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The Nature of Laws

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This paper is concerned with the question of the truth conditions of nomological statements. My fundamental thesis is that it is possible to set out an acceptable, noncircular account of the truth conditions of laws and nomological statements if and only if relations among universals — that is, among properties and relations, construed realistically — are taken as the truth-makers for such statements.

My discussion will be restricted to strictly universal, nonstatistical laws. The reason for this limitation is not that I feel there is anything dubious about the concept of a statistical law, nor that I feel that basic laws cannot be statistical. The reason is methodological. The case of strictly universal, nonstatistical laws would seem to be the simplest case. If the problem of the truth conditions of laws can be solved for this simple subcase, one can then investigate whether the solution can be extended to the more complex cases. I believe that the solution I propose here does have that property, though I shall not pursue that question here.[1]

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1 I am indebted to a number of people, especially David Armstrong, David Bennett, Mendel Cohen, Michael Dunn, Richard Routley, and the editors of this *Journal*, for helpful comments on earlier versions of this paper.

1. Some Unsatisfactory Accounts

The thesis that relations among universals are the truth-makers for laws may strike some philosophers as rather unappealing, for a variety of reasons. Perhaps the two most important are these. First, it entails a strong version of realism with regard to universals. Secondly, traditional semantical accounts of the concept of truth have generally been nominalistic in flavor. Not in the sense that acceptance of them involves commitment to nominalism, but in the sense that they involve no reference to universals. This seems, in part, an historical accident. Semantical accounts of truth in which a concept such as an object's exemplifying a property plays a central role can certainly be set out. For most types of sentences, accounts involving such explicit reference to universals may well introduce additional conceptual apparatus without any gain in philosophical illumination. However I will attempt to show that there is at least one class of statements for which this is not the case, namely, nomological statements.

I shall begin by considering some important alternative accounts of the nature of laws. I think that getting clear about how these accounts are defective will both point to certain conditions that any adequate account must satisfy, and provide strong support for the thesis that the truth-makers for laws must be relations among universals.

Perhaps the most popular account of the nature of laws is that a generalization expresses a law if and only if it is both lawlike and true, where lawlikeness is a property that a statement has, or lacks, simply in virtue of its meaning. Different accounts of lawlikeness have been advanced, but one requirement is invariably taken to be essential: a lawlike statement cannot contain any essential reference to specific individuals. Consider, for example, the generalization: "All the fruit in Smith's garden are apples." Since this statement entails the existence of a particular object — Smith's garden — it lacks the property of lawlikeness. So unless it is entailed by other true statements which are lawlike, it will be at best an accidentally true generalization.

There are at least three serious objections to this approach. First, consider the statement that all the fruit in any garden with property *P* are apples. This generalization is free of all essential reference to specific individuals. Thus, unless it is unsatisfactory in some other way, it is lawlike. But *P* may be quite a complex property, so chosen that there is, as a matter of fact, only one garden possessing that property, namely Smith's. If that were so, one might well want to question whether the generalization that all fruit in any garden with property *P* are apples was a law. It would seem that statements can be both lawlike and true, yet fail to be laws.

A second objection to this approach is that it cannot deal in a satisfactory manner with generalizations that are vacuously true, that is, which lack "positive" confirming instances.[2] Consider the statement: "Whenever two spheres of gold more than eight miles in diameter come into contact, they turn red." The statement is presumably lawlike, and is true under the standard interpretation. Is it then a law? The usual response is that a vacuously true generalization is a law only if it is derivable from generalizations that are not vacuously true. But this seems wrong. Imagine a world containing ten different types of fundamental particles. Suppose further that the behavior of particles in interactions depends upon the types of the interacting particles. Considering only interactions involving two particles, there are 55 possibilities with respect to the types of the two particles. Suppose that 54 of these possible interactions have been carefully studied, with the result that 54 laws have been discovered, one for each case, which are not interrelated in any way. Suppose finally that the world is sufficiently deterministic that, given the way particles of types *X* and *Y* are currently distributed, it is impossible for them ever to interact at any time, past, present, or future. In such a situation it would seem very reasonable to believe that there is some *underived* law dealing with the interaction of particles of types *X* and *Y*. Yet precisely this view would have to be rejected if one were to accept the claim that a vacuously true generalization can be a law only if derivable from laws that are not vacuously true.

A third objection is this. Assuming that there can be statistical laws, let us suppose that it is a law that the probability that something with property *P* has property *Q* is 0.999999999. Suppose further that there are, as a matter of fact, very few things in the world with property *P*, and, as would then be expected, it happens that all of these things have property *Q*. Then the statement that everything with property *P* has property *Q* would be both lawlike and true, yet it would not be a law.

One might even have excellent grounds for holding that it was not a law. There might be some powerful and very well established theory which entailed that the probability that something with property *P* would have property *Q* was not 1.0, but 0.999999999, thus implying that it was not a law that everything with property *P* would have property *Q*.

If this argument is correct, it shows something quite important. Namely, that there are statements that would be laws in some worlds,

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2 A vacuously true generalization is often characterized as a conditional statement whose antecedent is not satisfied by anything. This formulation is not entirely satisfactory, since it follows that there can be two logically equivalent generalizations, only one of which is vacuously true. A sound account would construe being vacuously true as a property of the content of a generalization, rather than as a property of the form of the sentence expressing the generalization.

but only accidentally true generalizations in others. So there cannot be any property of lawlikeness which a statement has simply in virtue of its meaning, and which together with truth is sufficient to make a statement a law.

A second attempt to explain what it is for a statement to express a law appeals to the fact tha laws entail some counterfactuals, and support others, while accidentally true generalizations do neither. If this approach is to provide a noncircular analysis, it must be possible to give a satisfactory account of the truth conditions of subjunctive conditional statements which does not involve the concept of a law. This does not seem possible. The traditional, consequence analysis of subjunctive conditionals explicitly employs the concept of a law. And the principal alternative, according to which truth conditions for subjunctive conditionals are formulated in terms of comparative similarity relations among possible worlds, involves implicit reference to laws, since possession of the same laws is one of the factors that weighs most heavily in judgments concerning the similarity of different possible worlds. The latter theory is also exposed to very serious objections.[3] As a result, it appears unlikely that any noncircular analysis of the concept of a law in terms of subjunctive conditional statements is possible.

A third approach to the problem of analyzing the concept of a law is the view, advanced by Ramsey, that laws are "consequences of those propositions which we should take as axioms if we knew everything and organized it as simply as possible in a deductive system."[4] My earlier example of the universe in which there are ten different types of fundamental particles, two of which never interact, shows that this account does not provide an adequate description of the truth conditions of laws. In the world where particles of types *X* and *Y* never meet, there will be many true generalizations about their behavior when they interact. Unfortunately, none of these generalizations will have any positive instances; they will all be only vacuously true. So knowledge of everything that happens in such a universe will not enable one to furmulate a *unique* axiomatic system containing

3 See, for example, the incisive discussions by Jonathan Bennett in his article, "Counterfactuals and Possible Worlds," *Canadian Journal of Philosophy*, **4** (1974), pages 381-402, and, more recently, by Frank Jackson in his article, "A Causal Theory of Counterfactuals", *Australasian Journal of Philosophy*, **55** (1977), pages 3-21.

4 F. P. Ramsey, "General Propositions and Causality," in *The Foundations of Mathematics*, edited by R. B. Braithwaite, Paterson, New Jersey, 1960, page 242. The view described in the passage is one which Ramsey had previously held, rather than the view he was setting out in the paper itself. For a sympathetic discussion of Ramsey's earlier position, see pages 72-77 of David Lewis's *Counterfactuals*, Cambridge, Massachusetts, 1973.

theorems about the manner of interaction of particles of types *X* and *Y*. Adopting Ramsey's approach would force one to say that in such a universe there could not be any law describing how particles of types *X* and *Y* would behave if they were to interact. I have argued that this is unacceptable.

2. Universals as the Truth-Makers for Nomological Statements

What, then, is it that makes a generalization a law? I want to suggest that a fruitful place to begin is with the possibility of underived laws having no positive instances. This possibility brings the question of what makes a generalization a law into very sharp focus, and it shows that an answer that might initially seem somewhat metaphysical is not only plausible, but unavoidable.

Consider, then, the universe containing two types of particles that never meet. What in that world could possibly make true some specific law concerning the interaction of particles of types *X* and *Y*? All the events that constitute the universe throughout all time are perfectly compatible with different, and conflicting laws concerning the interaction of these two types of particles. At this point one may begin to feel the pull of the view that laws are not statements, but inference tickets. For in the universe envisaged, there is nothing informative that one would be justified in inferring from the supposition that an *X* type particle has interacted with a *Y* type particle. So if laws are inference tickets, there are, in our imaginary universe, no laws dealing with the interaction of particles of types *X* and *Y*.

But what if, in the universe envisaged, there could be underived laws dealing with the interaction of particles of types *X* and *Y*? Can one draw any conclusions from the assumption that such basic laws without positive instances are possible — specifically, conclusions about the truth-makers for laws? I would suggest that there are two very plausible conclusions. First, *nonnomological* facts about particulars cannot serve as the truth-makers for *all* laws. In the universe in which particles of types *X* and *Y* never interact, it might be a law that when they do, an event of type *P* occurs. But equally, it might be a law that an event of type *Q* occurs. These two generalizations will not be without instances, but none of them will be of the positive variety. And in the absence of positive instances, there is no basis for holding that one generalization is a law, and the other not. So at least in the case of underived laws without positive instances, nonnomological facts about particulars cannot serve as the truth-makers.

What, then, are the facts about the world that make such statements laws? A possible answer is that the truth-makers are facts about particulars that can only be expressed in *nomological* language. Thus, in the case we are considering, one might try saying that what makes it a law that particles of types *X* and *Y* interact in a specific way are the nomological facts that particles of types *X* and *Y* have certain dispositional properties. But this is not to make any progress. The question of the truth-makers of underived laws without positive instances has merely been replaced by that of the truth-makers of statements attributing unactualized dispositional properties to objects, and if one is willing in the latter case to say that such statements are semantically basic, and that no further account can be given of the fact that an object has a dispositional property, one might equally well say the same thing of laws, that is, that there just are basic facts to the effect that there are specific laws applying to certain types of objects, and no further account of this can be given. In either case one is abandoning the project of providing an account of the truth conditions of nomological statements in nonnomological terms, and thus also the more general program of providing truth conditions for intensional statements in purely extensional terms.

The upshot, then, is that an account of the truth conditions of underived laws without positive instances in terms of nomological facts about particulars is unilluminating, while an account in terms of nonnomological facts about particulars seems impossible. This, then, is the second conclusion: no facts about particulars can provide a satisfactory account of the truth conditions of such laws.

But how then can there be such laws? The only possible answer would seem to be that it must be facts about *universals* that serve as the truth-makers for basic laws without positive instances. But if facts about universals constitute the truth-makers for some laws, why shouldn't they constitute the truth-makers for all laws? This would provide a uniform account of the truth conditions of laws, and one, moreover, that explains in a straightforward fashion the difference between laws and accidentally true generalizations.

Let us now consider how this idea that facts about universals can be the truth-makers for laws is to be developed. Facts about universals will consist of universals' having properties and standing in relations to other universals. How can such facts serve as truth-makers for laws? My basic suggestion here is that the fact that universals stand in certain relationships may *logically necessitate* some corresponding generalization about particulars, and that when this is the case, the generalization in question expresses a law.

This idea of a statement about particulars being entailed by a statement about a relation among universals is familiar enough in another context, since some philosophers have maintained that analytical statements are true in virtue of relations among universals. In this latter case, the relations must be necessary ones, in order for the statement about particulars which is entailed to be itself logically necessary. Nomological statements, on the other hand, are not logically necessary, and because of this the relations among universals involved here must be *contingent* ones.

The idea of contingent relations among universals logically necessitating corresponding statements about particulars is admittedly less familiar. But why should it be more problematic? Given the relationship that exists between universals and particulars exemplifying them, any property of a universal, or relation among universals, regardless of whether it is necessary or merely contingent, will be reflected in corresponding facts involving the particulars exemplifying the universal.

It might be suggested, though, that what is problematic is rather the idea of a contingent relation among universals. Perhaps this idea is, like the notion of a necessarily existent being, ultimately incoherent? This possibility certainly deserves to be examined. Ideally, one would like to be able to prove that the concept of contingent relations among universals is coherent. Nevertheless, one generally assumes that a concept is coherent unless there are definite grounds for thinking otherwise. So unless some reason can be offered for supposing that the concept of contingent relations among universals is incoherent, one would seem to be justified in assuming that this is not the case.

Let us refer to properties of universals, and relations among universals, as *nomological* if they are contingent properties or relations which logically necessitate corresponding facts about particulars. How can one *specify* such nomological properties and relations? If the properties or relations were observable ones, there would be no problem. But in our world, at least, the facts about universals which are the truth-makers for laws appear to be unobservable. One is dealing, then, with theoretical relations among universals, and the problem of specifying nomological relations and properties is just a special case of the problem of specifying the meaning of statements involving theoretical terms.

Theoretical statements cannot be analyzed in purely observational terms. From this, many have concluded that theoretical statements cannot, in the strict sense, be analyzed at all in terms of statements free of theoretical vocabulary. But it is clear that this does not follow, since the class of statements that are free of theoretical vocabulary does not coincide with the class of observation statements. Thus the statement, "This table has parts too small to be observed," although it contains no theoretical vocabulary, is not a pure observation statement, since it refers to something beyond what is observable. This situation can arise because, in addition to observational vocabulary and theoretical vocabulary, one also has logical and quasi-logical vocabulary — including expressions such as "part", "property", "event", "state", "particular", and so on — and statements containing such vocabulary together with observational vocabulary can refer to unobservable states of affairs.

This suggests the possibility, which I believe to be correct, that theoretical statements, though not analyzable in terms of observation statements, are analyzable in terms of statements that contain nothing beyond observational, logical, and quasi-logical vocabulary. The natural and straightforward way of doing this is suggested by the method of Ramsey sentences, and has been carefully worked out and defended by David Lewis in his article, "How to Define Theoretical Terms."[5] Essentially, the idea is this. Let *T* be any theory. If *T* contains any singular theoretical terms, eliminate them by paraphrase. Then replace all theoretical predicates and functors by names of corresponding entities, so that, for example, an expression such as "...is a neutrino" is replaced by an expression such as "...has the property of neutrino-hood." The result can be represented by $T(P_1, P_2, ..., P_n)$, where each P_i is the theoretical name of some property or relation. All such theoretical names are then replaced by distinct variables, and the corresponding existential quantifiers prefixed to the formula. The resulting sentence — $\exists x_1 \exists x_2 ... \exists x_n \quad T(x_1, x_2, ..., x_n)$ — is a Ramsey sentence for the theory *T*. Suppose now that there is only one ordered *n*-tuple that satisfies $T(x_1, x_2, ..., x_n)$. It will then be possible to define the theoretical name Pi by identifying the property or relation in question with the i_{th} member of the unique *n*-tuple which satisfies $T(x_1, x_2, ..., x_n)$.

Expressed in intuitive terms, the underlying idea is this. The meaning of theoretical terms is to be analyzed by viewing them as referring to properties (or relations) by characterizing them as properties (or relations) that stand in certain logical or quasi-logical relations to other properties and relations, both theoretical and observable, the logical and quasi-logical relations being specified by the relevant theory. One might compare here the way in which the mind is characterized in central state materialism: the mind is that entity, or collection of states and processes, that stands in certain specified relations to behavior. The above approach to the meaning of theoretical statements involves, in effect, a similar relational analysis of theoretical terms.

Some possible objections to this approach deserve to be at least briefly noted. One is that the procedure presupposes that the theoretical names will not name anything unless there is a unique *n*-tuple that satisfies the appropriate formula. I think that Lewis makes

5 *Journal of Philosophy*, **67** (1970), pages 427-446.

out a plausible case for this view. However the requirement can be weakened slightly. One might, for example, take the view that P_i is definable even where there is more than one n-tuple that satisfies $T(x_1, x_2, ..., x_n)$, provided that every n-tuple has the same ith element.

A second objection is that replacing predicates and functors by names is not automatic, as Lewis supposes. For unless there are disjunctive properties, negative properties, etc., there is no reason for thinking that there will be a one-to-one correspondence between predicates on the one hand, and properties and relations on the other. This point is surely correct. However it shows only that the initial paraphrase has to be carried out in a metaphysically more sophisticated way.

A slightly more serious difficulty becomes apparent if one considers some very attenuated theories. Suppose, for example, that T consists of a single statement $(x)(Mx \supset Px)$, where M is theoretical and P is observational. This theory will have the peculiarity that the corresponding Ramsey sentence is logically true,[6] and given Lewis's approach, this means that the property M-hood exists only if it is identical with P-hood.

One response is to refuse to count a set of sentences as a theory if, like T here, it has no observational consequences. However this requirement seems overly stringent. Even if a theory does not entail any observational statements, it may have probabilistic implications: the likelihood of R given Q together with T may differ from the likelihood of R given Q alone, where Q and R are observational statements, even though there are no observational statements entailed by T.

An alternative response is to adopt the view that the Ramsey sentence for a theory should be replaced by a slightly different sentence which asserts not merely that there is some ordered n-tuple $(x_1, x_2, ..., x_n)$ that satisfies the formula $T(x_1, x_2, ..., x_n)$, but that there is some n-tuple that satisfies the formula *and* whose existence is not entailed simply by the existence of the observable properties involved in the theory. Then, if there is a unique ordered n-tuple with those two properties, one can define the theoretical terms $P_1, P_2, ..., P_n$.

In any case, I believe that one is justified in thinking that difficulties such as the above can be dealt with, and I shall, in my attempt to state truth conditions for laws, assume that theoretical statements can be adequately analyzed along the Lewis-type lines outlined above.

There are three further ideas that are needed for my account of the truth conditions of nomological statements. But the account will be

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6 This problem was pointed out by Israel Scheffler in his book, *The Anatomy of Inquiry*, New York, 1963. See section 21 of part II, pages 218ff.

more perspicuous if the motivation underlying the introduction of these ideas is first made clear. This can perhaps best be done by outlining a simpler version of the basic account, and then considering some possible problems that it encounters.[7]

The simpler version can be seen as attempting to specify explicitly a small number of relations among universals that will serve as the truth-makers for all possible laws. One relation which seems clearly essential is that of *nomic necessitation*. This relation can be characterized — though *not defined* — as that relation which holds between two properties *P* and *Q* if and only if it is a law that for all *x*, if *x* has property *P* then *x* has property *Q*. Is this one relation of nomic necessitation sufficient to handle all possible laws? The answer to this depends in part upon certain metaphysical matters. Consider a law expressed by a statement of the form $(x)(Px \supset -Qx)$. If this type of law is to be handled via the relation of nomic necessitation, one has to say that the property *P* stands in the relation of nomic necessitation to the property of not having property *Q*, and this commits one to the existence of negative properties. Since negative properties are widely thought suspect, and with good reason, another relation has to be introduced to handle laws of this form: the relation of *nomic exclusion*.

Are these two relations jointly sufficient? Consider some problematic cases. First, laws of the form $(x)Mx$. Is it possible to state truth conditions for such laws in terms of the relations of nomic necessitation and nomic exclusion? Perhaps. A first try would be to treat its being a law that everything has property *M* as equivalent to its being true, of every property *P*, that it is a law that anything that has property *P* also has property *M*. But whether this will do depends upon certain issues about the existence of properties. If different properties would have existed if the world of particulars had been different in certain ways, the suggested analysis will not be adequate. One will have to say instead that its being a law that everything has property *M* is equivalent to its being a law that, for every property *P*, anything with property *P* has property *M* — in order to exclude the possibility of there being some property *Q*, not possessed by any object in the world as it actually is, but which is such that if an object had property *Q*, it would lack property *M*. This revision, since it involves the occurrence of a universal quantifier ranging over properties within the scope of a nomological operator, means that laws apparently about particulars are being analyzed in terms of laws about universals. This, however,

7 This version of the general theory is essentially that set out by David Armstrong in his forthcoming book, *Universals and Scientific Realism*. In revising the present paper I have profited from discussions with Armstrong about the general theory, and the merits of our competing versions of it.

would not seem to be a decisive objection to this way of viewing laws expressed by statements of the form $(x)Mx$.

A much more serious objection concerns laws expressed by statements of the form $(x)[Px \supset (Qx \vee Rx)]$. If the world were partially indeterministic, there might well be laws that stated, for example, that if an object has property P, then it has either property Q or property R, and yet no laws that specified *which* of those properties an object will have on any given occasion. Can the truth conditions for laws of this form be expressed in terms of the relations of nomic necessitation and nomic exclusion? The answer depends on whether there are disjunctive properties, that is, on whether, if Q and R are properties, there is a property, *Q or R*, which is possessed by objects that have property Q and by objects that have property R. If, as many philosophers have maintained, there are no disjunctive properties, then the relations of nomic necessitation and nomic exclusion will not suffice to provide truth conditions for laws of the form $(x)[Px \supset (Qx \vee Rx)]$.

A third case that poses difficulties concerns laws expressed by statements of the form $(x)(-Px \supset Qx)$. If negative properties are rejected, such laws cannot be handled in any immediate fashion by the relations of nomic necessitation and nomic exclusion. Nevertheless, this third case does not appear to raise any new issues. For if one can handle laws expressed by sentences of the form $(x)Mx$ in the way suggested above, one can rewrite laws of the form $(x)(-Px \supset Qx)$ in the form $(x)(Px \vee Qx)$, and then apply the method of analysis suggested for laws of the form $(x)Mx$. The result will be a law that is conditional in form, with a positive antecedent and a disjunctive consequent, which is the case just considered.

The conclusion seems to be this. The relation of nomic necessitation by itself does not provide a satisfactory account unless there are both negative and disjunctive properties. Supplementing it with the relation of nomic exclusion may allow one to dispense with negative properties, but not with disjunctive ones. It would seem best to try to set out a more general account that will allow one to avoid all dubious metaphysical assumptions. Let us now turn to such an account.

The first concept required is that of the *universals involved in a proposition*. This notion is a very intuitive one, though how best to explicate it is far from clear. One approach would be to attempt to show that propositions can be identified with set theoretical constructs out of universals. This treatment of propositions is not without its difficulties, but it is a reasonably natural one if propositions are viewed as nonlinguistic entities.

The second, and related idea, is that of the logical form or structure of a proposition. One can view this form as specified by a *construction function* which maps ordered n-tuples of universals into propositions.

Thus one could have, for example, a construction function *K* such that *K*(redness, roundness) = the proposition that all red things are round. Conceived in the most general way, some construction functions will map ordered *n*-tuples of universals into propositions that involve as constituents universals not contained in the original *n*-tuple. Thus *G* could be a function so defined that *G*(property *P*) = the proposition that everything with property *P* is green. Other construction functions will map ordered *n*-tuples of universals into propositions which do not contain, as constituents, all the universals belonging to the *n*-tuple. *H* could be a function so defined that *H*(property *P*, property *Q*) = the proposition that everything has property *Q*. In order to capture the notion of logical form, one needs a narrower notion of construction function, namely, one in which something is a construction function if and only if it is a mapping from ordered *n*-tuples of universals into propositions that contain, as constituents, all and only those universals belonging to the ordered *n*-tuple. In this narrower sense, *K* is a construction function, but *G* and *H* are not.

The final idea required is that of a *universal being irreducibly of order k*. Properties of, and relations among particulars, are universals of order one. If nominalism is false, they are irreducibly so. A universal is of order two if it is a property of universals of order one, or a relation among things, some of which are universals of order one, and all of which are either universals of order one or particulars. It is irreducibly so if it cannot be analyzed in terms of universals of order one. And in general, a universal is of order $(k + 1)$ if it is a property of universals of order *k*, or a relation among things, some of which are universals of order *k*, and all of which are either particulars or universals of order *k* or less. It is irreducibly of order $(k + 1)$ if it cannot be analyzed in terms of particulars and universals of order *k* or less.

Given these notions, it is possible to explain the general concept of a *nomological relation* — which will include, but not be restricted to, the relations of nomic necessitation and nomic exclusion. Thus, as a first approximation:

R is a *nomological relation* if and only if

(1) *R* is an *n*-ary relation among universals;

(2) *R* is irreducibly of order $(k + 1)$, where *k* is the order of the highest order type of element that can enter into relation *R*;

(3) *R* is a contingent relation among universals, in the sense that there are universals $U_1, U_2, \ldots, U_n$ such that it is neither necessary that $R(U_1, U_2, \ldots, U_n)$ nor necessary that not $R(U_1, U_2, \ldots, U_n)$;

(4) there is a construction function K such that
(i) if $P_1, P_2, ..., P_n$ are either properties or relations, and of the appropriate types, then $K(P_1, P_2, ..., P_n)$ is a proposition about particulars, and
(ii) the proposition that $R(P_1, P_2, ..., P_n)$ logically entails the proposition which is the value of $K(P_1, P_2, ..., P_n)$.

This characterization of the theoretical concept of a nomological relation in logical and quasi-logical terms can in turn be used to state truth conditions for nomological statements:

S is a true nomological statement if and only if there exists a proposition p which is expressed by S, and there exists a nomological relation R and an associated construction function K, and universals $P_1, P_2, ..., P_n$ such that

(1) it is not logically necessary that p;

(2) the proposition that p is identical with the value of $K(P_1, P_2, ..., P_n)$;

(3) it is true that $R(P_1, P_2, ..., P_n)$;

(4) it is not logically necessary that $R(P_1, P_2, ..., P_n)$;

(5) the proposition that $R(P_1, P_2, ..., P_n)$ logically entails the proposition that p.

The basic idea, then, is that a statement expresses a nomological state of affairs if is true in virtue of a contingent, nomological relation holding among universals. Different types of nomological relations are specified by different construction functions. A relation is a relation of nomic necessitation if it is of the type specified by the construction function which maps ordered couples (P, Q) of universals into propositions of the form $(x)(Px \supset Qx)$. It is a relation of nomic exclusion if it is of the type determined by the construction function mapping ordered couples (P, Q) of universals into propositions of the form $(x)(Px \supset -Qx)$.

It is critical to this account that a nomological relation be genuinely a relation among universals and nothing else, as contrasted, for example, with a relation that is apparently among universals, but which can be analyzed in terms of properties of, and relations among, particulars. Hence the requirement that a relation, to be nomological, always be *irreducibly* of an order greater than the order of the universals that enter into it. If this requirement were not imposed, every true generalization would get classified as nomological. For suppose that everything with property P just happens to have property Q, and consider the relation R which holds between properties A and B if and only if everything with property A has property B. Properties P and Q stand in relation R. The relation is a contingent one. Its holding between properties P and Q entails the proposition that everything with property P has property Q. So if condition (2) were dropped from the definition of the concept of a nomological relation, R would qualify as a nomological relation, and it would be a nomological truth that everything with property P has property Q.

But while condition (2) is essential, it is not quite adequate. For suppose that it is a law that everything with property S has property T, and that the truth-maker for this law is the fact that S and T stand in a certain relation W, where W is irreducibly of order two. Then one can define a relation R as follows: Properties P and Q stand in relation R if and only if everything with property P has property Q, and properties S and T stand in relation W. So defined, relation R will not be analyzable in terms of universals of order one, so condition (2) will not be violated. But if relations such as R were admitted as nomological, then, provided that there was at least one true nomological statement, all generalizations about particulars would get classified as nomological statements.

There are alternative ways of coping with this difficulty. One is to replace condition (2) by:

(2*) If $R(U_1, U_2, \ldots, U_n)$ is analytically equivalent to $C_1 \wedge C_2 \wedge \ldots \wedge C_m$, then every nonredundant C_i — that is, every C_i not entailed by the remainder of the conjunctive formula — is irreducibly of order $(k + 1)$.

This condition blocks the above counterexample. But given the somewhat ad hoc way in which it does so, one might wonder whether there may not be related counterexamples which it fails to exclude. What is one to say, for example, about a relation R defined as follows: Properties P and Q stand in relation R if and only if either everything with property P has property Q or properties P and Q stand in relation W? I would hold that this is not a counterexample, on the ground that there cannot be disjunctive relations. But this is to appeal to a view that some philosophers would reject.

A second, and more radical approach, involves replacing condition (2) by:

(2**) Relation R is not analyzable in terms of other universals of *any* order.

This more radical approach, which I believe is preferable, does necessitate another change in the account. For suppose that there is a nomological relation R_1 holding between properties *P* and *Q*, in virtue of which it is a law that everything with property *P* has property *Q*, and a nomological relation R_2 holding between properties *Q* and *S*, in virtue of which it is a law that everything with property *Q* has property *S*. It will then be a law that everything with property *P* has property *S*, and this may be so simply in virtue of the relations R_1 and R_2 which hold between properties *P* and *Q*, and *Q* and *S*, respectively, and not because of any additional relation holding between properties *P* and *S*. Given the revised account of nomological relations, and hence of nomological statements, the generalization that everything with property *P* has property *S* could not be classified as nomological. But this consequence can be avoided by viewing the revised account as concerned only with *basic* or underived nomological statements, and then defining nomological statements as those entailed by the class of basic nomological statements.

3. Laws and Nomological Statements

The class of nomological statements characterized in the preceding section does not seem to coincide with the class of laws. Suppose it is a nomological truth that $(x)(Px \supset Qx)$. Any statement entailed by this must also be nomological, so it will be a nomological truth that $(x)[(Px \wedge Rx) \supset Qx]$, regardless of what property *R* is. Now it is certainly true that the latter statement will be nomologically necessary, and thus, in a broad sense of "law", it will express a law. Nevertheless it is important for some purposes — such as the analysis of causal statements and subjunctive conditionals — to define a subclass of nomological statements to which such statements will not belong. Consider, for example, the nomological statement that all salt, when in water, dissolves. If this is true, it will also be a nomological truth that all salt, when both in water and in the vicinity of a piece of gold, dissolves. But one does not want to say that the cause of a piece of salt's dissolving was that it was in water and in the vicinity of some gold. In the description of causes one wants to exclude irrelevant facts. Or consider the counterfactual: "If this piece of salt were in water and were not dissolving, it would not be in the vicinity of a piece of gold." If one says that all nomological statements support counterfactuals, and that it is a nomological truth that all salt when both in water and near gold dissolves, one will be forced to accept the preceding counterfactual, whereas it is clear that there is good reason not to accept it.

Intuitively, what one wants to do is to define a subclass of nomological statements in the broad sense, containing only those involving no irrelevant conditions. Nomological statements belonging to this subclass will be laws.[8] But how is this class to be defined? It cannot be identified with the class of underived nomological statements, since it is certainly possible for laws in the strict sense to be entailed by other, more comprehensive laws. The most plausible answer, I think, emerges if one rewrites nomological statements in full disjunctive normal form.[9] Thus, if this is done for the statement $(x)[(Px \wedge Rx) \supset Qx]$, one has:

$$(x)\,[\,(Px \wedge Rx \wedge Qx) \vee (Px \wedge -Rx \wedge Qx) \vee (-Px \wedge Rx \wedge Qx) \vee (-Px \wedge -Rx \wedge Qx) \vee (Px \wedge -Rx \wedge -Qx) \vee (-Px \wedge Rx \wedge -Qx) \vee (-Px \wedge -Rx \wedge -Qx)].$$

Of the seven disjuncts that compose the matrix of the statement rewritten in this way, one is of special interest: $Px \wedge -Rx \wedge -Qx$. For if it is a nomological truth that $(x)(Px \supset Qx)$, it is nomologically impossible for anything to satisfy that disjunct. It is this feature, I suggest, that distinguishes between nomological statements in general and laws in the narrow sense. If so, the following is a natural analysis of the concept of a law:

S expresses a law if and only if

(1) *S* is a nomological statement, and

(2) there is no nomological statement *T* such that, when *S* is rewritten in full disjunctive normal form, there is a disjunct *D* in the matrix such that *T* entails that there will be nothing that satisfies *D*.

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8 This interpretation of the expressions "nomological statement" and "law" follows that of Hans Reichenbach in his book, *Nomological Statements and Admissible Operations*, Amsterdam, 1954. It may be that the term "law" is ordinarily used in a less restricted sense. However there is an important distinction to be drawn here, and it seems natural to use the term "law" in perhaps a slightly narrower sense in order to have convenient labels for these two classes of statements.

9 This method of handling the problem was employed by Hans Reichenbach in *Nomological Statements and Admissible Operations*.

This account is not, however, entirely satisfactory. Suppose that the statements $(x)(Px \supset Qx)$ and $(x)(Rx \supset Qx)$ both express laws. Since the statement $(x)[(Px \supset Qx) \wedge (Rx \supset Rx)]$ is logically equivalent to the former statment, it presumably expresses the same law. But when the last statement is written in full disjunctive normal form, it contains the disjunct $-Px \wedge -Qx \wedge Rx$, which cannot be satisfied by anything if it is a law that $(x)(Rx \supset Qx)$.

So some revision is necessary. The natural move is to distinguish between essential and inessential occurrences of terms in a statement: a term occurs essentially in a statement *S* if and only if there is no logically equivalent statement *S** which does not contain an occurrence of the same term. The account can thus be revised to read:

S expresses a law if and only if

(1) *S* is a nomological statement, and

(2) there are no nomological statements *S** and *T* such that *S** is logically equivalent to *S*, all constant terms in *S** occur essentially, and when *S** is rewritten in full disjunctive normal form, there is a disjunct *D* in the matrix such that *T* entails that nothing will satisfy *D*.

4. Objections

In this section I shall consider three objections to the approach advocated here. The first is that the account offered of the truth conditions of nomological statements is in some sense ad hoc and unilluminating. The second objection is that the analysis commits one to a very strong version of realism with respect to universals. The third is that the account offered places an unjustifiable restriction upon the class of nomological statements.

The basic thrust of the first objection is this. There is a serious problem about the truth conditions of laws. The solution offered here is that there are relations — referred to as nomological — which hold among universals, and which function as truth-makers for laws. How does this solution differ from simply saying that there are special facts — call them nomological — which are the facts which make laws true? How is the one approach any more illuminating than the other?

The answer is two-fold. First, to speak simply of nomological facts does nothing to *locate* those facts, that is, to specify the individuals that are the constituents of the facts in question. In contrast, the view advanced here does locate the relevant facts: they are facts about universals, rather than facts about particulars. And support was offered for this contention, viz., that otherwise no satisfactory analysis of the truth conditions of basic laws without positive instances is forthcoming. Secondly, the relevant facts were not merely located, but *specified*, since not only the individuals involved, but their relevant attributes, were described. It is true that the attributes had to be specified theoretically, and hence in a sense indirectly, but this is also the case when one is dealing with theoretical terms attributing properties to particulars. The Lewis-type account of the meaning of theoretical terms that was appealed to is just as applicable to terms that refer to relations among universals — including nomological relations — as it is to terms that refer to properties of, and relations among, particulars.

Still, the feeling that there is something unilluminating about the account may persist. How does one *determine*, after all, that there is, in any given case, a nomological relation holding among universals? In what sense have truth conditions for nomological statements really been supplied if it remains a mystery how one answers the epistemological question?

I think this is a legitimate issue, even though I do not accept the verificationist claim that a statement has factual meaning only if it is in principle verifiable. In the next section I will attempt to show that, given my account of the truth conditions of nomological statements, it is possible to have evidence that makes it reasonable to accept generalizations as nomological.

The second objection is that the analysis offered involves a very strong metaphysical commitment. It is not enough to reject nominalism. For one must, in the first place, also hold that there are higher order universals which are not reducible to properties of, and relations among, particulars. And secondly, although the account may not entail that Platonic realism — construed minimally as the claim that there are some uninstantiated universals — is true, it does entail that if the world had been slightly different, it *would* have been true.

The first part of this objection does not seem to have much force as an objection. For what reasons are there for holding that there are no irreducible, higher order relations? On the other hand, it does point to a source of uneasiness which many are likely to feel. Semantics is usually done in a way that is compatible with nominalism. Truth conditions of sentences are formulated in terms of particulars, sets of particulars, sets of sets of particulars, and so on. The choice, as a metalanguage for semantics, of a language containing terms whose referents are either universals, or else intensional entities, such as concepts, though rather favored by the later Carnap[10] and others, has not been generally accepted. Once irreducible higher order relations enter into the account, a shift to a metalanguage containing terms referring to entities other than particulars appears unavoidable, and I suspect that this shift in metalanguages may make the solution proposed here difficult for many to accept.

The second part of this objection raises a deeper, and more serious point. Does it follow from the analysis offered that, if the world had been somewhat different, Platonic realism would have been true? The relevant argument is this. Suppose that materialism is false, and that there is, for example, a nonphysical property of being an experience of the red variety. Then consider what our world would have been like if the earth had been slightly closer to the sun, and if conditions in other parts of the universe had been such that life evolved nowhere else. The universe would have contained no sentient organism, and hence no experiences of the red variety. But wouldn't it have been true in *that* world that if the earth had been a bit farther from the sun, life would have evolved, and there would have been experiences of the red variety? If so, in virtue of what would this subjunctive conditional have been true? Surely an essential part of what would have made it true is the existence of a certain psychophysical law linking complex physical states to experiences of the red variety. But if the truth-makers for laws are relations among universals, it could not be a law in that world that whenever a complex physical system is in a certain state, there is an experience of the red variety, unless the property of being an experience of the red variety exists in that world. Thus, if the account of laws offered above is correct, one can describe a slightly altered version of our world in which there would be uninstantiated, and hence transcendent, universals.

The argument, as stated, is hardly conclusive. It does depend, for example, on the assumption that materialism is false. However this assumption is not really necessary. All that is required is the assumption that there are emergent properties. It makes no difference to the argument whether such emergent properties are physical or nonphysical.

If our world does not contain any emergent properties, it will not be possible to argue that if our world had been slightly different, there would have been uninstantiated universals. However one can argue for a different conclusion that may also seem disturbing. For if it is granted, not that there are emergent properties, but only that the

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10 Compare Carnap's discussion in the section entitled "Language, Modal Logic, and Semantics," especially pages 889-905, in *The Philosophy of Rudolf Carnap*, edited by Paul A. Schilpp, La Salle, Illinois, 1963.

concept of an emergent property is coherent, then it can be argued that the existence of uninstantiated, and hence transcendent universals, is logically possible. A conclusion that will commend itself to few philosophers who reject Platonic realism, since the arguments usually directed against Platonic realism, if sound, show that it is *necessarily* false.

Another way of attempting to avoid the conclusion is by holding that if the world had been different in the way indicated, there would have been no psychophysical laws. This view may be tenable, although it strikes me as no more plausible than the stronger contention that there cannot be basic laws that lack positive instances. As a result, I am inclined to accept the contention that if the account of laws set out above is correct, there is reason to believe that Platonic realism, construed only as the doctrine that there are uninstantiated universals, is not incoherent.

The final objection to be considered is that there are statements that it would be natural, in some possible worlds, to view as nomological, but which would not be so classified on the account given here. Suppose, for example, the world were as follows. All the fruit in Smith's garden at any time are apples. When one attempts to take an orange into the garden, it turns into an elephant. Bananas so treated become apples as they cross the boundary, while pears are resisted by a force that cannot be overcome. Cherry trees planted in the garden bear apples, or they bear nothing at all. If all these things were true, there would be a very strong case for its being a law that all the fruit in Smith's garden are apples. And this case would be in no way undermined if it were found that no other gardens, however similar to Smith's in all other respects, exhibited behavior of the sort just described.

Given the account of laws and nomological statements set out above, it cannot, in the world described, be a law, or even a nomological statement, that all the fruit in Smith's garden are apples. If relations among universals are the truth-makers for nomological statements, a statement that contains essential reference to a specific particular can be nomological only if entailed by a corresponding, universally quantified statement free of such reference. And since, by hypothesis, other gardens do not behave as Smith's does, such an entailment does not exist in the case in question.

What view, then, is one to take of the generalization about the fruit in Smith's garden, in the world envisaged? One approach is to say that although it cannot be a law, in that world, that all the fruit in Smith's garden are apples, it can be the case that there is some property *P* such that Smith's garden has property *P*, and it is a law that all the fruit in any garden with property *P* are apples. So that even though it is not a nomological truth that all the fruit in Smith's garden are apples, one can, in a loose sense, speak of it as "derived" from a nomological statement.

This would certainly seem the most natural way of regarding the generalization about Smith's garden. The critical question, though, is whether it would be reasonable to maintain this view in the face of any conceivable evidence. Suppose that careful investigation, over thousands of years, has not uncovered any difference in intrinsic properties between Smith's garden and other gardens, and that no experimental attempt to produce a garden that will behave as Smith's does has been successful. Would it still be reasonable to postulate a theoretical property *P* such that it is a law that all the fruit in gardens with property *P* are apples? This issue strikes me as far from clear, but I incline slightly to a negative answer. For it would seem that, given repeated failures to produce gardens that behave as Smith's garden does, one might well be justified in concluding that if there is such a property *P*, it is one whose exemplification outside of Smith's garden is nomologically impossible. And this seems like a strange sort of property to be postulating.

I am inclined to think, then, that it is logically possible for there to be laws and nomological statements, in the strict sense, that involve ineliminable reference to specific individuals. But it does not matter, with regard to the general view of laws advanced here, whether that is so. If the notion of nomological statements involving ineliminable reference to specific individuals turns out to be conceptually incoherent, the present objection will be mistaken. Whereas if there can be such nomological statements, my account requires only minor revision to accommodate them. The definition of a construction function will have to be changed so that instances of universals, and not merely universals, can be elements of the ordered *n*-tuples that it takes as arguments, and the definition of a nomological relation will have to be similarly altered, so that it can be a relation among both universals and instances of universals. These alterations will result in an analysis of the truth conditions of nomological statements that allows for the possibility of ineliminable reference to specific particulars. And they will do so, moreover, without opening the door to accidentally true generalizations. Both condition (2*) and condition (2**), as set out in section 2 above, appear sufficiently strong to block such counterexamples.

5. The Epistemological Question

In the previous section I mentioned, but did not discuss, the contention that the analysis of nomological statements advanced here is unilluminating because it does not provide any account of how one determines whether a given nomological relation holds among specific universals. I shall argue that this objection is mistaken, and that in fact one of the merits of the present view is that it does make possible an answer to the epistemological question.

Suppose, then, that a statement is nomological if there is an irreducible theoretical relation holding among certain universals which necessitates the statement's being true. If this is right, there should not be any special epistemological problem about the grounds for accepting a given statement as nomological. To assert that a statement is nomological will be to advance a theory claiming that certain universals stand in some nomological relation. So one would think that whatever account is to be offered of the grounds for accepting theories as true should also be applicable to the case of nomological statements.

I should like, however, to make plausible, in a more direct fashion, this claim that the sorts of considerations that guide our choices among theories also provide adequate grounds for preferring some hypotheses about nomological statements to others. Consider, then, a familiar sort of example. John buys a pair of pants, and is careful to put only silver coins in the right hand pocket. This he does for several years, and then destroys the pants. What is the status of the generalization: "Every coin in the right hand pocket of John's pants is silver"? Even on the limited evidence described, one would not be justified in accepting it as nomological. One of the central types of considerations in support of a theory is that it in some sense provides the best explanation of certain observed states. And while the hypothesis that there is a theoretical relation *R* which holds among the universals involved in the proposition that every coin in the right hand pocket of John's pants is silver, and which necessitates that proposition's being true, does explain why there were only silver coins in the pocket, this explanation is unnecessary. Another explanation is available, namely, that John wanted to put only silver coins in that pocket, and carefully inspected every coin to ensure that it was silver before putting it in.

If the evidence is expanded in certain ways, the grounds for rejecting the hypothesis that the statement is nomological become even stronger. Suppose that one has made a number of tests on other pants, ostensibly similar to John's, and found that the right hand pockets accept copper coins as readily as silver ones. In the light of this additional evidence, there are two main hypotheses to be considered:

H_1: It is nomologically possible for the right hand pocket of any pair of pants of type *T* to contain a nonsilver coin;

H_2: There is a pair of pants of type *T*, namely John's, such that it is nomologically impossible for the right hand pocket to contain a nonsilver coin; however all other pairs of pants of type *T* are such that it is nomologically possible for the right hand pocket to contain a nonsilver coin.

H_1 and H_2 are conflicting hypotheses, each compatible with all the evidence. But it is clear that H_1 is to be preferred to H_2. First, because H_1 is simpler than H_2, and secondly, because the generalization explained by H_2 is one that we already have an explanation for.

Let us now try to get clearer, however, about the sort of evidence that provides the strongest support for the hypothesis that a given generalization is nomological. I think the best way of doing this is to consider a single generalization, and to ask, first, what a world would be like in which one would feel that the generalization was merely accidentally true, and then, what changes in the world might tempt one to say that the generalization was not accidental, but nomological. I have already sketched a case of this sort. In our world, if all the fruit in Smith's garden are apples, it is only an accidentally true generalization. But if the world were different in certain ways, one might classify the generalization as nomological. If one never succeeded in getting pears into Smith's garden, if bananas changed into apples, and oranges into elephants, as they crossed the boundary, etc., one might well be tempted to view the generalization as a law. What we now need to do is to characterize the evidence that seems to make a critical difference. What is it, about the sort of events described, that makes them significant? The answer, I suggest, is that they are events which determine which of "conflicting" generalizations are true. Imagine that one has just encountered Smith's garden. There are many generalizations that one accepts — generalizations that are supported by many positive instances, and for which no counterexamples are known, such as "Pears thrown with sufficient force towards nearby gardens wind up inside them," "Bananas never disappear, nor change into other things such as apples," "Cherry trees bear only cherries as fruit." One notices that there are many apples in the garden, and no other fruit, so the generalization that all the fruit in Smith's garden are apples is also supported by positive instances, and is without counterexamples. Suppose now that a banana is moving in the direction of Smith's garden. A partial conflict situation exists, in that there are some events which will, if they occur, falsify the generalization that all the fruit in Smith's garden are apples, and other events which will falsify the generalization that bananas never change into other objects. There are, of course, other possible events which will falsify neither generalization: the banana may simply stop moving as it reaches the boundary. However there may well be other gneralizations that one accepts which will make the situation one of inevitable conflict, so that whatever the outcome, at least one generalization will be falsified. Situations of inevitable conflict can arise even for two generalizations, if related in the proper way. Thus, given the generalizations that $(x)(Px \supset Rx)$ and that $(x)(Qx \supset -Rx)$, discovery of an object *b* such that both *Pb* and *Qb* would be a situation of inevitable conflict.

Many philosophers have felt that a generalization's surviving such situations of conflict, or potential falsification, provides strong evidence in support of the hypothesis that the generalization is nomological. The problem, however, is to *justify* this view. One of the merits of the account of the nature of laws offered here is that it provides such a justification.

The justification runs as follows. Suppose that one's total evidence contains a number of supporting instances of the generalization that $(x)(Px \supset Rx)$, and of the generalization that $(x)(Qx \supset -Rx)$, and no evidence against either. Even such meager evidence may provide some support for the hypothesis that these generalizations are nomological, since the situation may be such that the only available explanation for the absence of counterexamples to the generalizations is that there are theoretical relations holding among universals which necessitate those generalizations. Suppose now that a conflict situation arises: an object *b* is discovered which is both *P* and *Q*. This new piece of evidence will reduce somewhat the likelihood of both hypotheses, since it shows that at least one of them must be false. Still, the total evidence now available surely lends some support to both hypotheses. Let us assume that it is possible to make at least a rough estimate of that support. Let *m* be the probability, given the available evidence, that the generalization $(x)(Px \supset Rx)$ is nomological, and *n* the probability that the generalization $(x)(Qx \supset -Rx)$ is nomological — where $(m + n)$ must be less than or equal to one. Suppose finally that *b*, which has property *P* and property *Q*, turns out to have property *R*, thus falsifying the second generalization. What we are now interested in is the effect this has upon the probability that the first generalization is nomological. This can be calculated by means of Bayes' Theorem:

Let *S* be: It is a nomological truth that $(x)(Px \supset Rx)$.
Let *T* be: It is a nomological truth that $(x)(Qx \supset -Rx)$.
Let H_1 be: *S* and not-*T*.
Let H_2 be: Not-*S* and *T*.
Let H_3 be: *S* and *T*.
Let H_4 be: Not-*S* and not-*T*.
Let *E* describe the total antecedent evidence, including the fact that *Pb* and *Qb*
Let E^* be: *E* and *Rb*.

Then Bayes' Theorem states:

$$\text{Probability}(H_1\text{, given that } E^* \text{ and } E) = \frac{\text{Probability}(E^*\text{, given that } H_1 \text{ and } E) \times \text{Probability}(H_1 \text{ and } E)}{\sum_{i=1}^{n}[\text{Probability}(E^*\text{, given that } H_i \text{ and } E) \times \text{Probability}(H_1 \text{and } E)]}$$

Taking the antecedent evidence as given, we can set the probability of E equal to one. This implies that the probability of H_i and E will be equal to the probability of H_i given that E.

Probability(H_3, given that E)
= Probability (S and T, given that E)
= O, since E entails that either not-S or not-T.

Probability(H_1, given that E)
= Probability (S and not-T, given that E)
= Probability (S, given that E) -
Probability (S and T, given that E)
= m - O = m.

Similarly, probability (H_2, given that E) = n.

Probability(H_4, given that E)
= 1 - [Probability (H_1, given that E) +
Probability (H_2, given that E) +
Probability (H_3, given that E)]
= 1 - (m + n)

Probability(E^*, given that H_i and E)
= 1, if i = 1 or i = 3
= 0, if i = 2
= some value k, if i = 4.

Bayes' Theorem then gives:

Probability(H_1, given that E^* and E)

$$= \frac{1 \times m}{(1 \times m) + (0 \times n) + (1 \times 0) + (k \times (1 - (m + n)))}$$

$$= \frac{m}{m + k(1 - m - n)}$$

In view of the fact that, given that E^*, it is not possible that T, this value is also the probability that S, that is, the likelihood that the generalization that $(x)(Px \supset Rx)$ is nomological. Let us consider some of the properties of this result. First, it is easily seen that, provided neither m nor n is equal to zero, the likelihood that the generalization is nomological will be greater after its survival of the conflict situation than it was before. The value of $\frac{m}{m + k(1 - m - n)}$ will be smallest when k is largest. Setting k equal to one gives the value $\frac{m}{m + 1 - m - n}$ i.e., $\frac{m}{1 - n}$, and this is greater than m if neither m nor n is equal to zero.

Secondly, the value of $\frac{m}{m + k(1 - m - n)}$ increases as the value of k decreases, and this too is desirable. If the event that falsified the one generalization were one that would have been very likely if neither generalization had been nomological, one would not expect it to lend as much support to the surviving generalization as it would if it were an antecedently improbable event.

Thirdly, the value of $\frac{m}{m + k(1 - m - n)}$ increases as n increases. This means that survival of a conflict with a well supported generalization results in a greater increase in the likelihood that a generalization is nomological than survival of a conflict with a less well supported generalization. This is also an intuitively desirable result.

Finally, it can be seen that the evidence provided by survival of conflict situations can quickly raise the likelihood that a generalization is nomological to quite high values. Suppose, for example, that $m = n$, and that $k = 0.5$. Then $\frac{m}{m + k(1 - m - n)}$ will be equal to $2m$. This result agrees with the view that laws, rather than being difficult or impossible to confirm, can acquire a high degree of confirmation on the basis of relatively few observations, provided that those observations are of the right sort.

But how is this justification related to the account I have advanced as to the truth conditions of nomological statements? The answer is that there is a crucial assumption that seems reasonable if relations among universals are the truth-makers for laws, but not if facts about particulars are the truth-makers. This is the assumption that m and n are not equal to zero. If one takes the view that it is facts about the particulars falling under a generalization that make it a law, then, if one is dealing with an infinite universe, it is hard to see how one can be justified in assigning any non-zero probability to a generalization, given evidence concerning only a finite number of instances. For surely there is some non-zero probability that any given particular will falsify the generalization, and this entails, given standard assumptions, that as the number of particulars becomes infinite, the probability that the generalization will be true is, in the limit, equal to zero.[11]

In contrast, if relations among universals are the truth-makers for laws, the truth-maker for a given law is, in a sense, an "atomic" fact, and it would seem perfectly justified, given standard principles of confirmation theory, to assign some non-zero probability to this fact's obtaining. So not only is there an answer to the epistemological question; it is one that is only available given the type of account of the truth conditions of laws advocated here.

6. Advantages of this Account of Nomological Statements

Let me conclude by mentioning some attractive features of the general approach set out here. First, it answers the challenge advanced by Chisholm in his article "Law Statements and Counterfactual Inference":[12]

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11 See, for example, Rudolf Carnap's discussion of the problem of the confirmation of universally quantified statements in section F of the appendix of his book, *The Logical Foundations of Probability*, 2nd edition, Chicago, 1962, pages 570-1.

12 Roderick M. Chisholm, "Law Statements and Counterfactual Inference," *Analysis*, **15** (1955), pages 97-105, reprinted in *Causation and Conditionals*, edited by Ernest Sosa, London, 1975. See page 149.

> Can the relevant difference between law and non-law statements be described in familiar terminology without reference to counterfactuals, without use of modal terms such as 'causal necessity', 'necessary condition', 'physical possibility', and the like, and without use of metaphysical terms such as 'real connections between matters of fact'?

The account offered does precisely this. There is no reference to counterfactuals. The notions of logical necessity and logical entailment are used, but no nomological modal terms are employed. Nor are there any metaphysical notions, unless a notion such as a contingent relation among universals is to be counted as metaphysical. The analysis given involves nothing beyond the concepts of logical entailment, irreducible higher order universals, propositions, and functions from ordered sets of universals into propositions.

A second advantage of the account is that it contains no reference to possible worlds. What makes it true that statements are nomological are not facts about dubious entities called possible worlds, but facts about the actual world. True, these facts are facts about universals, not about particulars, and they are theoretical facts, not observable ones. But neither of these things should worry one unless one is either a reductionist, at least with regard to higher order universals, or a rather strict verificationist.

Thirdly, the account provides a clear and straightforward answer to the question of the difference between nomological statements and accidentally true generalizations: a generalization is accidentally true in virtue of facts about particulars; it is a nomological truth in virtue of a relation among universals.

Fourthly, this view of the truth conditions of nomological statements explains the relationships between different types of generalizations and counterfactuals. Suppose it is a law that $(x)(Px \supset Qx)$. This will be so in virtue of a certain irreducible relation between the universals *P* and *Q*. If now one asks what would be the case if some object *b* which at present lacks property *P* were to have *P*, the answer will be that this supposition about the particular *b* does not give one any reason for supposing that the universals *P* and *Q* no longer stand in a relation of nomic necessitation, so one can conjoin the supposition that *b* has property *P* with the proposition that the nomological relation in question holds between *P* and *Q*, from which it will follow that *b* has property *Q*. And this is why one is justified in asserting the counterfactual "If *b* were to have property *P*, it would also have property *Q*".

Suppose instead that it is only an accidentally true generalization that $(x)(Px \supset Qx)$. Here it is facts about particulars that make the generalization true. So if one asks what would be the case if some particular *b* which lacks property *P* were to have *P*, the situation is very different. Now one is supposing an alteration in facts that may be relevant to the truth conditions of the generalization. So if object *b* lacks property *Q*, the appropriate conclusion may be that if *b* were to have property *P*, the generalization that $(x)(Px \supset Qx)$ would no longer be true, and thus that one would not be justified in conjoining that generalization with the supposition that *b* has property *P* in order to support the conclusion that *b* would, in those circumstances, have property *Q*. And this is why accidentally true generalizations, unlike laws, do not support the corresponding counterfactuals.

Fifthly, this account of nomological statements allows for the possibility of even basic laws that lack positive instances. And this accords well with our intuitions about what laws there would be in cases such as a slightly altered version of our own world, in which life never evolves, and in that of the universe with the two types of fundamental particles that never meet.

Sixthly, it is a consequence of the account given that if *S* and *T* are logically equivalent sentences, they must express the same law, since there cannot be a nomological relation among universals that would make the one true without making the other true. I believe that this is a desirable consequence. However some philosophers have contended that logically equivalent sentences do not always express the same law. Rescher, for example, in his book *Hypothetical Reasoning*, claims that the statement that it is a law that all *X*'s are *Y*'s makes a different assertion from the statement that it is a law that all non-*Y*'s are non-*X*'s, on the grounds that the former asserts "All *X*'s are *Y*'s *and further* if *z* (which isn't an *X*) were an *X*, then *z* would be a *Y*", while the latter asserts "All non-*Y*'s are non-*X*'s *and further* if *z* (which isn't a non-*Y*) were a non-*Y*, then *z* would be a non-*X*."[13] But it would seem that the answer to this is simply that the statement that it is a law that all *X*'s are *Y*'s *also* entails that if *z* (which isn't a non-*Y*) were a non-*Y*, then *z* would be a non-*X*. So Rescher has not given us any reason for supposing that logically equivalent sentences can express different laws.

The view that sentences which would normally be taken as logically equivalent may, when used to express laws, not be equivalent, has also been advanced by Stalnaker and Thomason. Their argument is this. First, laws can be viewed as generalized subjunctive conditionals. "All *P*'s are *Q*'s", when stating a law, can be analyzed as "For all *x*, if *x* were a *P* then *x* would be a *Q*". Secondly, contraposition does not hold for subjunctive conditionals. It may be true that if *a* were *P* (at time t_1),

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13 Nicholas Rescher, *Hypothetical Reasoning*, Amsterdam, 1964, page 81.

then *a* would be *Q* (at time t_2), yet false that if *a* were not *Q* (at time t_2), then *a* would not have been *P* (at time t_1). Whence it follows that its being a law that all *P*'s are *Q*'s is not equivalent to its being a law that all non-*Q*'s are non-*P*'s.[14]

The flaw in this argument lies in the assumption that laws can be analyzed as generalized subjunctive conditionals. The untenability of the latter claim can be seen by considering any possible world *W* which satisfies the following conditions:

(1) The only elementary properties in *W* are *P, Q, F,* and *G*;
(2) There is some time when at least one individual in *W* has properties *F* and *P,* and some time when at least one individual in *W* has properties *F* and *Q*;
(3) It is true, but not a law, that everything has either property *P* or property *Q*;
(4) It is a law that for any time *t*, anything possessing properties *F* and *P* at time *t* will come to have property *G* at a slightly later time *t**;
(5) It is a law that for any time *t*, anything possessing properties *F* and *Q* at time *t* will come to have property *G* at a slightly later time *t**;
(6) No laws are true in *W* beyond those entailed by the previous two laws.

Consider now the generalized subjunctive conditional, "For all *x*, and for any time *t*, if *x* were to have property *F* at time *t*, *x* would come to have property *G* at a slightly later time *t**". This is surely true in *W*, on any plausible account of the truth conditions of subjunctive conditionals. For let *x* be any individual in *W* at any time *t*. If *x* has *P* at time *t*, then in view of the law referred to at (4), it will be true that if *x* were to have *F* at *t*, it would come to have *G* at *t**. While if *x* has *Q* at *t*, the conditional will be true in virtue of that fact together with the law referred to at (5). But given (3), *x* will, at time *t*, have either property *P* or property *Q*. So it will be true in *W*, for any *x* whatsoever, that if *x* were to have property *F* at time *t*, it would come to have property *G* at a slightly later time *t**.

If now it were true that laws are equivalent to generalized subjunctive conditionals, it would follow that it is a law in *W* that for every *x*, and every time *t*, if *x* has *F* at *t*, then *x* will come to have *G* at *t**.

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14 Robert C. Stalnaker and Richmond H. Thomason, "A Semantical Analysis of Conditional Logic," *Theoria*, **36** (1970), pages 39-40.

But this law does not follow from the laws referred to at (4) and (5), and hence is excluded by condition (6). The possibility of worlds such as *W* shows that laws are not equivalent to generalized subjunctive conditionals. As a result, the Stalnaker-Thomason argument is unsound, and there is no reason for thinking that logically equivalent statements can express non-equivalent laws.

Sevently, given the above account of laws and nomological statements, it is easy to show that such statements have the logical properties one would naturally attribute to them. Contraposition holds for laws and nomological statements, in view of the fact that logically equivalent statements express the same law. Transitivity also holds: if it is a law (or nomological statement) that $(x)\ (Px \supset Qx)$, and that $(x)\ (Qx \supset Rx)$, then it is also a law (or nomological statement) that $(x)\ (Px \supset Rx)$. Moreover, if it is a law (or nomological statement) that $(x)\ (Px \supset Qx)$, and that $(x)\ (Px \supset Rx)$, then it is a law (or nomological statement) that $(x)\ [Px \supset (Qx \wedge Rx)]$, and conversely. Also, if it is a law (or nomological statement) that $(x)\ [(Px \vee Qx) \supset Rx]$, then it is a law (or nomological statement) both that $(x)\ (Px \supset Rx)$, and that $(x)(Qx \supset Rx)$, and conversely. And in general, I think that laws and nomological statements can be shown, on the basis of the analysis proposed here, to have all the formal properties they are commonly thought to have.

Eighthly, the account offered provides a straightforward explanation of the nonextensionality of nomological contexts. The reason that it can be a law that $(x)\ (Px \supset Rx)$, and yet not a law that $(x)(Qx \supset Rx)$, even if it is true that $(x)\ (Px \equiv Qx)$, is that, in view of the fact that the truth-makers for laws are relations among universals, the referent of the predicate "P" in the sentence "It is a law that $(x)\ (Px \supset Rx)$" is, at least in the simplest case, a universal, rather than the set of particulars falling under the predicate. As a result, interchange of co-extensive predicates in nomological contexts may alter the referent of part of the sentence, and with it, the truth of the whole.

Finally, various epistemological issues can be resolved given this account of the truth conditions of nomological statements. How can one establish that a generalization is a law, rather than merely accidentally true? The general answer is that if laws hold in virtue of theoretical relations among universals, then whatever account is to be given of the grounds for accepting theories as true will also be applicable to laws. The latter will not pose any independent problems. Why is it that the results of a few carefully designed experiments can apparently provide very strong support for a law? The answer is that if the truth-makers for laws are relations among universals, rather than facts about particulars, the assignment of nonzero initial probability to a law ceases to be unreasonable, and one can then employ standard theorems of probability theory, such as Bayes' theorem, to show how a few observations of the right sort will result in a probability assignment that quickly takes on quite high values.

To sum up, the view that the truth-makers for laws are irreducible relations among universals appears to have much to recommend it. For it provides not only a noncircular account of the truth conditions of nomological statements, but an explanation of the formal properties of such statements, and a solution to the epistemological problem for laws.