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Two Concepts of Law of Nature

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ABSTRACT: I argue that there are at least two concepts of law of nature worthy of philosophical interest: *strong law* and *weak law*. Strong laws are the laws investigated by fundamental physics, while weak laws feature prominently in the "special sciences" and in a variety of non-scientific contexts. In the first section, I clarify my methodology, which has to do with arguing about *concepts*. In the next section, I offer a detailed description of strong laws, which I claim satisfy four criteria: (1) If it is a strong law that *L* then it also true that *L*; (2) strong laws would continue to be true, were the world to be different in some physically possible way; (3) strong laws do not depend on context or human interest; (4) strong laws feature in scientific explanations but cannot be scientifically explained. I then spell out some philosophical consequences: (1) is incompatible with Cartwright's contention that "laws lie" (2) with Lewis's "best-system" account of laws, and (3) with contextualism about laws. In the final section, I argue that weak laws are distinguished by (approximately) meeting *some but not all* of these criteria. I provide a preliminary account of the scientific value of weak laws, and argue that they cannot plausibly be understood as *ceteris paribus* laws.

KEY WORDS: Contextualism, counterfactuals, David Lewis, laws of nature, Nancy Cartwright, physical necessity.

In this article, I will suggest that there are (at least) two concepts of law of nature relevant to understanding scientific and philosophical discourse and these two concepts raise interestingly different philosophical problems. For the sake of clarity, I will call these concepts *strong law* and *weak law*. In what follows, I will describe these concepts in a little more detail and argue that they are, in fact, distinct concepts.[1]

[1] I would like to thank Patrick Maher, Jonathan Waskan, Dan Korman, Bob Wengert, and an anonymous reviewer for their insightful comments on earlier drafts of this article.

While I think that these results are of independent interest, they also have a direct bearing on some of the more traditionally "philosophical" debates about laws of nature. Specifically, these results suggest that philosophical attempts to identify the laws of the special sciences with laws of physics (e.g., by hypothesizing the existence of hidden ceteris paribus clauses) are misguided. For similar reasons, this conclusion also suggests that it would be inappropriate to demand that a particular philosophical analysis of laws of nature capture every use of the phrase 'law of nature.'

Arguing About Concepts

In order to argue that there are two distinct concepts of law, I will suggest that certain paradigmatically correct uses of 'law of nature' are incommensurable with other, also paradigmatically correct, uses of this phrase. This argument is premised on the fact that competent users (e.g., practicing scientists) of 'law' terminology are *not* massively mistaken in their judgments (or "intuitions") about laws in cases where these errors cannot be attributed to factual ignorance. So, for example, if such speakers regularly use appeals to 'laws of nature' to support counterfactuals or to ground explanations, we have good reason to think that there is a concept of law that is closely tied up with explanation and counterfactual truth. The cogency of this argument hinges on the assumption that competent speakers are, at least to some extent, authorities on how their concepts work. I do not take this to be a controversial assumption.[2] It does not rule out speakers being massively wrong about matters of fact (e.g., they falsely believe that *F=MA is a law* in cases where this error can be attributed to some sort of factual ignorance [e.g., they are unaware of Einstein's arguments]). It merely means that, absence evidence of inconsistency, charity requires that we assume that competent speakers are using their concepts correctly. In any case, it borders on incoherence to claim that speakers of a language are *massively* mistaken about the way that their own concepts are applied.

They have helped to improve it immeasurably. Any remaining mistakes or omissions are of course my own.

[2] I will often speak of 'concepts' as being something like the meanings of terms. The premise about the authority of competent speakers is compatible with, but does not require, Bealer's (1996, 2002) and Jackson's (1994, 1998) view that people have *a priori* access to their own concepts. So, for example, this premise would also fit well with Goldman's (1999) "naturalized" defense of intuitions. Goldman argues that naturalists ought to accept that competent speakers' intuitions ("conscious, spontaneous judgments") are a reliable indicator of whether a certain *concept* can be correctly applied, where *concepts* are non-conscious psychological states closely associated with the application of certain natural-language predicates. Goldman holds that speakers' intuitions provide us with strong *a posteriori* evidence about the extensions of various concepts (21–23).

So, if we discover that competent speakers have consistently believed that *were Newtonian mechanics to have been true, then F=MA would have been a law*, we have strong *prima facie* reasons to trust their judgments.

With this in mind, I will assume that if we can find clear criteria for applying phrases like 'law of nature' in one context and different (and inconsistent) criteria for applying 'law of nature' in another context, we can provisionally conclude that there are at least two concepts of law at work. The claim that the concept *weak law* is derivative (or merely metaphorical) can be dealt with in a similar way. As a matter of historical fact, it seems likely that the strong concept of law preceded the weaker one, and that the weaker concept came into use with the perception that certain other principles were like these strong laws in some way. This historical fact does not entail that the concept of weak law is illegitimate, however, nor that it can be identified with the strong concept. After all, some historians have hypothesized that the original concept of law of nature (which I have called *strong law*) originated in a metaphorical application of legal concepts to the natural world.[3]

It is also important to note a few things that I am *not* claiming. First, while I think it is clear that a satisfactory account of laws of nature must pay careful attention to scientists' (and philosophers') current and historical use of "law" language, it would be a mistake to suppose that this is the only (or even the most important) criteria by which a philosophical account of laws must be judged. After all, scientists use law terminology somewhat inconsistently, and there is thus little reason to suspect that a philosophical account that aimed at capturing all and only those principles that scientists actually called "laws" would be either coherent or interesting. Instead, my investigation will be aimed at explicating two *concepts* of law that play significantly different roles in scientific inquiry. The account will be successful to the extent that it accurately describes these concepts. Second, I will not be claiming that current scientific prac-

[3] The precise relationship between the legal and scientific concepts of law has been a matter of some debate. Zilsel (1942) and Needham (1951a, 1951b) contend that the scientific concept is essentially a straightforward application (by Descartes) of the legal concept onto the natural world, where God fills the role of a legislator. More complex (but roughly congruent) stories are given by Oakley (1961) and Ott (2009), who contend that the Cartesian concept of law is closely tied up with Descartes's beliefs concerning either (a) theistic *voluntarism* (i.e., the thesis that God is entirely free to act upon the world and is not constrained by the internal "essences" of things) or (b) natural law theory, which applied legal concepts to the moral world. Other writers have contended that the relationship between the two concepts of law is much more distant; for example, Ruby (1986) contends that the scientific concept of law arose from an analogy with mathematical or logical laws, and not from any direct analogy with legal concepts.

tice has discovered any strong or weak laws, or even that scientific inquiry is likely to discover such laws in the future. My (weaker) claim is simply that scientific practice (both historical and current) regularly makes *claims* about these two different sorts of laws, and that scientists regularly interpret observations as confirming or disconfirming claims about laws. In my conclusion, I will argue that even this relatively weak result has significant consequences for philosophical accounts of lawhood.

The First Concept of Law: Strong Law

I will label the first concept of law *strong law*. I will argue that strong laws (1) correspond to strict regularities, (2) are counterfactually robust, (3) do not depend on human interests or contexts, and (4) bear distinctive relations to explanations. Strong laws are the sorts of laws that those working on fundamental physical theory aim to discover, and are the types of laws relevant to philosophical debates about free will, physicalism, and induction. In a certain sense, the concept *strong law* is a relatively easy one to understand and examples of examples of theories that posit strong laws can easily be found. For example, in a universe governed by classical physics, Newton's laws of motion would be strong laws, as would his law of universal gravitation. Similarly, the equations of general relativity (GR) or quantum mechanics (QM) would plausibly express strong laws if true. So might the law of conservation of mass-energy and the second law of thermodynamics. Conversely, the "law of supply and demand" of economics is not a candidate for being a strong law, nor are the "laws" of folk psychology. I recognize that these examples are not entirely uncontroversial, and I will try to provide some motivation for accepting them in what follows.[4]

I take it that the concept of *strong law* is relatively clear. Moreover, it does not seem to be a concept that is of solely philosophical or historical interest, since one can easily find examples of physicists (mainly cosmologists) using law terminology in much the same manner that it is used historically (e.g., by Descartes or Newton). So, for example:

[4] Roberts (2004) and Kincaid (2004) provide a useful discussion of the differences (and similarities) between the principles appealed to in physics (including fundamental physical theory) and those appealed to in the social sciences (which includes principles such as the law of supply and demand). My own account suggests that there is perhaps a middle ground to be found in the debate over whether there are "laws" in the social sciences. In particular, my account of strong laws fits well with Roberts's characterization of the sorts of laws posited by fundamental physical theory (which he argues correspond to regularities and have a distinctive modal character), while my account of weak laws mirrors in important ways Kincaid's discussion of the role that "laws" play in the social sciences.

1. “For, like every other general law of nature, the law of transmission of light in *vacuo* must, according to the principle of relativity, be the same for the railway carriage as reference-body as when the rails are the body of reference.” (Einstein, 1921, 23).
2. “[Y]ou can guess already from my introduction that I am interested not so much in the human mind as in the marvel of nature which can obey such an elegant and simple law as this law of gravitation.” (Feynman, 1965, 24).
3. “What laws govern our universe? How shall we know them? How may this knowledge help us to comprehend the world and hence guide its actions to our advantage?” (Penrose, 2004, 7).

When used in contexts such as these, the terms ‘law’ and ‘law of nature’ are being used to pick out some fundamental principle of the universe, knowledge of which is *explanatory*. Such authors regularly refer to the laws as “governing” the universe and refrain from offering any suggestion that the laws of nature should be understood as true relative only to some particular context or purpose. Such authors are reasonably interpreted as making claims about strong laws.

A number of prominent philosophical discussions of laws of nature can also be construed as pertaining to strong laws. In particular, philosophical discussions of laws that emphasize features such as laws’ universality, their correspondence with strict regularities, and their sense of necessity can profitably be interpreted as being about strong laws. So, for example, consider Hempel and Oppenheim’s (1948, 152–157) influential description of what they call *fundamental laws*. Hempel and Oppenheim state that fundamental laws are “universal” principles of “non-limited scope” that cannot themselves be derived from laws that are more fundamental. They also claim that such laws form a sort of explanatory bedrock, insofar as they can be appealed to in explanations but cannot themselves be explained. Finally, like Newton and Descartes, Hempel and Oppenheim explicitly deny the idea that lawhood might be relativized to a particular community’s interests or evidence. Instead, laws are objective. Something like this conception of laws also seems to be at the heart of more recent debates about the reducibility (or irreducibility) of laws. So, for example, both Lewis (1973) and Armstrong (1983) agree with many of Hempel and Oppenheim’s claims about the general characteristics of laws.

With these uses of ‘law of nature’ in mind, we are in a position to make some general remarks about the distinctive features of strong laws. In this section, I propose to do just that, but with one major caveat: I will not be arguing that we have any justified beliefs about what the strong laws actually are, nor will I argue that there even exist any strong laws. My goal here is much more modest–I will simply aim to articulate what strong laws must be, if they are to be the types of things described in previous section. I will suggest that there are four distinctive characteristics of strong laws:

1. If it is a strong law that *L* then it is true that *L*.
2. If it is a strong law that *L* then, if it were the case that some physically contingent proposition *P* were true, then *L* would still be a strong law. For example, suppose that it really were the case that Newton's law of gravitation was a law of nature in our world. Then it should also be the case that this principle would *remain* a law, even on the supposition that physically contingent facts about our world (i.e., facts not necessitated by the laws of nature, such as those concerning the initial conditions of the universe) were different than they actually are.
3. The truth or falsity of the claim that *L is a strong law* is *objective* and *context-independent.*
4. If it is a strong law that *L* then *L* cannot be given a *scientific* explanation.

These points will undoubtedly be controversial to some readers, and I will present some reasons for accepting each. My main interest here, however, is not to definitively settle open philosophical or scientific debates about the nature of strong laws; rather, the idea is to identify a particular concept of law essential to understanding specific parts of scientific practice (and in particular, fundamental physical theory). In the next section, I will suggest that weak laws are distinguished by the fact that they lack one or more of these characteristics.

Strong Laws and Truth

The first distinctive characteristic of strong laws concerns truth. In particular, it seems plausible that, if the proposition *it is a strong law that L* is true, then *L* is true as well.[5] Descartes, for instance, explicitly claims that the laws he has discovered would hold in any universe God created, which clearly implies that such laws hold in our *own* universe. This principle has also been widely accepted in the philosophical literature on laws. So, for example, Humean reductionists such as Hempel and Lewis offer analyses according to which laws are identified with true sentences or true propositions, respectively; Hempel claims that laws are simply univer-

[5] This formulation assumes that *L* is a proposition. One might also express this principle in ontic terms (i.e., in terms of whatever it is that makes *L* true). For example, "If *L* is a strong law, then there are no violations of or exceptions to *L*."

sal generalizations that contain the appropriate types of predicates, while Lewis argues that they are extremely succinct summaries of the masses of particular facts. Similarly, the classic non-Humean accounts of Tooley, Dretske, and Armstrong conclude that propositions expressing laws of nature are in some strong sense *necessary* and thus, trivially, will be true in the actual world.

There are, of course, some well-known arguments concerning the "falsity" of laws. However, I do not think that these arguments, even if successful, threaten the analysis given here. So, for example, both Cartwright (1983, 1999, 2002) and Giere (1999) have argued that many paradigmatic claims about laws of nature would, even if true, fail to entail the existence of strict, exceptionless regularities.[6] To illustrate this point, Cartwright (1983) offers an extended argument that Newton's law of universal gravitation would fail to correspond to a strict regularity *even if the facts about gravitation were exactly as Newton claimed they were*. More specifically, she claims that if Newton's law of gravitation is interpreted as entailing any claim about the actual net acceleration experienced by massive bodies, then this claim will be false at nearly every Newtonian world. This is because massive objects in Newtonian worlds are almost always subject to other, non-gravitational forces that affects their acceleration.

According to Cartwright, the "falsity" of the law of gravitation need not prevent it from counting as a law at Newtonian worlds. This is because the law of gravitation does capture something related to acceleration–i.e., it captures the *power* or *capacity* of massive bodies to attract one another. So, on Cartwright's view, the proposition *it is a law of nature that any pair of massive bodies will experience an attractive force inversely proportional to the square of their distance* will be true just in the case that massive bodies have a capacity to attract one another that varies inversely by the square of their distance. By itself, however, the law does not entail anything about the existence of any regularity, strict or otherwise. Moreover, according to Cartwright, this problem is a fully general one, and one that cannot be overcome by noting the possibility that there exist laws governing additional forces (i.e., a Newtonian could not escape the problem by noting that the acceleration due to charge difference is captured by Coulomb's law).

[6] Cartwright's and Giere's arguments focus mostly on causal laws within fundamental physics. There are, of course, a variety of laws that would correspond to strict regularities if true–e.g., the law of conservation of mass-energy or the law that light has a maximum velocity. Cartwright's and Giere's claim is that this is not a universal feature of the laws discussed in fundamental physical theory.

Cartwright (1983, 54–74) offers an extended argument against the viability of the view that the law of gravitation and Coulomb's law describe *component forces* (e.g., that they describe *gravitational force* or *electrical force*). She has also repeatedly expressed pessimism about the very possibility of scientists' discovering a comprehensive "network" of laws that would jointly entail strict regularities. For example, in an early discussion of the covering-law model of explanation, she writes as follows:

> Covering-law theorists tend to think that nature is well-regulated; in the extreme, that there is a law to cover every case. I do not. I imagine that natural objects are much like people in societies. Their behavior is constrained by some specific laws and by a handful of general principles, but it is not determined in detail, even statistically. What happens on most occasions is dictated by no law at all …My claim is that this picture is as plausible as the alternative. God may have written just a few laws and grown tired. We do not know whether we are in a tidy universe or an untidy one. (1983: 49)

According to Cartwright, then, it is simply false that paradigmatic laws of nature entail strict regularities.

Several things can be said in response to such arguments. The first is that it is unclear whether Cartwright's arguments (even if successful) entail that (1) strong laws are very different from what most people take them to be (because they fail to entail the existence of strict regularities) or (2) there simply are no (actual) instances of strong laws. Insofar as our current aim is to describe a concept in actual use, the latter may provide a more plausible interpretation. If this is the case, then Cartwright's arguments can safely be put aside, since (as mentioned previously) I am claiming neither that there are any strong laws, nor that we can have any knowledge of any particular strong laws. Even if Cartwright is correct in her claim that Newton's laws do not entail regularities, for instance, it seems implausible to think that Newton (and his successors) understood them in this way. In the *Principia*, for instance, Newton seems quite optimistic about the possibility of (accurately) capturing the net forces that bodies are subject to via a system of laws modeled on his law of gravitation.

The Necessity of Strong Laws

The second distinctive characteristic of strong laws concerns their sense of "necessity" or "invariance" under various sorts of actual and counterfactual changes. Strong laws, unlike merely accidental generalizations, hold no matter what. So, for instance, most would grant that it is impossible for humans to *break* strong laws, even if some may argue for the metaphysical possibility of supernatural (i.e., "miraculous") violations of the law. Similarly, it seems plausible that strong laws would have continued to hold, even if physically contingent matters of fact were to be different than they actually are. So, for instance, had President Bush ordered a nuclear assault in response to the 9/11 attacks, the particular matters-of-fact about our world would have been far different than they actually are; however, the strong laws would be precisely the same. This distinctive relation between strong laws and counterfactual conditionals has been widely recognized by philosophers working on both topics. So, for example, Goodman (1947), Kneale (1950) and Stalnaker (1968) all affirm the principle that the laws of nature will be preserved under counterfactual antecedents with which they are logically consistent. The idea that a satisfactory analysis of laws should capture (something like this) relation with counterfactuals has been accepted by partisans of every stripe, including primitivists such as Carroll (1994, 7–10) and Lange (2000, 2005) and Humeans such as Urbach (1988), Ward (2003, 2005, 2007), and Roberts (1999, 2008).

The most commonly cited reason for denying the special relation between laws and counterfactuals involves its incompatibility with David Lewis's account of counterfactual semantics. Lewis argues (very roughly) that a counterfactual of the form *were P the case, then Q would be the case* is true just in the case that there are no worlds in which P is true and Q is false that are as similar to (or as "close to") to the actual world as worlds in which P and Q are both true. When considering the role that laws of nature ought to play in evaluating counterfactuals, Lewis considers and rejects the thesis that any world with the same laws of nature as the actual world will be more similar to the actual world than any world with different laws. In particular, Lewis argues that worlds with "small" miracles allowing the occurrence of P are more similar to the actual world than worlds with the same laws in which P holds because of differences in past particular matters of fact.[7]

While a critique of Lewis's proposed semantics for counterfactuals is obviously beyond the scope of this project, we can provide a response adequate to our purpose here. Lewis's argument against the thesis that laws have a special relationship to counterfactuals is based on considera-

[7] Lewis's argument is as follows:

> Suppose a certain roulette wheel in a deterministic world *i* stops on black at a time *t*, and consider the counterfactual antecedent that it stopped on red. What sorts of antecedent-worlds are closest to *i*? On the one hand, we have antecedent-worlds where the deterministic laws of *i* hold without exception, but where the wheel is determined to stop on red by particular facts different from those of *i*. Since the laws are deterministic, the particular matters of fact must be different at all times before time *t*, no matter how far back …On the other hand, we have antecedent-worlds …where the laws of *i* hold *almost* without exception; but where a small, localized, inconspicuous miracle at *t* or just before permits the wheel to stop on red in violation of the laws (1973: 75).

tions that are quite far removed from scientific practice or ordinary use–in particular, Lewis's argument assumes that the evaluation of counterfactual conditionals requires the consideration of concrete, non-actual worlds and that such worlds can be ranked according to objective similarity matrices. Neither of these premises can be directly vindicated by appeal to specific aspects of the way people understand counterfactuals; instead, they are theory-laden assumptions whose plausibility is taken to rest on the formidable apparatus of Lewis's proposed semantics for counterfactuals. So, insofar as we are interested in describing a concept of actual scientific practice, the fact that certain aspects of its application seem to conflict with a technical philosophical theory need not immediately concern us[8].

In any case, if strong laws are necessary in this sense, then they cannot be mere "summaries" of occurrent facts, as many have claimed. Notably, this means that our conception of strong law is incompatible with the "best system" account of law defended by Mill, Ramsey, and Lewis. This thesis identifies the laws of nature with the consequences of the axioms of our simplest, strongest true theory of the world.[9] Lewis describes the view as follows:

> Take all deductive systems whose theorems are true. Some are simpler, better systematized than others. Some are stronger, more informative than others. These virtues compete: an uninformative system can be very simple, an unsystematized compendium of miscellaneous information can be very informative. The best system is the one that strikes as good a balance as truth will allow between simplicity and strength …A regularity is a law iff it is a theorem of the best system. (Lewis, 1994: 478)

Following Lewis, I will define the thesis as follows:

> (MRL) L is a strong law if and only if L is a theorem of the true physical theory that best balances strength and simplicity.[10]

Strength here is intended as a measure of the information conveyed by the theory, while simplicity measures its economy of expression in a certain language. There are a number of *prima facie* problems that arise when one

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[8] Lewis (1979) suggests that, in general, we will judge that even small violations of laws render a world "less similar" to our own than do massive changes in particular matters of fact, and attempts to modify his semantics for counterfactuals to partially account for this fact. This suggests that Lewis recognizes this aspect of the ordinary concept of law, even if his proposed semantics for counterfactuals cannot entirely account for it.

[9] The view is first articulated by Mill (1874) and is later developed by Ramsey (1978). Lewis first proposes the view in his (1973: 73–74). Most contemporary formulations take Lewis's formulation as a starting-point.

[10] Lewis (1994) requires that candidate theories also be evaluated for how probable they make the actual distribution of non-nomic facts; Lewis calls this criterion that of *fit*. Since this is irrelevant to the discussion here, I've left it out.

tries to make these concepts more precise–for example, a good definition of *strength* should privilege useful information over mere listing of facts, and a good definition of *simplicity* should not end up being language-relative.[11] I will assume in what follows that some satisfactory account of these notions can be found.

The root problem with MRL is that it cannot account for the distinction between laws of nature and accidental generalizations–that is, it cannot account for the *necessity* of strong laws. To see why, consider the following propositions:

(U) There are no spheres of uranium more than a mile in diameter.

(G) There are no spheres of gold more than a mile in diameter.

It is plausible that, in the actual world, both *U* and *G* are true but that only *U* is a strong law. MRL can capture this distinction only if the inclusion of *U*, but not *G*, results in the deductive theory that best balances strength and simplicity. Since *G*'s inclusion would strengthen the theory, its exclusion can only be justified by appeal to the loss of simplicity. Whatever the success of this maneuver in the actual world, there are reasons to think that the strength and simplicity criteria cannot generally track the distinction between laws and accidental generalizations. Consider, for instance, the class of worlds that are populated only by gold spheres that are slightly smaller than a mile in a diameter. It seems reasonable to think that, on any reasonable weighting of strength and simplicity, *G* (or something similar) will count as a law by the MRL criteria. After all, the inclusion of *G* in our theory would allow for considerable predictive and descriptive power at such worlds. There is no independent reason, however, to think that *G* is a strong law in every such world. In particular, it seems plausible to claim that at least one of these worlds has the same laws as the actual world, according to which G is not physically necessary.[12] But, if this is the case, then the best system account fails as a definition of strong law.

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[11] For examples of some of the problems that arise with Lewis's original treatment of these concepts, see Armstrong (1983) and van Fraassen (1989). In response to these worries, Earman (1986, 87–90) and Loewer (1996) both offer revised definitions of strength and/or simplicity.

[12] Roberts (2008) has criticized MRL on the related grounds that it cannot distinguish widespread regularities that are the result of nomically contingent initial conditions from those regularities that are not so contingent. Roberts argues that this distinction is at the heart of "fine-tuning" arguments and plays a central role in scientific reasoning. In particular, scientists and philosophers have usually assumed that the first type of regularities, but not the second, must be given some explanation. In many cases, this belief has served as a stimulus to productive scientific theorizing. As an example, Roberts offers the following case: Laplace's nebular hypothesis was proposed to explain the fact that all the planets orbited on approximately the same plane, a fact which Newton had claimed resulted from God's arbitrary will. Laplace, but not Newton, hypothesized that this regularity resulted from nomically contingent initial conditions and was thus explicable.

The above example shows that being included in the best system is not a sufficient condition for a proposition's being a strong law. Other examples can be constructed to show that MRL fails to provide necessary conditions for lawhood. Consider the case of unobtainium, a hypothetical element discussed by Lewis (1994). Suppose that there are certain principles governing unobtainium's rate of decay analogous to those governing the decay-rates of other particles. For example, it may be that unobtainium has a 0.5 chance of decaying over 10,000 years. Further suppose, however, there only ever exists a single atom of unobtainium, and that it decays in exactly 9,520 years. Lewis's worry is that, in such scenarios, MRL may generate an incorrect law concerning unobtainium's rate of decay. There is a broader concern however: MRL may be incompatible with there existing any laws governing unobtainium at all. After all, if unobtainium is extremely rare, and if there exist no derived laws concerning its rate of decay, it is unlikely that the inclusion of a statement describing unobtainium's rate of decay in our axiomatized theory will strengthen this theory enough to outweigh the corresponding loss of simplicity. So, MRL will entail that there is no law governing unobtainium's rate of decay. Since an element's rate of decay is a paradigmatic example of a law-governed process, this shows that MRL fails to provide necessary conditions for lawhood.

The Objectivity of Strong Laws

The third distinctive characteristic of strong laws concerns their objectivity, where 'objectivity' means that the truth of claims such as *L is a law of nature* do not depend upon features such as the speaker's interest in asserting the claim or on the context in which the statement is being considered. Early users of the law-concept (such as Descartes and Newton) clearly take the laws of nature to represent objective matters of fact. This assumption has also been shared by the majority of their scientific successors and by the scientifically literate folk when they engage in discussions about what the laws of nature are. It has also been shared by most philosophers who have written about laws. There is thus a strong *prima facie* assumption that there is a concept of law according to which the truth of *L is a law of nature* depends only on non-contextual, non-subjective aspects of the physical world.

Unsurprisingly, there are at least a few analyses of law of nature according to which paradigmatic strong laws fail to be objective in this sense. In particular, some recent presentations of MRL-style views have advocated subjectivism or contextualism in order to solve the sorts of problems mentioned previously. Many of these accounts have purported to do this by explicitly defining the notion of *best system* in terms of the theory, perspective, or context within which it is evaluated. So, for example, Roberts (1999, 2001) has argued for an "indexical" interpretation of the best-system analysis of laws, Halpin (1998, 1999, 2003) has argued for a Humean "perspectival" account of laws and physical probability, and Ward (2002, 2003, 2004, 2005, 2007) has argued for a "projectivist" account. In each case, the general move has been to reconcile the apparent differences between MRL and our normal way of thinking about strong laws by appealing to some feature of the *context* in which the laws are being considered. The consideration of context, which includes factors such as language, world, and the purpose for which a theory is being used, allows for the possibility of there existing multiple theories that best balance of strength and simplicity, and thus, for their being multiple systems of "laws of nature".[13] For example, these authors suggest that the possibility of there being different laws in worlds with the same non-nomic facts is explained by the fact that which laws hold is determined partially by contextual features. One possible advantage of these approaches is that they give more determinate content to the overly vague notions of strength and simplicity. A second is that they might be able to better capture the distinction between laws and accidents.

I will not pursue objections to these specific accounts in detail, but it is worth noting a few ways in which these accounts diverge from our concept of *strong law*. First, these accounts entail that which propositions are laws of nature at a world will depend on the context in which that world is being considered. So, when considering the class of gold-sphere worlds described above, it is open for defenders of context-sensitivity to say that, depending on the context in which these worlds are being considered, *G* might be a law in all of these worlds, or some of them, or none of them. The same can be said for the analogous class of uranium-sphere worlds. The problem with this solution is that it fails to fully account for the differing ways in which we treat propositions such as *U* and *G*. In particular, no reasons have been provided for thinking that our *actual* judgments concerning *U* and *G* are a function of context. After all, we seem to be considering the propositions in quite similar contexts–we are assuming that

[13] Halpin's characterization of perspective is representative of what I am calling "context":

> First, it determines a language for all candidate theories. This language is the basis for the second aspect of perspective: standards of strength, simplicity, and fit. These notions we saw to be language dependent. Third, a perspective involves particular scientific methodologies and preferences – i.e. a scientific culture provides an understanding of the appropriate ways that scientific theorizing may proceed. (2003: 151)

Context in the above sense might be thought of, very generally, as being made up of everything the agent brings to the table with her when considering which theory (and which set of laws) to endorse.

these propositions are true, and are concerned in figuring out whether or not they would *continue* to be true, were the world to be changed in some way. It is difficult what feature of the context might explain our differing judgments. By contrast, there are very good reasons for supposing that the differences in the way we treat these propositions is an effect of our beliefs about the objective makeup of the world. In particular, it reflects our beliefs about the differing atomic makeup of gold and uranium, and the effects that this difference would make in the scenario we are considering. For this reason, I think contextualism fails as an account of how our *concept* of strong law actually works. This doesn't entail, of course, that contextualism might not have other redeeming virtues (for example, if we discovered that strong laws as ordinarily conceived of do not exist, embracing contextualism may provide a convenient "fall-back" position allowing us to preserve something of what was valuable about talk of laws).

A second problem concerns the opacity of the contextual notions to those engaged in debates over the laws of nature. In particular, it is difficult to see how a scientist could determine whether others engaged in a certain debate with her share her context. So, for instance, suppose that Marie is in a debate with a researcher who (1) agrees with her on the results of all actual experiments that have been and will be performed but (2) disagrees with her on what the results of certain counterfactual experiments would be. For example, suppose he claims that, were a certain experiment E to be performed in a perfect vacuum, then R_1 would be the result while she claims that, were this experiment to be performed in a perfect vacuum, R_2 would be the case. If both Marie and her colleague agree that perfect vacuums do not (and will not) exist, this cannot reasonably be interpreted as a disagreement about any non-nomic feature of the world. If one conjoins these contextualist views with some reasonable principle of charity, it would seem that Marie ought to interpret her disagreement with her colleague as an equivocation resulting from a difference in context. But this is false, since Marie is clearly right in interpreting her colleague as genuinely disagreeing with her. More generally, there do not seem to be any plausible examples of fundamental laws that vary according to context. Canonical descriptions of laws of nature by both classical and modern physicists (e.g., Descartes, Newton, Einstein, Feynman, or Hawking) never assign context anything like the role it plays on these sorts of views.

In any case, there is no need to present a knockdown argument against such views here. Whatever the merits of these contextualist views may be, no reasons have been provided for thinking that this lack of objectivity is a feature of the ordinary concept *strong law*. None of the previously mentioned authors argue for this claim based on appeals to current practice, however; instead, they claim that the thesis that the laws are subjective allows them to account for the laws' relation to counterfactuals without positing any problematic entities or relations.[14] Such analyses of 'law of nature' may or may not be successful as proposals for how we *should* speak about laws (i.e., they may succeed as explicata), but we have little reason to accept them as *descriptions* of concepts already in use (i.e., as clarifications of the explicandum).

Strong Laws and Explanation

The final distinctive characteristic of strong laws concerns their asymmetric relationship to explanation. In particular, while strong laws can often be used to provide scientific explanations of certain events or phenomena, they themselves cannot be given such explanations.

The use of strong laws in explanations has been widely recognized, so I will not argue for it here. As an example, consider Newton's *Principia*, which shows how the laws of Newtonian mechanics and the law of gravitation can be used to explain *why* the heavenly bodies move in the speeds and directions that they were known to move in.

More importantly for the purpose of distinguishing strong laws from weak laws, it does not seem that strong laws themselves can be given scientific explanations.[15] For example, if Newton had been *correct* in his claim that his laws of motion were the fundamental laws of the universe, then it would have been impossible to *explain* why these laws held in scientifically acceptable terms. This is reflected by the fact, when we are given a scientific explanation for why a certain 'law' holds, we will no longer regard as being a 'law' *in the same sense.* So, in explaining why Kepler's laws of planetary motion and Galileo's law of free-fall yielded correct predictions, Newton showed that they were not strong laws. This

[14] Ward defends the failure of projectivism to match up with our intuitions about the "factual status of laws" by noting that (1) the complexity of the projectivist analysis can explain why people may not have noticed that they are secretly projectivists and (2) "in light of that explanation, the naive intuition does not demand to be vindicated. Our judgment regarding the factual status of laws should be made in light of the respective merits and demerits of the candidate analyses *once they've been properly formulated"* (2002: 212).

[15] It is worth emphasizing the import of the *scientific* modifier here. Both Descartes and Newton thought that one could explain why the universe had the laws it did by reference to God's actions; a similar view is defended by Foster (2001, 2004). On these views, it is nevertheless the case that strong laws represent a sort of scientific explanatory bedrock–no explanation of the laws can be given without explicit mention of a God. The same might be said for explanations of complex laws that proceed by mathematically deducing them from known laws. In such cases, the explanation might appropriately be called "mathematical" as opposed to "scientific."

intuition is also reflected in many philosophical theories of explanation. I have already noted Hempel's and Oppenheim's (1948) "covering law" theory of explanation, according to which explanation proceeds by deduction from fundamental laws. By definition, such accounts of explanation cannot be applied to the explanation of strong laws themselves. The same phenomenon arises if one attempts to explain strong laws according to unificationist, mechanist, or counterfactual views of explanation. We can cite no further natural regularity that "unites" strong laws, no "mechanism" underlying their obtaining, and no particular state of affairs the obtaining of which is counterfactually related to the strong laws in the correct way.

The Second Concept of Law: Weak Law

I have argued that there is a scientifically significant concept of law of nature that picks out propositions that are true, objective, and bear distinctive relations to counterfactuals and explanation. I called this concept *strong law.* In this section, I will argue that *strong law* is not the only concept of law of nature that is relevant to scientific practice. More specifically, I will argue that certain (also paradigmatically correct) uses of phrases like 'law of nature' cannot plausibly be taken as pertaining to strong laws, since they violate at least one of the criteria laid out above. For the sake of convenience, I will call the concept associated with these other sorts of uses *weak law*. This concept approximates in certain ways the more familiar concept of *ceteris paribus law*. However, there are also significant differences between these concepts, which I will discuss in more detail later.

Paradigmatic weak laws include many of the important principles of the special sciences. One might also include (as borderline cases) such analogical uses of law-terminology such as "Murphy's laws" or "the laws of dating." All such uses of law-terminology share some significant similarities to the strong laws described above, but these putative laws fail to qualify as strong laws by the criteria offered there. With this in mind, here are some principles that, while appropriately called 'laws' in some sense, are clearly not strong laws:

1. **Newton's second law (mechanics):** The relationship between an object's mass m, its acceleration a, and the force applied to it F is given by the formula $F=ma$.
2. **Galileo's law of free-fall:** A body in free fall near the earth will accelerate at 9.8 m/sec^2.
3. **Boyle's law (thermodynamics):** For a gas held at a fixed temperature, the product of the pressure p and volume V is equal to a fixed constant k. The laws is expressed by the formula $pV=k$.

4. **Bode's laws (astronomy):** The mean distance a of planet n from the sun is described by the formula $a=(n+4)/10$, where earth's mean distance = 1, and $n = 0,3,6,12,24,\ldots$.
5. **Thorndike's law of effect (psychology):** A behavior that produces a satisfying effect in a given scenario is more likely to be repeated in future scenarios of the same type than a behavior that produces an uncomfortable effect.
6. **Mendel's law of inheritance (genetics):** The inheritance pattern shown by one trait will be independent of that shown by other traits.
7. **The law of demand (economics):** If the price of a good is reduced, demand will increase; if the price is increased, demand will decrease.
8. **The exponential law of population growth/Malthus's law (population ecology):** So long as the environment is stable, a population will grow or shrink exponentially.
9. **Dollo's law (evolutionary biology)**: Evolution is irreversible–no organism will have the exact same traits that some distant ancestor did.
10. **Fodor's law (folk psychology)**: If someone desires *D*, she will try to get *D*.

I assume that each of the uses (with the probable exception of "Fodor's law") above represents a plausible use of the word 'law', at least if uttered in an appropriate context. One can find numerous references to laws such as these in peer-reviewed scientific journals and philosophy of science textbooks. This suggests that the claim that "Newton's second law is not a law" is blatantly (if not analytically) false.[16] It only makes sense to deny that Newton's laws are laws if one already has a particular analysis of lawhood in mind. If one adopts this stance, however, once must grant that one is no longer talking about the concept of law that is relevant to the actual use of Newton's laws, and that one is instead relying on a philosophical *theory* of laws. One might also object to the lawhood of the above

[16] Some readers may think that I have overstated the case here a bit. After all, I've previously argued that Newton intended to make claims about *strong laws*; understood this way, it is clearly true that Newton's laws are not laws. However, I think that arguing this way is to miss the point. There is a perfect legitimate sense in which Newton's laws are laws–e.g., they are laws for disciplines not concerned with the sorts of scenarios where Newton's laws yield widely inaccurate predictions. Many textbooks in engineering, biomechanics, etc. regularly make reference to 'Newton's laws' and do so without any caveat.

examples by appealing to disagreement among practicing scientists (e.g., about whether the law of demand is really a law). Like the first objection, this does not seem relevant, since the vast preponderance of such disagreements concern empirical matters (e.g., about how widely applicable the principle is), and not the meaning of calling such principles 'laws'.[17] We may discover that none of the above principles are laws; nevertheless, this would fail to show any problem with the concept of *weak law*. Rather, such discoveries would reflect that the world was different than we had previously thought it was.

It is worth noting that all of the propositions listed above are false and hence, cannot be strong laws according to the criteria proposed in the previous section. Consider Newton's laws, for instance. General relativity shows that these laws, if taken as descriptions of actual systems (e.g., the orbits of the planets around the sun, or of the moon around the earth) are false. General relativity also shows, of course, why and to what extent these laws can be used to provide approximately accurate predictions– they are accurate of mid-sized bodies moving at speeds significantly less than the speed of light that are not subject to strong gravitational forces. Even in these cases, however, Newton's laws are literally false; the ontology it presumes simply does not exist in our world. The case with Boyle's law is similar. The formula, which describes the relationship between pressure, volume, and temperature, is false. As was the case with Newton's laws, however, it can be used to provide accurate predictions concerning certain types of systems–namely, those at relatively low temperatures and pressures. However, since its derivation depends on the assumption that gas particles have no volume, are subject to no intermolecular forces, etc., Boyle's law does not actually describe any actual gas. The same can be said of each of the other principles–in each case, they are literally false if taken as descriptions of the real world systems to which they are commonly applied.[18] Nevertheless, we have no problem in saying that these principles are 'laws' when considered in the correct contexts.

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[17] This is not to say, of course, that scientists never have semantic disputes about what ought to be called a 'law.' In most such cases, however, I suspect the underlying concerns are empirical–i.e., they concern the scope or usefulness of the principle in question. I suspect that few, if any, economists would take seriously the claim that the law of demand was not a law for the simple reason that *no principle of economics is a law*. To argue in such a manner would be to misconstrue the meaning of calling something a 'law" in the context of economics.

[18] Importantly, they are not all false for the same reason. Some weak laws are idealizations or abstractions that are false because they fail to account for other forces, while others are more fundamentally mistaken. Moreover, as I will argue in the next section, it is possible for weak laws to be true.

Earlier, I argued that strong laws share at least four distinctive characteristics: their correspondence with certain strict regularities, their objectivity and context independence, their preservation under certain counterfactual suppositions, and their asymmetric relation to explanation. I will suggest that weak laws are characterized by lacking *some but not all* of the distinctive characteristics of strong laws, and by the way they approximate meeting other criteria. So, while there are no necessary or sufficient conditions for any particular principle counting as a weak law, there is a clear sort of "family resemblance" between strong laws and weak laws.

Some Weak Laws are False

I noted above that each of the sample weak laws described in the previous section is false. This suggests that the truth of propositions such as *it is a weak law that L* are compatible with *L*'s being false. The immediate objection to this, perhaps inspired by Fodor (1991) and Pietroski and Rey (1995), might go as follows: while the sentences listed above are false, one can produce true sentences by appending a *ceteris paribus* (CP) clause of the form "other things being equal." Once this (already implicit) clause is tacked on, according to this story, one can see that the weak laws are true and do correspond to strict regularities in precisely the same way that strong laws do.[19] So, for example, we should not understand what I've called "Fodor's law" to be disproved by a person who forgoes satisfying his or her own desires in order to aid a family member; instead we should say that people will try to satisfy their desires only "other things being equal," and note that a family member in distress counts as a case in which other things are not equal. If this were true, then Fodor's law does correspond to a strict regularity–its obtaining rules out the possibility of there being a case in which (1) a person did not seek to satisfy her own desires and (2) other things were equal (i.e., there were no interfering factors that could be blamed).

There are a number of reasons for doubting that the laws explicitly discussed in the special sciences can be made true by appending CP clauses. So, for example, there is reason to think that CP clauses may render

[19] More importantly, at least for the defenders of CP-clauses, claims about laws in the social sciences can be confirmed or disconfirmed in the same manner as claims about the laws of physics. For instance, we can disprove claims about strong laws by discovering that the entailed regularities do not hold. Defenders of CP-clauses are committed to the idea that claims about "laws" in the social sciences can be disconfirmed in just the same manner. Laws of both sorts entail strict regularities; if these regularities are observed not to hold, then the purported law is not a law.

a generalization vacuous (Earman *et al.*, 2002, Woodward, 2002) and that the existence of such implicit clauses is incompatible with the way that the principles in questions are actually applied (Schiffer, 1991, Mitchell, 2002). While I am sympathetic to these points, I think there is a simpler reason for denying the adequacy of such a solution: namely, many of the laws of the special sciences cannot be made true simply by appending ceteris paribus clauses. Consider the laws of Newtonian mechanics, for instance, which appear to be paradigmatic of the sorts of "laws" used in disciplines such as engineering or biomechanics (i.e., quantitative disciplines outside of fundamental physical theory). There is no simply sense in which these statements of such laws are true "other things being equal." According to GR and QM, the relationship between mass, acceleration, and force posited by Newton's laws would be false *even if these were the only forces acting*; it is not merely that Newton's laws have left out relevant forces (of the type that could be accounted for by a ceteris paribus clause). At best, one might argue that Newton's laws are true in a certain sort of *idealized* case (e.g., they hold in a "perfectly" inertial reference frame), but one cannot coherently describe the ways in which actual situations differ from this ideal situation in terms of CP clauses that specify the ways in which actual situations differ from these ideal cases. After all, Newton's laws deal with massive bodies, and these bodies will (of physical necessity) experience *some* gravitational effects.

The case is even worse for laws such as Galileo's law of free-fall, which cannot coherently be described as being true even in an *idealized* case. After all, Newton showed that bodies in free fall do *not* accelerate at a constant rate at all, but that the acceleration due to gravity will change with the distance between the objects (i.e., gravity obeys an inverse square law). Galileo's simply describes (roughly) the rate of acceleration experienced by mid-sized bodies that happen to be in free-fall near the surface of the earth. Again, one could deny that Newton's laws and Galileo laws are 'laws' at all (even weak laws), but there is no evident reason to do so. Such laws are typical of the sorts of things that are often called "laws" in disciplines outside of fundamental physics. Such laws can be used to successfully predict the behavior of falling bodies and support counterfactuals (had I dropped a stone off the roof, it would have fallen in accordance with Galileo's law of free fall). They thus share certain other characteristics of strong laws; it is these similarities (and not a hidden CP clause) that makes them weak laws.

It is worth considering (especially given the examples offered above) whether weak laws are always false. If this were so, we might be able to offer a succinct explanation of the difference between strong laws and weak laws: the former are true and the latter are false. On closer inspection, however, it does not seem obvious that weak laws must be false. One could, with some effort, cook up a close relation of Bode's law that is literally true, and could be used to offer precisely accurate predictions. One might plausibly do something similar with Dollo's law, which was for a time thought to correspond to a strict regularity. Even if one succeeded in reformulating these principles to guarantee their truth, however, it does not seem that one would have succeeded in uncovering a new strong law. Instead, one would merely have discovered a more accurate (and probably more unwieldy) version of an existing weak law. I think a better explanation for the failure of such true weak laws to be strong laws cites their failure to meet the other criteria relevant to strong lawhood. It is to these criteria we will now look.

The Context-Dependence of Weak Laws

Some weak laws also violate the second criterion for strong lawhood–that is, claims about what is or is not a weak law do not depend solely on objective, context-independent matters of fact. To be more specific: it seems plausible that there is a proposition *WL* and pair of contexts C_1 and C_2 such that

1. In C_1, it is true that *WL is a weak law*, and
2. In C_2, it is false that *WL is a weak law*.

One can easily see this sort of context-dependence of weak laws reflected in scientific discussions of paradigmatic weak laws. For example, in contexts where we are concerned with objects in free-fall near the surface of the earth, it seems appropriate to call Galileo's law of free-fall a law, even though it obviously fails to be a strong law. Conversely, in contexts where we are concerned with objects in free-fall near the surface of the moon, Galileo's law cannot appropriately be called a law of any type. Similarly, while Mendel's law of inheritance plausibly counts as a weak law in a great many contexts, it would not count as a weak law for a research team interested in examining whether the inheritances of two specific alleles was actually independent. This sort of context-dependence does not occur with strong laws; so, for instance, there are no plausible examples of contexts in which *no information can be transmitted faster than the speed of light* does not count as a strong law.[20]

[20] Lange (2000) offers various examples of laws that are laws only relative to some discipline or context. For example, he considers the case of Boyle's law and van der Waal's equation, both of which deal with the relation between pressure, volume, and temperature in ideal gases, and both of plausibly express laws (2000: 211–220). Since these laws generate inconsistent predictions, Lange claims that cannot *both* be laws in a single context.

As another way of illustrating this point, consider how our claims about strong and weak laws might appear to the intelligent, but non-human, inhabitants of a different planet. Our claims about strong laws would presumably be relatively straightforward: whatever claims about strong laws that are true for the inhabitants of such a planet would also be true for us, and vice versa. It seems highly plausible that, were we to encounter alien life, one of the major areas of mutual interest would concern finding out what the other party knew about the strong laws. The principles I have called "weak laws," by contrast, might very well be of no interest to such beings. If the planet's mass differed from that of earth, for instance, Galileo's free-fall equations would fail to provide reasonably accurate predictions of the behavior of falling bodies; if the inhabitants' neurology and psychology differently sufficiently from that of humans, then their system of economic exchanges might massively violate our law of supply and demand. If this were case, it would be inaccurate to claim that these principles were weak laws *for these beings*.

This context dependence of weak laws suggests that weak lawhood is tied closely to usefulness. Galileo's free-fall principle, for instance, counts as a weak law just in those contexts in which it is expedient to use it for prediction. Similarly, the weak lawhood of folk-psychological, economic, or biological principles will be manifested only in contexts where there is an interest in predicting the behavior of the various life-forms (human and non-human) that inhabit our planet. If this claim about weak laws is correct, then the truth of claims like *it is a weak law that L* may be in some sense subjective or context-dependent, even if the truth or falsity of *L* is entirely objective. Of course, it does not follow that one can make arbitrary propositions into weak laws merely by manipulating features of the context in which they are discussed. So, for example, one cannot by fiat make wildly inaccurate principles into weak laws simply by treating them as such. Similarly, there is a perfectly objective sense in which, given a particular context, something is either a weak law or it is not. Aristotle's principle that massive bodies seek the center of the earth, for instance, represents an intuitive principle that many children (and uneducated adults) still appeal to on a regular basis. It is not, however, a plausible candidate for weak lawhood in any scientific context. This is because, in any context in which Aristotle's principle might be used to issue predictions, there are a wide variety of other principles–Galileo's law of free-fall, Newton's law of gravitation, etc.–that fill the predictive role better than Aristotle's principle does. The contrast here is not between truth and falsity—all three principles are false—but between those principles that have legitimate scientific uses and those that do not.[21]

Weak Laws and Counterfactuals

In the previous section, I suggested that strong laws are characterized by a certain distinctive relationship to counterfactuals. In particular, I argued that a strong law would remain a strong law under any physically possible counterfactual supposition.[22] This is plausibly false of all weak laws. For example, it does not seem that the law of demand would remain a law were human psychology to have evolved in a radically different way than it actually has. This dependence upon physically contingent matters-of-fact is characteristic of weak laws. Many (if not all) of the laws of biology, psychology, economics, medicine, etc. depend upon the fact that life on earth evolved in a certain way; similarly, Newton's laws serve the needs of engineers so well only because of certain (physically contingent) facts about the types of things we care about building. It is important to note that the capacity to support counterfactuals is independent of the truth of the weak law in question. The problem is rather that, had certain physically contingent facts been different than they actually are, most weak laws would fail to provide even approximately correct predictions.

For an illustration of what I am talking about, consider the following counterfactual claims, all of which I take to be correct:

1. Were the curvature of space to be much more extreme than it actually is, Newton's laws would not be weak laws.
2. If it were the case that humans wanted all and only goods that were in wide supply, the law of demand would not be a weak law.
3. If it were the case that there were a super-powerful being who periodically manipulated organisms' s DNA to resemble their ancestors, Dollo's law would not be a weak law.

[21] I think it would be overly strong to claim that there are no contexts in which Aristotle's principle is a weak law. It seems plausible, for instance, that this principle had legitimate claim to being a weak law in the time before early modern physics made it obsolete. This is, again, in sharp contrast to strong lawhood; Aristotle's principle is not and never was a strong law, even though it was widely believed to be so.

[22] That is, if a counterfactual supposition is logically compossible with the strong laws remaining the laws, then the strong laws would continue to be the strong laws, were that counterfactual supposition to be the case. It is, of course, logically possible for the strong laws to be different; the only point here is that it isn't physically (or nomologically) possible for them to be different.

The important point here is not that there are some counterfactual antecedents under which weak laws would cease to be weak laws (that is true of the strong laws, too), but that they would cease to be laws under physically possible counterfactual antecedents—i.e., under antecedents that are logically compossible with all the strong laws remaining strong laws.

While the weak laws fail to support counterfactuals in the distinctive manner that strong laws do, it is important to note the weak laws do support counterfactuals and that this support in some ways resembles the support to counterfactuals provided by strong laws. So, for instance, consider each of the following counterfactuals, along with the weak law that supports it:

1. Were a pencil to fall off of my desk, it would accelerate at a rate of around $9.8m/sec^2$. (Galileo's law)
2. Were Donald Trump to desire to acquire a 2004 Ford Taurus, he would undoubtedly own one. (Fodor's law)
3. If demand for tulips were to be much higher than it currently is, the price of tulips would also be much higher. (Law of demand)

Our confidence that such counterfactuals are correct suggests that we are committed to weak laws supporting at least certain sorts of counterfactuals. Some paradigmatic weak laws, such as Newton's laws of motion, seem to be distinguished by the fact that their accuracy is preserved under the types of counterfactual antecedents that are of special interest to us.[23] It may be that there is no specific relation to counterfactuals possessed by all and only weak laws; instead, it seems that many weak laws support counterfactuals in a manner that is somewhat analogous to the way that strong laws do.

Weak Laws and Explanation

I previously argued that strong laws can be used in explanations but cannot themselves be (scientifically) explained. Weak laws, conversely, may meet neither of these criteria. Many weak laws, including all of those offered as examples, can be explained. For example, GR can explain why

[23] A number of authors have written on the relationship between counterfactuals and the principles appealed to in the special sciences. Lange (1999, 2000), for instance, argues that the laws of the special sciences have a relationship to the non-nomic facts of the their domain that precisely mirrors the relationship of the laws of physics to domain of physics. Skyrms (1980, 1995), Mitchell (2000), and Woodward (2003) have also offered accounts that, while not agreeing with Lange's on specific details, concur in the conclusion that the principles of the special sciences relate to counterfactuals in a manner that resembles, but does not duplicate, the relationship between the laws of physics and counterfactuals.

Newton's laws hold for certain types of systems and facts about cellular biology and genetics underlie the truth of Dollo's law. Even in those cases where we cannot currently explain a weak law's obtaining, this seems to be merely a feature of our ignorance about the underlying mechanisms and not a fact about the nature of the world. Conversely, weak laws may themselves be of only limited explanatory value. In particular, many weak laws fail to explain their instances. So, for instance, one need not (and should not) appeal to Bode's law to explain *why* a particular planet has the orbit that it does, nor does it seem profitable to cite Dollo's law when one is asked why the traits of a particular organism differ from those possessed by a long-distant ancestor. This explanatory deficit obtains despite the fact that these principles are both predictively accurate and are relatively counterfactually invariant. Instead, the problem seems to be that such laws are best understood as *effects* that are to be explained and not as fundamental facts that are to be appealed to in the explanation of other phenomena.[24]

Again, it should be stressed that appeals to weak laws can and do feature prominently in scientific explanations. The law of supply and demand, for instance, can reasonably be cited in the explanation of many economic systems, and Newton's laws can be cited in the explanations of a wide variety of phenomena. The point here is merely that many weak laws are the types of principles that can be explained, and that not *every* weak law can itself used to generate informative explanations.

Conclusion

I have argued that there are (at least) two distinct concepts of law relevant to understanding current and historical scientific practice: *strong law* and *weak law.* I have also offered preliminary characterizations of both concepts, according to which strong laws must meet four specific criteria, while weak laws are distinguished by their *failure* to meet at least one of these criteria, and by their meeting (or approximately meeting) some of the remaining criteria.

As I have emphasized throughout, this account is intended primarily as a *description* of current scientific practice and not directly as a claim about the metaphysical and epistemological status of laws. I have not, for instance, attempted to argue that any weak or strong laws actually exist; nor have I offered an account of how claims about laws can be confirmed or disconfirmed. These are serious questions that any satisfactory account of laws must address. Nevertheless, I take it that this account has clear

[24] For a discussion of the way that the laws of psychology are often understood as effects, see Cummins (2000).

consequences for current philosophical work on these questions. In particular, if my argument is correct, then there is reason to think that many of the most popular philosophical accounts of laws of nature are, at best, orthogonal to the concepts of law relevant to characterizing scientific practice, and in other cases, would seem to directly entail that scientists are massively mistaken in the way they conceive of laws. So, for example, I argued above that strong laws (if they exist) would clearly violate Humean Supervenience. I also suspect that their unique relation to counterfactuals means that strong laws do not supervene upon (and cannot be explained in terms of) *powers, natures,* or *dispositions*.[25] For similar reasons, my account of weak laws suggest that there is little, if any, evidence to suggest that the social sciences makes widespread use of implicit *ceteris paribus* clauses of the sort that many philosophical accounts have posited.

While it would be implausible to require that philosophical accounts of laws of nature confine themselves to "mere" description and analysis of existing practice, the incredible success of scientific practice provides a strong *prima facie* case in favor of retaining our existing concepts of law of nature. In light of this, any philosophical accounts that would require abandoning or significantly revising these concepts is plausibly required to meet a heightened evidential burden. Of course, it may well turn out that the defenders of these accounts can meet this challenge. Whether or not they have successfully done so is worth considering.

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[25] Some representative powers-, dispositions-, or natures-based accounts of law of nature include Swoyer (1982), Cartwright (1983, 1999), Shoemaker (1998), Ellis (2001, 2010), Bird (2005a, 2005b, 2007), and Chakravartty (2010). Lange (2004) argues (correctly, in my view) that these views cannot account for the laws' relationship to counterfactuals.

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