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The Humean Tradition[1]

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David Hume's discussions of causation have placed constraints on most subsequent accounts of scientific laws. After motivating and describing these Humean constraints, I will argue that they are unsatisfiable. There are two reasons for this conclusion. The first is that extant attempts to give such an account of laws face serious objections. This will be argued by reviewing familiar problems with a Naive Regularity Account and by considering two accounts representative of attempts to avoid these problems. The two accounts are David Lewis's account and an account discernible in Brian Skyrms's *Causal Necessity*. The second reason for my anti-Humean conclusion is of a more general nature. I shall present an argument challenging a presupposition of any philosopher working within the Humean tradition.

I. The Constraints

The most interesting and perhaps the most perplexing feature of laws is their *modal character*. To appreciate this feature, assume that there is a single coin in my pocket and that it is a nickel. Then the generalization that all the coins in my pocket are nickels is true. Yet, it is not a law. The generalization does not qualify as a law, roughly, because it describes an "accidental connection." The generalization is *accidentally* true. In contrast, consider Newton's First Law: the generalization that if no force is exerted on a body, then its acceleration is zero. This generalization, assuming for the moment that it really is a law, is not accidentally true. Each body with no force exerted on it, in some sense, *must* lack acceleration. It is in this way that laws have a modal character, a modal character not shared by accidentally true generalizations. Though the notion of a modal character is being introduced in a somewhat informal

[1]Thanks to James Fetzer, John Pollock, Stephen Schiffer, Francis Sheehan, Roy Sorensen, Paul Teller and the editors of *The Philosophical Review* for helpful comments on earlier versions of this paper.

fashion, that should not be troubling. At this point, my concern is just to call attention to the distinction between laws and accidentally true generalizations. It is a substantive question—perhaps *the* substantive question—how that distinction should be explained in some more rigorous way.

To explain the modal character of laws, philosophers have sought an analysis of universal law (reporting) sentences. In other words, they have sought a necessarily true completion of the following schema:

> (S1) It is a law that all Fs are Gs if and only if. . . .

Not just any necessarily true completion will do, however. For example, consider:

> It is a law that all Fs are Gs if and only if it is a law that all Fs are Gs.

While the preceding is necessarily true, it is also circular and hence unilluminating. More illuminating completions of (S1) would not include the operator "it is a law that. . . ." One might suggest:

> It is a law that all Fs are Gs if and only if it is physically necessary that all Fs are Gs.

This completion of (S1) avoids any formal circularity, and for this reason, were it true and necessary, would be more interesting than the earlier analysis. But most philosophers still would not be satisfied. They would not be satisfied because of the similarities between physical necessity and lawhood. Specifically, physical *necessity* involves an obvious element of modality—an element of modality quite similar to the element of modality associated with laws. Thus, any completion of (S1) using a physical necessity sentence would fail to explain the modal character of laws.

Other completions of (S1) would be similarly lacking. Just as an element of modality is required for the truth of law sentences and physical necessity sentences, an element of modality is required for the truth of physical possibility sentences, causal sentences, subjunctive conditionals, physical probability sentences, disposition sentences, and explanation sentences.[2] Introducing some terminology, we can take law sentences, physical necessity and possibility sentences, causal sentences, etc. to be *nomic sentences* and to express *nomic facts*. We can take the element of modality involved in nomic facts to be *nomic modality*. Then, given the new terminology, the conclusion to be drawn is that accounts of universal laws which complete (S1) by including nomic sentences fail to provide understanding of nomic modality. As a result, the history of philosophy has been full of attempts to complete schema (S1) without using any nomic sentences. Philosophers have sought a reduction of nomic modality.

The search for this reduction has largely been inspired by a fear instilled by Hume. Hume's argument against the idea of necessary connection, though largely of a semantic nature involving—it is now safe to say—suspect semantic assumptions, contained an important and still plausible epistemological premise. That premise points out our lack of "direct perceptual access" to the nomic:

> All events seem entirely loose and separate. One event follows another, but we never can observe any tie between them. They seem *conjoined*, but never *connected*.[3]

The resulting fear is that, without a reduction of nomic modality, our lack of direct perceptual access to nomic connections would prevent us from having knowledge about causation and laws. It is feared, in other words, that failure to reduce invites skepticism.

Hume's influence extends beyond inspiring the search for a reduction of nomic modality; it has inspired the search for a special sort of reduction. Hume, while admitting the existence of properties and relations, denied that they were universals. More generally, he had a disdain for abstract entities of any kind. Whatever Hume held, most of his descendants within the Humean tradition

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[2]Wesley Salmon, in "Laws, Modalities and Counterfactuals," *Synthese* 35 (1977), pp. 191–229, argues persuasively for the close ties between subjunctive conditionals, physical possibility and necessity, probability, laws, explanation, causation and dispositions.

[3]*An Inquiry Concerning Human Understanding* (Indianapolis, Ind.: Bobbs-Merrill, 1955), p. 85.

have been thorough-going nominalists,[4] and hence have thought that their analyses should avoid reference to abstract entities, especially what are sometimes thought to be "modality-supplying" abstract entities like possible worlds or universals. Humeans have not resisted reference to mathematical entities with the same urgency because the ontological problem presented by such reference has correctly been viewed as an independent issue. It is an issue not closely tied to the modal character of laws. So, the primary concern of the Humean tradition has been to avoid reference to abstract entities *as a way of explaining nomic modality*. Reductive analyses of universal law sentences which do not appeal to abstract entities to explain nomic modality are what I take to be *traditional reductive accounts*. They are the philosophical accounts satisfying the Humean constraints on solutions to the problem of laws.

Before discussing traditional reductive accounts, I should make a few preliminary points. First, there is an assumption I have been making and will continue to make throughout this paper. The assumption is that universal laws are universal *material* generalizations. They are of the form:

$$(\forall x)(Fx \supset Gx)$$

where "$\supset$" is the material conditional of predicate logic.[5] This assumption is controversial. Universal laws typically are expressed by

[4]David Lewis, by virtue of his belief in possibilia, is the notable exception though even he resists postulation of universals. He is a nominalist in that sense.

[5]This contrasts with my discussion in "Ontology and the Laws of Nature," *Australasian Journal of Philosophy* 65 (1987), pp. 261–276. There I implicitly assumed, more non-traditionally, that laws were not material generalizations and, more importantly, that there was no additional property which needed to hold of a law, other than truth, for it to be a law. Hence, the focus there was on the "truth-makers" for laws. The assumption that there is no additional property which must hold of a law, other than truth, for it to be a law, now seems to me to be false; and much further from the truth than the assumption that universal laws are universal material generalizations. As I say in the text, universal laws typically are expressed by universally quantified indicative conditional sentences, but there are plenty of true universally quantified indicative conditional sentences that do not express laws. (Some examples are given in Section II.)

universally quantified *indicative* conditional sentences, and there is much debate as to whether the truth conditions of indicative conditional sentences are given by the material conditional. Nevertheless, I think the assumption is warranted at least for rhetorical reasons. Second, I want to point out one shortcoming of my discussion. Recognition of the existence of probabilistic laws has led to attempts to give an interpretation of physical probability, and these attempts, like accounts of universal laws, have been subject to Humean constraints. Because of the many idiosyncratic issues involved, I will be unable to focus any of my discussion on interpretations of probability. Instead, I will limit my attention to universal laws. Notice, however, that some probabilistic laws are universal laws. For example, any law of the form:

$$(\forall x)(Fx \supset PROB(Hx) = r)$$

where "PROB(. . .) = r" is a single-case probability operator, is a universal law and a probabilistic law. So there will be discussion of probabilistic laws—just no focus on interpretations of probability. Third, by taking defenders of traditional reductive accounts to constitute the *Humean* tradition, I do not mean to imply that *Hume* advanced a traditional reductive account. I use the name "Humean tradition" because of Hume's *influence* on defenders of traditional reductive accounts. What Hume actually held is a bit beside the point of this paper.

A final preliminary point concerns the relationship between laws and subjunctive conditionals. In order to discuss that relationship, it will help to say a little more about physical necessity and physical possibility. Physical necessity is usually defined so that a proposition is physically necessary if and only if it is true at all possible worlds with all and only the laws of the actual world. A proposition is physically possible if and only if its negation is not physically necessary. These definitions permit a concise statement of a commonly accepted principle governing the relationship between laws and subjunctive conditionals; a principle commonly accepted both inside and outside the Humean tradition. That principle states that a subjunctive conditional is true if its antecedent is physically possible and physically necessitates its consequent. Symbolically:

(SC) If $\underset{p}{\Diamond} P$ and $\underset{p}{\Box}(P \supset Q)$, then $P > Q$[6]

where "$\underset{p}{\Diamond}$" is the physical possibility operator, "$\underset{p}{\Box}$" is the physical necessity operator, and ">" is the subjunctive conditional. (SC) or some close facsimile has been used by many as a test of reductive accounts. I, too, will use it as such.

II. A Naive Regularity Account

The most basic traditional reductive analyses have come to be known as *Naive Regularity Accounts*. All such accounts may be summarized as follows:

> It is a law that all Fs are Gs if and only if (i) all Fs are Gs, and (ii) the generalization that all Fs are Gs is law-like.

Naive Regularity Accounts differ from one another in terms of how they cash out the property of being law-like (though all take this property to be an intrinsic, essential feature of the generalization). The Naive Regularity Account I shall consider is typical:

> It is a law that all Fs are Gs if and only if (i) all Fs are Gs, and (ii) the generalization that all Fs are Gs is law-like; that is, (a) it is not necessary that all Fs are Gs, and (b) the generalization is unrestricted (it involves only non-local, empirical predicates apart from logical connectives and quantifiers).[7]

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[6]For arguments in favor of this sort of connection between laws and subjunctive conditionals, see Jonathan Bennett's "Counterfactuals and Temporal Direction," *The Philosophical Review* 93 (1984), pp. 57–91, and John Pollock's *The Foundations of Philosophical Semantics* (Princeton, N.J.: Princeton University Press, 1984), pp. 116–140.

[7]This account is frequently criticized. David Armstrong, in *What is a Law of Nature?* (Cambridge, England: Cambridge University Press, 1983), considers it, and it is the account which George Molnar calls "The Regularity Theory" in "Kneale's Argument Revisited," *Philosophical Problems of Causation*, ed. Tom Beauchamp (Encino, Calif.: Dickenson Publishing Company, 1974). None of the problems I shall raise for the account are completely novel. Similar problems are discussed by Armstrong, Molnar, and others: Nelson Goodman, *Fact, Fiction and Forecast*, 4th ed., (Cambridge, Mass.: Harvard University Press, 1983), Carl Hempel, *The Philosophy of Natural Science* (Englewood Cliffs, N.J.: Prentice-Hall, 1966) and John

Local predicates include names of individual times, places, or objects. So, the following would be local: ". . . is in John's pocket," ". . . is in Manhattan," ". . . is a brother of Ronald Reagan," etc. It is difficult to characterize non-empirical predicates. I suppose, however, that the following would be examples: ". . . is a non-physical spirit," ". . . is a form in Plato's Heaven," etc. The most important problems with this Naive Regularity Account arise from the fact that it fails to provide sufficient conditions for a generalization's being a law. Here, briefly, are three different counterexamples to that effect. (The account may also fail to provide necessary conditions, but I will bypass that issue here.)

a. Vacuously True Generalizations. Because there are in fact no unicorns, the generalization that all unicorns weigh five pounds is true. It is also contingent and unrestricted. So the Naive Regularity Account has the unintuitive consequence that it is a law that all unicorns weigh five pounds. More generally, if there are no Fs and the generalization that all Fs are Gs is contingent and unrestricted, then according to the Naive Regularity Account it is a law that all Fs are Gs. So, not only is it a law that all unicorns weigh five pounds, it is a law that all unicorns weigh ninety pounds, it is a law that all orange elephants breathe fire, etc. As these examples illustrate, the account has the consequence that science is absurdly easy. To discover laws of nature, all we need do is conjure up generalizations which are vacuous, contingent and unrestricted. Admitting all contingent, unrestricted, vacuously true generalizations as laws also leads to inconsistencies deriving from (SC). For instance, if it is a law that all unicorns weigh five pounds and it is a law that all unicorns weigh ninety pounds, then two inconsistent counterfactuals must both be true. It must be true that if a unicorn existed it would weigh five pounds and if a unicorn existed it would weigh ninety pounds. Indeed, neither of these counterfactuals is true. If a unicorn existed there are many weights it *might* have—no one weight it *would* have. Thus, a tenable reductive account of laws cannot have the consequence that all vacuously true, contingent, unrestricted generalizations are laws.

Earman, "Laws of Nature: The Empiricist Challenge," *D. M. Armstrong*, ed. Radu Bogdan (Dordrecht, The Netherlands: D. Reidel Publishing Company, 1984).

b. Troublesome Predicates. Assume that all ravens are black. Since there are no unicorns, it is true that all unicorns or ravens are black. It is not necessary that all unicorns or ravens are black. Moreover, the generalization is unrestricted: there is no mention of an individual thing, time, or place, nor any mention of non-empirical spooks or spirits. So, according to the Naive Regularity Account, it is a law that all unicorns or ravens are black. But this is not a law. It is hardly the sort of thing one would expect to find as part of a scientific theory. If additional reasons are desired for denying this generalization the status of law, here are a couple. First, since the generalization that all unicorns or ravens are black entails the generalization that all unicorns are black, that generalization ought also to be a law. It is not. Second, we again encounter problems with counterfactuals. If we accepted that it is a law that all unicorns or ravens are black and hence that it is a law that all unicorns are black, we would further need to accept as true the false counterfactual that if a unicorn existed, it would be black. What seems to have gone wrong is that the generalization that all unicorns or ravens are black contains a troublesome predicate, the disjunctive predicate ". . . is a unicorn or raven."

c. A Puzzle.[8] Consider the generalization that all gold spheres are less than ten feet in diameter. The generalization is true, contingent and unrestricted. So, according to the Naive Regularity Account, it is a law that all gold spheres are less than ten feet in diameter. However, this generalization is not a law. After all, all that prevents there being a gold sphere of that size is the fact that no one has been curious and wealthy enough to gather up that much gold. This generalization presents a problem quite distinct from the earlier counterexamples because the generalization involves no obviously troublesome predicates and the generalization is not vacuously true. Furthermore, unlike the earlier counterexamples where we could at least put our reductive finger on the apparent source of the problem (that is, vacuity or troublesome predicates), it is not at all clear what gives rise to this final counterexample.

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[8]Bas van Fraassen, in "Armstrong on Laws and Probabilities," *Australasian Journal of Philosophy* 65 (1987), pp. 243–260 has a brief, but convincing, discussion of a similar counterexample. See pp. 245–246.

III. The Two Standard Approaches

Humeans typically have recognized that there are defeating objections to Naive Regularity Accounts and have tended to respond in one of two ways: (i) by taking a *systematic approach* or (ii) by taking an *epistemological approach*.[9] The nature of these two options will be illustrated by reconsidering the problem associated with vacuously true generalizations and the problem associated with troublesome predicates.

An initially tempting move to make in response to the problem posed by vacuously true generalizations is to maintain that no vacuously true generalizations are laws. This move fails, however, because there are vacuously true laws. Newton's First Law is the example usually cited. If our universe were a Newtonian universe, it would be a law that all bodies with no force exerted on them have no acceleration, and it would also be the case that there are no bodies with no force exerted on them.[10] There are other ex-

[9]Armstrong, *op. cit.*, pp. 60–66, and Earman, *op. cit.*, p. 191, also recognize that philosophers have tended to take either a systematic or epistemological approach to giving an account of laws.

[10]Is Newton's First Law vacuously true or would it be vacuously true if our universe were Newtonian? I think so, but why depends on exactly what Newton's First Law is. For no particular reason, I have opted for the formulation given above; namely:

(1) If no force is exerted on a body, it has no acceleration.

But some suppose that the correct formulation is:

(2) If no *net* force is exerted on a body, it has no acceleration.

If (1) is the correct formulation, then Newton's First Law would be vacuously true in any Newtonian universe with more than one body because of Newton's Law of Gravitation. So if our universe were Newtonian, the law would be vacuously true. However, if (2) is the correct formulation then the law might be non-vacuously true in a Newtonian universe, even one with more than one body, because the forces on a body might cancel each other out. Nevertheless, if our universe were Newtonian, it seems highly unlikely, given the number and diversity of bodies exerting forces, that there would be such a body (cf. John Earman and Michael Friedman, "The Meaning and Status of Newton's Law of Inertia and the Nature of Gravitational Forces," *Philosophy of Science* 40 (1973), pp. 329–359, esp. p. 341), and, more importantly, it is clear that the status of Newton's First Law as a law does not depend on the existence of such a body.

amples. C. D. Broad and A. J. Ayer have identified an entire class of vacuously true laws.[11] These vacuously true laws are derivable from *functional laws*, laws relating a quantitatively measurable property to one or more other quantitatively measurable properties. Functional laws, though typically not vacuously true, often hold for an infinite number of values of the quantitatively measurable properties. Not all of these values are instantiated. Hence, there is an entire class of vacuously true laws—laws relating these uninstantiated values—entailed by the functional laws. There is also a formal problem with adding a necessary condition to a Naive Regularity Account requiring that the generalization not be vacuously true. The problem arises from the fact that two generalizations may be logically equivalent but one be vacuously true and the other non-vacuously true. For example, let "$(\forall x)(Ux \supset Wx)$" express the generalization that all unicorns are white. It is equivalent to the generalization expressed by "$(\forall x)(\sim Wx \supset \sim Ux)$." Yet the former is vacuously true and the latter is not—there are no unicorns but there are non-white things. Presumably, it should not turn out to be the case that there could be two equivalent generalizations, one a law and the other not. (The proposal also has the related absurd consequence that "$(\forall x)(\sim Wx \supset \sim Ux)$" expresses a law.)

To solve the problem of vacuously true laws, some[12] have been tempted to invoke the distinction between *basic* and *non-basic* laws. The basic laws of a theory are, roughly, its fundamental postulates. The non-basic laws are then defined to be those generalizations entailed by the basic laws. Given this distinction, one could hold that the basic laws are all and only the non-vacuously true, contingent, unrestricted generalizations while allowing that there may be vacuously true, non-basic laws. But this suggestion also fails. The formal problem mentioned at the end of the previous paragraph rearises in a slightly different form. Without some further con-

[11]A. J. Ayer, "What is a Law of Nature?" *Philosophical Problems of Causation*, ed. Tom Beauchamp (Encino, Calif.: Dickenson Publishing Company, 1974), and C. D. Broad, "Mechanical and Teleological Causation," *Supplementary Proceedings of the Aristotelian Society* 14 (1935), pp. 83–112. Also see Armstrong, *op. cit.*, p. 22.

[12]For example, Ernest Nagel, *The Structure of Science* (London, England: Harcourt, Brace and World Inc., 1961), pp. 59–62.

straint on basic laws, nearly all vacuously true generalizations will qualify as non-basic laws, because almost every such generalization is entailed by a non-vacuously true, contingent, unrestricted generalization. For example, the generalization expressed by "$(\forall x)(\sim Wx \supset \sim Ux)$" will qualify as a basic law and the generalization expressed by "$(\forall x)(Ux \supset Wx)$" will qualify as a non-basic law. Furthermore, the suggestion implies that no basic laws are vacuously true and that consequence does not mesh well with the history of science. Newton's First Law, Gallileo's Law of Falling Bodies, Boyle's Law, and others arguably are vacuously true and were accepted as basic—they were not derived from any more fundamental postulates at least not at the time they were first accepted as laws.

Still, there might be something right in spirit about this suggestion. The suggestion ties lawhood to the relationships between generalizations in a theoretical *system.* While this simplistic suggestion fails, there is more to be said about that sort of approach. Lewis's traditional reductive account of laws, to be examined in Section IV, is a much more sophisticated example of an account which ties lawhood to the relationships between generalizations in a theoretical system. It is an initially promising attempt at taking a systematic approach to the problem of laws.

Others less impressed by the systematic approach, have taken an epistemological approach. There are a variety of different ways of doing so[13]—some more promising than others. A rather foolish way of taking an epistemological approach would be to try to offer a reductive account which distinguishes universal laws from accidentally true generalizations by involving the epistemic status of generalizations among cognizers. For example, one might offer

[13]There is one way of taking an epistemological approach to giving an account of laws which I will not discuss here. This way (sometimes described as Humean) has been taken by many authors including Ayer, *op. cit.*; Simon Blackburn, *Spreading the Word* (Oxford, England: Oxford University Press, 1984); and J. L. Mackie, "Counterfactuals and Causal Laws," in Beauchamp, *op. cit.* These authors do not attempt to provide a traditional reductive account, nor any sort of reduction of nomic modality. Rather, they are projectivists about nomic sentences. In view of the conclusions to be reached here, this way of taking an epistemological approach needs to be taken quite seriously. However, consideration will have to wait for another occasion.

the following sort of additional necessary condition to a Naive Regularity Account:

> It is a law that all Fs are Gs only if the generalization that all Fs are Gs has an epistemically privileged status among cognizers.

This might be spelled out in a variety of ways. For example, one might hold that for a contingently true, unrestricted generalization to be a law it must also be well-confirmed by scientists. Of course, there is a problem with this and any other similar proposal suggesting such a direct tie between laws and doxastic states. They contradict the objectivity of laws. What generalizations are laws does not depend, at least not in such a direct way, on what cognizers believe or are justified in believing about the generalizations.

A less foolish way of taking an epistemological approach is suggested by Nelson Goodman's attempt to deal with counterexamples involving troublesome predicates.[14] Goodman recognized that further restrictions needed to be placed on the predicates involved in laws. He also recognized that it is part of the epistemological nature of laws to be confirmed through induction. So, he suggested, at least initially, that what makes some generalizations laws is that they are confirm*able* by induction. Goodman's suggestion can be made more precise as follows. He showed that examining a sample of Fs all of which are Gs does not always provide reason to conclude that all Fs are Gs. For example, examining a sample of emeralds all of which are grue does not give one reason to conclude that all emeralds are grue. "F" and "G" must be the appropriate sorts of predicates in order for an examination of a sample of Fs all of which are Gs to provide reason to conclude that all Fs are Gs. The property expressed by the predicate "G" must be *projectible* with respect to the property expressed by the predicate "F." With regard to our earlier counterexample, the generalization that all unicorns or ravens are black, the property of being a unicorn or raven and many properties expressed by ordinary disjunctive predicates turn out to be non-projectible.

Goodman's suggestion illustrates how epistemological considerations can be relevant to giving an account of laws without

[14]Goodman, *op. cit.*, pp. 72–83.

threatening the objectivity of laws. His suggestion would not contradict the objectivity of laws as long as the projectibility of a property is an objective feature of it. For example, one might hold that the projectibility of a property is an essential feature of it. Then, the projectibility of a property would be an epistemological, essential feature of it; and hence would not vary with the beliefs cognizers had about laws. In Skyrms's *Causal Necessity*, there are the beginnings of a reductive account to be discerned which also takes an epistemological approach. This account in a sense reduces laws to subjective probabilities, but it, like Goodman's proposal, need not be subject to the objection that it contradicts the objectivity of laws. The Skyrmsian reductive account, to be considered in Section V, is a very sophisticated example of a Humean account which has taken an epistemological approach.[15]

Thus, in the following two sections, I will consider an initially promising attempt at taking a systematic approach, Lewis's account, and an initially promising attempt at taking an epistemological approach, the Skyrmsian account. To anticipate, each will be found to be subject to defeating objections. This will prompt suspicion concerning both the systematic and epistemological approaches. As these approaches are the only options standardly exercised in attempts to give a traditional reductive account, I will be led to question the prospects of completing the Humean project.

IV. Lewis and Ideal Systems

Lewis originally formulates his account as follows:

> A contingent generalization is a *law of nature* if and only if it appears as a theorem (or axiom) in each of the true deductive systems that achieves a best combination of simplicity and strength (1973, p. 73).[16]

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[15]*Causal Necessity* (New Haven, Conn.: Yale University Press, 1980). Apparently, though, this is not the account Skyrms intended to be offering. (That is why I refer to the account suggested to me as the "*Skyrmsian* Account.") In Skyrms's more recent book, *Pragmatics and Empiricism* (New Haven, Conn.: Yale University Press, 1984), he has indicated that he did not intend to be offering a reductive account of laws in *Causal Necessity*, but instead intended to offer "a specimen of a new kind of philosophical reduction" (pp. 12–13)—a pragmatic reduction. Nevertheless, the discernible beginnings of a reductive account are worth considering. Remaining references to Skyrms in the text will be to *Causal Necessity*.

[16]In this section, I will frequently be making references to several dif-

More recently, Lewis states basically the same account:

> A law is any regularity which earns inclusion in the ideal system. (Or, in case of ties, every ideal system.)

An ideal system according to Lewis must be entirely true, must be closed under strict implication, must be as simple in axiomatization as it can without sacrificing too much information content, and must have as much information content as it can without sacrificing too much simplicity (1983, p. 367). Still more recently, Lewis has made a revision in his account. I eventually will discuss this revision, but let us begin by considering problems with the original.

a. For Lewis, universal laws are those contingent generalizations which are part of the ideal system (or, in the case of ties, all ideal systems) where his characterization of ideal systems invokes the notions of simplicity and information content. However, simplicity and information content present their own philosophical puzzles —puzzles leading to problems in Lewis's account.

Lewis points out one such problem:

> The content of any system whatever may be formulated very simply. . . . Given system S, let F be a predicate that applies to all and only things at worlds where S holds. Take F as primitive, and axiomatize S (or an equivalent thereof) by the single axiom ∀xFx. . . . Then the ideal theory will include (its simple axiom will strictly imply) all truths and *a fortiori* all regularities. Then, after all, every regularity will be a law. That must be wrong (1983, p. 367).

In other words, the axiomatization of any system of true sentences can be as simple as possible. The axiomatization of any system, S, of true sentences can be a single sentence:

$(\forall x)Fx$

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ferent works of Lewis. For convenience, I will simply cite the references in the text using the year of publication and the page number. The works include: *Counterfactuals* (Cambridge, Mass.: Harvard University Press, 1973), "New Work for a Theory of Universals," *Australasian Journal of Philosophy* 61 (1983), pp. 343–377, and *Philosophical Papers*, Volume II (New York, N.Y.: Oxford University Press, 1986).

where "F" applies to all and only the objects existing at the worlds where S holds. ("F" intuitively should be understood as expressing something similar to what is expressed by the predicate ". . . is such that all the members of S are true.") This presents the following problem for Lewis. Suppose S is the system which includes all the truths of the actual world. So, all true generalizations must be part of S. Thus, according to Lewis, a generalization is a universal law if it is true.

What is Lewis's solution to this problem? He states:

> The remedy, of course, is not to tolerate such a perverse choice of primitive vocabulary. We should ask how candidate systems compare in simplicity when each is formulated in the simplest eligible way; or, if we count different formulations as different systems, we should dismiss the ineligible ones from candidacy. An appropriate standard of eligibility [is] not far to seek: let the primitive vocabulary refer only to perfectly natural properties (1983, pp. 367–368).

The appeal to natural properties supposedly solves the problem because the predicate "F" supposedly will not refer to a natural property. In a sense, Lewis's solution transforms his account of laws from a traditional reductive account to a non-traditional reductive account. Abstract entities—natural properties—have been invoked to explain the modal character of laws. Nevertheless, I include Lewis's theory in the discussion of traditional reductive accounts because his appeal to natural properties is more derivative than the appeal to abstract entities made by typical non-traditional reductionists like Armstrong.[17]

Lewis's solution presumes that there is a difference between natural and non-natural properties. It, of course, would be nice to have an account of this difference. Lewis (1983, pp. 347–348) suggests three distinct ways, each of which he finds somewhat attractive, to provide such an account: (i) by combining his own account of properties with Armstrong's theory of universals,[18] (ii) by taking "natural" as a primitive predicate of properties, or (iii) by recognizing primitive objective resemblance among particulars which might be used to analyze "natural" as a predicate of proper-

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[17]Armstrong, *op. cit.*

[18]Armstrong, *Universals and Scientific Realism* (Cambridge, England: Cambridge University Press, 1978).

ties. Unlike Lewis, I do not believe that any of these suggestions holds much promise.

Consider suggestion (iii). Natural properties and all other properties for Lewis are classes of *possibilia,* and to have a property is to be a member of a class. According to suggestion (iii), the critical difference between natural and non-natural properties is that members of natural properties resemble each other in some more fundamental way than members of non-natural properties. This suggestion has suspicious consequences when conjoined with his analysis of lawhood. Consider a predicate that could be part of a basic law, and hence must be able to be part of one of Lewis's ideal systems; for example, the predicate ". . . has positive charge." Since it may be part of an ideal system, Lewis is committed to holding that this predicate refers to a natural property. Lewis is also committed to the claim that the predicate "F" defined above does not refer to a natural property. According to Lewis's suggestion (iii), the former but not the latter refers to a natural property because the members of the class of possibilia which is the property referred to by the predicate ". . . has positive charge" resemble each other in some more fundamental way than the members of the class of possibilia which is the property referred to by the predicate "F." This is what I find suspicious. The members of the class referred to by the predicate "F" are all and only the objects of the actual world. These supposedly do not resemble each other in as fundamental a way as the members of the class of possibilia that have positive charge. But that class overlaps with the class of Fs in that it includes everything that actually exists and has positive charge. It also includes the counterpart of every actual object which might have positive charge and all sorts of bizarre possible entities that have positive charge (including possible winged-horses, elementary particles of who knows what sorts, and Martian chandeliers). Suspicious indeed!

One might hope that Armstrong's theory of universals would provide the necessary tools to distinguish natural properties from non-natural properties or, in Armstrong's terminology, to provide criteria for determining which universals exist. This is Lewis's first suggestion. Armstrong claims to have provided such criteria: a universal (i) must be identical in the many particulars that instantiate it, and (ii) must contribute to the causal power of the particulars which instantiate it. However, Armstrong's criteria appear to be fraught with problems. The first, which amounts to another appeal to objective resemblance between particulars, we have already seen to have troubles. It also has troubles which are independent of Lewis's rich ontology.[19] The second criterion appeals to causal facts. Causal facts are nomic facts and involve nomic modality. So invoking Armstrong's appeal to causal facts as a way to distinguish natural from non-natural properties undermines Lewis's original project; he could no longer be advancing a *reductive* account of universal laws.

What about Lewis's suggestion (ii), taking "natural" as a primitive predicate of properties? This, in a way, is the most plausible of Lewis's proposals. Simplicity and naturalness are important concepts, not because of their role in the analysis of law sentences, but because of their role in the *epistemology of science.* At least one of these concepts, and perhaps both, will be part of any plausible account of scientific confirmation. Thus, I do not want to argue that the concepts of simplicity and naturalness are unintelligible or deeply problematic in and of themselves. I also suspect that some such concept will need to be accepted as primitive. So, it behooves me not to be too unsympathetic to Lewis's second suggestion. Nevertheless, it does seem to me that there must be a better way to introduce a primitive predicate of naturalness or simplicity than as a predicate of classes of possibilia; some way which does not bring with it quite so much ontological baggage.

This discussion has been on *one* problem associated with simplicity and information content; a problem pointed out by Lewis himself and a problem he has not solved. There are others. Another, also noted by Lewis, concerns the psychological nature of simplicity and information content. On the one hand, it is natural to think that whether a system is simple or informationally rich in part depends on our own psychological make up. In short, if we thought in drastically different ways then different systems would be simple and different systems would be informationally rich. On the other hand, what generalizations are laws does not appear to be so dependent. In order to avoid this problem, Lewis (1986, p. 123) maintains that for a system to be ideal it must be as simple in

[19] See Quine, *Ontological Relativity and Other Essays* (New York, N.Y.: Columbia University Press, 1969), pp. 114–138.

axiomatization as it can be without sacrificing too much information content and as rich in information content without sacrificing too much simplicity, given *our actual* standards of simplicity and strength. But this proposal as to how to understand his analysis is *ad hoc* and, in a sense, chauvinistic. It commits Lewis to a kind of actual-world chauvinism for there is no reason to suppose that it is our world's standards of simplicity and strength out of all the possible standards of simplicity and strength which are the standards conceptually tied to laws. Worse, the proposal commits him to a cultural and present-time chauvinism in that it is *our* standards—the standards of our culture now—which make systems ideal. Why not the standards of any other culture at any other time? Thus, invoking simplicity and information content brings problems to Lewis's account.

b. Perhaps the most serious challenge to Lewis's account is that, even ignoring the problems just discussed, it is subject to a counterexample. This counterexample has evolved over a number of years from an example given by Michael Tooley.[20]

Consider a possible universe, U_1, in which no particles of type X are subject to fields of type Y though the generalization, L_1, that all X-particles subject to Y-fields have spin *up* is a law. There could be X-particles and Y-fields as well as other entities in U_1; it is just that no X-particle ever finds its way into a Y-field. Also assume that L_1 is the only basic law in U_1. That is, assume that there are no other laws in U_1 other than those generalizations entailed by L_1. Thus, nomically U_1 is somewhat barren. Nothing in U_1 is law-governed except X-particles and Y-fields and even those things never interact in such a way as to make the only basic law applicable. According to Lewis's account, L_1 is a law because it earns inclusion in the ideal system (or, in case of ties, every ideal system) of U_1. Thus, every ideal system in U_1 must include the system, call it *H*, that is axiomatizable by the single axiom L_1, and the ideal systems must overlap to *just* that extent. One would expect that the ideal system (or, at least, one of the ideal systems) in this universe would be H itself. However, if H is an ideal system then Lewis's account entails that L_1 is not a law, because there is a system which does not in-

[20]"The Nature of Laws," *Canadian Journal of Philosophy* 7 (1977), pp. 667–698. See esp. pp. 669–672.

clude L_1 but is just as simple in axiomatization and rich in information content. This system is the system axiomatizable by the single axiom, L_2, that all X-particles subject to Y-fields have spin *down*. Hence, H is not one of the ideal systems of U_1. But then one wonders what systems are ideal in U_1. Lewis's account leads one to expect that the ideal system (or, at least one of the ideal systems) would be the system H, and H doesn't work.

I doubt that there is a set of ideal systems in U_1 having the consequence that L_1 is the only basic law of U_1. I doubt there is because it seems likely that, for at least one member of any set of systems overlapping in just the right way, there will be an equally ideal system that does not include L_1: namely, the system which results from replacing the predicate ". . . has spin up" by the equally simple and equally rich predicate ". . . has spin down" each time it occurs in the original system. I have no proof that this is so, but that is partly because, having recognized that the system axiomatizable by L_1 cannot be ideal, I am left without a hint as to what systems are ideal in U_1. L_1 and L_2 are so similar both being true, contingent, unrestricted, equally simple, and equally rich that it is very difficult to believe that a set of ideal systems in U_1 could choose one over the other as the only basic law.

A common reply to this counterexample, though not the one I think Lewis would make, questions the possibility of U_1. Perhaps, or so the reply goes, in describing U_1, I am describing the impossible. Not every description picks out a genuine possibility and, if U_1 is not a genuine possibility, it fails as a counterexample. This reply is unpersuasive, however, unless some reason can be given for holding that U_1 is impossible. Those who have made this reply usually point out that L_1 is a single basic law, that L_1 is a vacuous law, or that L_1 is a single basic law *and* a vacuous law. However, objectors need to do more than just identify some feature of L_1; they need to say *why* that feature is a reason for denying that U_1 is possible. Objectors might as well point out that L_1 contains the predicate "has spin up." This fact, as far as I can tell, provides just as much reason—namely, none at all—for rejecting the possibility of U_1. Furthermore, there is some reason to think that these objectors can't provide the additional argument necessary for the reply to succeed. It would be a mistake, for example, to argue that single basic laws are impossible. Surely Newton was not flirting with the impossible by hypothesizing that in our universe there are only three basic laws. It would also be a mistake to argue that vacuous laws are impossible. The arguments of Section III should have convinced us of that. And it is especially difficult to see what problem single basic vacuous laws could present that is not presented by single basic laws nor by vacuous laws.

Still one might not be ready to give up on Lewis. Judgments of possibility and impossibility are, I think, largely theoretically motivated and it may be that independent attractions of Lewis's theory will make some hesitant to accept the counterexample, especially given that universes with single basic vacuous laws are a bit out of the ordinary. What, after all, is lost by denying the possibility of single basic vacuous laws? This reply might be of some consequence were U_1 the only counterexample to Lewis's account. It is not. I will argue in Section VI that U_1 threatens, not just Lewis's position but, the entire Humean tradition. So the question will again arise as to whether U_1 is genuinely possible. There, I will not rest with questioning the grounds for denying the possibility of U_1 as is done in the preceding paragraph. I will propose two other examples threatening the Humean tradition, examples which could have been used here in place of U_1. One of these counterexamples will not involve a single basic law and one will not involve any vacuous laws. Thus, any hesitancy to give up Lewis's account due to the extraordinary nature of single basic vacuous laws will be moot. Though these other examples may be slightly more persuasive, I introduce them later because they are more complex. U_1 is the simplest and the most dramatic of my counterexamples to Lewis's account.

As I said, I do not think Lewis would deny the possibility of U_1. Lewis's recent discussion and acceptance of *Humean supervenience* suggests a different reply:

> Humean supervenience . . . is the doctrine that all there is to the world is a vast mosaic of local matters of particular fact, just one little thing then another (1986, p. ix).

This stands in need of some qualification:

> First say it, then qualify it. I don't really mean to say that no two possible worlds whatsoever differ in any way without differing in their arrangements of qualities. For I concede that Humean super-

> venience is at best a contingent truth. Two worlds might indeed differ only in unHumean ways, if one or both of them is a world where Humean supervenience fails (1986, p. x).

He also adds, that for two worlds to differ in only unHumean ways "there would have to be extra natural properties or relations that are altogether alien to this world" (1986, p. x). Since Lewis admits the possibility of two worlds that differ in only unHumean ways, he must deny that his account of laws states a necessary truth. (Or else he needs to deny that considerations of simplicity and strength are matters of particular fact, but I take it that Lewis would resist this move.) I suspect he would hold further that his analysis holds only in worlds where Humean supervenience holds. If this is the correct understanding of Lewis, then the following reply to my counterexample is available. Lewis could admit that universe U_1 is possible (as well he should), but deny that it is a universe where Humean supervenience holds. Then U_1 would not be a legitimate test of his analysis.

Original though this response may be, it is unattractive. First, the response requires giving up the Humean project as traditionally conceived; a reductive account must state a necessary truth. Second, denying that his account of laws states a necessary truth together with his other remarks seems to imply that the *true* necessary and sufficient conditions of the concept of being a law are wildly disjunctive—the concept may apply in virtue of considerations of simplicity and strength *or* in virtue of there being extra natural properties and relations. Third, in order for this response to work there must be some *independent* reason for thinking that U_1 is a world where Humean supervenience fails, some reason other than the fact that it presents a counterexample to his theory, and it is hard to see what that reason could be. The counterexample stands.

c. As I said, Lewis has recently revised his account of laws. He feels the need to make the revisions because of problems he sees involving laws in a "chancy world." He worries that a generalization might be simple and informationally rich, but hold merely by chance and in fact may at one time have had a great chance of being false. Such a generalization could not be a law. Lewis gives an example:

> Suppose that radioactive decay is chancy in the way we mostly believe it to be. Then for each unstable nucleus there is an expected lifetime, given by the constant chance of decay for a nucleus of that species. It might happen—there is some chance of it, infinitesimal but not zero—that each nucleus lasted for precisely its expected lifetime. . . . Suppose that were so. The regularity governing lifetimes might well qualify to join the best system, just as the corresponding regularity governing *expected* lifetimes does. Still, it is not a law (1986, p. 125).

Accordingly, Lewis offers the following revision of his analysis:

> Previously, we held a competition between all true systems. Instead, let us admit to the competition only those systems that are true not by chance; that is, those that are not only true, but also have never had any chance of being false (1986, p. 126).

This revision succeeds in ruling out the regularity governing lifetimes as part of an ideal system since that regularity had a chance of being false.

Nevertheless, Lewis's revision does not avoid the problems I have raised to the unrevised analysis. The revision does not address problems involving simplicity and information content. Simplicity and information content play identical roles in the revision and the original. Also, the revision is subject to basically the same counterexample given above. We might suppose that, in U_1, neither the generalization that all X-particles subject to Y-fields have spin up nor the generalization that all X-particles subject to Y-fields have spin down ever had any chance of being false. (X-particles might never have had a chance of being subject to Y-fields.) Then the counterexample runs just as before. Moreover, the revised analysis places new emphasis on a sticky problem. Chance is a time-dependent, single-case physical *probability*. Physical probability sentences express nomic facts. So without some further analysis of chance in non-nomic terms Lewis's account ceases to be reductive. This does not create a new problem for Lewis because, even before giving the revised analysis, he had wanted to admit there were chances and had the Humean problem of reducing them. But the revised analysis does place new emphasis on this problem; a problem Lewis has been pessimistic about solving (1986, pp. 109–113 and 127–131).

V. Skyrmsian Reduction and Epistemic Invariance

The Skyrmsian reductionist takes an epistemological approach. Initial intuitive support for the account can be mustered by considering the following sketch of scientific practice. Scientists form hypotheses and subject them to tests. To determine if these hypotheses are true, scientists create and search for a variety of different circumstances which might provide counterexamples. If the hypotheses are *invariant*—if no counterexamples are found under a variety of circumstances—then there is good reason to accept the hypotheses as true. The Skyrmsian reductionist holds that the key to a reduction of nomic modality is the notion of invariance.

The Skyrmsian makes this precise via an appeal to *personal probabilities*, that is, subjective probabilities interpreted as a measure of rational degree of belief. Skyrms does not give a precise interpretation of the basic probability function(s). I suggest in this regard the following interpretation which, I feel, lends plausibility to the account:

> PR(P/Q) = r if and only if r is the degree of belief that an ideally rational cognizer would have in P given that he or she believed Q.

The value of this personal probability function for propositions P and Q will be determined by the constraints of ideal rationality—epistemological principles dictating what it is rational to believe given certain initial data. The Skyrmsian should in addition maintain that the principles of ideal rationality are necessary. Then, the value of the fundamental personal probability function for two propositions will not be contingent. As I will illustrate below, this allows the Skyrmsian to analyze lawhood in terms of personal probabilities without contradicting the objectivity of laws.

Though for the Skyrmsian reductionist the fundamental notion of probability is personal probability, he does in a sense recognize objective probabilities. "Objective probabilities are gotten from epistemic probabilities by conditionalizing out" (p. 22). That is, an objective probability function with respect to some personal probability function is determined by a specification of a *partition* where a partition is a set of propositions one of which must be true, but such that no two of the propositions can both be true. Using the fundamental personal probability function characterized above, an objective probability function given a partition T can be defined:

$$Pr(P) = r \text{ if and only if } PR(P/M) = r$$

where M is the true member of T.

Objective probabilities for the Skyrmsian reductionist are still not the probabilities which play a crucial role in his account of laws. These are what Skyrms calls "propensities." The Skyrmsian proposal is that propensities are those objective probabilities that are highly *resilient,* where resiliency is defined as follows:

> Resiliency of Pr(Q)'s being $\alpha = 1 - \text{Max}_i[\alpha - Pr_j(Q)]$ over $P_1, \ldots,$ P_n (where the Pr_j's are gotten by conditionalizing on some truth-functional compound of the P_i's which is logically consistent with both Q and its negation) (pp. 11–12).

Resiliency is a property of statements which state the value of an objective probability function. More carefully, resiliency is a binary function from statements of the form:

$$Pr(Q) = r;$$

and a set of propositions:

$$S = \{P_1, \ldots, P_n\}.$$

The value of the resiliency function is defined to be one minus the maximum distance between r and the conditional objective probability of Q given the various truth-functional compounds of the members of S logically consistent with both Q and its negation. S is *the scope of the resiliency*. Resiliency is the technical notion meant to capture the intuitive notion of invariance.

This elaborate technical apparatus allows the Skyrmsian to give at least what looks to be a partial analysis of universal law sentences. Says Skyrms:

> A universal law may be thought of as asserting that everything within the scope of its quantifier has a propensity of one to not be a counter-

> example. "All ravens are black" would thus be thought of as "Everything has a propensity of one to not be a nonblack raven" (p. 35).

This suggests:

> It is a law that all Fs are Gs only if everything has a propensity of one of not being an F and non-G.

Or equivalently:

> It is a law that all Fs are Gs only if, for all x, that Pr(Fx ⊃ Gx) = 1 is highly resilient with respect to scope S; where, for all P, Pr(P) is equal to PR(P/M) where M is the true member of partition T.

This restatement of the partial analysis merely incorporates the earlier definitions of propensities and objective probabilities.

In some ways, I feel that the ingenuity involved in the Skyrmsian partial analysis has not been appreciated. Since the value of the fundamental personal probability function is not contingent for any given propositions P and Q, personal probabilities will not be contingent on the psychological attitudes of cognizers. So, the Skyrmsian account analyzes law sentences in terms of *subjective* probabilities and yet preserves the *objectivity* of laws. One might worry that this move to preserve the objectivity of laws threatens the contingency of laws; that preserving the objectivity of laws within the Skyrmsian account requires holding that laws are necessary truths or that they are necessarily laws. This is not the case. Even though personal probabilities are not contingent, propensities are contingent. Propensities are contingent because the propensities in a possible world depend on what function is the objective probability function in that world, and what function is the objective probability function in a world depends on a contingent matter of fact. It depends on which member of the partition is true. Thus, the Skyrmsian account apparently preserves the objectivity and the contingency of laws. So, the Skyrmsian proposal needs to be taken very seriously. However, there are two problems. Both problems stem from the fact that, strictly speaking, the partial analysis is *not* a reductive account.

a. The partial analysis is just that: a *partial* analysis. No sufficient condition for a generalization's being a universal law has been offered. Furthermore, a difficult problem stands between the Skyrmsian and a complete analysis. For the Skyrmsian, it is a law that all Fs are Gs only if a rather complex universal generalization is true. One problem with Naive Regularity Accounts is that universal generalizations may be vacuously true, that some vacuously true generalizations are laws, and that there is no apparent way to distinguish between vacuously true generalizations which are laws and vacuously true generalizations which are not laws. An analogous problem arises for the Skyrmsian. Consider an empty universe. In that universe, no matter what F and G are, the complex generalization that for all x the propensity is one that x is not an F and a non-G is true. However, not all generalizations could be laws in an empty universe. This is just a version of the problem of vacuously true laws faced by Naive Regularity Accounts. Of course, this presents no counterexample to anything Skyrms or the Skyrmsian has said. A complete analysis of universal law sentences simply has not been given. It is open as to how to treat this problem. The point of this first criticism is just to show how much more difficult work needs to be done in order to complete the Skyrmsian account.

b. The second problem is far more serious. The so-called partial analysis does not even state a necessary condition for a generalization's being a universal law. It is not a closed sentence, and hence states nothing at all. The problem is that the sets T and S ostensibly referred to in the partial analysis have not been specified.

Furthermore, it is doubtful that these sets can be specified in such a way that the partial analysis will turn out true and reductive. To see this, assume that it is a law that all ravens are black. Setting aside problems about the specification of the partition, assume that a partition has been specified such that, for all x, the objective probability of x not being a non-black raven is equal to one. There are scopes that make the Skyrmsian account plausible with respect to the law that all ravens are black. There are other scopes from which unintuitive consequences follow; for example, the scope including only the proposition that there are selective pressures favoring the existence of white ravens in Australia. Given this scope, the objective probability that x is not a non-black raven would not be resilient for all values of x. So, the partial analysis incorrectly would exclude the generalization that all ravens are black from being a law. A plausible explanation of why that proposition should not be included in the scope is that, granted that it is a law that all ravens are black, that proposition likely is not *physically possible*. So, it looks as if the Skyrmsian needs to require that the scope include only physically possible propositions.[21] But such a specification of the scope is not available. Such a specification would make the account non-reductive.

Rather than trying to specify the partition and scope in nonnomic terms, the Skyrmsian could try to argue that law sentences involve an implicit statement of an intended partition and an intended scope of resiliency. This may even be what Skyrms had in mind (cf. "The rich variety of pragmatically conditioned objective probabilities is, I think, a fact of life" (p. 23) and "This account requires that probabilistic scientific laws carry with them an intended domain of resiliency" (p. 24)). This is tantamount to holding that the appropriate locution for the analysis is: "It is a law relative to scope S and partition T that all Fs are Gs." While this move has the consequence that the Skyrmsian has given a partial analysis rather than just a schema for a partial analysis, there also is no reason for thinking that these implicit relativizations are actually present in law sentences.

VI. NON-SUPERVENIENCE

What should we conclude from the preceding discussion of Lewis's account and the Skyrmsian account? Lewis's account was a promising representative of the systematic approach to providing a traditional reductive account of universal laws. The problems in his account give us some reason to be suspicious of that approach. Likewise, problems in the Skyrmsian account give us some reason to be suspicious of the epistemological approach. Thus, given that the systematic approach and the epistemological approach are the only approaches standardly exercised, we might begin to wonder whether a traditional reductive account is really possible. In this section of the paper, I will present an argument suggesting that, indeed, Humeans are attempting the impossible. My argument,

[21]Cf. Armstrong, *op cit.*, (1983), pp. 36–37.

like my counterexample to Lewis in Section IV, has evolved from examples originally presented by Tooley.[22]

The argument will be offered three different ways. The first two versions of the argument begin by describing a possible world. That world is used to conclude by analogy that there is a second possible world much like that original world but with different laws. The second possible world, it turns out, is so much like the original world with respect to the non-nomic, nominalistic facts apparently relevant to a generalization's being a law that the prospects for giving a traditional reductive account disintegrate. Rather than concluding the argument there, however, I go on to suggest that the reason that the prospects for advancing a traditional reductive account are so poor is that the two possible worlds pose a counterexample to a supervenience thesis presupposed within the Humean tradition. The two worlds pose a counterexample to the thesis that any two possible worlds agreeing on all non-nomic, nominalistic facts must also agree on what generalizations are laws.[23] So, I ultimately suggest that the two possible worlds appealed to in the argument agree on all non-nomic, nominalistic facts, but have different laws. The third version of my argument tries to establish the counterexample to the presupposed supervenience thesis in a less direct, but perhaps more convincing, fashion. I will say more about it shortly. I present the three versions of my argument in an order of increasing complexity in the hope of making the nature of my position as clear as possible.

The first version involves the universe U_1 which presented a counterexample to Lewis's account. Recall that in U_1, no X-particles are subject to Y-fields, but L_1 is a law:

L_1: All X-particles subject to Y-fields have spin up.

[22]Tooley, *op. cit.* He discusses his examples again and elaborates on some of them in his recent book, *Causation* (Oxford, England: Oxford University Press, 1987), pp. 47–48 and pp. 51–52.

[23]The supervenience thesis presupposed within the Humean tradition should not be confused with the thesis Lewis calls "Humean supervenience." One difference is that Humean supervenience is a contingent thesis; the thesis presupposed within the Humean tradition is not.

Furthermore, L_1 is the only basic law in U_1 in the sense that all other laws of U_1 are entailed by L_1. Let us add to our earlier characterization of U_1 that it contains no cognizers. If U_1 is genuinely possible, then by analogy there is a possible world in which the generalization, L_2, is the only basic law:

L_2: All X-particles subject to Y-fields have spin down.

That is, there is a possible world in which L_2 is a law and all other laws are entailed by L_2. Furthermore, just as there need be no X-particles subject to Y-fields in U_1 for L_1 to be the only basic law, there need not be any X-particles subject to Y-fields in a universe where L_2 is the only basic law. Just as there need be no cognizers in U_1 for L_1 to be the only basic law, there need not be any cognizers in a universe where L_2 is the only basic law. Consider one such world—a world in which L_2 is the only basic law, there are no X-particles subject to Y-fields, and there are no cognizers. Let this be U_2.

U_1 and U_2 present a problem for the Humean tradition. A traditional reductive account must specify non-nomic, nominalistic facts accounting for the lawhood of L_1 and L_2 in their respective universes, but it is not clear what these non-nomic, nominalistic facts could be. The similarities that might hold between U_1 and U_2 suggest that what initially appeared to be the most relevant non-nomic, nominalistic facts fail to distinguish L_1 from L_2. To wit, L_1 and L_2 are both true in both universes, L_1 and L_2 are equally simple in both universes, and L_1 has the same information content as L_2 in both universes. Furthermore, cognizers have precisely the same sort of epistemic attitudes toward L_1 and L_2 in the two universes (because there are no cognizers in either universe); and L_1 and L_2 each coheres as well with the independent laws in both universes (because there are no independent laws in either universe). Indeed, U_1 and U_2 agree on so many of the facts one might think relevant to the generalizations' status as laws that one must doubt that the lawhood of L_1 and L_2 can be accounted for in non-nomic, nominalistic terms.

The great many non-nomic, nominalistic similarities which I have argued hold between U_1 and U_2, similarities which undermine many initially plausible ways of advancing a traditional reductive account, and the suspicions warranted by troubles in Lewis's account and the Skyrmsian account lead me to suppose that U_1 and U_2 need not differ with respect to non-nomic, nominalistic facts. Thus, I reject the supervenience thesis presupposed by the Humean tradition. Others will not be so daring. They[24] might recognize the failure of traditional reductive accounts, but not be willing to give up the presupposed supervenience thesis, holding instead that there are *unspecifiable* non-nomic, nominalistic differences between universes U_1 and U_2. But the defender of this compromise position owes us an explanation of the failings of traditional reductive accounts. He or she needs to say why a traditional reductive account is impossible if it is not due to non-supervenience. Also, the compromise position will be difficult to maintain in light of the other versions of my argument to be offered below.

In order to maintain traditional reductionism, Humeans willing to admit the possibility of U_1 must take it on faith that there is some unspecified, but in principle specifiable, non-nomic, nominalistic difference between U_1 and U_2 accounting for the differences in laws. I am not sure what to say to these philosophers, but I prefer not to put that much stock in philosophers' ability to do analysis. A slightly better move for Humeans would be to deny that U_1 is a genuine possibility. However, as I pointed out in Section IV, it is not clear what grounds one could have for making that denial. Neither that L_1 is a single basic law, nor that it is a vacuous law, nor that it is a single basic vacuous law, appears adequate for making the denial. Furthermore, as I hinted in Section IV, it is not an essential feature of my argument that the original universe involve a single basic law or that it involve any vacuous laws.

Here's the version not involving any vacuous laws. Suppose U_3, throughout its entire history, has exactly eight out of nine X-particles in Y-fields with spin up. Most, but not all,[25] will admit that

[24]For example, Colin McGinn. See his "Modal Reality," *Reduction, Time and Reality*, ed. Richard Healey (Cambridge, England: Cambridge University Press, 1981).

[25]Some extreme interpretations of probability, like strict frequency interpretations, would entail that the relevant probabilities could not differ in this way. The counterexample could be made more convincing by reviewing familiar problems with strict frequency and other similar inter-

such a small collection of X-particles subject to Y-fields is not sufficient to determine whether the probability of such a particle having spin up is eight-tenths, nine-tenths, or any of a number of other values. Let us assume that L_3 is a law:

> L_3: All X-particles subject to Y-fields have a nine-tenths probability of having spin up.

Also, suppose that all other laws of U_3 are entailed by L_3 and that there are no cognizers in U_3. By analogy, there could be a universe with no cognizers, with exactly eight out of nine X-particles subject to Y-fields with spin up, and in which L_4 is the only basic law:

> L_4: All X-particles subject to Y-fields have an eight-tenths probability of having spin up.

Let U_4 be such a universe. For reasons similar to those given with respect to U_1 and U_2, I take it that there need not be any non-nomic, nominalistic differences in U_3 and U_4. They constitute another counterexample—one not involving vacuous laws—to the supervenience thesis presupposed within the Humean tradition.

My argument can also be presented in such a way that it does not depend on the existence of a universe with a single basic law. Rather than simply present this final version of my argument in the same fashion as the other two, I want to add some complications in the hope of convincing any remaining skeptics. In particular, I will rely heavily on principle (SC) stated in Section I.

Consider two possible universes, U_5 and U_6, that agree on temporally local matters of non-nomic, nominalistic fact up until some time t_0. At t_0, their histories diverge: W-particles, which have not existed in either universe, come into existence in U_5 with spin up and come into existence in U_6 with spin down. Also suppose that the laws of both universes permit *all* particles to go out of existence at time t_0 (and stay out of existence). This stipulation is crucial because it has the immediate consequence that it is physically possible in both worlds for all particles to go out of existence at t_0.

pretations. See van Fraassen, *The Scientific Image* (Oxford, England: Oxford University Press, 1980), pp. 181–190.

Lastly, assume that L_5 is one of the laws of U_5 and that L_6 is one of the laws of U_6:

> L_5: All W-particles have spin up.
> L_6: All W-particles have spin down.

The possibility of these two universes, I take it, is not in question. They present no counterexample to the supervenience thesis presupposed within the Humean tradition. There are differences in the non-nomic, nominalistic facts accompanying the differences in laws.

But consider two more worlds: U_{5*} and U_{6*}. Let U_{5*} be the world that would result had all particles gone out of existence in U_5 at t_0. Let U_{6*} be the world that would result had all particles gone out of existence in U_6 at t_0.[26,27] U_{5*} and U_{6*} will clearly agree on temporally local matters of non-nomic, nominalistic fact *during* and *after* t_0 since nothing exists in the two worlds during and after t_0. Furthermore, since the laws of U_5 and U_6 permit all particles to go out of existence at t_0, no changes need to be made to their histories prior to t_0 to accommodate that counterfactual supposition. So, U_{5*} and U_{6*} agree with U_5 and U_6 respectively—and hence with each other—on temporally local matters on non-nomic, nominalistic fact *before* t_0. So, U_{5*} and U_{6*} agree on temporally local matters of non-nomic, nominalistic fact before, during, and after t_0. Thus, they agree on all non-nomic, nominalistic facts. Yet U_{5*} and U_{6*} disagree on what generalizations are laws. From the specification of U_5, we have it that L_5 is a law and that it is physically possible that all particles go out of existence at time t_0. Since L_5 is a law, it follows from the definition of physical necessity that

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[26]I am assuming that there is a world that *would* result if all particles were to go out of existence in U_5 and U_6, and hence that it is not the case that there are many universes that *might* result. That assumption strikes me as plausible given the specification of U_5 and U_6. My argument goes through even without that assumption, but it would have to be complicated in significant ways.

[27]Worriers about absolute space can suppose that some particles remain, as long as none of the W-particles come into existence. I have constructed the example with all the particles going out of existence to drive home the point that U_{5*} and U_{6*} agree on all non-nomic, nominalistic facts.

it is physically necessary that L_5 is a law. Since it is physically necessary that L_5 is a law and it is physically possible that all particles go out of existence at time t_0, it follows from (SC) that if all particles were to go out of existence at t_0 then L_5 would (still) be a law. Thus, L_5 is a law of U_{5*}. An analogous argument shows that L_6 is a law of U_{6*}. Then, since L_5 and L_6 cannot both be laws of a single universe, it follows that U_{5*} and U_{6*} have different laws.

Therefore, U_{5*} and U_{6*} agree on all non-nomic, nominalistic facts though they have different laws. U_{5*} and U_{6*} present another counterexample—one not involving a single basic law—to the supervenience thesis presupposed within the Humean tradition. I find this final version of the argument especially convincing because it derives the counterexample from premises relating laws and counterfactuals, premises which have gained wide acceptance for reasons that are independent of the issues usually thought central to the analysis of lawhood.

There are other interesting, but more controversial, counterexamples. I hold, for instance, that there are many empty possible worlds. There is an empty world where the general principles of Newtonian Mechanics are laws and there is an empty world where the general principles of Aristotelian physics are laws. I also hold that there are possible worlds non-nomically like the actual world but which are different nomically, for example, a world non-nomically like ours but with no laws at all.[28] But, these more controversial counterexamples are not needed to defeat traditional reductionism. One counterexample is enough.

A philosopher still denying the possibility of the various pairs of universes, it seems to me, must do so from a strong prior commitment to traditional reductionism; a commitment probably stemming from the original Humean grounds for traditional reductionism. These grounds, recall, are the need for an illuminating explanation of nomic modality, ontological concerns, and epistemological concerns. Were these concerns serious enough, perhaps we would have to retain some faith in philosophers' ability to do analysis and look for some flaw in each of the versions of the preceding argument.

[28]Frank Jackson, in "A Causal Theory of Counterfactuals," *Australasian Journal of Philosophy* 55 (1977), pp. 3–21, calls this the *Hume World* (p. 5).

Though more will eventually need to be said,[29] I would like to suggest quickly, via an analogy, that these Humean concerns are not nearly that serious. The analogy involves Descartes's evil genius.[30] To Descartes and most others, it seemed that an evil genius could be presenting us with the sensations we actually have to deceive us into thinking that there are physical objects. Concerns stemming from this possibility led phenomenalists to seek a reduction of "physical object facts" to "perceptual facts." Phenomenalists, in effect, denied that the evil demon was a genuine possibility in that their reductive projects presupposed the supervenience of physical object facts on perceptual facts. However, phenomenalism has fallen out of favor. Impressed by the failings of phenomenalist reductions, we reject phenomenalism and accept what was always the natural intuition. We accept the evil demon as genuinely possible, in effect denying the supervenience of physical object facts on perceptual facts. I suggest that we adopt a similar position with regard to laws. My criticisms in the first five sections of this paper suggest that extant traditional reductive analyses are implausible. The two-possible-universe argument presents intuitively plausible counterexamples to the supervenience thesis presupposed within the Humean tradition. Accordingly, we should accept the non-supervenience of the nomic on non-nomic, nominalistic facts and admit that the Humean constraints on solutions to the problem of laws are unsatisfiable.

I ultimately want to take these conclusions a bit further. The natural reaction to problems in traditional reductive accounts is to think that the resources open to the traditional reductionist are too limited. That is, the natural reaction is to think that if one were allowed to appeal to abstract entities like universals or possible worlds then a reduction of nomic modality would be possible. Some, suffering this natural reaction, have attempted a non-tradi-

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[29]McGinn, *op. cit.*, begins to address these concerns as they apply to irreducibility positions on modality generally (not just nomic modality). He also points out that Hilary Putnam, in "There Is At Least One A Priori Truth," *Erkenntnis* 13 (1978), pp. 53–170, favored the non-supervenience of the nomic. See esp. p. 164.

[30]Robert Stalnaker, *Inquiry* (Cambridge, Mass.: The MIT Press, 1984), p. 153, draws the analogy to phenomenalism to argue, in a different manner, for the irreducibility of the nomic.

tional reductive account.[31] I have argued elsewhere[32] that these accounts fare no better than traditional reductive accounts. If my criticisms are sound, then we are pushed to two somewhat controversial positions. Since traditional and non-traditional reductive accounts of laws fail, we should first accept the *Irreducibility Thesis,* the thesis that *all* reductive accounts of laws fail. Since the best—maybe the only—reason for thinking that there could be non-nomic, non-nominalistic facts accounting for the nomic differences in the various universes discussed above would be that some non-traditional reductive account of laws was correct, and none are, we should second deny the *Supervenience Thesis,* the thesis that two possible worlds which agree on *all* non-nomic facts must agree on which laws hold. In sum, I recommend recognizing that nomic facts neither reduce to nor supervene on non-nomic facts; a somewhat controversial, but I think, exciting recommendation for future investigations of the nomic.

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[31]See Armstrong, *op. cit.,* (1983); Tooley, *op. cit.,* (1977, 1987); Fred Dretske, "Laws of Nature," *Philosophy of Science* 44 (1977), pp. 248–268; and Chris Swoyer, "The Nature of Natural Laws," *Australasian Journal of Philosophy* 60 (1982), pp. 203–223.
[32]Carroll, *op. cit.*