MIRACLES AND TWO ACCOUNTS OF SCIENTIFIC LAWS

by Steven Horst

Abstract. Since early modernity, it has often been assumed that miracles are incompatible with the existence of the natural laws utilized in the sciences. This paper argues that this assumption is largely an artifact of empiricist accounts of laws that should be rejected for reasons internal to philosophy of science, and that no such incompatibility arises on the most important alternative interpretations, which treat laws as expressions of forces, dispositions, or causal powers.

Keywords: causality; determinism; divine action; empiricism; free will; David Hume; miracles; philosophy of science; quantum mechanics; science

---

One of the distinctive features of the Abrahamic faiths is the belief in a God who acts in human history. In both the Bible and the Koran, God is described as communicating with and through prophets and as performing signs and wonders. Christians believe, additionally, that God became incarnate, lived a human life, died, and was raised from the dead. In recent centuries, however, liberal and modernist movements, principally in Christian theology, have sought to demythologize their religion by rejecting the supernatural elements in the Bible as incompatible with modern science, and reconstructing a theology around the moral teachings of Jesus and the Hebrew scriptures.[1] The most radical of such reconstructions rejects a supernatural God entirely. Less radical versions allow for a deistic God who created the world and established its initial conditions and natural laws, but does not intervene in creation.

What about modern science would lead theologians to undertake such a wholesale rethinking of their religion's assumptions? The line of reasoning one finds most frequently goes something like this. Modern science has revealed that the universe is governed by natural laws. Therefore, if we accept the laws proclaimed by the scientists, we must reject any kind of divine action in history that would violate those laws. Miracles, according to David Hume's influential definition, are events that violate natural laws ("On Miracles" in Hume [1748] 1902). And so, if we are committed to natural laws, we must reject miracles.

Steven Horst is Professor and Chair of Philosophy at Wesleyan University. He may be contacted at Department of Philosophy, Wesleyan University, Russell House, 350 High Street, Middletown, CT 06459, USA; e-mail shorst@wesleyan.edu.

 ISSN 0591-2385

Historical Preliminaries and the Problem for Miracles

The foregoing is, of course, a very informal development of the argument. To assess its validity and soundness, we will need to develop it more precisely. But before we begin that task, it is worth noting that neither the father of the modern notion of natural law (Descartes) nor the man who developed the first successful formulations of laws unifying the explanation of motions near the Earth and the motions of the planets (Newton) would have found the foregoing line of reasoning congenial. Both believed in miracles. For Newton, miracles and providence were almost an obsession (Dobbs and Jacob 1991). Descartes held to so strong a view of God's free will that he believed that God could arbitrarily change not only natural laws, but even the canons of logic (Descartes 1984, 291; 1991, 22–55). Somewhere between Newton and Hume, something important must have changed in the conception of laws of nature.

When Descartes introduced the notion of "natural laws," he really conceived of the regularities of nature on the model of prescriptive laws laid down by God for matter to obey—or at least (as matter cannot think and hence cannot truly *obey*) to *conform to*. In a slightly different vein, Newton and his circle, proponents of natural theology that they were, viewed natural philosophy (what we would today call "science") as a clue to God's intentions; and hence they also viewed natural laws as expressing the will of the Divine Sovereign. For Hume and later writers, however, the notion of laws of nature had slipped free from its original theological moorings. Hume's own official analysis of laws and causation is arguably psychological and epistemic rather than metaphysical. But other writers, including many who have styled themselves "Humean," have understood laws as regularities in nature itself.

In the past century, the most important heir to this broadly "Humean" tradition is the account (or accounts) of laws favored by the logical positivists and logical empiricists—really a number of accounts that differ in detail, but share a lineage and some central features. I shall thus refer at times to "the empiricist account" of laws, and at others to "empiricist accounts," depending on whether the emphasis is on the shared core features or the distinctive variations upon them. What these empiricist accounts share at their core—and hence "the account" in the more generic sense—is the assumption that *laws are (true) universally quantified claims about the real-world behavior of objects*. There are several variants of this account within the empiricist tradition. The simplest views the universally quantified conditionals expressing laws as *materially adequate*—that is, true of all actual events. Most versions add some sort of modal augmentation so that the laws hold true over counterfactual situations as well as actual ones, albeit not logically necessary. At a minimum, then, the empiricist account holds that *laws express materially adequate, universally quantified claims*

about how objects actually behave. Or, less formally, it holds that *laws express true universal claims about the real-world behavior of objects.* The principal difference between twentieth century empiricism and older forms of Human empiricism lies in the application of a type of logical regimentation that was unavailable in Hume's day, that of quantified logics.[2]

If we combine this account of laws with Hume's definition of a miracle as an event that violates a natural law, the problem with miracles becomes apparent. If a law-claim is a universal claim—a claim about what is true in *every* case—then a "violation" or exception is enough to falsify a law-claim. Conversely, *true* law-claims—real *laws*—cannot have exceptions. And thus, if we combine Hume's definition of 'miracle' with an empiricist account of laws, the notion of a miracle is incoherent. The problem is not so much that miracles have empirical evidence against them, but rather that there is a contradiction inherent in the very notion of an event that is an exception to an exceptionless law.

I take it that Hume's argument is *valid*. If laws are true universal claims and miracles are events that violate laws, then there can be no miracles. Indeed, if one takes Hume's characterizations of "law" and "miracle" as stipulative definitions, his argument is also *sound*, albeit at the risk of triviality. In order for the argument to be sound and nontrivial, two additional conditions must be met: Hume's characterization of "miracle" must correspond to the relevant usages of the term in theology, and the empiricist account of laws must be acceptable as an analysis of the laws that actually appear in the sciences.

Hume's definition of "miracle," of course, was original and theologically contentious. The modern notion of natural laws, pioneered by Descartes, was little more than a century old when Hume wrote his *Treatise*, and so theologians prior to Descartes could not have had it in mind. (Indeed, some quite explicitly embraced very different definitions.[3]) Hume's definitions, moreover, clearly imply the impossibility of miracles, and it is difficult to imagine that careful thinkers like Descartes and Newton would have missed this had they understood the terms 'law' and 'miracle' in the same way. And so, we might reasonably be suspicious that Hume made his task too easy by defining terms in a fashion that rendered the word 'miracle' self-contradictory by definition. A more general theological notion of 'miracle' might go something like this: a miracle is an event caused by special Divine action that would not or could not have occurred merely through the regular course of events in nature. Such a definition—or indeed any definition that does not define miracles as exceptions to exceptionless laws—would be sufficient to avoid Hume's argument against miracles.

But by Hume's day, another line of thought had also begun to develop, though it would not receive its most influential formulation until Laplace. This was the idea that a commitment to natural laws entails a commitment to determinism. And if this were correct, natural laws would present a

serious problem for miracles even on a much broader interpretation of the word 'miracle' If, as Laplace claimed, the laws of nature, combined with a complete description of the state of the universe at a time *t*, completely determine the state of the universe at any subsequent time $t+\partial$, then nothing happens (at least after creation is complete) that could count as a miracle, even on this very broad definition.[4]

The formulations of this view in the eighteenth and nineteenth centuries are, by contemporary philosophical standards, rather informal, and admit of a number of alternative interpretations. When I return to this matter in the "Empiricist Accounts of Laws" section below, I shall concentrate upon versions of empiricism that emerged out of the Vienna circle in the twentieth century, whose logical formulation will make it easier to assess the supposed tension between natural laws and miracles.In the "Miracles and Causal Powers" section below, I shall present a rival account of the nature of laws, which is much more compatible with miracles.

Laws and Their Philosophical Interpretations

What is a "natural law" or a "scientific law"? From the standpoint of philosophy of science, we must at least begin by dealing with the things called "laws" in the sciences themselves: things like Newton's inverse square law, the Boyle-Charles law, Coulomb's law, and the laws for chemical reactions. Often, these take the form of mathematical equations. Of course, the equations themselves are meaningless until the variable letters are interpreted as representing quantitative phenomena like mass, charge, and velocity; and they receive these interpretations *collectively* in the form of a theory or model. The success of applying particular laws, and the theories and models in which they occur, gives us reason to believe that those laws make true claims (or approximately true claims, or an apt framework for making more particular true claims[5]) about the relationships between variables.

Exactly *what* claim a law makes, however, is often underdetermined by the success of the law and the experimental evidence substantiating its truth (or approximate truth or aptness). For example, some favor the Humean regularist view that laws express mere empirical regularities among events, while others hold that they express unseen forces, dispositions, capacities, or powers. Within the regularist camp, there have been those who interpret laws as expressing only material generalizations and those who take them to express modal claims. Realists and instrumentalists may agree that a particular law is a good one, but disagree as to whether one of its variables expresses a real entity or property, or is simply instrumentally useful in understanding a system or predicting its kinematics. These are all *philosophical accounts* of the nature of laws, and the issues at stake between rival views are often distinct from those that are of interest to the scientist.

Philosophers can agree on the merits of, say, general relativity or quantum mechanics, while disagreeing on exactly what those theories and the laws they employ should be interpreted as expressing. In some cases, however, it is possible to show that a particular philosophical account of laws does not do justice to laws as they are used in the sciences. This, I shall argue, is the case with the empiricist account of laws.

Empiricist Accounts of Laws

There are, in fact, a number of accounts of the nature of laws that have received the label "empiricist." I am concerned in particular with those that have arisen out of the logical empiricist movement, which attempted to regiment a broadly Humean regularist account of laws by recasting laws in the rigorous logical formats of sentential and predicate calculi. The use of such logical resources opened the door to a number of alternative formulations of laws, such as the conditional form of, *ceteris paribus*, laws and the addition of modal operators to some more contemporary interpretations. What distinguishes the class of interpretations I am calling "empiricist" are two features:

> E1. *Universal quantification*. Law-claims are understood to be universally quantified claims, and a genuine law must be at least materially true.

> E2. *A domain of objects and events*. The domain of the law, and the properties expressed by the predicate letters, consist of objects, their properties, and the events in which they take part. (In particular, neither the variables nor the predicate letters express such things as forces, dispositions, powers, or capacities.)

These two features are, of course, dissociable. One could interpret laws as quantified claims, at least some of which are about forces, dispositions, powers, or capacities. Conversely, one could interpret laws as expressing forces, dispositions, powers, or capacities without employing a quantifier, as we shall see in the "Miracles and Causal Powers" section. Defining "empiricist" accounts in a fashion that excludes quantified accounts ranging over forces is to some extent a stipulation on my part.[6] My reason for restricting the scope of "empiricism" in this way for the purposes of this article is that it is the combination of E1 and E2 that results in a problem for miracles, and addressing this problem is the main target of this article. If the reader would prefer to draw the boundaries of empiricism more broadly, the same point could be made by distinguishing "kinematic" empiricist accounts (those whose domains exclude forces, dispositions, powers, and capacities) from "dynamic" empiricist accounts (which allow or even favor them).

Empiricist Laws, Determinism, and Miracles

The empiricist account (in my narrow "kinematic" sense) raises problems for miracles (and likewise for libertarian free will) because empiricism can be strengthened to imply determinism by the simple addition of one more claim: namely, that every physical event falls under at least one natural law of the right type. Suppose that a law-claim L* is the assertion some law L obtains in nature. If L* implies that event E1 entails the subsequent occurrence of event E2, then E1 occurring without E2 following would, on the empiricist interpretation, imply that L was not a genuine law, as a single counterexample materially falsifies a universally quantified claim. (And, as a modally strengthened version of such a claim would imply its material truth as well, a counterexample would falsify the modal version too.) In short, even God could not make it the case that L* was a true universally quantified claim that had a genuine counterexample, because that would be self-contradictory. It would not be self-contradictory for God to do things at one time that did not conform to the regularities that take place at every other time; but in such a case, there would not be a genuine empiricist law corresponding to those regularities.

Of course, there are several different sorts of laws, and the implications of the empiricist interpretation are different for each of them. The most important for our concerns are what might be called *causal laws*—that is, law-claims that say something about the relationship between antecedent and consequent conditions, like the laws of gravitation or electromagnetism. These laws apply to all bodies that have mass or charge, respectively. And, if interpreted as claims about how bodies with these properties actually behave in their interaction with one another, their application to a particular antecedent state of affairs (the cause) yields a particular consequent state of affairs (the effect). All macroscopic bodies have mass; and so, if the gravitation law makes true, materially-adequate, and nonprobabilistic claims about the resulting state of an antecedent event described in terms of mass and position, it would seem that the behavior of bodies with mass would have to be deterministic, on pain of the laws turning out to be materially false.

Not all types of scientific laws have this consequence. Laws of statics are about the state of a system at a single time, and probabilistic laws do not specify a unique resultant state. But even if the gravitation law were the *only* law that had this feature, the implications would be considerable. It would leave open the possibility that objects that do not possess mass might behave indeterministically, which, in turn, would open the doors for the possibility of such things as indeterminacy in quantum electrodynamics and free thought by God or Cartesian souls. It might also allow for revelations through prophecy and visions. But it would preclude a great number of biblical miracles, such as the parting of the Red Sea or the ascent of Elijah

into the sky, as those events *do* involve bodies with mass behaving in a fashion contrary to what the gravitation law would predict.[7] So, if we interpret the gravitation law as a universal claim about antecedent and consequent conditions, either such miracles do not happen, or else they falsify the law-claim.

Of course, some versions of empiricism deny that there is actual causation in nature at all, treating "causation" as either constant conjunction or a projection of an associative linkage from the mind onto the world. But even quantifying only over actual events and treating "cause" and "effect" as mere names of antecedent and subsequent events, we would have to conclude that miracles *do not* occur. Moreover, most forms of late twentieth-century empiricism strengthened the notion of a law beyond material adequacy to cover counterfactual cases and rule out accidental regularities. And if the scope of such conditionals covers counterfactual cases, and the conditionals are true and universally quantified, then miracles *could not* take place without rendering the laws false.

The empiricist interpretation of laws thus supplies a short road to at least a limited form of determinism—a form that would seem to be strong enough to create a problem for many of the biblical miracles. If a nonprobabilistic causal law-claim L* expresses a nonprobabilistic law L, and L* makes claims about the condition that always follows if the antecedent conditions are met, then either (a) any object O that falls under the scope of L behaves as described by L*, or else (b) L* is false and L is not a genuine law. And there is at least one nonprobabilistic causal law that would seem to apply to all macroscopic events, because all macroscopic bodies have mass. Formulations of the gravitation law, at least, are nonprobabilistic in form and are interpreted by empiricists as universal claims about antecedent and consequent conditions such as position and motion. And most of the biblical miracles involve bodies with mass behaving in ways that do not correspond to the gravitational conditionals. And so the empiricist account, while not directly asserting determinism, provides a basis for implying determinism with respect to a class of events into which many of the biblical miracles fall. Similar cases could no doubt be made, on the basis of different laws, for biblical miracles such as the multiplication of loaves and fishes, Jesus changing water into wine at Cana, the resurrection of Lazarus, or Philip's sudden change of geographic location after his conversation with the Ethiopian eunuch.

The reader should note that the ease with which the empiricist can move from an account of laws to determinism is a consequence of the two assumptions about laws cited earlier as E1 and E2: that is, that laws are understood as *universal* and *kinematic* claims about how objects *always actually behave*. Universal claims about forces, causal powers, or probabilities do not similarly lead to determinism; nor do weaker sorts of generalizations about actual events that are not framed in something like the form of

quantified classical logic. The combination of these two assumptions thus comes very close to sneaking determinism into the picture through the back door of logical quantification, with the small loophole that it does so only for those objects and events to which at least one causal law applies.

It is difficult to assess exactly how ideas from the sciences, and philosophical interpretations thereof, came to have an influence even in academic theology, much less in popular religious consciousness. My guess is that the notion that a world with natural laws must also be a deterministic world that has no room for miracles is one that took hold by way of a mixture of explicit argumentation and more intuitive assumptions about the implications of modern science. The importance of particular characterizations of laws in philosophy of science, however, stems not so much from their being the *source* of assumptions that are relevant to miracles, as from the fact that they allow us to *assess* those assumptions more carefully. There really does seem to be at least a *prima facie* problem for miracles, given the empiricist account of laws. And, as I shall argue later in the article, the same problem does *not* arise on an important alternative account.

Familiar Theological Objections

Beginning in "More Fundamental Problems with the Empiricist Account," I shall argue that the empiricist account, in all of its "kinematic" formulations, is deeply flawed in ways that have already been explored ably, and perhaps decisively, in philosophy of science. Before turning to this main critique, however, I shall briefly discuss several familiar objections that do not so fully reject the empiricist account.

The Initial Conditions Objection. The most straightforward objection is that, even in the empiricist account, laws alone do not determine outcomes. Only laws, *combined with initial conditions*, do so. As a result, God can act in a fashion consistent with laws by directly intervening in the initial conditions (Larmer 2009). Even Laplace explicitly listed initial conditions as among the things his "demon" would need to know in order to predict the future, in addition to knowing the laws.[8]

This account, however, admits of more than one interpretation. On the most natural interpretation, "initial conditions" means "conditions at the beginning of the universe." It is correct that the laws do not determine the initial conditions of the universe, and that this demonstrates that God could be responsible for particular events by engineering the initial conditions so that they were ensured to occur. This, however, conflates miracles with providence, and does not vindicate miracles as *special* interventions that cause outcomes that would not have happened merely on the basis of the normal operation of the laws of nature upon initial physical conditions. It provides a proof of the consistency of natural laws with a view like that

of Leibniz, which holds God to be a perfect architect of nature, but not with miracles.

There is also another, if more strained, interpretation of the objection. If laws apply only to matter that *already exists*, God might effect interventions directly at some moment in time after creation, and do so, not by altering or suspending laws, but by creating (or annihilating) matter in particular locations. (This *would* require a denial of the conservation of mass-energy in the universe as a whole, but arguably what the thermodynamic law in question really claims is that mass-energy is conserved *in a closed system*, and whether the universe is an open or closed system is precisely what is in question in a debate about miracles.) But while this would not require the alteration or suspension of laws, it is not clear that it is compatible with the laws being *true* when interpreted according to the empiricist account. Let us assume that there is a moment t just before such an intervention at $t + \partial$, where ∂ is infinitesimally small. The state of matter at t, combined with the laws of nature will, on the empiricist account, determine the state of all of *those* material bodies at $t+\partial$. Whatever God's intervention might be, it will need to be consistent with this if it is not to violate the empiricist's laws. This might allow God to create new material systems that will never interact causally with our universe, but that is not the kind of miracle that is central to the Abrahamic religions. If Elijah's body is at a particular position at t, its position at any subsequent $t + \partial$ would already be determined at t, regardless of what new things God might create, upon pain of the law being falsified.

The Ceterus Paribus Objection. The original theological conception of a law might be recast in modern dress as the view that the laws of nature are really *ceteris paribus* laws—laws that say, in effect, "*all else being equal*, things always behave thus." But the hedge of saying "other things being equal" provides room for such "other things" as God deciding to suspend or alter the laws on particular occasions, or to add additional causal forces in order to bring about miracles. Laws specify how objects will behave under specific scientifically identifiable conditions. They say nothing about how they will behave under other conditions, such as Divine intervention. To assume that the latter sort of condition can never obtain is question-begging in the context of a debate about Divine action (Ward 2002).

Ward's suggestion can be interpreted in two ways. On one interpretation, it utilizes a variation on empiricism that allows for *ceteris paribus* laws in which Divine actions are among the things that can appear in the *ceteris paribus* conditions. From a logical standpoint, this amounts to a successful consistency proof. But it does so at the cost of the "real" scientific laws (that is, the ones that are *true* according to empiricist lights) having hidden theological *ceteris paribus* clauses. From the standpoint of philosophy of

science, it would be preferable to find some way to respect the fact that scientific laws do not *seem* to include such theological content. And, to the extent that such an account could also be consistent with a commitment to miracles, it should, I think, be preferred by the advocate of miracles.

On the other interpretation, natural laws are "strict" laws and the *ceteris paribus* clauses about Divine action specify a set of antecedent conditions distinct from those which appear in the scientific laws themselves. This second interpretation, however, will be of no use in any instances where there is an applicable natural law, under the empiricist interpretation. For if the antecedent is true and the consequent false, the "law" is falsified. Conversely, if it is a true empiricist law, then if the antecedent is satisfied, the consequent must be satisfied as well.

The Quantum Objection. For some, the most obvious objection stems from the fact that science has discovered that some of the most important fundamental laws, unlike those envisioned by Laplacean classical mechanics, are probabilistic and (perhaps) indeterministic (Murphy 1995, 2006; Kane 1996). The objection goes like this. Quantum mechanics (QM), our best theory of electromagnetism, strong force and weak force, implies that the universe is not deterministic, but involves stochastic randomness at the level of the behavior of particles. Determinism is thus empirically false; and so any philosophical account that implies determinism must be mistaken, and any arguments that assume the truth of such accounts (such as the foregoing argument against miracles) cannot be sound. QM, moreover, opens up the possibility that God may be able to work miracles while at the same time "respecting" the fundamental (quantum) laws: God may be able to act in nature, in a fashion *consistent with* the probabilistic laws, by directly determining which of the possible outcomes becomes actual (Murphy 1995, 2006; Kane 1996).

The first premise of this argument, however, goes beyond the science itself and depends on a particular interpretation of QM. It is true that QM employs statistical machinery. It is likewise true that one influential interpretation of the presence of statistics in QM (the "Copenhagen" interpretation, proposed by Niels Bohr) interprets this as indicating true randomness.[9] There are, however, a number of alternative interpretations of QM that are consistent with a deterministic world. On the Einstein-Podolsky-Rosen "hidden variable" interpretation, the apparent quantum randomness is an illusion caused by our ignorance of some additional variable that, when added to QM (or replacing it), would result in a deterministic system. On the quantum multiverse interpretation—the view that each time a quantum event occurs, the world "splits" into multiple continuants, one for each of the possible outcomes—the multiverse is itself deterministic (Dewitt 1970). Moreover, it is difficult to see how best to reconceive the notion of a miracle in a quantum multiverse, as all of

the possible outcomes actually come about, only in different continuant worlds.

Indeed, it is not clear that even the Copenhagen interpretation provides what is needed for miracles. It is most naturally understood as describing the universe as a closed system, but one in which causal mechanisms are probabilistic rather than deterministic. What is needed to allow for miracles, however, is a view on which the physical universe is an *open* system—at least, one that is open to Divine intervention. If God merely "loads the dice," as it were—choosing from among the outcomes consistent with the wave equation by causing particular outcomes—those outcomes are no longer truly random, though they are underdetermined by the prior states and laws of QM.

All in all, QM is not a good foundation for the advocate of miracles to hang his or her hat upon. Not all interpretations of QM are compatible with miracles, and at present one's choice of interpretations tends to reflect philosophical taste more than a choice between empirical alternatives. And, importantly, the "interpretations" here are not merely alternative conceptualizations, but rival claims about what is really taking place. Either there *are* divisions of the world into independent multiverse pathways, or there are not. Either the foundations of quantum phenomena are truly indeterministic, or else there really are hidden variables we have yet to discover. QM thus provides at most an *epistemic* compatibility proof for laws and miracles: we are *not sure* whether the physical universe operates deterministically, and so we cannot be sure that arguments from determinism to the impossibility of miracles are sound. (We may, of course, be able to determine that they are unsound for other reasons.)

The Argument from Chaos. In a similar vein, chaotic systems defy at least *prediction* on the basis of laws and initial conditions. The notion of chaos is standardly developed on the assumption of a deterministic system ("classical chaos"); but where there is unpredictability, it is impossible to definitively determine whether one is faced with classical chaos or a situation involving true indeterminacy. This, again, might provide room for God to act in nature without violating natural laws (Polkinghorne 1989, 1998).

This argument can also be interpreted either epistemologically or metaphysically. As an epistemological argument, its conclusion is that there can be situations in which it is impossible to determine whether a system is indeterministic or deterministic but chaotic. And this can serve as a defeater for arguments for determinism in such cases, albeit a weak one. It blocks a conclusive argument for determinism in any such cases, but does not provide reason to believe that the universe *is* either indeterministic or an open system. Indeed, it also has the consequence that systems that may seem to be underdetermined may indeed be deterministic: that is exactly what is the

case with *classical* chaos, which assumes a deterministic system. Moreover, as argued in the previous section, the kind of causal openness needed for miracles is not the same thing as statistical indeterminism. All an argument from chaos addresses are questions of mathematical determination, not the possibility of Divine intervention.

The metaphysical version of the argument, to the conclusion that chaos theory provides room for miracles, seems quite unpromising. The objection from chaos is untenable as a metaphysical position if we are speaking of *classical* chaos, which assumes a deterministic system (cf. Drees 1996). If, however, we are speaking of quantum chaos, the concerns already raised about the use of QM to vindicate miracles apply.

The Argument from Emergence and Downward Causation. Advocates of emergence hold that the sciences generally give us reason to believe in "downward causation," in which a high-order complex system can produce novel effects in the kinds of elements that make up its simpler parts. (Biological laws, for example, can have molecular consequences.) If God is understood as immanent in nature, this provides a model on which God might cause more local effects on a model of top-down causation independently motivated in philosophy of science (Peacocke 1990).

There are at least two possible variations on this argument. On the first, the higher order causal principles are *lawful*. If this is the case, then the emergentist should hold that "low-level" laws, like those of fundamental physics, are *not* true on the empiricist account, as the universe does not behave as they claim when higher order principles are also at work. But Divine action that takes place by way of the operation of such high-order laws is not miraculous, at least if those laws are part of how nature operates on its own. (A conclusion that seems unavoidable if God is immanent.) The outcome would thus seem to be that lawful emergence shows the compatibility of Divine *action* with natural laws at the cost of such action not being regarded as *miraculous*.

On the second interpretation, the higher order causal principles can be *anomic* (that is, nonlawful). Causal powers that are not grounded in natural laws are, of course, something that the advocate of miracles needs to endorse. But it is not clear that the notion of "emergence" is doing any real work here. The idea of anomic causal powers is something *in addition to* the notion of emergence. And it is this idea, and not the notion of emergence, that does the work of carving room for miracles. Moreover, the operation of even anomic causation *stemming wholly from the properties of complex physical systems* would not count as miraculous, as it would be wholly a result of what nature does "on its own," Moreover, if all causal laws (couched at whatever level of complexity) are to be interpreted in line with the empiricist account, then events stemming from anomic causation (whether natural or supernatural in origin) would cause events to diverge

from what would happen if only the laws were in play, thereby falsifying some and perhaps all of the laws. The anomic emergentist must at very least look for some alternative to the empiricist account of laws.

More Fundamental Problems with the Empiricist Account

The objection from QM claimed that the empiricist account of laws was not a viable account of particular laws endorsed by the scientists. One can, however, make a more fundamental case that empiricism misunderstands the nature of causal laws in general, including nonstatistical and classical laws. Empiricism's principal error is this: it takes causal laws to be claims about *what actually happens* (that is, about particular events like motions of bodies). Taken in this way, many laws—for example, the law of gravitation—would turn out to be *false*. Indeed, it is doubtful that they would *ever* describe the actual unfolding of events—the *kinematics*, if you will—correctly. But the problem here is not a problem for the laws themselves, but for the empiricist account *of* them, because such laws are really claims of a different kind: namely, claims about things like *forces* such as gravitational attraction. Or, more generally, they *make claims about factors that make a regular contribution to how particular sequences of events unfold*. They are *dynamic* rather than kinematic claims.

The basic point can be made very simply. Consider Newton's gravitation law, $F = g(m_1 * m_2)/r^2$. This equation can be expressed in English by saying that the gravitational attraction between two bodies is proportional to the product of their masses and inversely proportional to the square of the distance between them. Suppose now that we were to interpret this according to empiricist lights as a claim about how bodies with mass *actually behave*—that is, how they *move*. Interpreted in this way, the law would imply that two bodies of equal mass, dropped from the same height above the Earth, should fall with equal acceleration and reach the ground at the same time. Now imagine taking two sheets of paper of equal mass, crushing one into a tight ball, and folding the other into a paper airplane, and then dropping them. Try it yourself if you are in doubt, but they will not fall at the same rate.

Now *if* the gravitation law actually implied that the two pieces of paper *must* reach the ground at the same time, this example would demonstrate that the law-claim is false, and I could expect a Nobel prize in due order. But, of course, that is not at all what the example shows. What it shows, and what even nonphysicists like myself already know, is that gravity is not the *only* principle at work. In this case, aerodynamics plays a dominant role; but we could easily come up with other examples where principles of magnetism (substitute a metal object for one piece of paper and add a sufficiently strong magnet to the experimental setup) or psychology (make

one of the objects a hundred dollar bill and the experimental location a crowded room) would play roles of similar importance. These are all possibilities about which the gravitation law tells us absolutely nothing. It speaks only to one of the factors contributing to the motions of objects. And the same is true, *mutatis mutandis*, for laws of aerodynamics, magnetism, and so on. In short, each law, taken individually, does *not* make or license *any* claims about the actual motions of objects. Rather, each expresses a single regular factor that can *contribute to* the actual motions.

This, moreover, is the interpretation that most naturally recommends itself when one reads Newton or subsequent scientists without trying to force their claims into the garb of quantified logic. The inverse square law $F = g(m_1 * m_2)/r^2$ does not *look like* an equation about motion, but about *force*. Newton did also derive from it kinematic equations describing ideal planetary orbits at equilibrium. But even this required the addition of another Newtonian innovation: the *summation of forces* as the bridge between theory and prediction, in this case gravitation and inertia. More generally, the actual motions of objects are determined by the combination of *all* of the forces acting upon them—something that goes beyond the scope of any single law. Indeed, it is only in the case of dynamic laws that we can make sense of the idea of composition of forces. If each law individually determined how objects would behave, there would be no need for a summation of forces; and, indeed, such a summation would produce a prediction of resultant motion different from those based on the individual laws. (And, of course, if those laws were interpreted according to empiricist lights, this would falsify the laws.)

Empiricist Variations: *Ceteris Paribus* Laws and Ideal Worlds

The main criticism I have offered of the empiricist account—that most laws would, if interpreted as universally quantified claims about real-world events, turn out to be false—is in some ways a familiar one. It has been offered at a similar level of generality (and with equally critical intentions) by Nancy Cartwright (1983, 1989, 1999), and I have developed it at greater length in my *Laws, Mind and Free Will* (Horst 2011). And, in a weaker form, it was recognized to exist for *some* laws by the logical empiricists themselves, who attempted to handle "exceptions" to laws through the use of boundary conditions and *ceteris paribus* clauses. These embed the claim actually stated in the law equation within a specification of the conditions under which it is true. (Or by specifying the conditions under which it is not true.) In sentential logic, $C \supset L$, where C specifies the conditions under which L is true. In predicate logic, the schematic form would be $\forall$[quantified variable(s)]$(C \supset L)$, where C and L are shorthand for formulas containing bound variables.

There are indeed scientific laws that are understood to hold only under particular conditions—for example, only for matter in the gaseous phase, or for fluids in laminar flow. But such *ceteris paribus* laws were generally assumed to be *different* in form from fundamental laws like gravitation, which were viewed as "strict and exceptionless."[10] Perhaps, however, concerns about "exceptions" to all laws can be handled by treating *all* laws as *ceteris paribus* laws? This interpretation is suggested by Cartwright in one of her early essays, where she suggests the following interpretation of the gravitation law: "*If* there are no forces other than gravitational forces at work, *then* two bodies exert a force between each other which varies inversely as the square of the distance between them, and varies directly as the product of their masses" (1983, p. 58).

This interpretation, however, has two fatal flaws. First, there are no such cases in the real world, so the law would be empirically vacuous. Second, the law, thus interpreted, would say nothing at all about cases where there are more than two bodies and/or nongravitational forces. But the gravitation law *does* tell us something about such cases—indeed, it tells us exactly the same thing it tells us about any two-body cases: namely, the contribution of pairwise gravitational interaction to the overall causal mix. In other words, this interpretation of the law would seriously misinterpret its scope of application.

A slightly more sophisticated and more recent approach is to treat laws as expressing true universal claims about the behavior of objects, not in the real world, but in an "ideal world" (Giere 1999).[11] This gambit, however, suffers from much the same problems. Because the laws, thus interpreted, do not make *any* claims about the real world, they would be empirically vacuous by definition; and by the same token, they would get the scope of real scientific laws wrong, as these *do* say something true about real-world interactions. Moreover, consider how different a world would have to be for it to, say, lack any nongravitational forces. Since most physical particles have properties in addition to mass, they would not exist in such a world, and likewise, *mutatis mutandis* for other laws and the forces they express. Indeed, there would be no such worlds in which more than one force was present, and hence no particles with, say, both mass and charge.

So, neither the original version of the empiricist account, nor those modified to include *ceteris paribus* clauses or to refer to ideal worlds, is a viable account of the nature of the laws employed by scientists. Moreover, the arguments marshaled toward this conclusion are based solely on philosophy of science, and in no way depend on any assumptions about miracles or supernatural agents. As a result, the argument against miracles based on the empiricist account of laws cannot be sound. This, in itself, is a significant conclusion. Suspicion of miracles, even among Christian theologians, has certainly grown significantly since the time of Hume's arguments against

miracles. And to the extent that the implications of empiricist accounts of laws, whether Humean or those of the twentieth century, fueled this suspicion, rejection of the empiricist accounts of laws provides a powerful defeater for those arguments. It may be true that if empiricist accounts of laws were correct, miracles would be impossible. But that need not trouble the advocate of miracles if the antecedent of that conditional is, as I have argued, false.

Moreover, the *source* of the problem with the empiricist account of laws is *precisely* the feature that generated problems for miracles: the "kinematic" interpretation of laws as claims about what always actually happens. This suggests that the supposed problem for miracles may be an artifact of a particular philosophical interpretation of laws. To explore this possibility further, let us turn to a major rival account of laws, sometimes called the "causal account."

The Causal Account

Over the past 40 years, a number of philosophers have suggested an alternative type of account of the nature of laws, which we may label *causal accounts*.[12] On these accounts, laws are understood to express what have variously been described as "causal powers," "causal capacities," "causal dispositions," or "potential partial causal contributors." Gravitational force would be a good paradigm example for explicating causal accounts. What the gravitation law expresses is a "power" or "capacity" objects with mass have to influence each other in a particular way: namely, by exerting an attractive force described by the inverse square law. This force is a *contributor* to the real-world motions that ensue, but is generally only a *partial* contributor, as other forces are usually at work as well. And in the case of some laws, the contribution is only "potential" or conditional, as there may be additional ancillary conditions that must be met for the potential to be activated (e.g., some chemical reactions only take place in the presence of a catalyst, the law of speciation through variation and selection will cease to be in play if planetary conditions cease to support life, and so on).

The observation leveled critically at the empiricist account—that each law speaks only to its own domain—is thus a central feature of causal accounts. And a commitment to the truth of a given law leaves us uncommitted on the further question of what other causal contributors there might be. The discovery of universal gravitation neither presaged nor excluded the possibility of electromagnetic force. Moreover, commitment to a given law leaves us uncommitted, not only on the question of what additional *laws* there may be, but also on the question of whether there might be additional causal contributors that are *anomic*.

Another way of putting the same point (and stressing continuities with Newton) is to say that laws like the gravitation law express *dynamic* rather than *kinematic* claims. Of course, there *are* laws that are kinematic rather than dynamic.[13] To illustrate this distinction more clearly, compare Newton's inverse square law with an important precursor: Galileo's claim that projectile motion is parabolic, the product of combining a horizontal component that covers equal distances in equal times with a vertical component that is accelerated linearly over equal times (Galilei 1738 [1974], Theorem 1, Proposition 1). Galileo's "theorem" is a mathematically formulated claim about the geometry of a particular type of motion. The principles from which it is derived—the "component motions"—are neither dynamic principles (they are not separate states that cause the actual motion) nor real motions, but abstractions ("formal causes" in the language still used in Galileo's day). The inverse square law, by contrast, expresses the *force* two bodies exert on one another as a function of their masses and the distance between them. It can be used to calculate approximate real-world motions through summation of forces using vector algebra, often with the inclusion of nongravitational contributions such as inertia. And it yields ideal models of motion in cases of equilibrium, such as the elliptical form of a stable planetary orbit.

In light of this distinction, we might rephrase the criticism of the empiricist account by saying that the error was to mistake dynamic laws (like universal gravitation) for kinematic laws. However, this is potentially misleading: kinematic laws like Galileo's theorem of parabolic motion are by no means exceptionless exact descriptions of real-world motion either—a fact to which anyone who has launched a projectile in a strong wind can attest. The parabolic motion of projectiles is an idealized model of a special case of the summation of gravitational and inertial forces, in which other real-world factors like aerodynamics have been bracketed. It is the dynamic laws that are more fundamental here, and the kinematic model's fit with real-world behavior is a function of the strength of the real-world contributions of the factors bracketed from the model.

On the causal account, laws—and the theories and models associated with them—provide insight into the dynamic principles that contribute to real-world events, and they do so in a piecemeal fashion. Each law attempts to capture causal regularities of a particular sort, and says nothing about what other causal powers there might be. In the terminology I developed in *Laws, Mind and Free Will* (Horst 2011), each law presents a model of a domain of phenomena, a model that is idealized in that it "brackets" indefinitely many other factors that may be at work in the real world. Of course, there are also questions about how well each law models even its own domain: the values of the constants may be incorrect or approximate, the law may employ a logarithmic equation while the phenomenon may be better described by a power law, and so on. But no matter how well a

law succeeds at describing the dynamic regularities of its own domain, its usefulness for prediction is further affected by what other causal powers are "in play" in a given situation. When we use a model to predict real-world kinematics, we *treat* the world *as though* only that law were in play, even though we know full well that this is generally not the case. Thus, when we are testing a law, theory, or model, we build experimental setups that screen off other causal factors as far as it is possible to do so. And, assuming we do not forget that we are dealing with an idealized model, we understand that the predictions generated by the model will approximate real-world events *to the extent that other potentially relevant causal factors are not in play*. What kind of approximation is "good enough" will depend on the context. And, again to borrow terminology developed in Horst (2011), a law, model, or theory may be called "apt" for a given context when it yields predictions that are good enough for the pragmatic constraints of that context.

The causal account lends itself naturally to explaining summation of forces, but also highlights the limitations of that technique. It is precisely because the laws pick out distinct causal contributors that we need an additional technique of calculating how those contributions combine to produce actual resultant phenomena. In classical mechanics, vector algebra was a suitable technique for this, as inertia, gravitation, the mechanical force of collisions, and electromagnetism were taken to be fundamental, independent, and nonprobabilistic, and each yields a contribution to resultant motion expressible by a vector. What such vectors express are not component *motions*, but component *forces* that together result in a single actual motion. And, given these assumptions, the application of vector algebra should yield increasingly good approximations of real-world behavior to the extent that (a) all of the contributions of these types are brought into the calculation and (b) there are no additional causal contributors of different types.

Summation of forces becomes more problematic in cases where assumptions of fundamentalness and independence cannot be made, which would include any special science laws but particularly those involving feedback systems (such as the brain) where the behavior of the different "units" is mutually dependent. Moreover, many scientific laws do not lend themselves to combination through vector algebra, whether because they are not quantitative, or because two quantified laws do not deal in commensurable measures (e.g., chemical properties like pH are quantified, but are not spatial like particle descriptions in classical mechanics), or because the ways two laws are idealized prevent their recombination. (Cartwright gives the example of two laws of chemical combination for a substance X, one for what happens when it is mixed with an acid, the other for what happens when it is mixed with a base, pointing out that what happens when you mix X with both acid and base cannot be obtained by adding the results of the two separate equations.)

While we should allow for methods of "composition of forces" other than vector algebra, it is not clear (a) that these are available for all cases, (b) that, when available, they produce exact results even in ideal cases, or indeed (c) whether their unavailability should be viewed as pointing to a "dappled world" (Cartwright 1999) or an artifact of the cognitive nature of science (Horst 2011). However, if one starts, as causal theorists do, with individual laws, theories, and models as expressions of individual potential regular causal contributors, and regards techniques for summing forces as things that we then seek in order to apply dynamic laws to produce kinematic predictions, one may be left with a very different set of expectations than if one begins with such assumptions as that laws are universally quantified claims or that scientific laws do (or should, or could) yield a comprehensive and self-consistent framework for explaining everything that happens.

Early modern thinkers hit upon the idea of the world as a great mechanism operating in accordance with a few comprehensible and nonprobabilistic laws. While many of them (notably Isaac Newton) held that God can and does tinker with the machine from time to time, the idea of the nomic world-machine pulled their successors down the path through a 'God of the gaps' to deism or atheism. But if we start by looking at the sciences as we actually find them, we find a number of separate laws, theories, and models of different regular patterns in nature, some of them suggesting particular types of causal powers. We find ways of combining these that are apt in some, but not all, contexts, and partial (but seldom complete) reductions between them. The methodological principle implied is two-sided. On the one hand, when we are applying known laws and models for prediction and explanation, we treat them *as if* only the causal powers they express are in play. On the other hand, we are well aware that this "as-if" assumption is unlikely to be true, and are open to the possibility of the discovery of additional causal powers and additional insights into how they work in tandem.

It is crucial to keep both sides of the methodology in mind. *Treating* a phenomenon as a closed (and perhaps deterministic) system is *something we do* for purposes of comprehension and calculation. It is a good methodology for testing theories and applying them to problems. But it should not be mistaken for a kind of *metaphysical principle*, either that *these* laws we are using are the only factors really at work, or even that the universe *is* a closed (and perhaps deterministic) system under *some complete* set of laws. Methodologically, the following should be regarded as open questions: (1) what other nomic causal powers there may be, (2) whether there are anomic causal powers, (3) how they interact to produce real-world phenomena, and (4) whether the kinds of laws we can comprehend can be made into a system that is at once comprehensive and self-consistent, or whether there are features of them (such as the idealized character they may need to be comprehensible to minds like ours) that may prevent this.

Miracles and Causal Powers

On the causal account, a commitment to any set of laws is quite compatible with a commitment to miracles. Of course, nothing in the scientific laws implies that miracles or other anomic events *do* occur. But neither are they precluded or even rendered unlikely. This tends to bear out the suspicion, raised at the end of the "Empiricist Variations: Ceteris *Paribus Laws* and Ideal Worlds" section above, that the apparent conflict between natural laws and miracles may be an artifact of the very feature of the empiricist account that made it unacceptable on other grounds. But more importantly, it shows that on a major account of laws that is more viable than the empiricist account, there is no conflict between the existence of laws and the occurrence of miracles.

Let us try to spell this out more specifically. On a causal account, what actually happens is a function of *all* of the causal powers that are in play. We know a number of lawful causal powers that explain a very great deal about the natural world. But there is no reason to assume (except in an "as-if" way for purposes of experiment or prediction) that these are *all* of the causal powers that are *ever* in play. Perhaps least controversially, there are very likely laws—perhaps even very fundamental laws—that we do not yet know about. But the fact that we understand the world of nature through the discovery of its lawful dynamic regularities by no means implies that there are not also causal powers that are not lawful or regular. Even if the laws (or at least some of the laws) tell us about causal factors that are *always* at work, this says nothing about whether there may be anomic causal factors as well, such as free will or God's miraculous interventions. To the extent that science is in the business of finding regularities, the irregular, the spontaneous, the anomic is systematically *screened out* of scientific laws and theories, and experimental methodologies aimed at finding the regularities will overlook it. *Nomic* Divine action could be tested through experimental intervention. (Though, of course, the experiment would not prove that the cause was Divine, but only that it was lawful.) *Anomic* Divine actions—miracles—cannot become the object of controlled experiment, because by definition, there is not a nomic relationship between variables.

In general terms, what the causal theorist should say about miracles is something like this. Miracles (if indeed they occur) involve the introduction, by special Divine action, of causal powers that are not grounded in natural laws. The miracle is a result of *all* of the causal powers involved, just like any other event in the world. The difference consists solely in the fact that there are causal factors at work that are not "routinely" in play simply by dint of the natural laws.

Of course, for something to be a miracle that happens in the natural world (as opposed to, say, someone being "caught up into heaven" in a vision), the event must begin with God willing something and setting

supernatural forces into motion. This falls outside the realm of science, and quite possibly of human understanding. But equally, it must end with things happening in some particular time and place, and to particular bits of matter: say, Jesus' physical body walking on the surface of the Sea of Galilee, or Elijah being lifted bodily from the surface of the Earth. In between, there will be a string of "secondary causes" through which God works: processes that are natural in their operation but supernatural in their origin.

I am pessimistic about the prospects of speculating about the *particulars* of how any particular miracle might come about. Its origin in the Divine will and the introduction of supernatural causal powers into the world seem to be things that lie, at best, in the realm of pious conjecture. It is, of course, possible to speculate about the added causal powers. Was Elijah lifted by a miraculous attractive power above him, pushed up by a repulsive power below him, or did God perhaps set into motion an actual whirlwind that lifted him up like Dorothy and Toto in *The Wizard of Oz*? Did the multiplication of the loaves and fishes involve the creation of new matter, or a miraculous reorganization of existing atoms? Again, such questions strike me as lying in the realm of pious conjecture and not of academic philosophy.

What philosophy can provide here is a compatibility proof: if, as causal accounts (to my mind rightly) claim, laws express dynamic principles that contribute to the real-world behavior of objects rather than universal claims about how the objects actually behave, a commitment to such laws does not imply (or even suggest) a commitment to determinism or to the causal closure of the universe under natural laws. Of course, demonstrating the compatibility of miracles with natural laws does not imply (or even suggest) that miracles actually occur. The causal account is also compatible with the possibilities (a) that the universe is deterministic, or (b) that the universe is indeterministic, but that the indeterminism is not a result of special divine intervention. Any attempt to adjudicate such questions would require a much broader inquiry, one that would need to draw upon debates in contemporary physics and cosmology as well as in theology. My intention here, by contrast, has been much more focused: namely, to show (1) that one very influential view of laws that has called miracles into question is untenable on other grounds, and (2) that at least one alternative view of laws is available that is compatible with a belief in miracles. To the extent that a person—say, a Christian or other theist—has *prima facie* reason to believe that miracles occur, the compatibility proof serves as a defeater for a particular objection. And to the extent that said objection has been historically influential in casting doubt upon miracles, the existence of a defeater for that objection is important for those whose theological beliefs include a commitment to miracles.

Of course, such a compatibility proof holds far less interest for anyone who does not feel any *prima facie* reason to believe in miracles. And whatever evidence there may be for the occurrence of miracles must be of a different sort from the evidence for scientific laws. The occurrence of miracles can neither be tested through experiment nor understood in natural terms. Our experiments cannot force God to perform a miracle; and, while in some cases, there may be plausible physical evidence and testimony that a miracle has occurred, there is no way of ruling out the possibility that these may be products of confabulation, forgery, illusion, or artifacts of data collection. While theists hold that miracles can serve to inspire religious belief, even their own sacred texts make it clear that skepticism is always a possible response. Likewise, even if miracles are accomplished through secondary causes, a real miracle requires there to be some action of God upon the world that involves some other, nonnatural sort of causation. How such causation might come about is beyond the reach of the natural sciences, and may well be beyond human understanding altogether. We cannot fully specify a *mechanism* through which miracles occur, because insofar as we regard an event as miraculous, an important component of any explanation would have to take the form of a claim such as "and then God intervened."

Summary

Since the late seventeenth century, both theists and atheists have suggested that the commitment of the Abrahamic religions to miracles is in tension, or is even outright incompatible, with a commitment to the existence of natural laws. I have argued that such an incompatibility arises, not from the laws themselves, but from a particular interpretation of the nature of laws, the empiricist account. This account is untenable for reasons arising from within philosophy of science, and thus no sound argument can be based upon it. The more plausible alternative, the causal account, is compatible with miracles, and the general framework of summation of forces can be extended to include the proximate causes of miracles, though, of course, the initial causal contribution of Divine action stands outside the scope of scientific inquiry, and perhaps of human understanding.

Notes

1. Friedrich Schleiermacher, D. F. Strauss, and Rudolf Bultmann are among the influential Christian theologians who took such a view (cf. Swinburne 1989; Houston 1994).

2. The term 'empiricism' is, of course, one with a long history, over the course of which it has been applied to a variety of doctrines, many of which have mutually incompatible basic assumptions. Hume's own writings arguably offer more than one such account, and those who have viewed their work as following in his footsteps have explored these differently. Using the label 'empiricism' thus risks confusion and misunderstanding. For example, Bas van Fraassen's "anti-realist" views, which are among the more influential contemporary views styled "empiricist," raise

different issues from the empiricisms that have stayed closer to the logical empiricist tradition, which tend to be either realist or at least regularist in their metaphysics.

3. Augustine, for example, argues in Book XXI, Chapter 8 of *The City of God*, that no event can be a transgression of the laws of nature, on the grounds that everything that happens by God's will happens "by nature," taking the epistemic view that we call things "miraculous" when they are not in accordance with our understanding of the laws of nature.

4. To quote Laplace's most memorable formulation of this view:

> We ought then to regard the present state of the universe as the effect of its anterior state and as the cause of the one which is to follow. Given for one instant an intelligence that could comprehend all the forces by which nature is animated and the respective situation of the beings who compose it—an intelligence sufficiently vast to submit these data to analysis—it would embrace in the same formula the movements of the greatest bodies of the universe and those of the lightest atom; for it, nothing would be uncertain and the future, as the past, would be present to its eyes. The human mind offers, in the perfection which it has been able to give to astronomy, a feeble idea of this intelligence. Its discoveries in mechanics and geometry, added to that of universal gravity, have enabled it to comprehend in the same analytical expressions the past and future states of the system of the world. Applying the same method to some other objects of its knowledge, it has succeeded in referring to general laws observed phenomena and in foreseeing those which given circumstances ought to produce. All these efforts in the search for truth tend to lead it back continually to the vast intelligence which we have just mentioned, but from which it will always remain infinitely removed. (Laplace 2007, 4–5)

5. While the mainstream philosophical assumption has been that laws (or law-claims) are either true or false, there have been important alternative views which, while agreeing that some law-claims are superior to others (e.g., relativistic to classical gravitation), hold that we need an honorific other than "true" to express what makes a law-claim a good one. Faced with problems like messy data, exceptions, and the recognition that a given law-claim may be only an approximation, some have suggested that we speak of the "approximate truth" of law-claims. Others, working from a cognitivist and/or pragmatist standpoint have suggested that laws (or the models and theories in which they play a role) be assessed in terms of "similarity" or "fit" with the phenomena they are used to explain (Giere 1999), or of "aptness" for particular explanatory or predictive contexts (Horst 2011).

6. Esfeld (2010) draws the lines in a similar fashion, though his article is concerned more with the metaphysics of events and laws, and consequently, the "empiricism" he describes involves the additional claim that "laws" are really nothing more than empirical regularities, and supervene upon the events themselves. Horst (2011) treats quantified force accounts as variants on empiricism, differentiating these "dynamic" empiricist accounts from "kinematic" empiricist accounts. As I go on to say in the main text, the apparent disagreement here is largely a matter of different stipulative uses of the word 'empiricism.'

7. A similar consequence is entailed for free will. Nothing about natural laws precludes an immaterial soul from having free thoughts. But for these to result in actions performed by the body, the bodily actions would need to be compatible with prior physical states. The situation here is more complicated than, say, the parting of the Red Sea or Jesus walking on water, as human action is mediated by electromagnetic and chemical reactions in the brain, and it is controversial both whether quantum electromagnetism is truly indeterministic and, even if it is, whether quantum-level effects play a role in neural dynamics.

8. Laplace is reported to have vacillated between deism and atheism, which differ precisely on the question of whether the initial conditions were chosen by God.

9. Independent of interpretation, the evolution of the wave function as described by Schrödinger's equation is deterministic. It is only what happens when classical observations are applied that is indeterministic.

10. This opposition between "strict" and "*ceteris paribus*" laws became particularly important in discussions of psychology and other human sciences in the latter twentieth century. See, for example, Davidson (1970), read as a response to the work of Dray (1957).

11. While I cite Giere's work as suggesting such a view, I am not certain that he actually means to endorse precisely the view I am criticizing here. His alternate formulation, which states that laws are true of "idealized models" of real-world situations, suggests a cognitivist

interpretation, on which it is the models that are idealized, without the suggestion that what the laws are true of are alternative possible worlds, a view that seems equivalent to that of Horst (2011).

12. In philosophy of science, proponents include Cartwright (1983, 1989, 1999), Harré and Madden (1975), Hacking (1983, 1986), Mumford (1998, 2004), Mumford and Anjum (2011), and Horst (2007, 2011). Metaphysical dispositionalism has additionally been explored by Shoemaker (1980, 2007), Bird (1998, 2007, 2009), and Martin (1994, 1997).

13. There are, in addition to these, laws of statics as well, which describe the state of a system at equilibrium.

References

Bird, Alexander. 1998. "Dispositions and Antidotes." *Philosophical Quarterly* 48:227–34.

———. 2007. *Nature's Metaphysics: Laws and Properties*. Oxford: Oxford University Press.

———. 2009. "Structural Properties Revisited." In *Dispositions and Causes*, ed. Toby Handfield. Oxford: Oxford University Press.

Cartwright, Nancy. 1983. *How the Laws of Physics Lie*. Oxford: Clarendon Press.

———. 1989. *Nature's Capacities and Their Measurement*. Oxford: Clarendon Press.

———. 1999. *The Dappled World: A Study of the Boundaries of Science*. New York: Cambridge University Press.

Davidson, Donald. 1970/1980. "Mental Events." In *Essays on Actions and Events*. Oxford: Oxford University Press.

Descartes, René. 1984. *The Philosophical Writings of Descartes*, trans. John Cottingham, Robert Stoothoff, and Dugald Murdoch, Vol. II. Cambridge: Cambridge University Press.

———. 1991. *The Philosophical Writings of Descartes*, trans. John Cottingham, Robert Stoothoff, Dugald Murdoch, and Anthony Kenny, Vol. III. Cambridge: Cambridge University Press.

DeWitt, Bryce S. 1970. "Quantum Mechanics and Reality." *Physics Today* 23:30–40.

Dobbs, Betty Jo Teeter, and Margaret C. Jacob. 1991. *Newton and the Culture of Newtonianism*. New York: Cambridge University Press.

Dray, William. 1957. *Laws and Explanations in History*. Oxford: Clarendon Press.

Drees, Willem B. 1996. "Gaps for God." In *Chaos and Complexity: Scientific Perspectives on Divine Action*, ed. Robert John Russell, Nancey Murphy, and Arthur Peacocke. Vatican City State: Vatican Observatory Foundation and Berkeley: Center for Theology and the Natural Sciences.

Esfeld, Michael. 2010. "Humean Metaphysics versus a Metaphysics of Powers." In *Time, Chance and Reduction: Philosophical Aspects of Statistical Mechanics*, ed. Gerhard Ernst and Andreas Hüttermann. Cambridge: Cambridge University Press.

Galilei, Galileo. [1738] 1974. *Two New Sciences*. Trans. ed. Stillman Drake. Madison: University of Wisconsin Press.

Giere, Ronald. 1999. *Science without Laws*. Chicago: University of Chicago Press.

Hacking, Ian. 1983. *Representing and Intervening*. Cambridge: Cambridge University Press.

———. 1996. "The Disunities of the Sciences." In *The Disunity of Science: Boundaries, Contexts, and Power*, ed. Peter Gallison and David J. Stump. Stanford, CA: Stanford University Press.

Harré, Rom, and Edward H. Madden. 1975. *Causal Powers*. Oxford: Blackwell.

Horst, Steven. 2007. *Beyond Reduction: Philosophy of Mind and Post-Reductionist Philosophy of Science*. New York: Oxford University Press.

———. 2011. *Laws, Mind, and Free Will*. Cambridge, MA: MIT Press.

Houston, Joseph. 1994. *Reported Miracles*. Cambridge: Cambridge University Press.

Hume, David. [1748] 1902. *An Enquiry Concerning Human Understanding*, ed, Lewis Amherst Selby-Bigge. Oxford: Oxford University Press.

Kane, Robert. 1996. *The Significance of Free Will*. New York: Oxford University Press.

Laplace, Pierre Simon. 2007. *A Philosophical Essay on Probabilities*. Trans. Frederick Wilson Truscott and Frederick Lincoln Emory. New York: Cosimo Press.

Larmer, Robert. 2009. "Divine Agency and the Principle of the Conservation of Energy." *Zygon: Journal of Religion and Science* 44:543–57.

Martin, Charles B. 1994. "Dispositions and Conditionals." *Philosophical Quarterly* 44:1–8.

———. 1997. "On the Need for Properties: The Road to Pythagoreanism and Back." *Synthese* 112:193–231.
Mumford, Stephen. 1998. *Dispositions*. Oxford: Clarendon Press.
———. 2004. *Laws in Nature*. London: Routledge.
———, and Rani Lill Anjum. 2011. *Getting Causes from Powers*. Oxford: Oxford University Press.
Murphy, Nancey. 1995. "Divine Action in the Natural Order: Buridan's Ass and Schrödinger's Cat." In *Chaos and Complexity: Scientific Perspectives on Divine Action*, ed. Robert John Russell, Nancey Murphy, and Arthur Peacocke. Vatican City State: Vatican Observatory Foundation and Berkeley: Center for Theology and the Natural Sciences.
———. 2006. *Bodies and Souls, or Spirited Bodies?* Cambridge: Cambridge University Press.
Peacocke, Arthur. 1990. *Theology for a Scientific Age*. Oxford: Blackwell.
Polkinghorne, John. 1989. *Science and Providence: God's Interaction with the World*. Boston: Shambhala.
———. 1998. *Belief in God in an Age of Science*. New Haven, CT: Yale University Press.
Shoemaker, Sydney. 1980. "Causality and Properties." In *Time and Cause*, ed. Peter van Inwagen. Dordrecht, The Netherlands: Reidel.
———. 2007. *Physical Realization*. Oxford: Oxford University Pres.
Swinburne, Richard. 1989. *Miracles*. London: Macmillan.
Ward, Keith. 2002. "Believing in Miracles." *Zygon: Journal of Religion and Science* 37:741–50.