understood for a causal account of explanation. What is important for present purposes is simply the element of explanatory practices that such a categorization focuses upon, namely, what form of dependence is explanatory. This construal is more commonly attached to causal and mechanistic accounts of explanation than to unification or D-N accounts, but I believe it suits the latter accounts as well. Friedman (1974), a prominent advocate of a unification account, articulates the question of explanation as that of the

mechanistic accounts, which also require causal dependence, have enjoyed broad appeal.

There are, of course, many other features of explanatory practices aside from the type of dependence that counts as explanatory. And philosophers disagree significantly about the nature of some of these other features as well. But those disagreements tend to be formulated as downstream issues about a particular account of explanation. In other words, the defining feature of an account of explanation is typically the posited form of explanatory dependence – is it a causal account, a law-based account, or something else? Only once this is settled do most philosophers consider other elements of explanatory practices. For example, one might embrace Woodward's version of a causal account of explanation, where causation is understood in terms of difference-making and invariance is taken to be explanatorily important. This leads to an emphasis on the value of general explanations like the ideal gas law (see Woodward 2003). Or one may embrace Salmon's version of a causal account of explanation, where causation requires mark-transmission and the explanatory value of causal processes is taken to be central (see Salmon 1984). This disqualifies some of the explanations that Woodward emphasizes, including the ideal gas law (or, at least, that is Salmon's view). In light of the prevailing philosophical focus on the type of explanatory dependence, though, these deep disagreements are treated as ancillary

---

relation between the phenomenon explained and the phenomenon doing the explaining. The D-N requirement of citing a natural law also coheres with this construal; that amounts to the requirement that *A* account for *B* in virtue of natural law.

concerns that merely distinguish different varieties of the causal account of explanation.

Overemphasis on this single element of explanatory practices has, I believe, eclipsed the significance of several other features of scientific explanations and philosophical disagreements about those features. In this paper I articulate eight such features and some of the philosophical views about each. I note dependencies among views of different features of explanation where those exist. But by and large, these are eight distinct and independent questions that can be posed about the nature of scientific explanation – or nine questions, if we include the question about the explanatory dependence relation(s). The purpose of this paper is not to develop an account of explanation, or to defend any one conception of these features. Instead, the aim is to further philosophical debate about the nature of scientific explanation by distinguishing among relatively independent features of explanatory practices and, for each, clarifying what is at issue. These various features of explanation fall roughly into three categories, reflected in the following three sections. There are questions to be asked about the role of human explainers in the project of scientific explanation (§2); representational questions about what explanations should actually be formulated and the relationship those explanations bear to other scientific projects (§3); and finally, ontological questions surrounding what, out in the world, explains (§4). This last category includes the classic question of what form of dependence is explanatory, but it includes other questions as well.

Philosophical progress does not always involve resolving the main dispute. My aim in this paper is to contribute to a different kind of progress, namely, drawing attention to philosophical questions about scientific explanation that are distinct from whether all explanations require citing causal dependences, and other questions about the nature of explanatory dependence. It is in that sense that this is a paper about explanation beyond causation. I hope this results in the identification of features of explanation that have not been sufficiently explored; clarification of what is at stake between opposed views about those features; and thus the development of a more nuanced understanding of the philosophical issues surrounding scientific explanation. I believe there are at least eight questions to ask about scientific explanation, aside from whether causal dependence relations are always or ever explanatory. Let us now consider them.

2. Human Explainers

I begin by exploring open issues regarding human explainers. This may seem odd, given the overwhelming emphasis in the literature on the explanatory dependence relation, a question about ontology. But, as will become clear further below, I do so for a principled reason. There are two kinds of questions about human explainers. First, one can ask how the people doing the explaining, and the audiences for those explanations, influence explanatory practices. Second, one can ask to what degree those influences are relevant to a full-fledged account of explanation. I will begin with the latter question, whether philosophical accounts of explanation should address human influences on explanatory practices.

Question 1: Priority of Communication

A debate has recently emerged, or perhaps been revived, surrounding the so-called ontic versus communicative senses of explanation. This is at root a debate about the significance, or lack thereof, of human explainers to a philosophical account of scientific explanation. Proponents of an ontic or ontological approach to explanation judge the important features of scientific explanation to be independent of human influences. This includes independence from who in particular is doing the explaining, as well as the fact that all explanations are formulated by humans. A position like this has been advocated at different times and in different contexts by David Lewis (1986), Wesley Salmon (1989), Michael Strevens (2008), and Carl Craver (2014), among others. Other philosophers have adopted the opposed view that human explanatory practices must be the starting point for any account of explanation. Notable instances of this view include Sylvain Bromberger's (1966) treatment of why-questions, Bas van Fraassen's (1980) pragmatic account of explanation, and Peter Achinstein's (1983) illocutionary account. In contrast to a primarily ontic or ontological approach, one might think of these views collectively as a communicative approach to explanation. They all focus substantially on the communicative roles explanations are formulated to play, and look there for insight into the nature of scientific explanation. I have also motivated a communicative approach to explanation (see Potochnik 2015, forthcoming b). Ontic and communicative approaches thus provide two different answers to the question about the priority of communication to an account of explanation: the former judges the specificities of human

explainers to be irrelevant to a philosophical account of explanation, the latter takes them to be central.

One role of human explainers is wholly uncontroversial. Humans, and particular individuals at that, are responsible for formulating the requests for explanation. This means that human characteristics and idiosyncrasies find their way into what *explananda* are targeted by scientific explanations – that is, what events scientists attempt to explain and how those events are characterized. Some think this influence extends also to a more fine-grained characterization including not only the event to be explained, but also the alternative state of affairs the event is to be contrasted with, often referred to as the explanandum's contrast class. According to a contrastive approach to explanation, different explanations are warranted when explaining why a car crashed at night rather than not crashing at all, versus why a car crashed at night rather than crashing during the day.

From an ontic perspective, once the explanatory agenda is set (the explanandum specified, and perhaps the contrast class as well), the proper human influence on scientific explanations has been exhausted. All the remaining work is done by an account of explanatory dependence. The explanatory agenda simply determines what, out in the world, explains a given event. From a communicative perspective, in contrast, this is just the tip of the iceberg. Human influences on scientific explanations are taken to extend beyond setting the explanatory agenda, in one way or another influencing which explanation satisfactorily accounts for some explanandum and contrast class. For example, on van Fraassen's (1980) account, human characteristics and concerns also influence the explanatory

relation itself, that is, the relationship an explanation should bear to the event to be explained.

If human explainers, their interests and idiosyncrasies, are taken to be central to the enterprise of explaining, then other questions are raised about the relationship an explanation must bear to its audience, and what is required for an explanation to succeed in explaining. For this reason, much of what I say below about the other questions about human explainers presupposes a communicative approach to explanation. One can certainly recognize additional questions about human explainers without adopting a communicative approach to explanation. It's just that, from an ontic perspective on explanation, these further questions will tend to be seen as unimportant to philosophical questions about scientific explanation. For instance, Lewis (1986) dismisses questions around the "pragmatics" governing explanation as not distinctive questions for scientific explanation, but questions about human discourse in general. Similarly, a proponent of an ontic approach may take there to be interesting questions about the psychology of explanation, but deem these incidental to a philosophical account of explanation.

Question 2: Connection to Understanding

Another question about the human element of explanation that has recently received more attention is the nature of the relationship between explanation and understanding. The basic question is whether explanation and understanding are inextricably linked. One might wonder whether any explanation must result in

understanding in order to succeed. And one might wonder whether any and all understanding must issue from an explanation.[2]

Consider, first, the question of whether an explanation is necessary for understanding. Peter Lipton (2009) has argued that understanding can be possessed in circumstances in which we would hesitate to say there is an explanation. One such circumstance is understanding via tacit causal knowledge gained from images, the use of physical models, or physical manipulations. Lipton also argues that understanding can emerge from examining exemplars, or from modal information. In his view, none of these sources of understanding are of the right sort to give rise to *explanations* of the phenomena they help one understand. This is because, according to Lipton, an explanation must be able to be communicated, at least to oneself (so cannot be tacit), and must contain information about the object of understanding, that is, about why something in fact came about (which modal information arguably does not). Notice that the first of these requirements presumes something about the human element of explanation, namely, that any scientific explanation must play the proper communicative role.

Strevens (2013), in contrast, argues that there is no understanding but by way of explanations. In his view, understanding a phenomenon just is to grasp a correct explanation of that phenomenon. Strevens responds directly to some of Lipton's purported cases of understanding without explanation. He disputes Lipton's claim that explanations must be explicit, able to be communicated; in his

[2] De Regt (2013) provides a nice summary of the debate surrounding these questions.

view, tacit understanding simply arises from grasping a tacit explanation. Strevens and Lipton thus disagree about a prior issue, namely the significance of the communicative sense of explanation. As we have already seen, Strevens adopts an ontic approach, deeming the communicative purposes of explanations unimportant to an account of explanation. Strevens also argues that, when something tacit like physical intuition is the source of understanding, this understanding arises only in virtue of the *accuracy* of the physical intuition. He says, of a particular example, "it amounts to genuine understanding why, I suggest, only insofar as the psychologically operative pretheoretical physical principles constitute a part of the correct physical explanation" (see Strevens 2013: 514). For Strevens, it is precisely the ontic element of explanations – that they track an explanatory dependence relation – that is supposed to fill the gap between intuition and legitimate explanation.

Besides this debate of whether explanation is necessary to generate understanding, there is also a question of whether any explanation must be sufficient to produce understanding. Can there be a (successful) explanation that does not generate understanding, or that does not even have the potential to do so? This question seems to not often be addressed explicitly, at least not as formulated here. But a position on the issue is suggested by those who affirm the importance of an account of explanation accounting for the production of understanding. This move is one way of affirming the importance of an explanation connecting in the right way to its human audience. For example, Hempel (1965) motivated the classic deductive-nomological account of explanation with the idea that

deductions from laws of nature show that "the occurrence of the phenomenon was to be expected," and that "it is in this sense that the explanation enables us to understand why the phenomenon occurred" (337). Explanatory dependence relations out in the world are clearly insufficient for producing understanding. To generate understanding, information about those relations must be communicated to an audience, and must be communicated in a way that leads to the cognitive achievement of understanding. The opposite view on this question – that explanations need not generate understanding – seems to follow from a strongly ontic approach to explanation, where explanations exist out in the world, even if they are never identified or communicated.

Question 3: Psychology of Explanation

A third topic that relates to human explainers is the psychology of explanation. Explanation in general and scientific explanation in particular is a topic of empirical research in cognitive psychology. That research aims to uncover the cognitive roles played by explanation, and what features accepted explanations tend to possess. For example, Lombrozo (2011) surveys empirical research suggesting that the act of explaining improves learning of general patterns and causal structure. She also discusses research suggesting a broad preference for simple explanations and explanations that are highly general. Philosophical accounts of explanation can differ in the degree of importance they attach to the psychological elements of explanation, the type of relevance those psychological

elements are supposed to have, and (if relevant) which psychological elements of explanation they take to be significant.

If the communicative roles explanations play are taken to be central to the nature of explanation, then why and how explanations are in fact formulated is directly relevant to a philosophical account of explanation. On this approach explanations cannot succeed without being accepted as explanatory, so what features humans value in explanations and explanations' cognitive purposes influence the features explanations should possess. Some advocates of a strongly ontic approach to explanation instead hold that the important features of explanation are independent of the features of those formulating and receiving explanations. In that case, research into the psychology of explanation is at most indirectly relevant to the norms of explanation. Our intuitions about what is explanatory may track the norms of explanation, but they cannot influence them.

3. Explanations as Representations

A second category of philosophical questions about scientific explanation regards representation. As with human explainers, one can ask what relevance representational decisions have to a philosophical account of scientific explanation. And, as with the first category of questions, granting a role for questions of representation introduces downstream questions, such as what should be represented in an explanation, and with what fidelity. These are questions about the role that abstraction and idealization should play in scientific explanations. Finally, as I discuss below, debate about the representational

features of explanation relates also to questions about the relationship between explanation and other scientific aims.

Question 4: Priority of Representation

Just as one can question whether human explainers and explanations' communicative and cognitive roles shape scientific explanations in a philosophically significant way, so too one can ask whether representational decisions shape scientific explanations in a way that is central to providing a philosophical account of explanation. Since representational decisions can be made for purposes of improved communication or cognition, these two questions may be related, and I suspect they have sometimes been conflated. But some who embrace an ontological approach to explanation afford a central role in an account of explanation to representational decisions, but not for communicative or cognitive purposes. A prime example is Strevens' (2008) kairetic account of explanation. Strevens develops what he calls a two-factor account of explanation. The first factor is an account of the type of metaphysical dependence relation that can be explanatory, and the second factor is a separate account that determines which facts about such relations belong in any given explanation. This second factor is at least in part a question of representation. Evidence of this is that a central feature of Strevens' account is the determination of the right degree of generality, or abstractness, of an explanation. This is a matter about how to represent the world – with greater or less detail. Indeed, in Strevens' view, citing a general law simply is to cite the underlying physical mechanism, but the former is

a better explanation (see Strevens 2008: 129-130). The difference can't be metaphysical, then, but representational.

And so, within an ontological (versus communicative) approach to explanation, there is still a question of primacy to an account of explanation of facts out in the world or how we go about representing those facts. Some proponents of an ontological approach think that the ontological side – the nature of explanatory dependence relations – is where all of the work, or at least all of the important work, is located. For a good example of this, see Craver (2014). Others, like Strevens, think there are significant questions about how the explanatory dependence relations are represented.

Also analogous to, but distinct from, the case of the ontological/communicative divide is the question of whether the ontological dimension of explanation is always "upstream" from, that is logically prior to, to any representational dimension of explanation. This can be understood as the question of what needs to be settled first in order to get traction on any other questions about explanation. On this I believe Strevens and Craver would agree: the type of explanatory dependence, and the nature of that dependence in some particular phenomenon to be explained, must be settled first. Put another way, their view is that making true claims about explanatory dependence is the primary determinant of the content of explanations. Arnon Levy (draft) suggests, against this kind of a view, that the "goodness" of an explanation might be enhanced by sacrificing some truth. This might be so if explanations can be improved by

incorporating idealizations, or assumptions recognized as false.[3] One such view is advocated by Robert Batterman (see, e.g., Batterman 2002, 2009). He argues that one central form of explanation, what he calls asymptotic explanation, is impossible without idealization. If this is right, it requires granting that some questions about *how* our explanations should represent must be settled prior to – or at least independently from – what, out in the world, they should represent.

Question 5: The Representational Aims of Explanation

The weaker claim articulated above about the representational features of explanations is that those features can be distinctive and warrant consideration, even if they are "downstream" from explanations' ontological features. If one grants at least this much, then this introduces questions about what, and how, the explanations generated in science should represent. In particular, when (if ever) should explanations represent more abstractly, by including less detail, and when (if ever) should explanations represent less accurately, by including idealizations? If one holds the stronger view that the representational requirements for explanation can influence explanations' ontological features, then this opens up additional possibilities for when explanations should omit or falsify some details. Views abound about the role of abstraction and idealization in scientific explanations; some of those views suggest this weaker commitment regarding the representational features of explanation, whereas others require the stronger.

[3] Strevens (2008) has a view of idealizations' explanatory role that does not stray in this way from a fully ontological approach to explanation.

Consider first the matter of an explanation's abstractness. Is more detail (about explanatorily relevant dependence) always better than less detail? Or are explanations ever improved by omitting information? The issue is a bit subtle, as much rides on what is built into the determination of "explanatorily relevant dependence." This is an ontological issue, and as such, I'm postponing it until the next section. Strevens' view again provides an illustration of both the subtlety and also a position on the question of abstraction. At first glance, Strevens' answer is, definitively, that explanations should leave out lots of information. For him, the raw material of explanations is causal entailment; this is the first factor in his two-factor account. But then there's a question of which representations of causal entailment are most explanatory; answering this is the job of the second factor. Strevens argues that only causal factors that are difference-makers (in his sense) should be included in an explanation; this results in explanations with the right degree of generality and abstractness.

But this doesn't fully settle the issue, as there's still a question of how many difference-making factors an explanation should feature. Should explanations be "elongated," that is, expanded to include factors that made a difference to the cited difference-making factors? Should explanations be "deepened," that is, expanded to include a physical explanation for any high-level laws that are cited? Both of these are ways of incorporating additional details and, thus, making explanations less abstract, but they are distinct issues from each other, and distinct also from the first way in which Strevens thinks explanations should be abstract. Strevens' answers are that elongation is optional but it

improves an explanation, and that deepening is compulsory (see, e.g., 2008: 133). However, this is not so for "causal covering-laws," such as the kinetic theory of gases, since as I mentioned above, Strevens thinks that citing such a law is the same thing as citing the underlying physical mechanism (129-130).

I said that Strevens' view illustrates not only how one might take abstractness to be a desirable feature of explanations, but also the subtlety of the issue. Strevens encourages abstract explanations in one sense (omitting non-difference-makers), while allowing them and prohibiting them in two other senses (non-elongated explanations and non-deep explanations, respectively). As for the subtlety of the issue, it is difficult to determine which of these positions concerns the question of what things are explanatory (i.e., the ontological element of explanation) and which, if any, concerns the question of how explanatory things should be represented. That non-difference makers should always be omitted seems to be an ontological question of what facts about the world are explanatory; Strevens holds that only difference-makers (in his sense) explain. Yet the matter is murkier for his positions regarding elongation and depth. Elongation seems to be a question of how many of the explanatory dependence relations to represent, so perhaps this issue is not ontological but representational. I find the requirement of depth to be more puzzling still. Strevens claims that this requirement is "quite consistent with a high degree of abstraction" (130), and that an abstract causal covering-law is, from an ontological perspective, one and the same explanation as the physical mechanism(s) underpinning it. He says the former has a "communicative shortcoming" but not an "explanatory shortcoming" (131). But

this suggests that determination of difference-making is, for Strevens, not purely an ontological matter after all. A causal covering-law omits information about the underlying physical mechanism because those details are not difference-makers. But the ontological explanation provided by a causal covering-law is supposed to be the same as what would be provided by citing the underlying physical mechanism. The determination of difference-making seems, then, to regard not the ontological explanation but what details are included – that is, *represented* – in a causal model.

There are, of course, other views about how abstract explanations should be. Like Strevens', these other views are by and large developed within the structure of particular accounts of the explanatory dependence relation. But it needn't be so. One might bracket the issue of the nature of explanatory dependence by approaching the issue of explanations' abstractness from the perspective of existing explanatory practices and findings about explanation from cognitive psychology (introduced as Question 3 above).

Let's move on to the issue of explanations' fidelity, that is, whether explanations can and should include idealizations. As I mentioned above, one notable advocate of idealized explanations is Batterman (2002, 2009). Batterman argues that there is an important style of explanation, what he calls asymptotic explanation, that relies essentially on the use of idealizations. Roughly, the idea is that explanations of how phenomena behave as they approach a limit are enabled by idealizing parameters as having an extreme value of zero or infinity. If this is right, some explanations are impossible without including idealizations. In

contrast, Norton (2012) acknowledges the importance of this style of explanation, but he disputes the claim that setting a parameter to zero or infinity is an idealization; he takes these simply to be approximations. Like Batterman, Strevens also defends the explanatory value of idealizations, but he limits their role to standing in for non-difference-makers, thereby expressing what did *not* make a difference to the phenomenon. Alisa Bokulich (2011) endorses a position somewhat between these views, for she argues that "fictionalized" representations can explain, but that they do so by correctly capturing the explanatory counterfactual dependence. It's worth pointing out that Bokulich takes such explanations to be non-causal in virtue of the fictions they incorporate, because in her view fictional entities cannot have causal powers. This is a view about the ontological question of explanatory dependence that is informed by a position regarding the representational question of idealized explanations, rather than the other way around.

Many other philosophers have views about idealizations' role in explanation, but I will mention my own view as a final example, since I take it to contrast nicely with Strevens' and to exemplify a view of the relationship between communicative, representational, and ontological elements of explanation opposed to his. I think explanations employ idealizations not only to signal what did not make a difference to the phenomenon, but also (and more commonly) to signal that researchers' interests lie elsewhere (Potochnik, forthcoming a). Adopting for the nonce Strevens' view of the explanatory dependence relation, even important difference-makers might be idealized away in order to simplify an

explanation and draw attention to other difference-makers, the ones in which those formulating the explanation are primarily interested. This reverses the priority of communicative and ontological features of explanation. In my view it is the communicative or psychological needs of an explanation's audience that determines what should be veridically represented and what should be omitted or falsified, and that determination in turn sheds light on what sort of dependence is explanatory. I will not defend this idea here; I simply mention it as an alternative view of the explanatory role of idealizations.

Question 6: Relationship to Other Scientific Aims

Another question about scientific explanation regards its role in the scientific enterprise. In particular, one might wonder how explanation relates to other scientific aims. For example, Heather Douglas (2009) argues that the role of explanation in generating good predictions has been overlooked, and that this has weakened accounts of explanation. She says that explanations are a cognitive tool to aid in generating predictions, for they "help us to organize the complex world we encounter, making it cognitively manageable" (54). In direct opposition to this idea, I have argued that different scientific aims, including explanation and prediction, motivate different types of scientific activities and products (see Potochnik 2010a, 2015b, forthcoming a). On this view, a perfectly good explanation, such as an explanation that idealizes many important causal influences in order to represent the causal role of just one kind of factor, may be poorly suited as the basis for making predictions.

One might wonder why I include this in a list of questions about representational features of explanation. For one thing, notice that the two views I briefly characterized both regard explanations in their representational sense. Douglas's description of explanations as cognitive tools clearly is not about what facts out in the world are explanatory, but the useful ways in which scientists represent those explanatory facts. Only facts that are known and represented can be cognitive tools. Similarly, my contrasting view is not a view about the ontological dimension of explanation: whatever dependencies are explanatory presumably are also helpful in the formulation of predictions. The question is whether explanations actually formulated should also lend themselves to generating accurate predictions. A view on this issue will have implications for the kind of representations our explanations should be, including their abstractness and fidelity. If explanations should support accurate predictions, then they must be accurate enough, and specific enough, about the full range of the applicable dependence relations to play this role. A strong view of the explanatory role of idealization thus commits me to a division between explanation and other scientific aims, including prediction.

4. Ontic Explanations

The third category of philosophical questions about scientific explanation I will discuss regards ontology. As with human explainers and the representational form of explanations, the two categories of questions discussed above, there is a

question of how central the ontological dimension of explanatory practices is to a philosophical account of explanation. There are also questions about the nature of this ontological dimension, that is, the form(s) of explanatory dependence. In contrast to the issues I have surveyed surrounding human explainers and representation, few deny that explanations' ontological dimension is central to providing a philosophical account of explanation. Accordingly, most all philosophers who address scientific explanation engage with one or another ontological question about explanation, or at least grant the significance of those questions. Indeed, I suggested at the outset of this paper that attention to the nature of the explanatory dependence relation, which I take to be an ontological question, tends to eclipse many of these other disagreements about explanation. I begin the present section by discussing this question that's at the center of so many philosophical accounts of explanation. I then move on to the question of the priority of the ontological dimension of explanation, and then discuss a further, arguably ontological question about explanation, namely the issue of level(s) of explanation.

The Question of the Nature of Explanatory Dependence

I have suggested that one ontological issue about explanation gets an undue share of philosophical attention. This is the matter of the explanatory dependence relation, the question of what, out in the world, explains.[4] Many a philosophy of

[4] Note that accounts of explanatory dependence vary in the degree to which they are strictly ontic. For example, the deductive-nomological account takes explanation to occur among propositions about phenomena and laws, whereas

science course has contained a unit on scientific explanation that looks something like: scientific laws explain!; no, it must be causes; but, unification! This perhaps is continued with: causal mechanisms explain; or is it causal difference-makers? The more general question is sometimes introduced of whether there's a unitary account to give of the form of explanatory dependence. This is often yoked to the question of whether purely mathematical dependencies can ever be explanatory.

This question of what form(s) of dependence are of explanatory value in science is undoubtedly important, and the debate about how to answer this question rages on. Versions of a causal account of explanation have dominated the literature in recent decades, which is part of the motivation for this volume's focus on non-causal explanation. Above I described how Bokulich rejects a causal approach to causation because of the extensive fictions employed in explanations. Others who have challenged a causal approach focus directly on the nature of explanatory dependence. Some who have emphasized the explanatoriness of broad patterns think this undermines the idea that explanatory dependence is always causal. This includes, notably, advocates of the unification approach (see Friedman 1974), but also Batterman (2002) and others. Some of these accounts share with Bokulich's an acceptance of the explanatory significance of difference-making, while denying that difference-making constitutes causal influence. Others focus on cases when the explanatory dependence seems to be purely mathematical (see Pincock 2012; Lange 2013).

Craver (2014) argues that explanations are ultimately relations among phenomena out in the world.

This is an important, live debate. But I hope it is clear from what I have said so far in this paper that developing a view of the explanatory dependence relation is not in itself sufficient to provide a philosophical account of scientific explanation. Too many other questions are left unanswered. Of course, many proponents of one or another view about the explanatory dependence relation have much to say about some of these other issues surrounding explanation. But far too often, those other issues are treated as merely add-on features to a core account, an account that is named for its commitment to some form of explanatory dependence. Instead, they are separate, partially independent questions about the nature of scientific explanation.

Question 7: Priority of the Ontological Dimension

I suspect that one reason the nature of the explanatory dependence relation has received the lion's share of philosophical attention is the common presumption that the ontological dimension of explanation is primary, or even solitary, in its importance. This raises the next question about the ontology of explanations I want to discuss, namely the centrality of this dimension as compared to the representational and communicative dimensions of explanation. This is the counterpart of Questions 1 and 4 in the previous two sections, about the priority of communication and representation, respectively, for explanation.

Few deny that dependence relations out in the world are relevant to what qualifies as an explanation. For our scientific explanations to succeed, they must track some dependence – of the right kind – that actually exists in the world.

Perhaps van Fraassen (1980) comes the closest to denying this, since he argues that there is not a unitary account to be given of explanatory dependence relations, that this depends on an explanation's communicative context. As we have already seen, many others think that the ontological issue of explanatory dependence is where all the work in providing an account of explanation, or at least all the important work, is located. Communicative influences are often relegated to the category of the ``pragmatics'' of explanation, and Lewis (1986) influentially argued that the pragmatics of explanation are nothing special, that is, are in no way distinct from the pragmatics of linguistic communication more generally. Craver (2014) holds an extreme version of an ontological, or ontic, view of explanation. He argues that what counts as an explanation is purely an ontological matter, not representational or communicative, for "our abstract and idealized representations count as conveying explanatory information in virtue of the fact that they represent certain kinds of ontic structures (and not others)" (29).

Views about the priority of the communicative sense of explanation or representational issues in explanation, the first and fourth questions discussed above, have obvious implications for this issue. If one grants the significance, or even primacy, of the audience's influence on the content of an explanation, then this amounts to rejecting a purely ontological approach to explanation. And if one grants the importance of representational matters, including whether and how explanations should abstract and idealize what they represent about the world, then one has at least strayed from an extreme ontic view like Craver's. In contrast, a commitment to a view like Craver's or Lewis's can – and has – been used to

justify producing an account of explanation that consists solely of a view about the nature of explanatory dependence. Other views are in a confusing middle ground. As we saw in the previous section, Strevens explicitly claims that his account of explanation is ontological in nature, yet a good deal of that account focuses on representational issues, including both abstraction and idealization.

Question 8: Level of Explanation

Another well-identified question about explanation regards the proper *level* of explanation. Unlike many of the other questions about explanation I've surveyed so far, this issue is often treated separately from providing an overarching account of explanation. It also has been linked to positions on a range of other issues in philosophy of science, for example, about reductionism, ontology, and the relationships among different fields of science. Classic, reductionist approaches to the unity of science claimed that the reduction of all scientific findings to microphysical laws and happenings entailed the successful explanation of those findings in microphysical terms (see, e.g., Hempel 1948). An opposed position is to declare that some explanations are benefitted from being at a higher level than microphysics. This idea has been developed in a variety of ways by different philosophers over the years. In this context, "higher level" might mean more abstract, more general, invoking bigger entities, invoking laws outside of microphysics, or some combination of these. Putnam (1975) memorably illustrated high-level explanation with the example of explaining why a square peg with one-inch sides did not fit through a round hole with a one-inch diameter.

There continue to be proponents of high-level explanation (see, e.g., Weslake 2010), pluralism about the proper levels of explanation (see, e.g., Potochnik 2010b), and explanatory reductionism (see, e.g., Kim 2008).

The question of the proper level of explanation is plausibly about the ontological dimension of explanation. One might phrase the question as: what are the kinds of things that can explain? Are these always only microscopic particles and the laws governing them, or sometimes middle-sized objects and the relationships among them? And example of these options are, respectively, the molecular structure of Putnam's peg and board, and the geometric relationship obtaining between the peg and the hole in the board and the rigidity of the two objects. On the other hand, one might think of the question of the proper level of explanation as primarily or solely regarding representational decisions. Recall Strevens' claim that to cite a causal covering-law just is to cite the physical mechanism responsible for said law. It seems that, in his view, the ontological element of those explanations is identical – all that distinguishes them is representational differences. Yet one of the two explanations is at a higher level, in the sense of being more abstract and avoiding reference to the fundamental physics of the phenomenon. I'm not inclined to accept this interpretation of the issue. I agree, of course, that the proper degree of abstraction is a representational issue. But in my view, representational decisions can't help but influence explanations' ontic features, that is, what out in the world explains (see Potochnik forthcoming b).

5. Conclusion

I began this paper with the suggestion that the debate about the nature of explanatory dependence has eclipsed several other philosophical questions about scientific explanation. What followed, in the bulk of the paper, was a rapid-fire listing of eight of these other questions, with brief discussions of the nature of each question and a sampling of views about them. I have tried to articulate these questions about explanation in a way that clarifies any relations of dependence among views about different questions, and that emphasizes the independence of each from an account of the explanatory dependence relation.

These questions about explanation fall, roughly, into three categories. They are: questions about the human element of explanation, that is, whether and how explanations are shaped by communicative purposes and cognitive needs (§2); questions about the representational element of explanation, that is, whether and how explanations are shaped by representational decisions (§3); and questions about the ontic element of explanation, that is, how explanations are shaped by features of the world and the relationships they bear to the phenomena to be explained (§4). The logically primary question in each category is whether and to what degree that element of explanation is relevant to giving a philosophical account of explanation. Other questions in each category regard the nature of that element's relevance. For the human element of explanation, these questions include how explanations (generated by humans) relate to human understanding, and the cognitive psychology of explanation. For the representational element of explanation, these questions include how explanations should represent – in

particular whether and when they should abstract and idealize, and the relationship explanations generated in science bear to other scientific aims, such as prediction. Finally, for the ontic element of explanation, there's the familiar question of the nature of explanatory dependence, as well as the question of the proper level(s) of explanation.

Historically, the ontic element of explanation has been presumed to be of either central or sole relevance. Even accounts of explanation that focus on explanations in the representational sense, such as the deductive-nomological and unification accounts, placed the source of explanatoriness on the ontic side – e.g. for the D-N account, the laws of nature cited and facts accurately described, and for Friedman's (1974) unification account, in a relation among phenomena. With a few prominent exceptions, there has been little attention devoted to defending the centrality of the ontic element of explanation. In contrast, attention to communicative elements of explanation must always begin with a defense of the relevance of those issues, or else risk the dismissive response that the discussion is irrelevant to the real issues about explanation. I began this paper with questions about the human element of explanation in order to demonstrate that the traditional ordering of priorities for an account of explanation is not inevitable. Despite the strong precedent for accounts of explanation that are ontic-first or ontic-only, there are significant questions about how our explanations are shaped by communicative purposes and cognitive needs, and whether and how these are distinctively human. Those questions often can be addressed directly, rather than merely as add-on components to an account of the ontic element of explanation.

Furthermore, how these questions about the communicative element of explanation are answered can have implications for an account of the ontic element of explanation. This is so for my own view of explanation (see Potochnik forthcoming a).

The recognition that there are other questions about explanation is, of course, not uniquely mine. As I have surveyed here, there already exists philosophical work on most or all of the topics I've listed. My hope is that the contribution of this paper consists partly in the delineation and categorization of these many issues, and partly in the demonstration of their distance from the question of what, out in the world, explains. My aim in surveying so many questions is to illustrate the vast space for different kinds of disagreements about scientific explanation. Surely other philosophical questions about scientific explanation exist even beyond those I have detailed here. Philosophers of science working on, or considering work on, the nature of scientific explanation: I urge you to consider this range of largely independent questions about scientific explanation. Choose a question to explicitly develop a view on; show interrelationships among views one might hold about a few of these features; articulate still further questions in need of answers. If you must, develop a new account of the sort of dependence that is explanatory. But please, do not be convinced that the main philosophical question about explanation is whether causes, laws, or something else are the kind of thing that explains.

Acknowledgments

Thanks to the editors for including me in this project and for their effective leadership of the project. The ideas and prose of this paper were significantly improved by a reviewer for this volume.

References

Achinstein, Peter (1983), The Nature of Explanation (Oxford University Press).

Batterman, Robert W. (2002), The Devil in the Details, (Oxford University Press).

Batterman, Robert W. (2009), 'Idealization and Modeling', in Synthese 169: 427–446.

Bokulich, Alisa (2011), 'How Scientific Models can Explain', in Synthese 180: 33–45.

Bromberger, Silvain (1966), 'Why-Questions', in R. Colodny (ed.), Mind and Cosmos (University of Pittsburgh Press), 86–111.

Craver, Carl F. (2014), 'The Ontic Conception of Scientific Explanation', in Andreas Hütteman and Marie Kaiser (eds.), Explanation in the Biological and Historical Sciences (Springer).

de Regt, Henk W. (2013), 'Understanding and Explanation: Living Apart Together?', in Studies in History and Philosophy of Science 44: 505–509.

Douglas, Heather (2009), 'Reintroducing Prediction to Explanation', in Philosophy of Science 76: 444–463.

Friedman, Michael (1974), ‘Explanation and Scientific Understanding’, in the Journal of Philosophy 71: 5–19.

Hempel, Carl (1965), Aspects of Scientific Explanation and Other Essays in the Philosophy of Science (Free Press).

Hempel, Carl, and Paul Oppenheim (1948), ‘Studies in the Logic of Explanation’, in Philosophy of Science 15: 135–175.

Kim, Jaegwon (2008), ‘Reduction and Reductive Explanation: Is One Possible Without the Other?’, in Jakob Hohwy and Jesper Kallestrup (eds.), Being Reduced: New Essays on Reduction, Explanation, and Causation (Oxford University Press).

Lange, Marc (2013), ‘What Makes a Scientific Explanation Distinctively Mathematical?’, in British Journal for the Philosophy of Science 64: 485–511.

Levy, Arnon (draft), ‘Against the Ontic Conception of Explanation’.

Lewis, David (1986), ‘Causal Explanation’, in David Lewis (ed.), Philosophical Papers (Oxford University Press), vol. II.

Lipton, Peter (2009), ‘Understanding Without Explanation’, in Henk W. de Regt, Sabina Leonelli, and Kai Eigner (eds.), Scientific Understanding: Philosophical Perspectives (University of Pittsburgh Press), chap. 3, 43–63.

Lombrozo, Tania (2011), ‘The Instrumental Value of Explanations’, in Philosophy Compass 6: 539–551.

Norton, John D. (2012), ‘Approximation and Idealization: Why the Difference Matters’, in Philosophy of Science 79: 207–232.

Pincock, Christopher (2012), Mathematics and Scientific Representation (Oxford University Press).

Potochnik, Angela (2010a), ‘Explanatory Independence and Epistemic Interdependence: A Case Study of the Optimality Approach’, in The British Journal for the Philosophy of Science 61: 213–233.

Potochnik, Angela (2010b), ‘Levels of Explanation Reconceived’, in Philosophy of Science 77: 59–72.

Potochnik, Angela (2015a), ‘Causal Patterns and Adequate Explanations’, in Philosophical Studies 172: 1163–1182.

Potochnik, Angela (2015b), ‘The Diverse Aims of Science’, in Studies in History and Philosophy of Science 53: 71–80.

Potochnik, Angela (forthcoming a), Idealization and the Aims of Science (The University of Chicago Press).

Potochnik, Angela (forthcoming b), ‘Scientific Explanation: Putting Communication First’, in Philosophy of Science.

Putnam, Hilary (1975), Philosophy and our Mental Life (Cambridge University Press), Philosophical Papers, vol. 2, chap. 14, 291–303.

Salmon, Wesley (1984), Scientific Explanation and the Causal Structure of the World (Princeton University Press).

Salmon, Wesley (1989), Four Decades of Scientific Explanation (University of Minnesota Press).

Strevens, Michael (2008), Depth: An Account of Scientific Explanation (Harvard University Press).

Strevens, Michael (2013), 'No Understanding Without Explanation', in Studies in History and Philosophy of Science 44: 510–515.

van Fraassen, Bas C. (1980), The Scientific Image (Clarendon Press).

Weslake, Brad (2010), 'Explanatory Depth', in Philosophy of Science 77: 273–294.

Woodward, James (2003), Making Things Happen: A Theory of Causal Explanation (Oxford University Press).