

THE METAPHYSICAL NECESSITY OF NATURAL LAWS

Quentin Smith

1. Introduction

In this paper I will defend the thesis that natural laws are metaphysically necessary, i.e. obtain in every possible world. Metaphysical necessity and possibility are the unrestricted modalities in the semantical interpretation of the modal logic system S5, which I adopt in this paper. I shall defend the following definition of a law of nature:

- (D1) L is a natural law if and only if
- (i) L obtains in every possible world
 - (ii) L is synthetic
 - (iii) L is a posteriori
 - (iv) L is a universal generalization
 - (v) L mentions no times, places or particular things or events.
 - (vi) L entails corresponding counterfactuals.

Since I am interested in defending the least widely accepted of these conditions, condition (i), I shall not enter the debates about the other five conditions.

I begin by defending condition (i) against five objections (section 2). Following this, I show that the theory that laws obtain contingently encounters three problems that are solved by the theory that laws are metaphysically necessary (section 3). In section 3, I criticize the regularity theory of natural laws and the universals theory of Armstrong, Dretske and Tooley, and also show how the metaphysical theory solves the "inference problem" that Van Fraassen (1989) posed for any theory of natural laws.

2. Traditional Objections to the Thesis that Laws are Metaphysically Necessary

There are five mostly familiar objections to the thesis that natural laws are metaphysically necessary, but I will argue these objections are unsound.

2a. The Objection that All Necessity is A Priori.

One argument is that all metaphysically necessary truths are a priori and natural laws cannot be known a priori. However, this is a fallacy, since the a priori is an epistemic notion and necessity is a metaphysical notion, and there is no reason to think they are identical or logically equivalent notions. A proposition is a priori if and only if it is knowable independently of experience. A proposition p is knowable independently of experience if and only if (a) for each possible finite mind x , and for each possible world W in which x exists, p is true and x has the concepts in p , it is the case that (b) x has enough experience to come to know p simply by virtue of understanding or reasoning about p . If a proposition p is metaphysically necessary, then p is true in all possible worlds. It is evident from this that *p is a priori* neither entails (in the sense of relevance logic) nor is entailed by *p is metaphysically necessary*. Thus, the argument that laws are metaphysically contingent because a posteriori is unsound. Philosophers have traditionally identified these notions or taken them to be logically equivalent, but since the work of Marcus [1961], Kripke [1972], Putnam [1975], [Swoyer, 1982] and others, philosophers have begun to recognize they are distinct.

2b. The Objection that All Necessity is Logical

Another argument is that all metaphysical necessity is logical necessity, be it explicit (tautological) or implicit (analytic). An example of an explicit logical necessity is *All married females are females* and an example of an implicit logical necessity is *All wives are females*. This, however, seems an unjustified assumption, inasmuch as has not been demonstrated that the examples philosophers have offered of *synthetic* necessities are not genuine examples. In ethics, some offer as an example of a synthetic necessity, *Causing needless suffering is something that*

ought not be done. Other philosophers argue propositions about colors are synthetic a priori necessities, such as *Red is a color* or *Nothing can be simultaneously red all over and green all over*. In the absence of a successful demonstration that such examples are either contingent or analytic, the position that all metaphysical necessity is analytic or tautological is unjustified.

2c. The Objection that Counterlegals are Conceivable

A third reason offered by the defenders of the orthodox claim that natural laws are contingent is that if the negation of a proposition *p* is conceivable or imaginable, then *p* is contingent, and if *p*'s negation is inconceivable or unimaginable, then *p* is necessary. Since counterlegals such as *If the world were governed by Newton's laws of motion, some bodies would be accelerated beyond the speed of light* are conceivable and, indeed, imaginable, it follows (so the objection goes) that the actual laws (e.g., of Einstein's general theory of relativity) are not metaphysically necessary. But this argument seems multiply flawed. To begin with, there are numerous counterexamples to the objection. I cannot imagine an infinite series of objects, but it is possible there is an infinite series. Further, I cannot conceptually construct a proof with an infinite number of premises, but that does not imply such proofs are impossible. Also, I can conceive and imagine that there are ghosts and instances of precognition but these are arguably not metaphysically possible: (a) If the future is essentially open and not yet settled, then there is nothing there to be known in cases of alleged precognition, so it is metaphysically impossible to know the future in this way. (b) A ghost is popularly understood as a being that is both embodied and disembodied, which is a logical contradiction, and I succeed in imagining and conceiving it only by forming a confused image of some sort of "ethereal body" that hides from me the fact that it has no body and yet has a body. Moreover, I can conceive that Phosphorus may not be Hesperus, but as Marcus has shown, identities are necessary. Thus, neither the conceivability nor the imaginability of *p*'s negation entails *p*'s metaphysical contingency, and neither the inconceivability nor the unimaginability of *p*'s negation entails *p*'s metaphysical necessity.

Besides being vulnerable to the method of counterexamplification, this "argument from conceivability" is open to the charge of "psychologism".

Conceiving and imagining are psychological properties, and assertions about psychological properties are not identical with or logically equivalent to assertions about metaphysical modalities. Just as the epistemic category of the a priori must be distinguished from the metaphysical category of the necessary, so the psychological category of the inconceivably otherwise must be distinguished from metaphysical category of the necessary.

Furthermore, "the argument from conceivability" is open to the charge of "speciesism". Why should what it is metaphysically possible, impossible or necessary be determined by what can or cannot be conceived or imagined by the species of organisms to which we belong? The thesis that metaphysical modalities are determined by the mental capacities of the human species is only slightly less implausible than the thesis that metaphysical modalities are determined by the mental capacities of chimpanzees.

2d. The Objection that Metaphysically Necessary Laws Cannot Be Explained

A fourth objection is that many natural laws can be explained and that if laws were metaphysically necessary, they could not be explained. The objection is that arguments of the form " $\Box(x)(Fx \supset Gx)$; therefore $(x)(Fx \supset Gx)$ " are not explanations. A version of this objection is made by Van Fraassen [1989: 87]; he writes: "If it is true that wood burns in all possible worlds, then it is true that wood burns here, because our actual world is possible. But why is that reflection called explanatory?". The answer to Van Fraassen's question is that some explanations are of the form "Because it could not possibly be otherwise." In case of metaphysically necessary states of affairs, the answer to why they are the way they are is that they could not possibly be otherwise. To deny that this is a type of explanation is simply to adopt the question-begging assumption that all explanations are explanations of contingent facts in terms of other contingent facts. It would be analogous to objecting that probabilistic explanations are not genuine explanations because they are not deductive explanations. A theory of explanation has its own data for which it must account, namely, recognizable examples of explanation, and an adequate theory cannot reject some of these examples on the basis of an unjustified assumption about what is and what is not to count as an

"explanation".

However, there is a better answer to Van Fraassen's question, since he chooses a non-ultimate law of nature as his example. The law that wood burns is deducible from more fundamental laws and this deduction is what the questioner is seeking when she asks about why wood burns. Van Fraassen is right that "the proffered information must provide the missing piece in the puzzle that preoccupies the questioner" [1989: 87] and in his example the questioner is really looking for a more fundamental law that explains why wood burns, e.g. a law about the kind of molecules that compose wood and the kind of causal factors that bring about the combustion of these molecules. Thus, strictly speaking, the answer "because it could not possibly be otherwise" is appropriate only for the most fundamental laws of nature, such as (perhaps) the field equation of general relativity or Schrödinger's wave function equation. If these laws are metaphysically necessary, then the missing piece in the puzzle for the person who asks "Why is the curvature of spacetime dependent on the amount and distribution of mass-energy?" is that spacetime could not possibly be otherwise—this is an ultimate and metaphysically necessary law of nature.

2e. The Objection that Metaphysically Necessary Laws Eliminates All Contingency

A fifth objection is that the Elimination of Contingency is the alternative to the theory that natural laws are contingent. Philosophers have assumed that if we do not accept that natural laws are contingent, then contingency will be removed from reality and we will be left with a world-view such as Hegel's or Bradley's. Armstrong [1983] offers this as a reason for rejecting the theory that natural laws are necessary. Armstrong's argument is that we have to accept brute fact or contingency at some point and that this point is the ultimate laws of nature. He believes this since he believes the only other alternative is to trace "back all appearance of contingency to a single necessary being, the Absolute, which is the sole reality...[But] no serious and principled deduction of the phenomena from the One has ever been given, or looks likely to be given" [1983: 159]. Since we must accept contingency, we should accept it (according to Armstrong) at the level of the laws of nature.

But Armstrong's alternative is a false one. The two alternatives are

not postulating a single necessary being as the sole reality and accepting that laws of nature obtain contingently. We can accept that there is contingency, but at the same time explain this contingency in terms of *necessarily* obtaining *probabilistic* laws. There may be laws of the form $\Box(x)(Fx \supset Px)$, where P is the propensity of x to be G . Suppose F is the property of being an atom of plutonium 239 and G the property of decaying. Let P be a property of x that is an objective chance, specifically, a propensity. More specifically, let P be the propensity of 0.5 to decay sometime during an interval of 24,000 years. The formula, $\Box(x)(Fx \supset Px)$, may then be interpreted as saying that in all metaphysically possible worlds, anything that is an atom of plutonium 239 has the propensity of 0.5 for decaying during a 24,000 year interval. Now let us suppose that in the actual world there is a certain atom A of plutonium and that A decays 23,943 years after it was first formed. There is another possible world in which this very atom A , *that atom* (to use Kaplan's rigidifying functor) decays 18,420 years after it was first formed. This shows that there is at least one event, the decay of A 23,943 years after it was formed, whose occurrence is metaphysically contingent.

But we can go further than this in preserving our intuitions of contingency. We can account for the contingency of all the macroscopic objects and events we see around us and indeed of all the particular microscopic and macroscopic configurations in the universe in terms of the probabilistic symmetry breaking laws that were instantiated within the first one ten thousandth of a second after the big bang. The symmetry breaking laws and the initial conditions at the big bang imply that the fundamental constants of nature, specifically, the strength of the four forces (the electromagnetic, gravitational, strong and weak forces) and the masses of the elementary particles were settled randomly during the first one ten thousandth of a second after the big bang. For instance, the breaking of the electroweak symmetry might have resulted in the weak force having a slightly smaller value than it actually possesses, in which case no hydrogen atoms (and thus no stars and planets) would have formed. The merely possible world in which there are no hydrogen atoms, but merely plasma of free electrons, protons and neutrons, is vastly different from the actual world. Thus, the intuition that what we see around us is an astonishing occurrence, a sheer contingency, can be preserved on the theory that laws are metaphysically necessary.

In fact, we do not even need to appeal to probabilistic laws to account for contingency. Given that laws are metaphysically necessary, a deterministic law has the form $\Box(x)(Fx \supset Gx)$; it does not have the form $\Box(\exists x)(Fx) \ \& \ \Box(x)(Fx \supset Gx)$. The obtaining of a deterministic law does not entail that the antecedent of the law is instantiated. Assuming Newtonian laws for the sake of illustration, it is true in all possible worlds that any body that is subject to no forces remains in a state of rest or uniform motion, but there are some worlds, such as the actual world, in which there are no bodies not subject to any forces. The fact that the antecedent of a deterministic law *is instantiated* is a contingent fact, even if it is not a contingent fact that this law *obtains*. In the actual world, Newton's first law obtains but its antecedent is not instantiated; this law obtains in every possible world but its antecedent is instantiated in only some of them.

Thus, we locate metaphysical contingency at the level of the existence of concrete particulars, not at the level of laws. This preserves the modal intuition that the existence of atoms, humans, planets and galaxies is a contingent fact.

I conclude that the five standard arguments for the thesis that laws of nature obtain contingently are unsound. But this does not show, of course, that natural laws are metaphysically necessary. We need, in addition, some positive arguments that laws are metaphysically necessary. These arguments are presented in the next section.

3. Critique of The Regularity Theory of Laws and the Universals Theory of Laws

My target in this section is the regularity and universals theories of natural laws. According to most standard regularity theories of natural laws, a natural law is defined in terms of these characteristics:

- (D2) L is a natural law if and only if
- (i) L is a universal generalization
 - (ii) L mentions no times, places or other particulars
 - (iii) L entails counterfactuals
 - (iv) L is omnitemporally true
 - (v) L is contingently true
 - (vi) L has certain epistemic, pragmatic or systematic feature that

distinguishes it from accidental generalizations, such as being widely accepted by the relevant scientific community, being well-confirmed, being used to make predictions, being used to explain observations, being integrated in the relevant way into deductive systems (e.g. is a theorem in all true deductive systems with the best combination of simplicity and strength.)

The regularity theory has been extensively criticized in the past twenty years or so by proponents of the universals theory of natural laws, Armstrong, Dretske and Tooley. The universals theory suggests the following definition of a law (in the simplest case):

- (D3) L is a natural law if and only if
- (i) L involves a relation of nomic necessitation N between two universals F and G and has the form (N(F,G))
 - (ii) N obtains contingently (i.e., in some but not all possible worlds)
 - (iii) L is omnitemporally true
 - (iv) L mentions no times, places or other particulars
 - (v) L entails counterfactuals

Of course, natural laws can take other or more complicated forms than N(F,G); for example, a functional law will have a form such as (N(F = fG)).

I will argue that there are three insurmountable problems faced by the regularity and universals theory and both theories should be rejected. The three problems are entitled *the problem of inferred necessities* (see sections 3a and 3b), *the problem of inferred counterfactuals* (see section 3c), and *the problem of inferred universal generalizations* (see section 3d). As will become apparent, I am indebted to Hochberg [1981] and Van Fraassen [1989] in my formulation of the third problem, the problem of inferred universal generalizations (this is Van Fraassen's "problem of inference"). The Metaphysically-Necessary theory, I will show, solves these three problems.

3a. The Problem of Inferred Necessities in the Regularity Theory

It is a datum that theories of natural laws must explain that there is a

difference between argument-forms A and B, both of which are valid:

- (A) (1) It is a law of nature that Fs are Gs
 Therefore
 (2) It is necessary that Fs are Gs.
- (B) (3) It is an accidental universal generalization that Fs are Gs
 Therefore
 (4) It is not necessary that Fs are Gs.

Both regularity theorists and universals theorists regard "necessary" in (A) and (B) as having the force of nomological necessity but not metaphysical necessity.

Now regularity theorists typically do not believe there is any "necessity in nature" so they try to explain the validity of argument-forms A and B in a different way than the universals theorists, who claim there is "necessity in nature". As I hope to show, both camps fail to explain the validity of (A), since both deny that "L is nomologically necessary" entails "L is metaphysically necessary".

The regularity theorists hold that there is no necessity in nature and so the validity of (A) will be explained in some way that does not countenance a relation of de re necessity that obtains between Fs and Gs. "It is necessary that Fs are Gs" will be explained in terms of it being a law that Fs are Gs. The familiar line is that the reason that it is true that "it is necessary that Fs are Gs" is that *it is a law that* Fs and Gs. But this does not explain the validity of argument-form (A), but merely asserts that (A) is valid. The datum that needs to be explained is why laws and not accidental generalization entail statements of the form "It is necessary that Fs are Gs" and this datum is not explained by repeating the datum that needs to be explained. An explanation will have to specify the part or property of the nomic operator "It is law that ..." that is missing from the operator "It is an accidental generalization that..." that enables conclusions of the form "It is necessary that Fs are Gs" to be derived only from sentences of the form "It is a law that Fs are Gs". The point of a theory of laws is not to simply *note* this difference-- to merely *list* this datum among the features of laws-- but to *explain* why laws have this feature and accidental generalizations do not, and this explanation will involve singling out one or more feature of laws that warrants the

inference to statements of the form "It is necessary that Fs are Gs".

The regularity theorists are confined to the data on their list of features of laws. Of course, the regularity theorist may point to the datum that laws entail corresponding counterfactuals and say this feature of laws warrants the inference to necessities, but I shall shortly show the regularity theory fails to deal adequately with the problem of counterfactual inference and thus an appeal to counterfactual inference here is of no avail. What is distinctive about regularity theories—what differentiates them from universals theory— is largely the fact that they define laws in terms of epistemic, pragmatic or systematic features. But such features by their very nature are not sufficient to warrant the inference to necessities. For example, "S is widely believed by the relevant scientific community" does not entail "it is necessary that S". And the pragmatic features of a relevant sentence S "being used to make predictions" or "being used to explain data" clearly do not entail "it is necessary that S", for how a sentence is pragmatically used by people entails facts about the linguistic behavior of certain people, not facts about necessity of the state of affairs the sentence is about. Systematic features fare no better; for example, it hard to see how a sentence S's feature of *being a theorem in all the true deductive systems that best combine simplicity and strength* warrants the inference to S's necessity. It seems this is an invalid inference pattern:

- (1) The sentence "All Fs are Gs" is a theorem in all true deductive systems that best combine simplicity and strength; therefore,
- (2) it is necessary that Fs are Gs.

One problem with this inference pattern is that its skeletal form instantiates the obviously invalid argument-form "It is actually true that S; therefore, it is necessarily true that S". Adding the qualifications about simplicity and strength do not enable the necessity to be derived, since systematic simplicity and strength are non-modal notions and the modal notion of necessity cannot be extracted from them. Since the above-mentioned "systematic" version of the regularity theory may suggest to some David Lewis's [1973] theory, it is worth pointing out that in his theory he defines "It is nomologically necessary that S" in terms of "S is implied by the laws of nature" which is indicative of the problem I

mentioned at the outset, namely, that this amounts to simply making the observation that the argument-form (A) is valid. I suggest to the contrary that it is a requirement upon a theory of laws that it explains why (A) is valid, i.e., what it is about laws that enables necessities to be derived from them.

If the regularity theorists deny that the datum *that (A) is valid* needs to be explained, this will not help them. For the problem may be rephrased by saying that the regularity theory is *inconsistent* with the fact that (A) is valid. There is no feature ascribed to natural laws by the regularity theory that enables natural laws to entail statements with necessity operators.

By contrast, the validity of (A) is neatly explained by the theory that laws are metaphysically necessary. The reason that (A) is valid is that "It is a law of nature that Fs are Gs" means, in part, that "It is metaphysically necessary that Fs are Gs" and this sentence entails "It is necessary that Fs are Gs". The feature of laws that warrants the inference to necessities is the feature of *obtaining in all possible worlds*. Since the theory that laws are metaphysically necessary rejects the idea that nomological necessity is a restricted necessity and differs from unrestricted (i.e. metaphysical) necessity, the "necessary" in the argument-form (A) is taken as metaphysical necessity. If we wish to reserve the expression "nomological necessities" for only those metaphysical necessities that are laws of nature, we may say that something is nomologically necessary if and only if it is metaphysically necessary and has the other five features of natural laws listed in section one (being synthetic and a posteriori, being universal generalizations that do not mention particulars or times or places, and entailing corresponding counterfactuals).

3b. The Problem of Inferred Necessities in the Universals Theory

The universals theory of Armstrong [1983], Dretske [1977] and Tooley [1987] is largely based on the proclamation that this theory succeeds in explaining inferred necessities. But does it? This theory implies that a law of nature consists of universals related by the relation N, where N is the relation called "nomic necessity". But can the postulation of this relation solve the problem of inferred necessities? I shall argue the answer is negative. The universals theory is faced with the trilemma that

nomological necessity, (I) if definable in a way that is consistent with argument-form (A), has a viciously circular definition and, (II) if primitive, is of dubious intelligibility, and (III) if definable in a noncircular way, is inconsistent with the argument-form (A).

First, let us recall some basic principles of modal logic. "It is necessary that p " entails "It is actual that p " and the latter entails "It is possible that p ". Modal logic in the standard preferred system S5 warrants the theses that "*It is necessary that p* is true in world W if and only if p is true in every world", "*It is actual that p* is true in W if and only if p is true in W ", "*It is possible that p* is true in W if and only if p is true in some world". These definitions fit metaphysical necessity, actuality and possibility; the definitions refer to all worlds, without restriction. Restricted possibility, such as nomological possibility is alleged to be, is defined in terms of relative possibility or accessibility. Thus, we have the definition "*It is nomologically possible that p* is true in world W if and only if p is true in some world nomologically accessible to W ". The fact that "nomologically" appears both before and after the biconditional suggests one form the problem will take for the universals theory, namely, that the definition of nomological necessity will be viciously circular or the notion is indefinable but useless to demarcate laws from accidental generalizations.

(I) The first horn of the trilemma is that the definition is consistent with argument-form (A) but circular. Let us begin by attempting to define nomological necessity in a noncircular way. It seems that this might work: *It is nomologically necessary that p* is true in world W if and only if p is true in every world nomologically accessible to W . This definition will be helpful only if we are in possession of criteria for determining which worlds are nomologically accessible to W . There are several ways to define nomological accessibility; the strictest definition is that a world W_1 is nomologically accessible to W just in case all and only the laws of nature in W are laws of nature W_1 . However, this fails to avoid circularity, since the laws of nature in W are themselves defined in terms of the notion of nomic necessity. Something is a law of nature in W just in case it consists of a nomically necessary relation between universals. Thus, in order to know what nomic necessity is, we need to know what nomic accessibility is, and in order to know what nomic accessibility is, we need to know what laws of nature are, but in order to know what laws of nature are, we must know what nomic necessity is. This vicious

circularity will also hold for other definitions of nomologically accessibility, e.g., the most latitudarian definition, which is that a world W_1 is nomologically accessible to W if and only if some law of nature in W is a law of nature or a true accidental generalization in W_1 . Since "some law of nature in W " appears after the biconditional and a law of nature is defined in terms of a nomically necessary relation between universals, the same circle appears.

(II) The second horn of the trilemma is that nomic necessity is primitive but of dubious intelligibility. If nomic necessity is a primitive relation, as Armstrong claims [1983: 88], then the above-mentioned circle (which reduces to the biconditional "p is nomically necessary if and only if p is nomically necessary") will still obtain but we can no longer object that it is a circular definition. The problem now is that we have no intelligible or proper criterion for distinguishing laws from accidental generalizations.

(a) If nomological necessity or the N-relation is primitive, then it seems we are forced to determine if something is a law of nature by inspecting the universals involved and discovering if the N-relation obtains between them. I think it is safe to say, however, that no such relation can be discerned by inspecting universals. If "nomic necessity" is said to stand for a primitive relation, this phrase appears unintelligible.

(b) But even if the N-relation were intelligible, inspecting universals to see if they instantiated the N-relation does not seem to be a proper criterion for distinguishing laws from accidental generalizations. Indeed, such a determination seems incompatible with the scientific method: The way to determine if it is a law of nature that light travels at 186,000 mps is not to inspect the universals *being a light ray* and *traveling at 186,000 mps* and seeing if a primitive N-relation obtains between. If this were the correct procedure, then it seems that science could be done without attending to particulars and their interrelations; we need only contemplate universals and their interrelations. But science is not the contemplation of universals.

If the primitive N-relation is not supposed to be something we can inspect, but is a theoretical posit, then the unintelligibility is even more apparent, for we then have no idea of what it is we are positing. If it is said that we know what we are positing, since we are positing whatever primitive relation makes the argument-form (A) valid, then the unsatisfactoriness of this procedure will be evident, for it would be like

developing a developing an epistemological theory that postulates a primitive G-property of justification, such that the G-property is said to be whatever solves the Gettier problem. Is this procedure is patently inadmissible in epistemology, why should a similar procedure be admissible in the theory of natural laws?

The universalists theorists cannot escape these two horns of definitional circularity and unintelligible primitiveness by adopting Pargetter's [1984] definition of nomological necessity. Pargetter defines nomological necessity in terms of accessibility. A universal generalization is nomologically necessary if and only if it is true in all accessible worlds; it is accidental if and only if it is not true in all accessible worlds. However, the above-mentioned circle is still present. According to Pargetter, something is a law if and only if it is a universal generalization that is true in all accessible worlds. But what makes a world accessible? Pargetter says a world W is accessible to the actual world if and only if all the laws in the actual world are true in W . Thus, accessibility is defined in terms of laws and laws in terms of accessibility, which provide no escape from the circle. Pargetter denies this circularity: "our grasp of accessibility is not dependent upon the concept of physical law. The relation does not only hold between worlds which have the same laws; all that is required is that the appropriate generalizations are true in accessible worlds" (1984: 340). But this phrasing fails to disguise the circularity since "the appropriate generalizations" here refers to the generalizations that are laws in one of the worlds. Thus, Pargetter's definition of accessibility is in effect synonymous with the definition that W is accessible from the world W_1 if and only if the generalizations that are laws in W_1 are true in W , which clearly does "depend upon the concept of physical law". Pargetter later suggests (but does not endorse) other ideas, e.g., the idea that accessibility may be defined in epistemic terms in terms of the true generalizations "held with certainty in this world" (so that a law becomes a true generalization held with certainty), but a suggestion of this sort lands us back with the problems with regularity theories, that the epistemic proposition "p is believed with certainty" does not entail the modal proposition "it is necessarily the case that p".

(III) The last remark suggests that the horns of the dilemma about definitional circularity and unintelligible primitiveness may be avoided only at the price of sacrificing the inference to "it is necessary that p".

This turns out to be the case in Tooley's noncircular definition of nomic necessity. Tooley argues that the relation of nomic necessitation consists, in at least some worlds, of a relation involving conjunctive universals in a given world. He writes: "the relation of nomic necessitation that holds between universals P and Q, when it is a law that everything with property P has property Q, is simply a matter of its being the case that the universal P exists only as a part of the conjunctive universal P and Q [in a given world W]" (Tooley, 1987: 127). However, this cannot be the relation of nomic necessitation since "P exists only as part of P and Q in world W" does not entail "it is necessarily the case that Ps are Qs" but merely "it is actually the case that Ps are Qs" (assuming W is the actual world). Tooley writes in his unpublished review of Van Fraassen's *Laws and Symmetry*: "For suppose that, in a given world, universal F exists *only* as part of the conjunctive universal, F and G. Here is a possible relation between two universals, and one whose obtaining logically entails that every object with property F *must* also have property G" [Tooley, unpublished: 6]. (The emphasis on "must" is mine.) This argument is invalid, since all that follows from the first sentence is "Here is a possible relation between two universals, and one whose obtaining logically entails that every object with property F also *has* the property G." The "must" in Tooley's original sentence, which brings a reference to worlds other than the given world, needs to be eliminated in order for the argument to be valid.

If a defender of the universals theorist endeavors to escape the trilemma I have outlined by objecting that he "rejects the idea that there are possible worlds" and thus that my argument is based on a premise the universals theorist need not accept, I would have two responses. First, the assertion that "possible worlds exist" need not be taken in the way David Lewis takes it, namely, that there are other concrete maximal spatiotemporal wholes. I interpret "possible worlds exist" as meaning that there exist abstract objects (propositions) of a certain sort. A possible world is a maximal proposition W, such that for every proposition p, W entails p or $\sim p$. The actual world is the only maximal proposition that is true. Now the universals theorist is hard put to object to the existence of abstract objects such as propositions, for universals are paradigms of abstract objects and propositions are plausibly conceived as composed in part of universals. If possible worlds require uninstantiated universals, I would refer the reader to Tooley's arguments (against Armstrong) that

there are uninstantiated universals ([Tooley, 1987]).

The nominalist may consistently argue that there are no possible worlds and hence that a non-question-begging argument against regularity theories (many of which presuppose nominalism) cannot assume modal realism. However, I would note that my arguments against the regularity theory (and the universals theory) can be construed by the nominalist as not implying a commitment to modal realism. Bas Van Fraassen has argued that possible worlds semantics captures the accepted patterns of inference in a certain area of discourse, but that we need not for all that postulate possible worlds as existent abstract (or concrete) objects. Rather, possible worlds semantics can be viewed as providing us with "a family of models of discourse" [1989: 68]. I have doubts about the soundness of this interpretation of possible worlds semantics, but I would give this to nominalists--that it is arguable that my modal arguments against the regularity and universals theory remain sound if possible worlds semantics are interpreted along Van Fraassen's line. However, I do not see how the positive part of my theory, that laws of nature obtain in every possible world, can be true if a nominalist interpretation is adopted. (Thus the argument in this paper may be an unintended gift to the anti-realist about laws, such as Van Fraassen, since the anti-realist will welcome the idea that there are sound arguments against the regularity and universals theory of natural laws, but no sound arguments for the theory that there are metaphysically necessary laws of nature in my modal realist sense.)

3c. The Problem of Inferred Counterfactuals

A requirement upon a theory of natural laws is that it explains why laws entail the corresponding counterfactuals. It is not sufficient to simply *note* that laws entail corresponding counterfactuals. The fact that laws entail corresponding counterfactuals is a datum that needs to be explained by a theory of laws. What is it about a law of nature that enables it to entail a corresponding counterfactual? It is instructive that many philosophers who develop theories of natural laws simply *put forth the observation* that natural laws differ from accidental generalizations in that the former alone entail corresponding counterfactuals, without ever getting to the real task of specifying the distinguishing feature of natural laws that enables them alone to entail corresponding counterfactuals.

Regularity theories do not possess the resources to explain why natural laws entail counterfactuals. The first difficulty is that the relevant argument-form (C) is invalid:

(C) (1) $(x)(Fx \supset Gx)$.

Therefore

(2) If this x were to F , it would be G .

The fact that all observed and unobserved F s happen also to be G s does not entail of this x , which is not an F , that if it were to be an F , it would be G . Noting that (1) has certain epistemic, pragmatic or systematic features, such as being widely accepted by the relevant scientific community or being a theorem in every true deductive system with the best combination of simplicity and strength, does not suffice to show that (C) is valid. Indeed, the fact that many regularity theorists tend to use the metaphor "support" when talking about the relation between (1) and (2) suggests that they are aware that (1) does not "imply" or "entail" (2) in any known sense. But the resort to metaphor merely disguises the difficulty; it does not solve it.

The datum that needs to be explained is that laws of nature entail (in the sense of relevance logic) the corresponding counterfactuals. Suppose I uttered

(3) All light rays travel at 186,000 mps.

Therefore

(4) If something were a light ray, it would travel at 186,000 mps.

You would accept this inference, but not because of its form. Rather, you would accept it because of the conversational implicature (in Grice's sense) that (3) is a law of nature. Thus, you hear me as tacitly meaning by (1) "It is a law of nature that all light rays travel at 186,00 mps". *This nomological operator* licenses the inference to (4). But this is to say that the universal generalization possesses a nomological feature (or operator) that licenses the inference and this feature should appear in the definition of a law of nature. But an examination of the regularity theorist's list of items in the definition shows that none of these items suffice to sanction the inference. This failure is not readily apparent since the regularity theorists, instead of including in their definition of a law the nomological

feature that warrants the entailment of corresponding counterfactuals, include in their definition merely the datum that laws entail (or "support") corresponding counterfactuals.

As a first approximation, we may say that the nomological feature that warrants the inference of the corresponding counterfactual is that there is something about a light ray that *makes* it travel at 186,000 mps and that *prevents* it from traveling at any other speed. Indeed, this is what is understood as conversationally implied in the above conversation. You take me as conversationally implying that it is a law of nature that light travels at 186,000 mps and thus that there is something about the nature of a light ray that prevents it from going at any other speed. It cannot be a light ray and yet at the same time do something that a light ray cannot--namely, travel at some speed other than 186,000 mps. This is the reason why anything *would* travel at 186,000 mps if it *were* a light ray.

The universals theory of Armstrong, Dretske and Tooley attempts to flesh out this first approximation by postulating a nomic necessity, specifically, a nomic necessary relation between universals. However, since they claim that "L is nomic necessary" does not entail "L is metaphysically necessary", their attempt to explain the datum that laws entail counterfactuals will prove to be unsuccessful, as the following considerations will show. (These considerations are independent of, and additional to, the difficulties with the N-relation discussed in section 3b.) The universals theorists hold to be a valid argument-form:

(D) (5) N(F,G)

Therefore

(6) If x were F, x would be G.

On the face of it, this argument-form (without further characterization) appears to be invalid, since F and G are related by N (nomic necessitation) contingently. If it is metaphysically contingent that F and G are related by N, then there are some metaphysically possible worlds in which F is not related to G by N and if there are such worlds, there appears to be nothing that guarantees that if this particular x, call it *a*, were F, it would be G. There is a metaphysically possible world W in which *a* is F but not G, such that in W, F is not related to G by N and in which the corresponding universal generalization $(x)(Fx \supset Gx)$ is false. Consequently, it appears that (D) is invalid and N(F,G) merely entails

that, for any x , if x were F , x *might be* by G .

A natural response from the proponents of possible world semantics for counterfactuals is that we consider only the most similar worlds in evaluating (6) and if we do so, we will see that (6) is entailed by (5). However, if this response is correct, we should be able to build these similarity considerations into (D) as supplementary premises that enables us to see clearly how (6) follows from (5). First, we note that the truth conditions of (6) are that it is true if and only if in the most similar world in which x is F , x is also G (this is Stalnaker's [1968] analysis, which I adopt for the sake of simplicity). Since (6) is logically equivalent to its truth conditions, we may substitute for (6)

(6A) In the world most similar to the actual world in which x is F , x is also G .

However, $N(F,G)$ will not entail (6A) without further premises. One premise is

(5A) Worlds in which $N(F,G)$ obtains are more similar to the actual world than worlds in which $N(F,G)$ does not obtain.

But even (5A) will not enable (6A) to be deduced, since we need the further premise that

(5B) In any world in which $N(F,G)$ obtains, $(x)(Fx) \supset (Gx)$ is true.

Unless $N(F,G)$ implies the corresponding universal generalization, then the fact that $N(F,G)$ obtains in the most similar world will not entail that if x is F in this world, x is also G .

With these premises added, (D) becomes valid. However, it is unsound, since (5A) and (5B) are false. In the next section I will indicate that (5B) is false. However, here I will show that (D) is unsound if only for the reason that (5A) is false.

Let us substitute a particular law for $N(F,G)$ in order to see why (5A) is false, the law that *being a light ray* nomically necessities *traveling at 186,000 mps*. The fact that the light-law obtains in some merely possible world W does not entail that every other actually obtaining law also obtains in W . In particular, there are many worlds in which the light

law obtains but in which the actual fundamental laws of physics, e.g., Einstein's general theory of relativity, Schrödinger wave function law, etc., do not obtain. These worlds are not more similar to the actual world than worlds that have the same laws and particular matters of fact as the actual world, except for the fact that there is a negligibly different light law, that light travels at 185,999.9999999 mps. Indeed, for each actually obtaining law L , there is another world W_1 in which (a) L does not obtain but a law negligibly different from L obtains instead, (b) there obtain all actual laws compatible with the non-obtaining of L , and (c) matters of particular fact are the same as the actual ones (compatible with the non-obtaining of L). W_1 is more similar to the actual world than a world W_2 in which L obtains but in which no other actual law obtains (unless its obtaining is required by L 's obtaining) and there are instead vastly different laws and matters of particular fact. Since this holds for each law L , (5A) is false. (Even if it only holds for some laws, (5A) is still false.)

It might be objected to this argument against (5A) that the number of shared laws is not relevant to the similarity among worlds. Although on first glance this objection seems implausible, David Lewis had defended it on the grounds that difficulties about infinities arise. He holds that "It's blind alley to count the violated laws" (1985: 55) in some world W in an attempt to determine its similarity to the actual world. Lewis is considering (in order to reject) the suggestion that "big miracles are other-worldly events that break many of the laws that actually obtain, whereas little miracles break only a few laws" (1986: 55). If this suggestion were true, then we could say a world where many actually obtaining laws are broken is less similar to the actual world than a world where only a few of the actually obtaining laws are broken. Lewis argues against this suggestion by saying that if we consider both fundamental and derived laws, then there will be infinitely many laws and "any miracle violates infinitely many laws; and again it doesn't seem that big miracles violate more laws than little miracles." [1986: 55] Thus, "it's a blind alley to count the violated laws" in determining similarity.

This reasoning does not appear to be sound, since (as Lewis admits) it is reasonable to think there will be only a few fundamental laws, and the infinity of laws only appears when we take into account the derived laws. Given the finite number of fundamental laws, there is a way to make "more or less" judgments about violated laws. Each fundamental law will determine a natural class of laws, with each such class consisting

of one fundamental law and all the laws that can be derived from that fundamental law. There will be only a few natural classes of laws, the same number as the number of fundamental laws. For example, the field equation of general relativity is a functional law involving magnitudes that can take on any one of an infinite number of values. For each of these values, there will be a derived law. Likewise, the Schrödinger equation is a functional law that determines a class of derived laws. Let us suppose there are ten fundamental laws and thus ten natural classes of laws. A world where events violate all ten of these natural classes of actual laws (by violating the fundamental law that determines the natural class) will be less similar to the actual world (all else being equal) than a world where events violate only one of these natural classes. Even though an infinite number of laws are violated in both worlds, there is a difference in the number of natural classes of laws that are violated, and this makes meaningful to "count laws" in determining the similarity of worlds. Consequently, the objection that "it's a blind alley to count laws" does not appear to be sound.

Lewis makes a further remark whose meaning does not wear itself on its sleeve; he appears to suggest that it is false that big miracles violate more fundamental laws than little miracles, on the grounds that there are only a few "fundamental laws altogether. Then *no* miracle violates many fundamental laws; *any* miracle violates the Grand Unified Field equation, the Schrödinger equation, or another one of the very few, very sweeping fundamental laws" (1985: 55). The context of the discussion suggests that Lewis regards this as an argument that big miracles do not violate more fundamental laws than small miracles. But such an argument does not appear to succeed. If the "or" in the passage quoted is an exclusive disjunction, this statement seems false, since it is possible for one miracle to violate the Grand Unified Field equation and the Schrödinger equation, and for another miracle to violate only the Grand Unified Field equation, in which case the former miracle violates more fundamental laws than the latter. But if the "or" is an inclusive disjunction, then this statement lends no support to the claim that a big miracle does not violate more fundamental laws than a little miracle, since a big miracle could violate two or more fundamental laws and a little miracle only one fundamental law. Thus, there appears to be no good argument that it is a blind alley to count fundamental laws in determining the similarity relations among worlds.

If the possible worlds semantics for counterfactuals do not enable the universals theorist to explain why contingently obtaining laws entail corresponding counterfactuals, the universals theorist may appeal to the "condensed argument" or "law theory" of counterfactuals (of Goodman and others). The problem is to explain the datum that laws, but not accidental generalizations, entail corresponding counterfactuals. The "law theory" of counterfactuals says that "if x were F , it would be G " is true just in case " Gx " can be deduced from two premises, one of which is "It is a law that F s are G s" and the other is " x is F ". Now it is clear that this theory cannot *explain* why law statements entail counterfactuals, and accidental generalizations do not, since this theory takes as an underived and unexplained assumption the datum that the law-statement, conjoined with a statement of the counterfactual's antecedent, entails the counterfactual's consequent. This theory neither specifies the feature of laws that enables them (when conjoined with the antecedent) to entail the consequent, nor does it provide any argument that there would be such an entailment if laws obtain contingently. If it is possible that some F s are not G s, it remains unclear why a law and the premise that this x is F should jointly entail that this x is also G .

The problem of counterfactual inference is solved on the metaphysical theory of natural laws. According to this theory, the statement about light that is a law of nature is

(7) In all possible worlds, whatever is a light ray travels at 186,000 mps.

Therefore,

(8) If something were a light ray, it would travel at 186,000 mps.

This argument is clearly valid, since there is no possible world in which something is a light ray and yet does not travel at 186,000 mps. We have specified a feature of the law, the metaphysical necessity operator, that licenses the inference of the corresponding counterfactual, and thus we explain why laws entail corresponding counterfactuals. We go beyond merely noting the datum that laws entail corresponding counterfactual and we avoid the objection that "there is no entailment since it is possible for the particular mentioned in the antecedent not to obey the law."

3d. The Problem of Inferred Universal Generalizations

The universals theory implies that laws have the form (in the simplest case)

- (1) $N(F, G)$
and entail universal generalizations
(2) $(x)(Fx \supset Gx)$.

This is not a valid inference pattern. (1) is a singular statement about a relation between universals and (2) is a universal generalization about particulars. Armstrong (1978) and Tooley (1977) in their original expositions simply assumed it was valid. Dretske (1977) recognized that he cannot show the inference is valid and attempted to make the inference plausible by drawing an analogy with legal relationships, but Hochberg [1981] has shown the analogy fails. Armstrong [1983; 1993] has subsequently endeavored to explain this inference by introducing further postulates, but Van Fraassen [1989: 94-128; 1993] has shown that even with these additional postulates the inference cannot be shown to be valid. Tooley [1987: 123-129; unpublished: 6] argues that the inference is valid if nomic necessity is defined in terms of conjunctive universals, but we have seen in section 3b that nomic necessity cannot be defined this way. Van Fraassen has also shown at length that a similar "problem of inference" confronts the regularity theories (see Van Fraassen, 1989: 40-64).

The problem of inferred universal generalizations is solved if laws have the form I suggested; it is obvious that

- (3) $\Box(x)(Fx \supset Gx)$
entails
(2) $(x)(Fx \supset Gx)$

Thus, the theory that laws are metaphysically necessary not only avoids the five standard objections to this theory (see section 2), but also solves three problems that are insoluble given the regularity and universals theories, the problem of inferred necessities, the problem of inferred counterfactuals and the problem of inferred universal generalizations

(section 3).

Western Michigan University

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