# Powers and Capacities in Philosophy: The New Aristotelianism

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CHAPTER 6

# Dispositions for Scientific Realism

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## 1. Introduction: Dispositions in the Philosophy of Science

Causal powers, and the modern concepts in terms of which they are commonly discussed—capacities, dispositions, propensities, and tendencies—have been on the comeback trail in recent philosophy. Perhaps the most fundamental argument in favour of a realism about dispositions (my term of choice here) is that by positing their existence, one gains explanatory power. Why do objects that share properties figure in the same sorts of causal relations? Why are most objects of common experience likely to behave in highly similar ways in highly similar, counterfactual circumstances? What grounds the regularities we describe in terms of laws of nature? Answers to these questions given by neo-Aristotelian, dispositional realists appeal to explanatory force: if there were dispositions, this would facilitate explanations of the relevant phenomena—explanations that would be lacking otherwise—and this is rendered as evidence for their existence. Conversely, the neo-Humean tradition is typified by a rejection of such demands for explanation. It would be better, its adherents contend, to have no explanations at all than to have explanations in terms of an ontology of dispositions.

In this paper, I will not delve into debates between neo-Aristotelians and neo-Humeans directly. Instead, given that the weight of any putative explanatory power can only be assessed when one has a clear understanding of what the relevant explanations *are*, precisely, my aim is to investigate the question of what work can be done by the notion of dispositions in a specific context within the philosophy of science. This context is that of perhaps the most central debate within the philosophy of science, namely the debate between realists and antirealists with respect to scientific knowledge. The debate is an epistemological one, concerning how best to understand the epistemic status of theories and models produced within mature domains of scientific theorizing and experiment, but as we shall see, the metaphysical posit represented by dispositional realism yields significant benefits for the economy with which scientific realism is conceived, and relatedly, for the very plausibility of the position. One may ultimately reject this conception of scientific realism for any number of reasons, including Humean sceptical reasons, but my goal here is to elaborate its virtues, so that we may be clear about the cost of rejection.

In the context of scientific realism, the benefits of dispositional realism go well beyond those associated with the traditional metaphysical arguments I have mentioned above. These further benefits arise very specifically from thinking about scientific knowledge. In Section 2, I consider one profound consequence of dispositional realism in this arena: the prospect of a positive transformation in discussions regarding how best to formulate the idea of scientific realism itself. Perhaps the two otherwise leading candidates for this formulation—entity realism and structural realism—are generally viewed as diametrically opposed to one another, but dispositional realism permits a welcome synthesis of their most compelling features. In Section 3, I consider a second benefit of disposition realism: the prospect of an economical unification of the core metaphysical presuppositions of this newly synthesized position. Scientific realists often appeal to metaphysical concepts—most commonly causal interactions, laws of nature, and natural kinds of properties, entities, and processes—in formulating and defending their realism. Dispositional realism affords a tightly integrated view of these concepts. In Section 4, I consider one last virtue of dispositional realism: the prospect of resolving a pressing challenge to scientific realism in the form of the use of inconsistent models in scientific practice. I close in Section 5 with some brief reflections on the dialectic between dispositional realists and antirealists in light of the explanatory virtues here described.

## 2. Synthesis: Entity Realism Versus Structural Realism

Scientific realism, to a rough, first approximation, is the view that scientific theories correctly describe both observable and unobservable aspects of a mind-independent world. This optimistic epistemic attitude towards the sciences, however, must be qualified in various ways if it is not to be rejected immediately, since only our best theories if any are likely to merit such an attitude, and even these theories are likely at best only close to the truth in various ways, as opposed to being correct in every detail. The task of



elaborating the nuances of the position is thus substantial, and often intertwined with the project of responding to a number of sceptical or "antirealist" challenges. One of the most forceful of these challenges is what is commonly referred to as the "pessimistic induction" (Laudan 1981 gives a canonical treatment), and as I shall now attempt to show, it is in this context that dispositional realism can play an important role in synthesizing some of the most important realist insights to emerge in recent decades.

Consider the history of scientific theorizing in any particular domain. From the perspective of the present, most past theories are considered false, strictly speaking. There is evidence of severe discontinuity in theorizing over time regarding the sorts of entities and processes described, and this evidence makes up a catalogue of instability in the things to which theories ostensibly refer. By induction based on these past cases, it is likely that present-day theories are also false and will be recognized as such in the future—a pessimistic conclusion indeed. Different responses to this pessimistic induction have been explored in some detail, but in my view the most promising response is presented by versions of realism that attempt to be selective in what they endorse for epistemic commitment. Theories can be interpreted as making many claims about their target systems, but selective approaches to realism present some of these claims in particular as having greater epistemic warrant than others, and therefore, as being more likely to survive theory change over time. On these views, the question of how best to be a realist boils down to the question of which aspects of theories one should believe.

Traditionally, selective realists have fallen into two broadly defined camps—entity realism, and structural realism—which I will outline in turn. Entity realism is the view that under certain conditions, in which we have impressive abilities to exploit entities causally in various ways (Hacking 1983; Cartwright 1983, chapter 5; Giere 1988), we have good reason to believe that the entities described by scientific theories exist, and thus, it is this aspect of theory (claims about the existence of specific entities) that we can reasonably believe to be true. This positive thesis is counterbalanced by a further, negative thesis: by endorsing only certain existential claims, entity realism is thereby sceptical of the truth of the various theories that may describe these entities. It is this combination of positive and negative theses that constitutes the selectivity of the position, by means of which it is offered as a possible response to the pessimistic induction. For if, as entity realism suggests, the realist need not believe in the truth or approximate truth of theories *per se*, the fact that past and even current theories are false is no cause for concern. On this view, so long as one is able to affirm realism in connection with the existence of various theoretical entities, one has a defensible form of realism.

Conversely, structural realism is the view that insofar as scientific theories offer approximately true descriptions of the world, they do not tell us about its *nature*, or more specifically, the nature of its unobservable parts. Rather, they tell us about its *structure*. The basic idea is that the parts of theories in which realists should invest epistemic commitment concern certain relations between entities, rather than any substantive account of the entities themselves (Worrall 1989; Ladyman 2009). Note that structural realism, like entity realism, incorporates both positive and negative theses, thus allowing it to function as a possible response to the pessimistic induction. While endorsing claims about certain structures, the position is sceptical about the natures of the entities that putatively inhabit these structures. Thus, on the one hand, if theories are to some significant extent correct in mapping the structures of the natural world, as one might argue on the basis of instances of structural preservation across theory change in the past, then a form of realism is vindicated. On the other hand, since this view rejects any substantive knowledge of the entities described by these theories, there is plenty of theoretical content left over to surrender in response to the pessimistic induction.

As one might expect, there are healthy debates in the literature about whether entity realism and structural realism are ultimately compelling, and it is not my intention to consider these debates here. Rather, I wish to draw attention to a very striking feature of these two positions which may well, as I have suggested, furnish the two most promising responses to the pessimistic induction available to the scientific realist. Entity realism and structural realism are united in offering a response to the antirealist, but strikingly, the responses these positions afford seem *radically opposed*. That is, they give apparently opposite advice regarding the question of how realists should be selective in determining which parts of scientific theories have greatest epistemic warrant. Entity realism advocates realism about certain entities described by scientific theories, but not in connection with theories *per se*, thus entailing antirealism in connection with the descriptions of relations between entities that comprise theories more generally. This stands opposed to structural realism, because the notion of structure is mostly plausibly understood precisely in terms of the relations between entities described by scientific theories. Structural realism advocates realism with respect to certain structures, and promotes antirealism with respect to knowledge of any entities so related. But entity realism is a realism about certain entities.

This apparently stark opposition between entity realism and structural realism is, I believe, highly detrimental to the credentials of scientific realism as a coherent epistemic attitude to take towards scientific theories and models. It is here, however, that dispositions can play a positive role in synthesizing the best insights of the two positions. The most compelling feature of entity realism is its grounding of epistemic warrant in causal knowledge. The greater one's ability to employ such knowledge so as to affect phenomena of scientific interest, often in highly intricate and amazingly detailed ways, the better the warrant. Of course, this is not a knockdown argument against antirealist scepticism very generally, but rather an intuitive prescription: one's warrant, however great or small, is plausibly a function of the ability to exploit causally the subjects of one's knowledge claims. Conversely, the most compelling feature of structural realism is its identification of certain relations described by theories as the sorts of things that are likely to be preserved across theory change; for some highly suggestive case studies indicate that descriptions of relations of this sort are generally preserved in some form or other as theories are revised over time (Post 1971; French and Kamminga 1993). And so, one might reasonably wish to marry the story of epistemic warrant told by entity realists to the story of theoretical preservation told by structural realists. But how?



Begin with causality. In the context of scientific knowledge, causation is naturally theorized by dispositional realists in terms of dispositions associated with properties of scientific interest. The properties of entities investigated in this context are *causal* properties: they confer dispositions for behaviour on the entities that have them. Why and how do such things interact with one another, as well as with scientific instruments of detection and measurement? It is because they have certain properties that they behave in the ways revealed by scientific investigation. Masses, charges, accelerations, volumes, temperatures, and so on confer causal powers: dispositions to behave in certain ways when in the presence or absence of other properties. For example, the property of mass confers, *inter alia*, the disposition of a body to be accelerated when subject to a force. The property of volume possessed by a gas confers, *inter alia*, the disposition of that gas to become more highly pressurized when heated. It is the ways in which entities with such properties are disposed to act, often in consort with others, that produce causal activity.

Now, armed with this conception of properties investigated by the sciences, it is a short step to the revelation that a knowledge of entities is tightly interwoven with a knowledge of structures. Recall that structures are understood here in terms of relations. The dispositional account of properties of scientific interest characterizes them in terms of dispositions for . . . relations! The behaviours that entities manifest in virtue of the dispositions they possess are generally described by scientific theories in terms of relations, often in the form of mathematical equations relating variables whose values are determinate magnitudes of the properties in question. The dispositional realist offers an account of structure by means of relations that are manifested in keeping with the dispositions conferred by these properties. The properties of entities are thus intimately connected to the structures in which these properties and entities figure. And so, on this view, a dispositional account of properties of scientific interest is intimately connected to structural knowledge, which itself incorporates a knowledge of properties. To speak metaphorically, structures are "encoded" in the properties of entities, because these properties confer dispositions for precisely the relations one recognizes as structures.

In this way, dispositional thinking synthesizes the very notion of a causal property of scientific interest with that of the structure of natural phenomena. Knowledge of one entails knowledge of the other. Particularly in connection with many of the unobservable entities with which scientific realism is most concerned, it is only by means of a knowledge of their relations that one is able to interact with them causally, and thus, the epistemic warrant that entity realists identify with certain forms of causal knowledge is evidently parasitic on structural knowledge. Lacking the relevant structural knowledge, it would be simply impossible to design and perform experiments to detect and manipulate such entities. For the dispositionalist, a converse sort of dependence is also evident, since a knowledge of structure immediately suggests a knowledge of properties. Given that properties are understood, *ex hypothesi*, in terms of dispositions for relations, knowledge of a given structure will entail at least some knowledge of the properties that stand in the relevant relation or relations. Having interwoven the concepts of property and relation via dispositions, the scientific realist is now in a position to conjoin previously disparate insights regarding epistemic warrant, associated with entity realism, and structural preservation across theory change, associated with structural realism.

## 3. Unification: Causation, Laws, and Natural Kinds

Let us move on now to consider a second benefit of dispositional realism in the context of scientific realism. One feature of the literature in the latter domain that commonly passes without scrutiny is the appeal by scientific realists to certain metaphysical concepts, such as causation, laws of nature, and natural kinds of entities and processes, in formulating and defending the position. As I suggested earlier, the most promising epistemological considerations in support of realist belief in various unobservable properties, structures, and entities involve reflections on causal knowledge. But this is just a beginning, for more generally, scientific knowledge is often described as a knowledge of laws, concerning diverse categories of things found in the natural world. It is here that a realism about dispositions can play an important unificatory role, by facilitating a neatly integrated view of



the concepts of causation, law, and kindhood. This affords scientific realism a high degree of economy in describing the metaphysical concepts central to its formulation and defence. In this section, I will provide an overview of this unified conceptual economy.

Why is it important to the scientific realist to have a unified economy of underlying metaphysical concepts? There are at least two reasons, I believe, for thinking that this is a desideratum for scientific realism. First, it is not uncommon to hear scientific antirealists complain that the relevant concepts are problematic: at best unclear in considerations of scientific knowledge; at worst incoherent and thus of no use to the epistemology of science. An exposition of these concepts and a demonstration of how they may form a consistent and coherent framework for thinking about scientific realism thus furnishes an important response to this sort of antirealist scepticism. Are the metaphysical foundations hollow, or can they be shown to provide a strong basis for the articulation of the position? Second, in the domain of metaphysics, the unity of concepts is a desideratum in its own right. For here, though our best work must be consistent with and responsive to empirical evidence, other theoretical virtues play a large role in the assessment of philosophical proposals. The possible organization of the metaphysical concepts underlying scientific realism into a consistent, coherent, and unified framework inevitably features centrally in its assessment.

Having outlined the project and its motivation, let us now turn to the project itself. We have already considered (in Section 2) how taking dispositions seriously yields a particular account of causation. "Disposition" is a causal concept par excellence; as suggested earlier, if causal properties are properties that confer dispositions for behaviour on the things that have them, then it is the ways in which these things are disposed to act, often in combination with others, that produce causal activity. On such a view, a natural picture of causal activity presents itself: entities with causal properties are engaged in continuous processes of interaction, in which dispositions borne by these entities are manifested in accordance with the presence and absence of other objects and properties. Entities with causal properties are thus, on this "process" view, in a continuous state of causal interaction, a state in which relations between causal properties obtain. Consider, for example, a volume of gas that comes into contact with a source of heat: it expands in virtue of the dispositions afforded such volumes by properties such as temperature and pressure, and as a consequence, it comes into contact with other regions of space–time, where it may encounter further entities and properties. The property instances present in these new regions together with those of the gas determine how both are further affected, and so on. In this way, the notion of dispositions unifies the concepts of entities and causal processes subject to scientific investigation.

With this understanding of causation in hand, the scientific realist is well placed to offer an integrated account of laws and kinds. The idea of "natural" kinds is common among scientific realists, and the primary motivation for holding that there are such things is the further idea that dividing nature up into categories that reflect its own, objective divisions will yield groups of entities that are capable of supporting the successful inductive generalizations and predictions found in our best science. That is to say, the recognition of natural categories should facilitate these practices, and thus furnish an explanation of their success. This would seem to be a widespread intuition: no doubt the belief that an entity will exhibit certain properties or behaviours—ones that have been observed in connection with others of its type—receives support from the notion that it is bound to (or likely to) exhibit such properties and behaviours, as a member of a kind that is *typified* by such properties and behaviours. As a number of philosophers have contended, "[t]he causal structure of the world as exhibited in natural kinds ... provides the natural ground of inductive inference" (Kornblith 1993, p. 7); "[i]t is a truism that the philosophical theory of *natural* kinds is about how classificatory schemes come to contribute to the epistemic reliability of inductive and explanatory practices" (Boyd 1999, p. 146).

This connection between the ideas of kinds and successful inductive practice suggests a concomitant relationship between scientific categories of things and laws of nature. After all, the idea that a kind is typified by certain properties and behaviours suggests that to know such things is to know what these entities in the world are like and how they behave, and traditionally, this is precisely what is identified with a knowledge of laws. Indeed, what better warrant could there be for inductive practices such as generalization and prediction than the laws of nature? Now, having just sketched a view of dispositions and causal processes, an account of laws and natural kinds follows almost immediately. One ubiquitous use of the term "law" in the scientific domain is to label relations between causal properties, as in Newton's second law of motion ($F = ma$), or the ideal gas law ($PV = nRT$). Here, variables representing causal properties are related to one another in the form of mathematical equations applicable to the behaviours of certain classes of entities. Many scientific descriptions of phenomena among those commonly referred to as laws are devices of just this sort.

It is only fair to note, however, that the expression "law of nature" is a term of art, and other putative examples of law statements concerning scientific categories of things do not appear to take the form of descriptions of relations between causal properties. For example, the putative law statement "all planets in solar systems move in approximately elliptical orbits" makes no explicit reference to any such relations. Let us refer to this sort of law statement more specifically as a *behavioural* generalization, since it takes the form of a description of how members of a category of entities behave. A further and (I think) final use of the term "law" is evidenced by more philosophical examples, in which law statements take the form of generalizations that describe the natures of members of categories of entities in terms of one or more of their characteristic properties, as in the widespread philosophical toy example "water is $H_2O$." Here, samples belonging to the category water are described in terms of their molecular composition. Let us call this sort of law statement a *definitional* generalization, since statements of this type make partial and sometimes exhaustive reference to a property or properties whose possession defines membership in category of entities.



We have already seen how dispositional realism fits seamlessly into a view of laws according to which they are relations between properties, and from this follows a straightforward understanding of law statements constituted by generalizations regarding such relations. The case of behavioural generalizations is likewise straightforward, despite the fact that law statements of this type do not make explicit reference to causal properties, because the dispositional view entails that entities that *possess* (instantiate, exemplify, etc.) causal properties are disposed to behave in certain ways in certain circumstances—precisely the sorts of regularities described by behavioural generalizations. That is, the predictive regularities of the entities described in behavioural generalizations hold in virtue of the properties these entities possess. Wherever the members of a class of entities share certain causal properties—those identified with membership in the relevant kind—generalizations regarding their behaviours will be true. In this way, relations between causal properties and the regular behaviours of entities having such properties, both of which are commonly associated with the concept of laws, are integrated neatly with an ontology of dispositions.

The case of definitional generalizations is somewhat more complex, in part because there is significant controversy regarding whether these sorts of generalizations are properly regarded as laws of nature at all, as opposed to mere conventions adopted in order to facilitate systematic inquiry into phenomena of interest to human inquirers. Consider the following: is what we call "water" essentially composed of the elements of hydrogen and oxygen in an atomic ratio of 2:1? Or is it rather the case that we have simply defined the term "water" this way, which then establishes a useful convention, thereby facilitating (*inter alia*) scientific investigations in various domains? I submit that dispositional realism is neutral with respect to this dispute and, even better, explanatory of the inductive success of kind talk in either case. For whatever the ontological status of scientifically useful categories of entities, whether objectively natural in the sense of the essentialist or artefacts of convention, so long as the properties associated with the members of these kinds dispose them to behave in certain ways in certain circumstances, one has a viable explanation of inductive success, because law statements regarding relations between the relevant causal properties and behavioural generalizations may be true regardless.

## 4. Resolution: Scepticism By Way of Inconsistent Models

In the previous two sections, I considered the utility of dispositional realism for an articulation of scientific realism (by means of a synthesis of the most promising elements of rival formulations of the view), and for an articulation of its metaphysical foundations (by means of a unification of the concepts of causation, laws of nature, and natural kinds). In this section, I will attempt to show how the concept of dispositions can be employed to help answer a very specific challenge to the epistemic cogency of scientific realism, in the form of a common feature of scientific practice: the concurrent use of models whose associated descriptions of the phenomena are inconsistent with one another; for example, as a consequence of incorporating incompatible assumptions regarding one and the same target system in the world. Given that scientific realism entails a positive epistemic attitude towards the outputs of our best science, the everyday use of inconsistent models in scientific practice presents a *prima facie* challenge to the plausibility of the view. Once again, however, dispositions will prove a useful tool for scientific realism, by facilitating a resolution of this pressing sceptical challenge.

In scientific practice, what appear on the surface to be mutually incompatible collections of models are often employed in connection with one and the same target system. One instance of this, attracting detailed scrutiny in recent case studies, is the example of different models of fluids that are commonly employed in considering different aspects of fluid flow (Morrison 1999; Teller 2001; Rueger 2005). In explaining how water flows or how its waves propagate, the models employed treat it as a continuous, incompressible medium. On the other hand, the explanation of how compounds diffuse in water employs models that treat it as a collection of discrete particles in thermal motion. But water cannot be both a continuous, incompressible medium and a collection of discrete particles! These models clearly attribute what appear to be mutually incompatible properties. This sort of inconsistency is sometimes found even in the treatment of one type of behaviour. For example, models concerning fluid flow around immersed solids, along solid walls, and in various other circumstances generally adapt and apply the relevant mathematical description (the Navier-Stokes equations) in rather different ways, with the result that, once again, different models appear to attribute incompatible properties to fluids.



The common use of these apparently incompatible collections of models in scientific practice fuels an obvious challenge to scientific realism. If scientific explanations of the relevant phenomena employ models that are inconsistent in what they say about the natures of these phenomena, how might one justify any sort of realist attitude towards them? It would seem that from a realist perspective, at best one of any such collection of models could be endorsed as furnishing the truth, but scientific practice itself neither suggests nor identifies any such privilege, and even if it did, given the ubiquity of the use of apparently incompatible models, the realist conception of scientific knowledge would be greatly impoverished if it required such a drastic restriction on the scope of models yielding genuine knowledge of the world. The alternative, however, courts antirealism: one might say that models employed in different fluidic contexts offer different and incompatible perspectives on the nature of fluids, no one of which is privileged beyond the immediate context in which it is used, in the service of some very specific scientific end. From some perspectives, we simply treat water as though it were a continuous medium, and from others, as though it were made up of discrete particles, and this exhausts our epistemic ambitions.

It is here, I believe, that dispositional realism once again proves a boon to the scientific realist. What the realist requires in the face of this sceptical challenge is some means of translating talk of different and apparently conflicting descriptions of the properties of a given target system, across and within different contexts of investigation, into talk of consistent sets of descriptions of one and the same system, quite independently of context. With consistency thus restored by means of translation, the challenge to scientific realism presented by the mere surface appearance of inconsistency would be met. But how might one realize such a translation? Let us appeal here, once again, to the dispositional conception of the nature of properties and relations described by scientific theories and represented by models. On this view, scientific knowledge is a knowledge of property-conferred dispositions for certain kinds of behaviour in particular sorts of circumstances. As I shall now suggest, this insight alone is sufficient to diffuse the challenge represented by apparently inconsistent models.

For the dispositional realist, different and apparently incompatible descriptions of systems of scientific interest may simply reflect the dispositional nature of the properties of these systems. Since dispositions are often manifested differently in different circumstances, it should come as no surprise that when scientific interest turns to the explanation of different sorts of phenomena in connection with a given target system, or even one and the same phenomenon but in different ambient conditions, the manifestations associated with that target system may vary. In many cases, one and the same property confers dispositions for different sorts of manifestations, elicited under different conditions. What is striking about this picture for our consideration of the present sceptical challenge is that facts about how a given property (or properties) of a target system disposes it to behave do not depend on any given context—these facts are context-independent. What typically varies with context is not facts about dispositions, but facts about manifestations.

Thus, while scientists must undoubtedly investigate the natures of systems of scientific interest *within* particular contexts (specific ambient circumstances or conditions), what they discover thereby is how certain properties manifest themselves in those contexts, and generally, knowledge concerning the dispositions that give rise to such manifestations is not likewise contextually bound. In this way, the dispositional view effectively allows for a translation of seemingly inconsistent descriptions into consistent sets of descriptions regarding different sorts of manifestation. An appearance of inconsistency is presented, in the case of fluids, by the observation that a fluid cannot both comprise a continuous medium and a collection of discrete particles (for example). For the dispositionalist, however, this observation simply masks a more perspicuous characterization of the nature of the target. Fluids, in virtue of their properties, are disposed to behave like continuous media in certain kinds of circumstances, and *in* such circumstances, it is hardly surprising that the idealized models in which they are represented *as* continuous should prove useful in explanation. The dispositionalist diagnoses a mistake, however, in the naïve identification of the surface features of such models with the precise natures of the target systems modelled.

Let me explicate this prescription further in application to a simple, everyday sort of example. Is the salt in my kitchen salt shaker soluble? Solubility is the disposition of a substance to dissolve when placed in a solvent, and so, based on my experience, it would seem that the answer is affirmative. The philosopher-scientist may object, however. For salt does not always dissolve when placed in a solvent like water, for instance. There are various conditions under which it does not: water saturated at a given temperature and pressure, water in a sufficiently strong electromagnetic field, etc. This observation might serve as the basis of a *prima facie* argument against knowing certain properties of water, since we are seemingly presented here with an inconsistent combination of descriptions: salt is both soluble and insoluble. But of course, there is no contradiction here. The dispositionalist takes this surface appearance of contradiction as indicative of a more perspicuous characterization of the nature of salt: it sometimes dissolves in water, and at other times does not, depending on the ambient conditions. The relevant manifestations—dissolving and not dissolving—are realized in different sorts of conditions. The relevant dispositions coexist in



salt unproblematically, and one may describe them without fear of inconsistency. Thus we see how an apparent contradiction may be re-described, consistently, in dispositional terms.

This recourse to dispositions is not intended to suggest that scientific knowledge is exhausted by attributions of properties such as solubility and insolubility. Indeed, often the attribution of dispositions at a certain level of description functions as a heuristic for further scientific work, in which subsequent investigation yields knowledge of further, underlying properties implicated in the behaviours associated with the previously discovered dispositions and manifestations. The chemistry of solubility is an excellent example of this, where subsequent investigations into molecular structure and the development of a theory of inter- and intra-molecular forces ultimately became crucial to explanations of how and why different manifestations are realized under the relevant stimulus conditions. These explanatory details, concerning such things as the atomic and molecular constitutions of salt and water, their electromagnetic properties, and the types of bonds and bond angles they form, are part and parcel of the dispositions of solubility and insolubility of salt in water.

On some occasions, the heuristic function of dispositional ascription yields further scientific knowledge, but not in ways that shed further light on the nature of the dispositions as such. Consider, for example, nineteenth-century wave theories of the nature and behaviour of light, which explicated the phenomenon of light propagation using models inspired by the study of the oscillations of classical waves, such as water and sound waves. Subsequent investigations into the dispositions of light to behave in various wave-like manners in diffraction, refraction, processes of constructive and destructive interference, and so on, subsumed this dispositional knowledge into theories of electromagnetic radiation and, ultimately, into modern-day field theory. In this case, however, though each subsequent theoretical development has incorporated the dispositions of light for wave-like behaviours, they have not done so in quite the way illustrated in the case of solubility. In the case of scientific theorizing about light, we still have no underlying explanation of why and how these wave-like manifestations occur, despite the fecundity of a preoccupation with the relevant dispositions over the course of twentieth-century physics.

An appreciation of the heuristic function of a knowledge of dispositions is an ancillary bonus for the scientific realist in grappling with scientific practice. Paying due attention to the widespread use of apparently inconsistent models throughout this practice generates a significant sceptical challenge to scientific realism, and we have seen how dispositional realism can be employed to contend with this challenge. Understanding scientific modelling in terms of descriptions of the dispositional properties of target systems in the world thus resolves the issue of the epistemic cogency of scientific realism in this area, adding yet another virtue of dispositional realism to those of synthesis and unification canvassed earlier.

## 5. Conclusion: Rival Ontologies for Scientific Realism

My aim in this chapter has been to explore some key ways in which a belief in the reality of dispositions can help to facilitate the position known as scientific realism. It is perhaps no surprise that, having some insight into virtues such as these, a number of philosophers who are sympathetic to the idea of scientific realism in some way, shape, or form are also dispositional realists. There are healthy debates, however, about whether those who are interested in scientific realism should engage in theorizing about metaphysical issues at levels of philosophical discourse that are not, arguably, part of the domain of scientific knowledge per se. And even among those who believe that such issues are important ones for the philosopher of science to consider in working out how best to interpret scientific knowledge, there are healthy debates concerning precisely *which* metaphysic at these extra-scientific levels of discourse one should adopt. Dispositional realism fits well with the groundswell of recent neo-Aristotelian theorizing found in a number of philosophical spheres, but neo-Humean alternatives are alive and well. Let me close with a few brief thoughts on the dialectic between these approaches.

In Section 3, I made the case that a serious consideration of the metaphysical concepts in terms of which scientific realism is generally described and often defended is an important task for anyone who is attracted to the position. Indeed, it would seem to be an important task for the antirealist as well, insofar as this person offers objections to these concepts in arguing for scientific antirealism. This does not suggest, of course, that any given philosopher interested in scientific realism or antirealism must also do hardcore metaphysics—after all, there is nothing wrong with divisions of labour within philosophy—but it does rather place a significant onus on those who would depend on or seek to undermine metaphysical concepts that are constitutive of these epistemologies of science to engage with them in some way. This is precisely the sort of work I have attempted here. Debates between those attracted to and repelled by metaphysical concepts such as dispositions have traditionally focused on the explanatory power of these notions: whether they have any at all and, if so, the extent of this power. In the context of the philosophy of science and, more specifically, scientific realism, the concept of dispositions can be employed to do real work, as we have seen. Whether this work is weighty enough to render the concept plausible or irresistible, however, is a question I must leave to the reader to decide (for related discussion, see Chakravartty 2007, section 1.5).



Even if the heavy lifting performed by the idea of dispositions in the preceding discussion is as impressive as I take it to be, those with Humean sympathies might nonetheless hope to have their cake and eat it too. Perhaps the concept of a disposition could be accepted, but only in a "manner of speaking," deflationary sort of way: one might hope to use the concept to do all the sorts of work described here, and yet give a deflationary analysis of the concept in non-dispositional terms. Such analyses have been attempted by different sorts of empiricists throughout the ages, and the plausibility of this kind of analysis is no less a subject of debate today than the more ontologically ambitious notion of a disposition. It is for these reasons of healthy debate that I will not end here with the conclusion that the cause of scientific realism can only and exclusively be served by dispositional realism in the ways I have described. Perhaps scientific realism could be served just as well by some merely deflationary concept of dispositions. It does seem evident, however, that assuming the reality of dispositions, a case can be made for the benefits to scientific realism I have explored, and it is not yet evident that this same story can be told, *mutatis mutandis*, given a deflationary picture. This latter proposition is thus something of a promissory note. And even if it can be made to work, one might forgive the dispositional realist for thinking that this would have all the virtues of theft over honest toil.

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