The Necessity of Accidents

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We will argue that a successful philosophical account of natural lawhood should imply that if there are natural laws, then there are also accidental truths. This is (we believe) a new criterion of adequacy on any philosophical account of natural lawhood. After defending this criterion, we will examine which of the rival proposed philosophical accounts of lawhood can satisfy it and which cannot.

When we say that there must be accidents if there are laws, we mean that there must be accidents if there are contingent truths that are laws, that is, if there are truths that are laws but possess no stronger modal status than natural lawhood. It is standardly believed that beyond physical necessity (the kind of necessity associated with lawhood), there are stronger varieties of necessity: logical, mathematical, metaphysical, and so forth.[1] It is also widely held that any truth possessing one of these stronger varieties of necessity also automatically possesses physical necessity (but not vice versa). When we say that there must be accidents if there are laws, we mean that there must be accidents if there are truths that are *merely* laws – that is, that have

[1] Exceptions are dispositional essentialists such as Bird (2005, 2007), who regard the laws as metaphysically necessary. See section 2.4.

physical necessity but lack any stronger variety of necessity.[2] (Unless otherwise specified, by "laws" we mean truths that are *merely* laws.)

Some philosophers (for example, Adlam 2022: 29; Bird 2014:287; Chen 2021:121; Chen 2023; Jalloh forthcoming: 20) have suggested that the laws could determine everything contingent in the universe's history. This would be a very strong form of determinism (since determinism is standardly taken to be the view that the universe's entire history is determined by the laws *plus* the universe's accidental state at a given moment). However, if we are correct, then no account of lawhood should permit such strong determinism. (We are not thereby ruling out *standard* determinism, since a deterministic world can contain plenty of accidents).

An example that might seem to be a world containing no accidents is a world roughly similar to the actual world where the dynamical laws are deterministic and the universe's precise initial conditions are also fixed by law. In that case, every event is physically necessary. However, according to our criterion, an adequate account of lawhood should imply that no such "world" is metaphysically possible. (We will explicate our criterion in section 1.)

Our argument for this criterion will *not* be that there are actually accidents so any account of lawhood is more plausible insofar as it correctly predicts that there are. That argument treats the existence of accidents as a fact that we have discovered empirically. But this would beg the

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[2] Lange (2009) argues that there may be more than one variety of physical necessity. If that is correct, then by "mere" natural laws, we mean truths possessing at least one variety of physical necessity but no variety of necessity that is stronger than all of the varieties of physical necessity.

Some philosophers may want to leave room for physical necessities that are not laws. For instance, an advocate of the Best System Account (see section 2.3.1) might take any members of the "best system" that are not general to be physically necessary but not laws. Such a philosopher may therefore regard the "Past Hypothesis" (ascribing low entropy to the universe's initial conditions) as physically necessary but not as a law. But when we say "laws", we intend to refer to all physical necessities; we are arguing that if there are any (mere) physical necessities, then there must be accidents. Accidents, correspondingly, are facts that lack physical necessity (and perforce lack any stronger variety of necessity). Those philosophers who want to leave room for physical necessities that are not laws will need to tweak our statements accordingly.

question against the view (floated by, for example, Penrose 1987:106-7, 1989:432, 1990:654) that there are neither accidents nor "mere" laws because every fact about the universe possesses logico-mathematical necessity. We are not precluding this view; we are arguing that there must be accidents if there are *mere* laws. Furthermore, we believe that the existence of accidents if there are laws is metaphysically necessary, not a mere empirical discovery.[3]

In section 1, we will give our main argument for our new criterion. We will argue that if an account of lawhood countenances a possible world where there are laws but no accidents, then that account must portray the laws in that world as playing few, if any, of the most important roles characteristic of laws. But entities that cannot function as laws are not laws. If (as we argue) it is impossible for all contingent facts to function as laws, then there is no possible world where all contingent facts there are laws, and so any account of lawhood is mistaken if it permits such "no-accident worlds."

Of course, some laws *happen* not to play certain roles that set laws apart from accidents. An uninstantiated law, for instance, has nothing falling within its scope and so explains nothing. Nevertheless, an uninstantiated law *could* have had cases falling within its scope and so *does* play a key role characteristic of laws: it is able to "support" counterfactuals. If (by contrast with uninstantiated laws) the laws alone determine everything so that there are no accidents, then (we

[3] Similarly, we are not motivating our new criterion by arguing that any account of lawhood should *explain why* there are accidents. Several philosophers have recently argued that any account of lawhood should explain why there are *laws* – and that Humean accounts are deficient because they make the existence of laws unlikely or inexplicable. Other philosophers have replied that these arguments beg the question against Humeanism: there is no objective probability distribution (according to Humeanism) under which the existence of some laws rather than none is unlikely, and the existence of laws does not (according to Humeanism) require scientific explanation. Therefore, on a Humean view, the existence of laws is not a brute, unlikely fluke. In the spirit of arguments that any account of lawhood should probabilify or explain why there are some *laws* rather than none, one might argue that any account of lawhood should probabilify or explain why there are some *accidents* rather than none. However, we suspect that any such argument would turn out to be question-begging for the same reasons as the analogous arguments concerning the existence of laws. (For more on this dispute, see Beebee (2006), Bhogal (ms), Filomeno (2021), Loewer (2024) and references therein.)

will argue) the laws support no counterfactuals in the manner characteristic of laws and it is no accident that the laws causally explain nothing. None of the "laws" then plays the laws' key distinctive roles. In that event, we believe, there are no laws at all.

In section 2, we will examine which proposed philosophical accounts of lawhood satisfy our new criterion of adequacy. In particular, we will examine whether, according to various accounts of lawhood, the lawmakers can still obtain even without any accidents and so even if the "laws" cannot play key roles distinguishing laws from accidents. Interestingly, the division between those accounts that satisfy our new criterion of adequacy and those that do not cross-cuts the standard distinctions among accounts of lawhood. Some Humean accounts and some non-Humean accounts permit laws to hold without any accidents; others do not. Some accounts according to which the laws acquire their lawhood as a system (rather than individually) permit laws to hold without accidents; other "system-based" accounts do not. The categories carved out by our new criterion of adequacy fail to coincide with any traditional distinctions among proposed accounts of lawhood.

1. Roles Characteristically Played by Laws Require Accidents

In this section we present our argument that many of the laws' characteristic roles require accidents. Subsections 1.1 and 1.2 develop the bulk of that argument, while subsection 1.3 addresses three objections.

1.1 The Laws' Behavior under Counterfactuals

Laws are widely believed to differ from accidents by standing in a special relation to the facts expressed by counterfactual conditionals (which take the form "If *p* had been the case, then *q*

would have been the case") and subjunctive conditionals ("If *p* were the case, then *q* would be the case"). (We will use "$p \mathrel{\square\!\!\rightarrow} q$" for both kinds of conditionals and refer to both as "counterfactuals.") The laws' special relation to counterfactuals is roughly that the laws would still have been true under any counterfactual antecedent that is logically consistent with the truth of all of the laws. No accident has this invariance under counterfactual antecedents. For example, had Earth's axis been perpendicular to its orbital plane, then the laws would still have been true but plenty of accidents would not still have held; for instance, "if the planet had no slouch, it wouldn't have seasons" (Hall 2021).

Here is one common way of making this special relationship more precise. Consider the "subnomic" facts (that is, the facts involving nothing modal, nomic, or counterfactual). How do the accidental subnomic facts differ from the physically necessary subnomic facts in their counterfactual invariance? It is often maintained that for any subnomic claim *p* (that is, any claim that would, if true, express a subnomic fact), the laws would still have been true if *p* were (or had been) the case, as long as *p* is logically consistent with all of the truths that are laws – and that no accident is invariant under this range of counterfactual antecedents.[4] Reserving lower-case letters for subnomic claims, we will call this view "Preservation" (PRES):

> PRES: For any *m* and in any possible world, the following biconditional holds: *m* is a law if and only if $p \mathrel{\square\!\!\rightarrow} m$ and $\sim(p \mathrel{\square\!\!\rightarrow} \sim m)$ for any *p* that is logically consistent with all of the *r*'s taken together where it is a law that *r*.[5]

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[4] Here we mean "laws" in the broad sense that includes both "mere" laws and stronger necessities.

[5] The "...and $\sim(p \mathrel{\square\!\!\rightarrow} \sim m)$" condition is included in PRES simply to ensure that *m*'s invariance under *p* is non-trivial. Here is an alternative way of stating PRES, making more explicit that the principle concerns all possible worlds (again using lowercase letters for subnomic claims and now using *W* for possible worlds): (*W*)(*m*) (*m* is a law in *W* iff

Among the philosophers who endorse PRES (or cognate principles) are some Humeans (from Goodman (1983: Ch. 1) to, more recently, Albert (2015:41-2), Bhogal (2021:191-92), Dorst (2022:546), and Loew and Jaag (2020:105-11)), many non-Humeans (such as Carroll (1994:59), Lange (2009:20), and Maudlin (2007:21-34)), various philosophers who examine counterfactuals without defending any account of law (such as Bennett (1984), Horwich (1987), Jackson (1977) and Vihvelin (2017)), and psychologists who study counterfactual reasoning (such as Seelau *et al.* 1995).

Lewis (1986) famously dissents. He argues that (at least if the laws are deterministic) small "miracles" (violations of the actual laws) occur in the closest *p*-world, even when *p* is logically consistent with the laws, in order for *p* to obtain while the closest *p*-world is exactly like the actual world for a long stretch of the past. For our purposes, it will ultimately make no difference whether Lewis or PRES is correct, since according to both views, the actual laws are all still accurate regarding the events *downstream* from *p*, when *p* is logically consistent with the laws, and this is the key respect in which laws differ from accidents in their relations to counterfactuals. According to either Lewis or PRES, laws have this special influence that accidents lack in determining the closest *p*-world, when *p* is logically consistent with the laws. This is all that we will need going forward. For simplicity, then, we will focus mainly on PRES, but we will occasionally point out why the same (or analogous) points hold on Lewis's account. On either account, it is the laws' behavior under counterfactual antecedents that are logically

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in W, (p) [{p is logically consistent with all of the r's taken together such that it is a law that r} $\rightarrow$ {($p \mathrel{\square\!\!\rightarrow} m$) and $\sim(p \mathrel{\square\!\!\rightarrow} \sim m)$}]).

consistent with the laws (that is, the range of antecedents in PRES's scope) that distinguishes laws from accidents.

PRES reflects the laws' characteristic necessity. The laws *must* hold in that they *would* all still have held no matter what (as far as subnomic facts are concerned) – that is, under any counterfactual supposition *p* under which the laws *could* all still have held (in that *p* is logically consistent with all of the laws). By contrast, no accident is invariant under the range of counterfactual antecedents identified by PRES as distinguishing the laws' invariance. For example, suppose it is accidental that all of the coins in my pocket now are silvery-colored. Here is a counterfactual antecedent under which this accident is not preserved but that falls within the range of counterfactual antecedents identified by PRES: had I placed a penny in my pocket a moment ago. For that matter, if *p* is accidental, then "had *not-p* been the case" is a counterfactual antecedent under which *p* is not preserved but that falls within the range of counterfactual antecedents identified by PRES. An accident can be preserved under *some* counterfactual antecedents in this range, but not under all of them.

A law's invariance under the wide range of counterfactual antecedents identified by PRES (or, on Lewis's account, a law's accuracy downstream from any of these counterfactual antecedents) is typically thought to underwrite its capacity to answer a wide range of what Woodward (2003) calls "what-if-things-had-been-different" questions ("w-questions"). For instance, Newton's second law of motion $\boldsymbol{F} = m\boldsymbol{a}$ (supposing, for simplicity, that it is a law) answers the w-question "What would have happened if the net force on the body had been twice as great?" The law can answer this question because, in accordance with PRES, the law is preserved under this counterfactual antecedent (or, on Lewis's account, because the law is

accurate regarding what would have ensued had the force been greater). By contrast, the fact that all of the coins in my pocket are silvery-colored does not answer w-questions such as "What would have happened had a penny been in my pocket?" An accident does not have the capacity to answer the same range of w-questions as a law because an accident is not invariant under the range of counterfactual antecedents identified by PRES.

Of course, a law's range of invariance is limited. For instance, take the law that a longtime stationary, infinitely long, uniform line-charge has an electric field that diminishes linearly with distance. This is a derivative law; it follows from and is explained by the more fundamental law (part of Coulomb's law) specifying that a longtime stationary point charge's electric field diminishes with the square of the distance. Now consider this counterfactual antecedent: Had there been a longtime stationary isolated point charge with an electric field that does *not* diminish with distance. This counterfactual antecedent is logically consistent with the derivative law. But it is not logically consistent with Coulomb's law and so it does not fall within the range of counterfactual antecedents identified by PRES. Therefore, PRES does not require that the line-charge law be invariant under this antecedent. And, of course, it is not, since the more fundamental law responsible for it is not. The antecedent is a counterlegal and PRES does not require that all laws be invariant under a counterlegal. Indeed they cannot all be.

This is all familiar from the philosophical literature. What has not been discussed is that if there are laws but no accidents, then there are no counterfactual antecedents in the range identified by PRES; there are no false subnomic claims that are logically consistent with all of the subnomic truths that are laws. Therefore, if there are laws but no accidents, then (since PRES identifies the laws' special behavior under counterfactual antecedents), no special behavior under

counterfactual antecedents is associated with lawhood. Every counterfactual antecedent that might have afforded the laws an opportunity to display their characteristic invariance (such has "Had the force on the body been twice as great" or "Had Earth's axis been perpendicular to its orbital plane") is a counterlegal and so falls outside PRES's scope. The laws do not *violate* PRES, but there is no invariance that reflects their lawhood.

PRES has standardly been taken to capture the laws' characteristic sort of invariance under counterfactual antecedents. This sort of invariance (in turn) has standardly been taken as what enables the laws to play their other characteristic roles in science (as we will elaborate in the next subsection). But we just saw that in (putative) worlds with laws but no accidents, PRES identifies no range at all of counterfactual antecedents under which the laws are invariant, since no (subnomic) counterfactual antecedent is logically consistent with all of the laws. In that case, the fact that various subnomic facts are laws rather than accidents is not reflected in their invariance under counterfactual antecedents. There is nothing special that the "laws" do under counterfactual antecedents that their alleged lawhood enables them to do there. Since there is nothing that amounts to behaving like a law (in connection with counterfactuals) when there are no accidents, can there *be* laws when there are no accidents? We will argue in the next subsection that the answer is negative: if the so-called "laws" lack the counterfactual invariance that is typically associated with laws, then they will fail to play many of the standard roles that we expect laws to play, and so (we suggest) they do not constitute laws in the first place.

The same issue arises under Lewis's account of counterfactuals as under PRES. Ordinarily (according to Lewis's account), laws carry special weight in fixing which *p*-worlds are closest to the actual world because the minimization of "miracles" (violations of the actual laws) in a

p-world is especially important to making that world closer, though a miracle can be outweighed by a long period during which the events in that world are exactly like those in actual world. But suppose that in the actual world, there are no accidents. Then in order for an ordinary counterfactual conditional $p \mathrel{\square\!\!\rightarrow} q$ (with false *p* and *q*) to be true, the closest *p*-world will typically have to contain infinitely many miracles, since in it there will occur infinitely many departures from the actual world and each of those departures is logically inconsistent with the actual laws because each event in the actual world is a matter of law; none is accidental. For instance, the truth of "Had the apple broken off from the tree today, it would have fallen" requires that the closest *p*-world contain not only the miracle of the apple detaching from the tree, but also the miracles of its position and velocity at each subsequent moment. Clearly, the closeness metric that Lewis takes to apply ordinarily in (non-backtracking) counterfactual reasoning (which gives special, though not overriding weight to the minimization of miracles) should not be applied in the case of counterfactuals holding in worlds without accidents. This makes good sense: minimizing "miracles" and achieving long stretches of events exactly like those in the actual world come to the same thing if every event holds as a matter of law, so a metric that directs us to trade them off against each other seems inapplicable. Lewis's account thus arrives at the same result as PRES: in a possible world where there are no accidents, the laws do not manifest their lawhood in the counterfactuals holding there, again raising the question of whether they ought to constitute laws in the first place. (For simplicity, we will focus below on PRES rather than on Lewis's account, since the same morals can be drawn under each.)

1.2 Implications of PRES's Inapplicability in No-Accident Worlds

Let's now see how little the so-called "laws" act like laws if there are no accidents and so the laws do not exhibit the counterfactual invariance characteristic of laws. Recall that laws are supposed to answer w-questions (such as "What would have happened if the net force on the body had been twice as great?") by virtue of being preserved under various counterfactual antecedents (such as "Had the net force on the body been twice as great") as required by PRES. However, if there are no accidents, then no counterfactual antecedents fall within PRES's scope. So in obeying PRES (that is, in their capacity as laws), laws answer no w-questions. Consequently, there are a host of further roles that laws characteristically play but cannot play if there are no accidents.

For instance, if there are no accidents, then laws do not help to provide causal explanations of events. It is widely believed that for a law to help provide a causal explanation, the law must specify what would have happened differently had the cause not happened (or happened differently in some respect).[6] A law determines the outcome under these counterfactual antecedents (or, for a statistical law, determines the outcome's chance) because these counterfactual antecedents are logically consistent with the laws and so (by PRES) the laws are invariant under these antecedents. For instance, the law $\boldsymbol{F} = m\boldsymbol{a}$ helps to explain why the 1 kg body accelerates by 1 m/s^2, when it feels a net force of 1 N, because $\boldsymbol{F} = m\boldsymbol{a}$ determines what the body's acceleration would have been if the body had felt a net force of 2 N (or any other value) while remaining 1 kg. But if there are no accidents, then $\boldsymbol{F} = m\boldsymbol{a}$ is not guaranteed to be preserved

[6] This is suggested, for example, by Lewis's (1973b) counterfactual analysis of causation coupled with his (1986) account of causal explanation. On such an account, laws help to provide causal explanations by figuring into the truth conditions for counterfactuals, which are used to analyze causation and hence causal explanation. For a different approach, see Woodward and Hitchcock (2003a,b); while their discussion emphasizes explanations that appeal to "invariant generalizations" rather than laws, their account works equally well with laws.

under such a counterfactual antecedent; PRES was *supposed* to supply that guarantee, but now any such counterfactual antecedent falls outside of PRES's scope. Therefore, if there are no accidents, then laws do not help to provide causal explanations of events.

Our conclusion applies not only to causal *explanations*, but also to causal *relations*. It is widely believed that for one event to cause another, the two events must possess causally relevant properties connected by a law. Furthermore, in many cases, the causal relation between the two events requires some sort of counterfactual connection between them – such as (in the simplest case) that had the cause been different in its causally relevant property (or had the cause not occurred at all), then the effect would have been different in its causally relevant property (or not occurred at all). Any such counterfactual connection is thought to be associated with a law connecting those properties. For example (once again), the occurrence of the 1 N net force is a cause of the body's 1 m/s^2 acceleration, and this causal relation is associated with the law $\boldsymbol{F} = m\boldsymbol{a}$ being preserved under a wide range of counterfactual antecedents (as PRES ensures, if there are accidents) and so determining what the body's acceleration would have been had the net force been different. But if there are no accidents, then PRES cannot ensure that $\boldsymbol{F} = m\boldsymbol{a}$ is invariant under such counterfactual antecedents, since all of those antecedents are counterlegals. Therefore, the law cannot stand in its characteristic association with any causal relations. Thus, if causal relations must be backed by laws ensuring counterfactual relations among the causal *relata*, then there are no causal relations in a world with no accidents. Alternatively, if causal relations can still obtain in such a world, then they are not underwritten by laws by virtue of their status as laws.

Of course, the specifics regarding the association between laws, counterfactuals, and causal relations have long been subjects of philosophical dispute. Lewis (1986), for instance,

believes that laws are partly responsible for the truth of various counterfactuals and that those counterfactuals, in turn, are responsible for causal relations, which causal explanations describe. By contrast, Lange (2009) turns part of this picture upside-down; he believes that the truth of various counterfactuals are responsible for making certain subnomic facts constitute laws. Furthermore, the relation between causal relations and counterfactuals is widely recognized to be complicated. That event E is counterfactually dependent on event C is neither necessary nor sufficient for C to be a cause of E. But none of this makes any difference to the argument we just gave. Whichever of these ingredients is ontologically prior to the others and whatever the reasons for the associations between laws, counterfactuals, and causal relations – and whatever the details of these associations – the laws cannot be associated with causal relations if they cannot be associated with counterfactuals in the neighborhood. If there are no accidents, then PRES cannot connect the laws to such counterfactuals because those counterfactuals are counterlegals. Therefore, if there are no accidents, then laws (acting in their capacity as laws, that is, in accordance with PRES or Lewis's analogue to it) are not associated with causal relations and explanations.

Once again, their inability to play the laws' characteristic roles raises the question of whether the so-called "laws" are indeed laws if there are no accidents. Admittedly, if there are no accidents, then the fact that it is a law that *p* could still help to scientifically explain why it is the case that *p*. That it is a law that *p* makes *p* (physically) necessary and so explains why *p* obtains: because not-*p* was impossible.[7] But by our previous argument, the laws are nevertheless unable to

[7] In section 2.5 we will see a reason to reconsider whether in a no-accident world, *p*'s (alleged) lawhood really does ensure that *p* is (physically) necessary. If *p*'s necessity is associated with *p*'s preservation under the range of counterfactual antecedents within PRES's scope, then since there are no such antecedents in a no-accident world, there is arguably no such necessity either.

play their characteristic roles in connection with causal explanations and causal relations among events. For instance, if there are no accidents, then if the body accelerates by 1 m/s^2, it is physically necessary that the body so accelerate. The laws making that acceleration necessary thereby suffice to explain it. But no laws help to explain the acceleration *causally* or stand behind the causal relation between the net force and the body's acceleration. In short, if there are no accidents, laws lose their connection with any non-trivial causal or counterfactual-dependence relations that may obtain between events.

Causal explanations of events are not the only explanations in which laws play a key role. Laws also help to explain other laws. In trying to understand this role, we encounter the "notorious" (Salmon 1989:52) difficulty that an arbitrary conjunction of laws entails but does not explain a given law (Hempel 1965:273). Whereas Coulomb's law is stronger than and explains the line-charge law, the conjunction of the line-charge law and the ideal-gas law is also stronger than – but does not explain – the line-charge law. How is this difference to be accounted for? Woodward and Hitchcock (2003a,b) nicely suggest that Coulomb's law answers many w-questions about a given uniform line-charge that cannot be answered by the line-charge law alone. These w-questions concern how things would have been, had things been different in various ways that form a set of alternatives reachable by (roughly speaking) "smooth" alteration of the line-charge. For example, Coulomb's law tells us what the electric field would have been had the line-charge instead been a charged loop, and Coulomb's law also covers the "smoothly varying" intermediate states between the line-charge and the charged loop. By contrast, although the conjunction of the line-charge and ideal-gas laws can answer w-questions about a line-charge that cannot be answered by the line-charge law alone, those questions all concern what would

have been the case if the line-charge had instead been a gas. Any "smooth" alteration of a line-charge into a gas (if there is any) would have to pass through many states that neither the line-charge law nor the ideal-gas law covers.

On this approach, one law explains another by virtue of answering various w-questions. To answer those questions, the more fundamental law must be invariant under the relevant counterfactual antecedents (for example, "Had the charge been in a loop"). But if there are no accidents, then any such counterfactual antecedent is a counterlegal and so PRES cannot ensure that the more fundamental law is preserved under it. Thus, once again, the laws cannot play one of their characteristic roles if there are no accidents.

Furthermore, the laws' capacity to answer w-questions is characteristically associated with the role that our beliefs about the laws should play in our practical deliberations. We should be guided by our beliefs about the laws because we know that the laws tell us what would happen, were we to pursue one or another course of action. But if an agent believes that perhaps there are no accidents, and if she believes that it is a law that *p*, then we do not see why she should reason that were she to perform action A, then *p* would still be true and so the results of her A-ing would be as *p* requires. Rather, she should reason that perhaps it is not the case that were she to A, then *p* would still be true – since perhaps this antecedent is a counterlegal and so falls outside of PRES's scope. If it is a counterlegal, then the laws (such as *p*) cannot all be preserved under it.[8] (Of course, if she actually turns out to A, then "Were she to A" is not a counterlegal. But until she knows what action she will perform, she does not know whether or not this antecedent falls within PRES's scope and so she does not know whether *p* is invariant under this antecedent. Yet she is

[8] We will return to the issue of counterlegals in section 1.3.

supposed to be using *p* to *guide* her decision about whether or not to perform A.) Our knowledge of the laws seems unable to play its action-guiding role if a no-accident world is epistemically possible for us.

To summarize: in a world without accidents, laws do not by virtue of their lawhood support counterfactuals, answer w-questions, provide causal explanations of events, underwrite causal relations, explain other laws, or effectively guide our practical deliberations. Clearly, these roles are central to lawhood, and the laws' capacity to play them is at least a large part of what makes laws (in Hall's (ms: 40) words) distinctively appropriate targets of scientific inquiry. If a possible world has laws but not accidents, its laws cannot play the central roles distinguishing laws. Since they do not act like laws, there is nothing they do that we would explain by positing that they are laws in the first place.

The philosophical literature on lawhood rightly and routinely employs the same sort of inference we are making: from some truth in a given world (not) behaving there in the manner of a law to its (not) being a law in that world. For example, philosophers rightly and routinely test any proposed account of lawhood by whether it classifies as laws in the actual world exactly those facts that function there as laws—regardless of whether or not those facts are standardly called 'laws.' An account of lawhood is widely considered mistaken if it fails to classify, for example, 'Archimedes' Principle' and 'Hund's Rule' as actual laws (as far as we know), since they play the laws' characteristic roles. It is likewise mistaken if it classifies, for example, 'Bode's Law' as a law in the actual world, since it does not function there as one. In the same way, we are arguing that since the truths in an alleged "no-accident" world fail to play the roles characteristic of laws, they are not laws. The principal debates in the philosophical literature on laws (such as why *p*'s

lawhood entails *p*'s truth and why *p*'s lawhood gives *p* some distinctive scientific explanatory power) all presuppose that *p*'s lawhood explains why *p* plays various roles.

Seen in this context, our argument takes a very familiar form. In an alleged no-accident world, there is nothing for the lawhood of some truth to explain. Hence, there is no reason to believe it to be a law there. We thus take it to be a problem for an account of lawhood to permit worlds with laws but no accidents.

1.3 Three Objections

In this section we respond to three objections to our main argument. The first objection questions an implicit assumption we have been making so far: that if there is a world with laws and no accidents, then it would be like the actual world in having a significant counterfactual structure. That is, there would be plenty of non-trivially true counterfactuals $p \mathrel{\square\!\!\rightarrow} q$ with false *p* and *q*. This counterfactual structure underwrites substantive answers to w-questions, causal relations and explanations, etc. But if there are no accidents, then the laws cannot play their standard roles in their capacities as laws: the roles are *there to be played*, but the laws are not playing them in virtue of being laws, and this seems problematic.

However, this way of putting things suggests that one could avoid the problem by denying that there is any such counterfactual structure in a no-accident world. If there *are no* non-trivially true counterfactuals with false *p* and *q* in a world containing laws but no accidents, then perhaps in such a world if anything had been different, everything else would have been the same: nothing would have made a difference to anything else. It would then follow that in such a world, there

are no substantive answers to w-questions and no substantive causal or causal-explanatory relations between events. In short, the laws' characteristic roles are not there to be played, so perhaps it is not so problematic that the laws are not playing them.[9]

We do not think that this maneuver resolves the problem. Even in a no-accident world that has no such counterfactual structure, the laws still fail to play their characteristic roles in connection with counterfactuals, w-questions, causation, etc. The laws are supposed to play those roles *simpliciter*, not to play them *if they are there to be played*. If the roles go missing, the laws cannot play them. The absence of any such counterfactual structure just makes it more obvious that the laws are failing to act like laws.

The second objection directs us to consider a world with a "Humean mosaic" (the totality of the particular matters of subnomic fact obtaining in that world) that is highly impoverished, for example, that contains only a lone electron moving inertially forever. In such an impoverished world, the objection goes, it would be unsurprising for there to be no accidents, since there is so little going on in the first place. Laws alone could easily dictate the mosaic's entire content, making everything that happens there physically necessary. Arguably, then, it is not particularly troublesome for an account of laws to permit no-accident worlds, at least when those worlds have severely impoverished Humean mosaics. One might say that it is the world's fault (in being so impoverished), rather than the laws' fault, that they play none of their characteristic roles.

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[9] This move might seem especially natural for Lewis to make regarding no-accident worlds, considering that his closeness metric directs us to minimize violations of actual law. Suppose that in the actual world, there are no accidents and the apple does not detach from the tree and does not fall. Consider again the counterfactual, "Had the apple broken off from the tree today, it would have fallen." If the entire Humean mosaic is fixed by actual law, then we minimize miracles by picking a world where the apple detaches from the tree but then the course of events immediately reverts to what happens in the actual mosaic. So if we continue to apply Lewis's standard closeness metric in no-accident worlds, our apple counterfactual comes out false. Rather, if the apple had broken off from the tree, it would not have fallen, because it would have immediately again been attached (and so accorded with the laws of the actual world).

We find this suggestion fairly compelling[10], though we would also stress that intuitions about worlds with severely impoverished mosaics, and their relevance to various accounts of lawhood, are notoriously divisive. Some philosophers take these intuitions quite seriously (Carroll (1994), Roberts (1998)), whereas others do not share them (Beebee (2000)), and still others think they may be discounted because such worlds are so different from the actual one (Loewer (1996), Woodward (2014)) . Given their highly contested nature, we will refrain from using such worlds in evaluating whether various accounts of lawhood violate our criterion. Thus, we are willing to grant that an account of lawhood might not be seriously impugned by countenancing no-accident worlds with severely impoverished mosaics.

However, we think it clearly *is* problematic for an account of lawhood to imply that there are worlds with rich mosaics (like the actual world's) that nevertheless contain laws but no accidents. Unlike severely impoverished worlds, these worlds afford the laws plenty of opportunities to play their characteristic roles, and these worlds are not easily dismissed as too remote from actuality to bear on the notion of natural law that we use in actual science.

The third objection takes issue with our claim that if there are no accidents, the laws' characteristic roles disappear. We argued that if there are no accidents, then PRES identifies no counterfactual antecedents under which the laws are invariant, but the laws' characteristic roles depend on a wide range of counterfactual antecedents falling within PRES's scope. However, PRES says nothing about the laws' behavior under counterlegal antecedents. This leaves room for

[10] However, it is worth pointing out that according to this response, counterfactuals with (say) causal claims in their consequents might return surprising results. Consider, for example, "If there had only been a single electron moving inertially, it would have produced a magnetic field." If we allow that there are no accidents in this lone-electron world, and if causal relations can only obtain when they are backed by laws that underwrite a counterfactual connection between the cause and the effect, then this counterfactual would turn out false, since the laws would not underwrite a counterfactual connection here (at least absent some nonstandard recipe for evaluating such counterfactuals).

the objection that the counterlegal conditionals obtaining in a no-accident world allow its laws (all of its facts) to play the roles characteristic of laws (without depending on PRES), manifesting that the world contains no accidents.

The laws' behavior under *counterlegal* suppositions has received relatively scant attention. But many philosophers (for example, Bennett 2003:227-8) have floated the basic idea that under a counterlegal antecedent, we should make the minimal changes to the laws needed to accommodate the antecedent. For example, Pollock (1976:93-97) explicates this idea in terms of jettisoning as few as possible of the fundamental laws.[11] However this basic idea about the semantics of counterlegals is precisified, the result will be that the actual laws exhibit considerable invariance under counterlegal suppositions. The objection is that this attenuated invariance may suffice to enable the laws to play their characteristic roles (e.g., answering w-questions, underwriting causal explanations) even in worlds without accidents.

We do not find this objection persuasive. For a fact to behave like a law rather than an accident under counterfactual antecedents, it does not suffice that the fact have some or another wide range of invariance. It must have the particular range characteristic of laws (which PRES specifies). Even an accident can have a wide range of invariance. For example, consider the accident g that whenever the gas pedal on my car is depressed by x inches and the car is on a dry, flat road, the car's acceleration is given by the function $a(x)$.[12] Although g is invariant under a wide range of counterfactual suppositions (such as, "Had the gas pedal been depressed a bit

[11] This fits widely accepted counterlegals such as "Had the strong nuclear force been 1% stronger, then the electromagnetic force law would have been unchanged so carbon could not have formed inside stars." But Pollock's approach presupposes a modularity among the fundamental laws that we think is suspect. (What if there is only a single fundamental law?) In any case, any account of counterlegals requires some metric to precisify the "minimal changes" needed to accommodate a given counterlegal supposition.

[12] See. Lange (2009:13).

farther this morning") and hence answers many w-questions and so is relevant to practical reasoning in many circumstances, *g* remains accidental. What is characteristic of laws is invariance under the specific range of antecedents given by PRES. That in no-accident worlds, the so-called "laws" have an attenuated invariance under various (allegedly counterlegal) antecedents is not enough to show that they are playing the laws' characteristic roles.

To bring out this point, consider an allegedly no-accident world *w* where the dynamical laws (resembling the laws in Newtonian physics) are deterministic and the initial conditions are also fixed by law. Suppose that *w* always contains exactly two bodies, A and B, which at time *t* are 10 cm apart. Consider the counterfactual supposition "Had B been 5 cm from A at *t*". By what recipe should we arrive at the closest possible world(s) where this (alleged) counterlegal holds?

Perhaps in any such world, the initial conditions differ from those in *w* but the dynamical laws remain fixed. This recipe seems very intuitive; it yields such plausible counterfactuals as "...then the A-B electrostatic force would have been four-times stronger." But under this recipe, the alleged law specifying the initial conditions behaves under alleged counterlegals in exactly the way that accidents behave under ordinary counterfactual antecedents. We therefore see no reason to regard the initial conditions as physically necessary. The original allegedly no-accident world has been misdescribed: in fact it contains accidents (such as the initial conditions).

In other words, if the allegedly no-accident world's initial conditions are physically necessary (just like the dynamical laws), there is no reason why the "minimal change" to the laws needed to accommodate a counterfactual antecedent should always involve a departure from the initial-conditions law, never from a dynamical law. But the dynamical laws' priority is easily

explained if the initial conditions are not laws after all. (We reach the same sort of conclusion if, counterintuitively, the initial conditions always take priority over the dynamical laws.)

On the other hand, suppose instead that for some counterfactual antecedents (in some contexts), the dynamical laws take priority over the initial conditions, but the reverse occurs in other cases. On this recipe, various truths in this world are invariant (in various contexts) under various counterfactual antecedents. But no set of these truths possesses a pattern of invariance characteristic of laws. So what reason is there to deem them laws? We are not entitled to simply *stipulate* that they are laws; rather, their behavior (for example, under counterfactual antecedents) must reveal them to be laws. And the truths of this world behave like accidents, not like laws.

It might be objected that if the antecedent ("Had B been 5 cm from A") is a counterlegal, then laws need not be invariant under it, in the manner characteristic of laws, in order for them to behave like laws. But to assume that this antecedent is genuinely counterlegal is just to beg the question here. We see no reason to grant that the initial conditions and dynamical principles are all laws if they lack the laws' characteristic counterfactual profile and hence fail to play the various roles identified in section 1.2. In a world *with* accidents, the invariance of some set of facts under all the suppositions logically consistent with them would manifest the facts' lawhood. But in a world allegedly *without* any accidents, this pattern of invariance is exhibited either by no set of facts or by some proper subset of the facts (such as the dynamical principles). The remainder, we maintain, are actually accidents.

In short, our argument that no-accident worlds are impossible is not undercut by the way that laws function under counterlegals. A world cannot simply be stipulated to possess no

accidents. Rather, the facts holding in an allegedly no-accident world must *deserve* to be understood as laws. We have argued that they don't.[13]

If our arguments so far are correct, we have here a new constraint on any adequate account of lawhood: it should not admit worlds with rich mosaics where there are no accidents. Let's now examine which proposed accounts of lawhood satisfy this constraint.

2. Accounts of Lawhood and No-Accident Possibilities

In the following subsections, we will explore some prominent accounts of lawhood and evaluate whether they allow no-accident worlds with rich mosaics. Allowing them, we think, would be a serious mark against such an account. Of course, this deficiency might be outweighed by certain advantages (just as the advantage of *satisfying* our criterion might be outweighed by certain disadvantages). We do not aim to reach any all-things-considered verdicts on these accounts, merely to evaluate whether they satisfy our new criterion.

2.1 Nomic Primitivism

Primitivists regard laws as elements of reality that cannot be reduced to or analyzed into other elements. For instance, Maudlin (2007) takes the paradigm laws to be "Fundamental Laws of Temporal Evolution." FLOTEs, such as Newton's second law and Schrödinger's equation (*ibid.*: 11), govern the evolution of physical states over time. A FLOTE cannot operate alone. The force laws (such as Coulomb's law) are required to extract dynamical implications from Newton's second law and the system's Hamiltonian is required to extract dynamical implications from Schrödinger's equation. Such "adjunct principles" are also laws (*ibid.*: 14).

[13] Compare Lewis (1983:366; 1986:xii) on having to *deserve* to be understood as laws and necessitation.

What does such a view imply about the possibility of no-accident worlds? Maudlin doesn't explicitly say, but he seems to assume that there are accidents. For example, his recipe for evaluating counterfactuals is (1) to choose a Cauchy surface, as directed by the counterfactual antecedent; (2) to minimally modify the physical magnitudes on that surface to make the counterfactual antecedent true; and (3) to evolve this altered state forward according to the FLOTEs. This recipe requires the FLOTEs to be applicable to a Cauchy surface where physical variables take non-actual values. So it seems like there must be multiple physically possible histories (and hence accidents in the actual history).

However, nothing in the account of laws requires this – even for worlds with rich mosaics. There are two ways in which Maudlin's laws might reduce the number of physically possible histories to one. First, every dynamical law restricts the set of permitted initial conditions. If we express such a law as a partial differential equation, then the solutions to that equation give us the possible initial conditions with which it is compatible. Conceivably, then, the FLOTEs may restrict the possible initial conditions so that there is only one global history compatible with them. Second (and perhaps more plausibly), the FLOTEs themselves may be compatible with many different initial conditions, but the "adjunct principles" may permit only one set of initial conditions. In either case, there are no accidents; everything is required by law.

Maudlin's is not the only primitivist view. Chen and Goldstein's (2022) "Minimal Primitivism" also takes laws to be fundamental elements of reality but seeks to avoid Maudlin's commitment to a fundamental direction of time. It is "minimal" in imposing no restrictions on the form that the laws must take; in particular, it does not require them to be dynamical, merely to constrain the physical possibilities (*ibid*.: 18).

Because their view is so minimal, it must countenance the possibility of no accidents even in worlds with rich mosaics. Indeed, Chen and Goldstein are aware of this. They imagine a two-dimensional world where matter is distributed exactly in accord with the Mandelbrot set graphed in the complex plane, and they suggest that the laws of that world could be given by the function generating the Mandelbrot set. In that case, the world would have laws but no accidents; everything about the (static) matter distribution would be determined by the laws.[14]

2.2 Universals

Armstrong (1983), Dretske (1977), and Tooley (1977) propose accounts of laws as contingent relations among universals. Dretske says little about the nomic relation, so we will focus on Tooley's and Armstrong's accounts. They require separate treatments.

2.2.1 Tooley's Account

Tooley's view allows for great latitude in the sorts of contingent relations between universals that are nomological. He appeals to the notion of a "construction function," which maps ordered *n*-tuples of universals to propositions. For example, the construction function G maps ordered pairs of universals (G_1,G_2) to propositions of the form "All G_1s are G_2s." Other construction functions map such ordered pairs to propositions of the form "No G_1s are G_2s," "Exactly one G_1 is G_2," etc.

Tooley places no substantive restrictions on the construction functions.[15] He is also very permissive about universals, even allowing them to refer to particulars (as in the Smith's garden case (*ibid.*: 57-58)). Consequently, Tooley's account permits worlds with rich mosaics where

[14] Adlam (2022) develops a similar account which also permits there to be laws but no accidents (*ibid*: 29).
[15] The sole restriction is that the universals appearing in the proposition must be exactly those in the *n*-tuple.

every fact holds as a matter of law. For example, suppose that the actual world fundamentally involves the instantiation of *m* Tooleyan universals. Take the construction function mapping *m*-tuples of universals to a proposition that, for the actual world's *m*-tuple, specifies the actual world's entire history of fundamental property instantiations. Tooley's account allows this to be a law, so it implies that there is a possible world where there are no accidents but is otherwise exactly like the actual world.

2.3.2 Armstrong's Account

Armstrong's (1983) account also appears to have this implication, though the verdict is slightly less certain. According to Armstrong, if it is a law that all Fs are Gs, then the universal F bears the "nomic necessitation relation" N(F,G) to the universal G: F-ness nomically necessitates G-ness. It is a contingent fact that F and G stand in this relation, so there are worlds where this is not the case. But in any world where N(F,G) holds, all instances of F are also instances of G.

Armstrongian universals are "sparse" in that not every collection of objects contains exactly the objects instantiating one. Rather, universals correspond to "elite" properties (for example, possessing 3 grams of mass, possessing 6 statcoulombs of charge) identified by fundamental physics. However, Armstrong suggests that we might need to countenance universals making reference to particulars (*ibid*.: 93) and even some negative universals, i.e., universals of the form "not-G-ness" (*ibid.*: 135). He thinks so because he wants to permit a wide variety of law forms but is inclined to regard all laws as involving the same dyadic relation between universals. An "exclusion law" of the form "No Fs are Gs" is then difficult to accommodate without negative universals (allowing for N(F,~G)).

Ultimately, Armstrong is not committed to regarding all laws as involving the same dyadic relation; he remains unsure about some cases.[16] However, to evaluate whether his account permits no-accident worlds, let us suppose that all Armstrongian laws are indeed instances of the dyadic relation. If, under that restriction, his account permits no-accident worlds, then it does so under more liberal conceptions of the nomic relation.

In discussing the forms that laws can take, Armstrong formulates determinism as follows: "for every (first-order) universal, there exists a deterministic (strictly universal) law, such that the universal is the consequent universal in that law" (*ibid.*: 133). This is a surprising way to formulate determinism (partly because it makes no reference to *time*) but it enables us to ascertain whether there could be laws with no accidents. Under Armstrongian determinism, the instantiation of every fundamental physical property is necessitated by the instantiation of some other fundamental physical property. Armstrongian determinism does not imply that there are no accidents; rather, it implies that for every fact *f* consisting of the instantiation of some fundamental physical property, there is a collection of other physical facts that nomically necessitates *f*.

Armstrong allows that such determinism could be a *law*, i.e., the nomic necessitation relation could hold between the properties of (i) being a first-order universal and (ii) being nomically necessitated by a first-order universal – or, as he writes it:

(1): N(*being a first-order universal, being N-ed by a first-order universal*).[17]

He thus admits that the (very general) second-order universal of "being a first-order universal" may figure into nomic necessitation relations.

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[16] Consider a law of the form "If something is F, then something or other is G." He doubts that this is reducible to the dyadic necessitation relation, but he is also unsure whether there really could be laws of this form (*ibid.*: 144-145).

[17] If the nomic necessitation relations here are all deterministic, then what Armstrong calls "strong determinism" obtains—which differs from what Chen (2021) and Penrose (1987) call "strong determinism".

If he allows (1), then he has no obvious grounds to preclude the following:

(2): N(*being a particular state of affairs, being necessitated by an N-relation*)

This says that it is a law that for every particular state of affairs there is some law that necessitates it. It is difficult to see what Armstrong could object to here: in the antecedent position is a (very general) first-order universal, and in the consequent position is a relational property that might attach to universals – which is just what Armstrong places in (1)'s consequent (*ibid.*: 134).

Under (2), there are no accidents. (Indeed, (2) goes further: it says that *it is a law that* there are no accidents.) Moreover, we reached this result without assuming anything about the character of the world in question. So Armstrong's account seems to allow worlds with rich mosaics to contain no accidents.

2.3 Humean Approaches

Humeans regard laws as certain sorts of regularities in the Humean mosaic. Humean views differ in how they construe the mosaic's contents and the sorts of regularities that are laws. We will consider three Humean approaches.

2.3.1 The Best System Account

On Lewis's (1973a, 1986, 1994) Best System Account ("BSA"), the laws are the regularities in the optimally simple and strong deductive systematization of the Humean mosaic. The standards of simplicity and strength are supposed to be the standards scientists themselves use when they are investigating the laws.[18] The laws are thus efficient summaries of what happens in the world's history.

[18] This point is made clear at Lewis (1983: 41) and (1986: 123).

A longstanding worry for the BSA is that it can be trivialized without some restrictions on the language used in the systematization. Consider the predicate F representing the property of "existing in a world in which the following happens…[here follows a precise description of the entire mosaic]" (Lewis 1983: 367). Then (x)Fx is true and an optimal summary of the mosaic, since it is extremely simple and also maximally informative. If it were a genuine candidate system, then it would win the competition for best system. Moreover, it would collapse the nomological possibilities to one, since "F" fully specifies the mosaic. This maneuver could be applied to any world, so there would be no accidents in any world.

Lewis viewed this implication as disastrous, so he restricted the language in which the competing systems are formulated so that their predicates refer only to perfectly natural properties. Such properties roughly correspond to those that could be Armstrongian universals: they are the elite properties to be identified by fundamental physics. Of course, "F" is not perfectly natural, so a system that employs it is precluded from winning the competition for best system.

Although this naturalness restriction prevents the BSA from entailing that all worlds are no-accident worlds, the BSA still countenances plenty of worlds where there are laws but no accidents. For example, suppose the mosaic displays significant diachronic regularities so that on the BSA, determinism holds (both forwards and backwards). Additionally, suppose that the universe's state at some moment in its history is remarkably simple (e.g., all the particles "line up" in a simple manner), though at other times, its state may be very complex. The actual world itself could be like this. Then a specification of that simple state coupled with the forward- and reverse-deterministic dynamics entails everything that happens. The addition of that simple state description to the deterministic diachronic regularities would contribute enormous

informativeness with only a small loss in simplicity, yielding the best system. In such a world, according to the BSA, there are no accidents.[19]

2.3.2 The Package Deal Account

Loewer's (2007, 2020) Package Deal Account ("PDA") differs from Lewis's BSA in several respects, including that the competition for best system determines not only the laws, but also the perfectly natural properties and even the character of the mosaic's fundamental arena (for example, spacetime). On the PDA, the standards determining the best combination of perfectly natural properties and deductive system of truths are supposed to be (as on the BSA) the standards used in scientific theory-choice, though the PDA permits these standards to go beyond simplicity and strength. The roster of perfectly natural properties yielded by the best-system competition will be coordinated with the deductive system of truths that the competition also yields, producing the optimal combination. The PDA thereby avoids positing that the perfect naturalness of certain properties is metaphysically independent from the competition. Hence the PDA precludes the possibility that science (guided by its standards for theory-choice) should settle on a final theory of everything ("TOE") that diverges from the best system because the properties that the TOE deems fundamental are not the perfectly natural properties. Such a divergence, Loewer argues, would be problematic for the BSA since science should then care about the TOE, not the BSA's laws.

What does the PDA imply about the possibility that there are no accidents? The answer is not entirely straightforward. Since the perfectly natural properties are settled by the competition,

[19] This worry is raised by Hall (ms:44) and Frisch (2014:225-226). Both seem to be endorsing (in passing) the criterion we are proposing: that an account of lawhood preclude "no-accident" worlds. (Hall even calls it, without argument, "a nonnegotiable desideratum on an account of laws" (p. 44).) But neither of them develops this criterion systematically, gives a general motivation for it (as we did in section 1), or applies it across-the-board to all of the leading accounts of lawhood (as we are now doing).

there is greater flexibility in the properties that a system can employ than on the BSA. This flexibility may make it easier for everything that happens in the mosaic to be entailed by the laws. Presumably, then, there are possible worlds where the PDA deems there to be laws but no accidents, whereas in those same worlds, the BSA (confined to its pre-competition catalog of perfectly natural properties) would endorse a less comprehensive system of laws and so imply that there are accidents.

This verdict would not follow, however, if one scientific standard for theory-choice is to favor theories positing accidents. In that case, it would be difficult for there to be no accidents under the PDA. However, we are unsure how to argue that the existence of accidents is a scientific desideratum for theory-choice. One might appeal to our arguments from section 1, according to which the laws cannot play many of their central roles if there are no accidents, so if one epistemic standard for lawhood is that laws play these roles, there would be a reason for science's epistemic standards to include a preference for theories according to which there are accidents. But standard lists of science's desiderata for theory-choice do not include anything like this preference. They include such desiderata as logical consistency, unity, simplicity, explanatory power, and scope. The capacity of the laws posited by a scientific theory to play various roles seems more appropriately viewed as a metaphysical marker of lawhood than as a scientific criterion for theory-choice. And it is the scientific standards that the PDA employs.

Moreover, even if science's standards for theory-choice include a preference for theories that admit accidents, this would be only one standard among many. These standards must be traded-off against one another. Hence, there would presumably be worlds (with rich mosaics) where there are no accidents.

2.3.3 Pragmatic Humeanism

Another Humean approach revises the standards used in the competition so that they produce a system that is more useful to epistemically-limited creatures like us than an efficient summary of the mosaic would be. Such proposals have been developed by Hicks (2018), Dorst (2019), and Jaag and Loew (2020). We will focus on the latter two.

According to both Dorst's Best Predictive System Account ("BPSA") and Jaag and Loew's Cognitive Usefulness Account, the best systematization of the Humean mosaic is a set of principles that is maximally predictively useful to creatures in our epistemic situation. These principles will have extensive implications regarding a wide variety of physical systems. In any complex world like ours, there will be an enormous variety of physical systems whose behavior could be predicted, so instead of listing every system's behavior (very cumbersome!), the best predictive system's (BPS) principles are likely to take an input/output form; the input consists of information about the physical system in question, and the output returns details about its behavior over time. Ideally, we would want the highest possible ratio of outputs to inputs. Moreover, it is preferable for the input to be the sort of information that we typically have or can easily gather. Since we tend to have better access to information concerning what is nearby in space and time, Dorst (2019: 889-893) suggests that the BPS is subject to the desiderata of spatial and temporal locality (roughly: the input consists of information local to the physical system or, at least, the output depends less and less on input concerning conditions increasingly remote from the system). Likewise, it may be desirable for the BPS to exhibit various spatiotemporal symmetries so that we do not have to orient ourselves in spacetime before we can use the principles for making predictions.

Jaag and Loew point out that we rarely have fully precise and accurate information about the exact microstates of physical systems whose behavior we are trying to predict. Rather, our information is often incomplete and approximate. Therefore, it is desirable that the principles we use to make predictions have "robust applicability," that is, return approximately correct predictions for approximately correct inputs.[20] Making predictions from such information requires applying the laws to non-actual circumstances. The laws' "modal latitude" (that is, their applicability to non-actual circumstances) is "a necessary condition for the laws' allowing inferences from incomplete or slightly inaccurate information" (Jaag and Loew 2020:2540).

This argument appears to show that in worlds with rich mosaics where the exact microstates of most systems are often inaccessible to us, the laws (according to these pragmatic Humean accounts) apply to non-actual circumstances. Thus, the *actual* circumstances are not the only nomologically possible ones, so there must be accidents. But what about the problem afflicting the original BSA: that if the laws end up being forward- and reverse-deterministic and at some moment the universe occupies an exceedingly simple state, then a description of that state could well belong to the best system, so it specifies the total history uniquely? Couldn't this problem also afflict the BPSA or Cognitive Usefulness Account?

Jaag and Loew (*ibid*.: 2543) argue that it would not; adding a description of the universe's momentarily simple state to our set of predictive principles would not help in most predictive contexts. For example, one can predict the trajectory of a tennis ball quite accurately without knowing its exact microstate. Attempting instead to derive its trajectory from a description of the universe's momentarily simple state and dynamical laws would require enormously many extraneous and potentially intractable calculations. Adding a description of the total state to the BPS would thus make it somewhat more complex without appreciably increasing its useful

[20] This point about the laws' error tolerance is also emphasized by Callender (2017: chs. 7,8).

predictive power. These pragmatic Humean accounts thereby secure the verdict that there are accidents in worlds with rich mosaics, even if it turns out that the world momentarily occupies a simple state.[21]

3.4 Dispositional Essentialism

Dispositionalists (for example, Bird (2005, 2007), Bigelow *et al.* (1992), Chakravartty (2007), Ellis (2001)) argue that a (fundamental) property's essence consists of its nomological roles. These roles are often its stimulus and manifestation conditions. For instance, mass's essence includes that if an object with mass m felt net force $\boldsymbol{F}$, then it would undergo acceleration $\boldsymbol{F}/m$. According to dispositional essentialism, laws express the dispositional essences of (fundamental) properties.

As with Armstrong's theory, it is not immediately clear how to connect this view with the question of whether there are no-accident worlds. The fundamental properties' essences might permit many trajectories through state space. Yet there seems to be nothing to prevent a world from having such rich, well-coordinated fundamental properties that they suffice to determine the world's state at every moment, precluding accidents.

Furthermore, in their account of counterfactuals, essentialists (such as Ellis (2001:205,275) and Bigelow *et al.* (1992)) appeal to *a world*'s essence as determining the fundamental kinds of objects, properties, and processes there. They also appeal to the actual

[21] What about worlds with severely impoverished mosaics? Perhaps the BPS of such a world could just describe the entire mosaic (resulting in no accidents), though this depends on subtle questions about exactly how the notion of "predictive utility" is conceived. Can a predictive system just be a summary that contains every fact that it could be used to predict? Or must it have an amplifying effect so that it generates information about some chunks of the mosaic given information about other chunks? Neither Dorst nor Jaag and Loew say. In the former case, the BPS could pin down the entire mosaic if it were impoverished enough; in the latter case, it is less clear whether the BPS alone (absent any input information that it would amplify) could pin down the entire mosaic. Regardless, given the contested relevance of such worlds to accounts of lawhood (see section 1.3), we do not reach a conclusion about the BPSA or Cognitive Usefulness accounts on this basis. What seems clearer is that the BPS of a *rich* mosaic will imply the existence of accidents.

world's essence as securing the conservation laws. To understand such laws in a dispositionalist framework, Bird (2005) employs Bigelow *et al.*'s (1992) idea that the world's essence requires that charge, mass-energy, etc. be conserved. Bird adds that the world's essence should be construed dispositionally; the world is disposed to conserve those quantities in every interaction.

This appeal to a world's essence raises the possibility that its essence is even richer – rich enough to determine everything that happens. If worlds have essences, a world could be disposed to exhibit not merely energy conservation, but its entire history – and hence to include no accidents. Since nothing in this argument depends on the mosaic's character, dispositional essentialism has to countenance possible worlds with rich mosaics that contain no accidents.

2.5 Counterfactual Stability

In section 1, we argued that no accident possesses the laws' characteristic range of invariance under counterfactual antecedents because no accident is preserved under every antecedent in the range identified by PRES: every antecedent logically consistent with the laws. However, if *p* is an accident, then *not-p* is among those antecedents. Of course, it is logically impossible for *p* to be preserved under *not-p*. So it is unfair to regard *p* as failing to stand in an intimate relation to counterfactuals merely because *p* fails to be preserved under every counterfactual antecedent that is logically consistent with the laws. So argues Lange (1999, 2009), who then seeks a more reasonable standard for judging that accidents fail to stand in the laws' intimate relationship to counterfactuals.

He defines a set of subnomic truths (containing every subnomic logical consequences of its members) as "stable" if and only if for every member *m* of the set and every *p* that is logically consistent with the set's members, $p \mathrel{\square\!\!\rightarrow} m$ and $\sim(p \mathrel{\square\!\!\rightarrow} \sim m)$. From PRES, it follows that the set

of laws is stable. By contrast, take the set containing exactly the logical consequences of the accident that all gold cubes are smaller than a cubic mile. Its members are *not* all invariant under every antecedent that is logically consistent with its members. For instance, if a *very* rich person had wanted to have a gold cube constructed exceeding a cubic mile, then such a cube might well have existed, in which case not all gold cubes would have been smaller than a cubic mile. Yet the antecedent that a very rich person wants such a cube constructed is logically consistent with all gold cubes being smaller than a cubic mile. Therefore, this set is unstable.

Lange argues that every set of subnomic truths containing an accident is like the above set in being unstable – except, perhaps, for the set of all subnomic truths (the "maximal" set), since any subnomic falsehood is logically inconsistent with that set and so there are no subnomic falsehoods under which this set must be preserved in order to be stable. Since stability (unlike PRES) does not use the laws themselves to pick out the relevant range of counterfactual antecedents, stability provides a better standard for judging that no accident bears the laws' intimate relationship to counterfactuals. A set containing *p* does not have to be invariant under *not-p* in order to qualify as stable. The laws' collective stability is an achievement that the set of laws can legitimately "brag about" as compared to any nonmaximal set containing accidents since in the definition of "stability" (unlike PRES), the relevant range of counterfactuals has not been "biased" in favor of the laws.

Lange maintains that the set containing exactly the logical truths, conceptual truths, metaphysically necessary truths, mathematically necessary truths, etc. (that is, the set of truths possessing stronger-than-physical necessity) is stable, and Lange shows that for any two stable sets, one must be a proper subset of the other. Lange proposes that what makes it a law that *p* is

that *p* belongs to the largest nonmaximal subnomically stable set; any larger nonmaximal set contains an accident and so is unstable.

On Lange's account, there is no possible world where every subnomic fact is a matter of law: the laws in such an alleged world would be the members of the maximal set, but the account requires that the set of laws be nonmaximal.[22] The nonmaximality condition on the set of laws is not an *ad hoc*, underhanded means of achieving the result that there are accidents if there are laws. Rather, the condition is independently motivated: it ensures that the laws' stability is a significant achievement. A maximal set acquires its stability not by withstanding an impressively wide range of subnomic counterfactual perturbations, but rather by zeroing out the relevant range of counterfactual antecedents by making every subnomic counterfactual antecedent logically inconsistent with the set. So the nonmaximality condition ensures that a set's stability is something it can "brag about": its standing in a special relation to counterfactuals. A maximal set's invariance under every subnomic counterfactual antecedent with which the set is logically consistent (namely, none) is the "degenerate case."[23] A nonmaximal set's stability constitutes its members' distinctive variety of necessity (for example, the laws' physical necessity). But a maximal set's stability is too cheap to constitute any sort of necessity.

On Lange's account, one subnomic fact's lawhood depends on the presence or absence of other laws. That is because *m*'s lawhood – its membership in a stable set – is (as Lange puts it) a *team effort* rather than *m*'s individual achievement:

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[22] Lange's account of why the laws cannot suffice to determine all of the subnomic facts generalizes to explain why the meta-laws cannot suffice to determine all of the (first-order) laws. That is, Lange's account of meta-laws (the role played, according to many physicists, by symmetry principles) entails that some facts about the laws do not hold as a matter of meta-law. See Lange 2009:115-16.

[23] Suppose we try to construct a world where all of the subnomic facts follow from the laws alone by imagining a classical-physics world with deterministic dynamical laws and some law specifying the universe's initial conditions. Then on Lange's account, we fail to make all of the subnomic facts follow from the laws alone because the maximal set cannot be the set of laws. Instead, the laws are the members of the largest nonmaximal stable set. Perhaps (depending on which sets are stable) the laws would be the conservation laws and Newton's second law of motion (which, in a classical-physics world, may form a stable proper subset of the laws, according to Lange).

> Each member of the set [of laws] depends on the others to help specify the range of invariance that it has to possess in order to be a law. That is, each member of the set participates in delimiting the range of suppositions under which every member must be invariant in order for the set to be stable. The laws derive their lawhood collectively: their sub-nomic stability means that they are *together* as resilient under sub-nomic counterfactual suppositions as they could *together* be. They form a unified, integrated whole – a system. (Lange 2009:81)

That the laws derive their lawhood collectively differentiates Lange's account from many others. On the universals view, for example, a nomic necessitation relation's holding between two universals is entirely independent of whether or not such a relation holds between two other universals. Likewise, according to scientific essentialism, one property's dispositional essence generally imposes no constraints on another's (unless the first property's essence is, for instance, to bring about an instance of the other property in certain circumstances). By contrast, on Lange's picture, for any facts *m* and *n*, whether *m* is a law depends on whether *n* is a law because *n*'s lawhood would restrict the range of counterfactual antecedents under which *m* must be invariant for *m* to belong to the set of laws. Since one subnomic fact's lawhood depends on the presence or absence of other laws, *m*'s lawhood can depend on there not being so many other laws that adding *m*'s lawhood would make every subnomic fact determined by the laws.

Like Lange's account, the BSA and PDA both hold that *m*'s lawhood depends on *m*'s place in a system. But they nevertheless differ from Lange's account in permitting no-accident worlds. Systematicity is therefore not sufficient to meet our new criterion of adequacy. Nor is it strictly necessary; consider an "account" that implies that the only law in any possible world is that electrons have negative charge. This account seems to imply that there are accidents (e.g., it

doesn't settle how many electrons there are, nor does it say what else happens in that world), though it is clearly inadequate for other reasons. However, both proposed accounts we have identified as satisfying our criterion (Pragmatic Humeanism and Lange's account) are systematic. Perhaps any tenable account needs to have elements of systematicity in order to do so.

3. Conclusion

Laws and accidents play different roles in scientific practice. A philosophical account of lawhood must explain what laws are such that they are able to play their distinctive roles. We have argued that if, in some world, the laws (according to some philosophical account) suffice to determine everything occurring there, then those alleged laws cannot play many of the central roles characteristic of lawhood. That is, if an account portrays a world's "laws" as so *strong* as to determine the world's complete history, then (we have argued) the world's "laws" (according to that account) are actually so *weak* that they can do little by way of playing the laws' characteristic roles. They do not act like laws, and we think that in fact they are not laws at all. We have concluded that if there are indeed laws, then there must also be accidents.

We have argued that some proposed accounts of lawhood leave room for worlds where there are laws but no accidents, whereas other accounts deem such worlds impossible. We maintain that an account is better insofar as it deems such worlds impossible. We have identified two dissimilar, non-*ad-hoc* ways for an account to do so; there may be others as well. We suggest that philosophers look into them.

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References

Adlam, Emily. “Laws of Nature as Constraints.” *Foundations of Physics* 52.1 (2022): 1-41. 10.1007/s10701-022-00546-0

Albert, David. *After Physics*. Cambridge: Harvard University Press, 2015.

Armstrong, David. *What is a Law of Nature?* Cambridge: Cambridge University Press, 1983.

Beebee, Helen. “The Non-Governing Conception of Laws of Nature.” *Philosophy and Phenomenological Research*, 61 (2000): 571-594. 10.2307/2653613

Beebee, Helen. “Does Anything Hold the Universe Together?” *Synthese*. 149.3 (2006): 509–533. 10.1007/s11229-005-0576-2

Bennett, Jonathan. “Counterfactuals and Temporal Direction.” *The Philosophical Review*. 93 (1984): 57-91. 10.2307/2184413

Bennett, Jonathan. *A Philosophical Guide to Conditionals*. Oxford: Clarendon, 2003.

Bhogal, Harjit. “Nomothetic Explanation and Humeanism about Laws of Nature.” In *Oxford Studies in Metaphysics, vol. 12.,* edited by Karen Bennett and Dean W. Zimmerman. Oxford: Oxford University Press, 2021.

Bhogal, Harjit. “Does Anything Explain the Regularity of the World?” Unpublished manuscript.

Bigelow, John, Brian Ellis, and Caroline Lierse. “The World as One of a Kind: Natural Necessity and the Laws of Nature.” *British Journal for the Philosophy of Science* 43 (1992): 371-388. 10.1093/bjps/43.3.371

Bird, Alexander. “The Dispositionalist Conception of Laws.” *Foundations of Science* 10 (2005): 353-370. 10.1007/s10699-004-5259-9

Bird, Alexander. *Nature’s Metaphysics: Laws and Properties.* Oxford: Oxford University Press, 2007.

Bird, Alexander. “Time, Chance, and the Necessity of Everything.” In *Chance and Temporal Asymmetry*, edited by Alastair Wilson. New York: Oxford University Press, 2014. 10.1093/acprof:oso/9780199673421.003.0014

Callender, Craig. *What Makes Time Special?* Oxford: Oxford University Press, 2017.

Carroll, John. *Laws of Nature*. Cambridge: Cambridge University Press, 1994.

Chakravartty, Anjan. *A Metaphysics for Scientific Realism: Knowing the Unobservable.* Cambridge: Cambridge University Press, 2007.

Chen, Eddy Keming. "The Cosmic Void." In *Non-Being: New Essays on the Metaphysics of Nonexistence*, edited by Sara Bernstein and Tyron Goldschmidt. Oxford: Oxford University Press, 2021.

Chen, Eddy Keming and Sheldon Goldstein. "Governing without a Fundamental Direction of Time: Minimal Primitivism about Laws of Nature." In *Rethinking the Concept of Law of Nature,* edited by Yemima Ben-Menahem. Cham: Springer, 2022.

Chen, Eddy Keming. "Does quantum theory imply the entire Universe is preordained?" *Nature* 624 (2023): 513-515.

Dorst, Chris. "Towards a Best Predictive System Account of Laws of Nature." *British Journal for the Philosophy of Science* 70 (2019): 877-900. 10.1093/bjps/axy016

Dorst, Chris. "Why do the Laws Support Counterfactuals?" *Erkenntnis* 87 (2022): 545-566. 10.1007/s10670-019-00207-1

Dretske, Fred. "Laws of Nature." *Philosophy of Science* 44 (1977): 248-268. 10.1086/288741

Ellis, Brain. *Scientific Essentialism*. Cambridge: Cambridge University Press, 2001.

Filomeno, Aldo. "Are Non-Accidental Regularities a Cosmic Coincidence? Revisiting a Central Threat to Humean Laws." *Synthese* 198.6 (2021): 5205-5227. 10.1007/s11229-019-02397-1

Foster, John. *The Divine Lawmaker*. Oxford: Clarendon, 2004.

Frisch, Mathias. "Why Physics Can't Explain Everything." In *Chance and Temporal Asymmetry*, edited by Alastair Wilson. New York: Oxford University Press, 2014.

Goodman, Nelson. *Fact, Fiction, and Forecast, 4th ed.* Cambridge: Harvard University Press, 1983.

Hall, Ned. "Humean Reductionism about Laws of Nature." Unpublished manuscript. Accessed at <https://philpapers.org/archive/HALHRA.pdf>

Hall, Shannon. "Summer Solstice 2021 and the Search for Life in the Galaxy." *The New York Times*, June 18, 2021. https://www.nytimes.com/article/summer-solstice-meaning-sunset.html

Hempel, C.G. *Aspects of Scientific Explanation*. New York: Free Press, 1965.

Hicks, Michael. “Dynamic Humeanism.” *British Journal for the Philosophy of Science* 69 (2018): 987-1007. 10.1093/bjps/axx006

Horwich, Paul. *Asymmetries in Time.* Cambridge, MA: MIT Press, 1987.

Jaag, Siegfried and Christian Loew. “Making Best Systems Best for Us.” *Synthese* 197 (2020): 2525-50. DOI:10.1007/s11229-018-1829-1

Jackson, Frank. “A Causal Theory of Counterfactuals.” *Australasian Journal of Philosophy* 55 (1977): 3-21. 10.1080/00048407712341001

Jalloh, Mahmoud. “The Π-Theorem as a Guide to Quantity Symmetries and the Argument Against Absolutism.” In *Oxford Studies in Metaphysics*, edited by Karen Bennett and Dean W. Zimmerman,. Oxford: Oxford University Press, forthcoming.

Lange, Marc. “Laws, Counterfactuals, Stability, and Degrees of Lawhood.” *Philosophy of Science* 66 (1999): 243-267. 10.1086/392686

Lange, Marc. *Laws & Lawmakers*. New York: Oxford University Press, 2009.

Lewis, David. *Counterfactuals*. Cambridge: Harvard University Press, 1973a.

Lewis, David. “Causation.” *Journal of Philosophy*. 70 (1973b): 556-567. DOI:10.2307/2025310

Lewis, David. “New Work for a Theory of Universals.” *Australasian Journal of Philosophy* 61 (1983): 343-77. 10.1080/00048408312341131

Lewis, David. *Philosophical Papers, Volume II*. New York: Oxford University Press, 1986.

Lewis, David. “Humean Supervenience Debugged.” *Mind* 103 (1994): 473-90. 10.1093/mind/103.412.473

Loew, Christian and Siegfried Jaag. “Humean Laws and (Nested) Counterfactuals.” *The Philosophical Quarterly* 70 (2020): 93-113. 10.1093/pq/pqz037

Loewer, Barry. “Humean Supervenience.” *Philosophical Topics* 24 (1996): 101-127. 10.5840/philtopics199624112

Loewer, Barry. “Laws and Natural Properties.” *Philosophical Topics* 35 (2007): 313-328. 10.5840/philtopics2007351/214

Loewer, Barry. “The Package Deal Account of Laws and Properties.” *Synthese* 199 (2020): 1065-1089. 10.1007/s11229-020-02765-2

Loewer, Barry. “Are Humean Laws Flukes?” In *Humean Laws for Human Agents*, edited by Christian Loew, Siegfried Jaag, and Michael Towson Hicks. Oxford: Oxford University Press, 2024.

Maudlin, Tim. *The Metaphysics within Physics*. New York: Oxford University Press, 2007.

Penrose, Roger. “Quantum Physics and Conscious Thought.” In *Quantum Implications: Essays in Honour of David Bohm*, edited by B.J. Hiley and F. David Peat. New York: Routledge, 1987.

Penrose, Roger. *The Emperor’s New Mind*. Oxford: Oxford University Press, 1989.

Penrose, Roger. “Precis of ‘The Emperor's New Mind.’” *Behavioral and Brain Sciences* 13 (1990): 643-655.

Roberts, John. “Lewis, Carroll, and Seeing through the Looking Glass.” *Australasian Journal of Philosophy.* 76 (1998): 426-438. 10.1080/00048409812348541

Salmon, Wesley. “Four Decades of Scientific Explanation.” In *Scientific Explanation,* edited by Wesley Salmon and Philip Kitcher. Minnesota Studies in the Philosophy of Science, volume XIII. Minneapolis: University of Minnesota Press, 1989.

Seelau, Eric P., *et al*. “Counterfactual Constraints.” In *What Might Have Been: The Social Psychology of Counterfactual Thinking*, edited by Neil J. Roese and James M. Olson. Hillsdale, NJ: Erlbaum, 1995.

Tooley, Michael. “The Nature of Laws.” *Canadian Journal of Philosophy*. 7 (1977): 667-698. 10.1080/00455091.1977.10716190

Vihvelin, Kadri. “How the Laws Constrain: Causation, Counterfactuals, and Free Will.” In *Le Libre Arbitre*, edited by Jean-Baptiste Guillon. Paris: Collège de France, 2017.

Woodward, James. *Making Things Happen*. New York: Oxford University Press, 2003.

Woodward, James. “Simplicity in the Best Systems Account of Laws of Nature.” *The British Journal for the Philosophy of Science*. 65 (2014): 91-123. 10.1093/bjps/axt026

Woodward, James and Christopher Hitchcock. “Explanatory Generalizations, Part I: A Counterfactual Account.” *Noûs* 37 (2003a): 1-24. 10.1111/1468-0068.00426

Woodward, James and Christopher Hitchcock. “Explanatory Generalizations, Part II: Plumbing Explanatory Depth.” *Noûs* 37 (2003b): 181-99. 10.1111/1468-0068.00435