

ON THE NECESSITY OF NATURAL KINDS

John Collier
Department of Philosophy
University of Newcastle
Callaghan, NSW 2308
pljdc@alinga.newcastle.edu.au

Natural kinds are central to most scientific reasoning about the world. For that matter, they are central to most kinds of systematic reasoning that are not purely analytic. In this paper I will investigate why natural kinds are used in science, and the extent to which science requires them. These issues revolve around the role of nomological necessity in science, and the role of natural kinds in natural laws. I will give an account of nomological necessity and the necessary (essential) properties of natural kinds that distinguishes the necessity involved from analyticity, logical necessity, and metaphysical necessity. The distinction is based on a metaphysical difference between propositions that must be true and propositions that cannot be false.

Systematic reasoning about the world requires the classification of particular objects and properties found in the world so that generalisations can be made about them. The simplest form of systematic statement about the world is a correlation of the extensions of two classes of such particulars. More complex statements that relate classes of particulars can be formulated purely extensionally, but modal concepts are required to go beyond mere correlations. Systematic reasoning about the world need not go beyond mere correlations. We

might decide to restrict systematisation just to correlations (perhaps because of epistemic scruples about unobserved entities), or else it might be that a particular world we want to reason about does not support anything but correlations (for example, a world in which all correlations are accidental). If, however, we have reason to include general statements supporting counterfactuals (laws) in our systematic reasoning, we must also permit modal relations.

There are three general reasons for thinking that we need to support counterfactual statements in scientific reasoning. First, scientific laws and principles support counterfactuals. That is, if a person accepts a scientific law¹, then, *ceteris paribus*, that acceptance sanctions their asserting particular counterfactual statements of the same form as the law. (The main exception would be cases in which the person accepts the law, but is considering situations in which the law might or does not hold.) This reason is a very weak one, since it is purely descriptive of

¹ Although I use laws here, everything I say can be generalised to theories that cannot be expressed as a simple set of conditional laws, capable of being applied individually. The translation uses a model theoretic approach, such that if a particular system satisfies a particular theory, then it will have such-and-such properties.

scientific reasoning in practice. It does not tell us that science *needs* counterfactuals, unless we have some additional reason for thinking that something that has laws that do not support counterfactuals would not be science. It would not gain us anything to make this a matter of the definition of science.

A second reason for thinking that scientific reasoning must support counterfactual statements is that it uses inductive techniques to establish universal generalisations. In science, under appropriate conditions we project observed regularities to all future cases. That is, in projecting to some presumed law that all A are B, we infer that if we *were* to find an A, then it *would* also be a B. The subjunctive form of the inference indicates its support for counterfactuals. It might appear that this gives us our additional reason for thinking that science needs counterfactuals, since science, at the very least, requires inductive generalisations to universal statements. There is a way around this conclusion, however. We can interpret scientific laws purely extensionally, in which case particular instances would be material conditionals. We can then explain the subjunctive reasoning above as reducible to material conditionals. The subjunctive form, however convenient, is not required.

This move, however, must be suspect, since it seems to be central to science to distinguish between accidental generalisations and scientific laws. The latter, in addition to being simply true, involve some form of necessary connection, reintroducing modalities. Since scientific laws are contingent, the necessity involved must in some way depend on the particularity of our world. Thus it can't be metaphysical necessity or analyticity, since both of these are, in different ways, independent of the particularity of our world. The most likely candidate is the sort of necessity associated with causation. This brings us to the third reason for

thinking that scientific reasoning requires counterfactuals: the centrality of causal reasoning to scientific reasoning.

Causal reasoning is common in science. Despite attempts to expunge causality from science, it has been notably resilient. Scientific explanations are irreducibly causal in nature, even though there has been a long history of attempts to replace causal with inferential or statistical relations (Salmon, 1984, 1989). Causal reasoning invokes counterfactual statements by establishing correlations among hypothetical classes (Giere, 1984). Necessity plays a central role in causal reasoning, since ascertaining causal connections by direct observation, abstraction and comparison alone is impossible, as David Hume firmly established.

I suppose that a science involving only correlations would be possible. It would be justified if there were nothing but accidental correlations in the natural world. However, if some correlations are non-accidental, but still contingent, then they fall clearly within the domain of science. Causal relations, in particular, fit into this category. Since our world is one in which causation occurs, then science, at least contingently, must support counterfactuals.

A causal relation between a and b, such that if a occurs, b must occur, requires that a is of such a kind that if it occurs, something of a kind of which b is a member must occur. That is, there must be two kinds, one of which a is a member, and the other of which b is a member, such that if an event of the first kind occurs, then an event of the second kind must occur. Many of the characteristics of a and b will be incidental to their causal interaction. We can strip these away by abstraction until we are considering only those properties that are required to maintain the necessity of the causal interaction. We are left with the properties defining the least determinate classes to which a and b must belong to in order to maintain the necessity of their causal

interaction. Anything which instantiates these two classes will also have a causal connection (due to the maintenance of necessity). Thus, the relation between these least determinate classes constitutes a universal necessary relation. I would be inclined to call this a law, except for one problem. Particular values of the general properties are (in general) required for a to cause b (imagine a is an initial configuration of particles, and b is a later configuration). Laws, on the other hand, apply to a range of values.

Tempting as it is to abstract away from the particular values of properties essential to the causal interaction of a and b to reach the realm of universals, we cannot do this and still guarantee causation will occur. Not just any values for the properties of a and b essential to causation will do. In order to preserve causation, we need to preserve the mathematical relations between the relevant properties of a and those of b. To abstract away from the particular values instantiated in a and b so that the universal necessary relation abstracted to is of the form of a law, L, the mathematical form of L must be incorporated into the properties defining the appropriate classes for a and b. This is required in order to preserve the necessity of causal relations that are instances of L. We can conclude that abstraction from causal instances to causal laws entails that the mathematical form of the law is implicit in the properties essential to the causal interaction in the instances. Otherwise, abstraction would not be solely to less determinate properties, i.e., it would not be a generalisation. So, the abstraction of general causal laws from particular causal instances entails that properties involved in the particular instances contain all of the entailments of the properties involved in the laws. Furthermore, the necessity of laws supervenes on the necessary relations of particulars. It also seems reasonable to hold that the laws themselves supervene on the relations of particular things; nothing that

makes a difference is gained by holding otherwise. Nonetheless, we can say that laws are necessary relations between kinds of individuals², the kinds being defined as abstractions from the values of the properties of the least determinate class required to maintain the necessity of the causal relations of the things that instantiate the laws³. A law, then, will hold, and hold necessarily, if it is instantiated at least once.

To recap briefly: A modestly rich science must presume that there are discoverable necessary connections in the world. Causal relations are the most familiar of these, if not the sole example. Assuming that causal relations hold in virtue of certain properties of the related entities, these properties must imply the causal laws they support, i.e., if the properties required to support the necessity of causation are instantiated, then the law itself is instantiated. No additional conditions (e.g., that the properties are instantiated in a world in which the law holds) are required. This follows from the stipulation that the relevant properties are abstractions from the concrete causal properties that ensure the necessity of causation in particular instances. On this account, necessitation in particular instances is primitive. I will show below that the extension of this necessity to classes and laws by abstraction gives an adequate account of nomological necessity.

It is first necessary to show that these classes are natural kinds. Since the classes related by laws are causally based, and are derived ultimately from causal relations in the natural world, it seems reasonable to call them natural

² I have been deliberately ambiguous about whether the things I am talking about are objects or properties of some sort. Since objects are individuated solely by their properties, I am not convinced it makes much difference.

³ If necessary connections other than causation are (contingently) required by science, the notion of law can be amended to include them.

classes in the sense of Duhem (1954: 25). According to Duhem, a natural classification is one that classifies things according to the way they are related in the world. Such a classification might be more or less abstract, depending on the degree of determination of the classifying properties. Highly abstract classes are of little use to science, since they are difficult to use for prediction, control and explanation. The most useful classification is into kinds, such that if something falls into a kind, the type of its relations to things of other kinds are fully determined (i.e., as determined as they can be). Duhem would probably deny the scientific relevance of classifications of this sort, because they would seem to him to involve metaphysics (essential relations). If we include causal relations under the scope of science, however, causal kinds (and other kinds involving contingent necessitation) would form the basis for such useful classifications. Since their basis is entirely natural, it is reasonable to consider them as candidates for natural kinds. These kinds correspond directly to the natural classes I have been describing. They are fundamental, in the sense that no *less* determinate class would do the job (causal relations would not be preserved), but also that no *more* determinate class would do the job (it would be unnecessarily specific). I propose, then, to identify the classes I have defined with natural kinds, and I conclude that natural kinds are (contingently) required by science.

What else can be said about these natural kinds? First, the set of natural kinds gives the most general natural classification sufficient to account for causal necessity in particular cases. This follows from the abstraction process by which they were defined. Birds and bees are not natural kinds, since 1) their causal interactions with other things can be abstracted to more general classes, and 2) biologically, their origin depended on particular circumstances involving

particular values of certain causal properties. The first point, and perhaps the second, applies as well to the chemical elements. Whatever the natural kinds are, they must be *very* abstract. Perhaps masses and intervals are natural kinds. Second, necessary relations (other than analytic and metaphysical relations) among natural kinds are given by the laws that relate them. This follows from the need to incorporate the laws into the definitions of the kinds. Third, the existence of a natural kind implies that these natural necessary relations hold, at least potentially. It is impossible for the relevant kinds to exist, and for these relations not to hold. Again, this follows from the requirement that the mathematical relations asserted by laws be incorporated into the definitions of the kinds. Fourth, because of the requirement of maximal indeterminateness, there is a unique classification into natural kinds. If there are two different routes along which to abstract from instances, both of which maintain the necessity of the causal interaction, then neither is least determinate. At the very least, a disjunction of the endpoints of the two would be less determinate, but would still maintain the required necessity.

There are several reasons against taking the classes defined above as natural kinds. First, it might appear that least determinacy is too strong a condition, since laws need not relate fundamental entities. The gas laws, for example, describe gases, but gas is not a natural kind on my account, since gases are a) made up of particles and b) under certain conditions cannot be distinguished from liquids and/or solids. The best response to this complaint is that not all laws are fundamental, and evidence for the non-fundamentality of a law is evidence that the basic instances have either not been identified correctly or have not been abstracted to greatest generality, or both. Even non-fundamental laws, however, would still follow from the necessary

relations of natural kinds, since the non-fundamental laws are particular consequences of the fundamental laws. Second, it might be objected, the kinds obtained from the proposed definition are not the traditional natural kinds. The simplest answer to this objection is that science has been wrong before, and will likely be shown wrong again. Third, it might be objected that there is no guarantee that the defined classes will form any useful groupings at all. They might be too diffuse, and many could be singular. The simplest answer in this case is to allow the possibility, and remark that it is fortunate for science that we are not in a world in which the possibility holds too widely. A fourth set of objections hold that the defined classes do not meet certain desiderata for natural kinds. I will deal with these next.

It would be desirable to show that if something belongs to a natural kind, it belongs to it essentially, that nothing can belong to inconsistent natural kinds, and further to show that nothing can belong to more than one natural kind. The first is impossible to show in general, since it is possible to define highly gerrymandered entities. Likewise, the second and third points have counterexamples among the arcana of mereology. If we are going to satisfy the three desiderata above, we must restrict our scope to natural entities. Anything must have a unity relation that makes its parts parts of the same thing. For most, if not all, natural things, this will be a causally based relation. Elsewhere (Collier, 1988), I have called this causally based relation *cohesion*. In general, cohesion has a spatial and a temporal component. The cohesion of a thing is essential to it; destroy the cohesion, and you destroy the thing. It seems reasonable (I can think of no exceptions) that the same basic laws underlie the cohesion of a thing throughout

its existence⁴. If so, then there will be at least one natural kind involved throughout its existence, and that natural kind will be essential to it. This alone does not preclude the possibility that the thing also belongs inessentially to some natural kinds, but if we are serious about saying that the thing as a whole, and not some part of it, interacts causally with something else, it seems likely that the properties involved in the kind or kinds it belongs to essentially will be involved in its causal interactions with other things. If so, any kind it belongs to it would belong to essentially. Again, I can think of no exceptions. An electron, for example, can interact through its mass, spin, charge or size, but it cannot do without any of these and still be an electron.

If my argument that natural things belong to the natural kinds they belong to essentially is close to correct, then nothing can belong to inconsistent natural kinds, even at different times. All the natural kinds it belongs to, it must belong to at all times. On the other hand, objects can be of more than one natural kind, or so it seems. An electron, for example is both charged and massive, but some particles are just massive. So far as we now know, electromagnetism and gravity are different properties, so it seems that electrons belong to both the kind gravitating system and the kind electromagnetic system. Properties, though, because of the abstracting process to least determinate property, cannot belong to more than one kind unless there are different routes of abstraction to a most general property that can sustain the necessity of causal interactions in which they are involved. I can think of no cases. Present evidence suggests, then, that natural kinds give a unique natural classification that is unitary for properties, but not for objects.

⁴ The Aristotelian principle that something must remain constant through a change in anything goes in the right direction, but is not itself adequate to get this result.

Despite the above, there are still some reasons to believe that scientific classifications are always accidental, even if loaded with the language of necessity. If so, necessity plays no real role in science, and natural kinds are at best arbitrary. One possibility is that even if there are natural classifications, they are inaccessible to science; any classification we can make is completely or largely accidental to any properties the things classified might actually have. Several arguments have been directed towards this being systematically true, but aside from some reflectively dubious empirical generalisations by some historians and sociologists of science, it seems to me that they all stem from the inseparability of theory and observation. I have argued that elsewhere (Collier, 1987) that the point behind the theory ladenness of observation is a dilemma for any empiricist: Either observed entities are rich enough to provide an empirical basis for theorising (are projectible), in which case they are pre-classified in potentially questionable ways, or else they are not pre-classified, in which case they are not rich enough to provide an empirical basis for theorising. If we can't unequivocally determine what properties are involved in an instance of causation, then we can hardly abstract from them to a unique classification, as described in the earlier part of this paper. The same point, I believe, underlies Nelson Goodman's new riddle of induction, and arguments for Kuhn-Feyerabend incommensurability and Quinean indeterminacy of translation. I believe the problem can be met, but to do so would be outside of the scope of this paper. Instead, I will set such epistemological problems aside in order to examine the nature of the necessity involved in my account of natural kinds.

The traditional distinction between universals and particulars suggests that necessity (if invoked) must be ontologically fundamental, since relations among particulars depend on the

existence of the particulars, and are thus contingent (though they may be necessary given the existence of the particulars). David Lewis (1994), however, has developed a systematic view of the world in which all generalities, including necessary generalities, are supervenient on particulars. The cost is a commitment to ontologically fundamental possible worlds, and to a view of chance that is a little bit peculiar. My account avoids these problems (the latter I cannot show here), but at the expense of making the necessity of particular instances of causation primitive. Otherwise, I agree here that all generalities supervene on particulars. The differences won't matter in what follows.

Scientific laws must be contingent, but it is unclear how the same thing could be both necessary and contingent. We need an account of necessity that allows for the sort of contingency that we have come to expect in science. The way I have defined natural kinds, if something behaves as it does in virtue of its natural kind, it could not behave otherwise. This might seem unduly restrictive. Indeed, it might seem to imply that the necessity involved in natural kinds as I have defined them is really metaphysical necessity. This appearance is wrong, as I will show, because of my reliance on the supervenience of the general on the particular. It will be useful to first look at other alternatives for reconciling contingency with necessity.

One place to look is in the function of language. Analyticity is a form of necessity that is distinct from metaphysical necessity, the contrary of contingency. Perhaps laws can be analytic but still contingent. Scientific laws often do have some similarities to analytical statements. For example, Newton's Second Law not only states an empirical fact, but it also helps to define the notions of mass and force within Newtonian mechanics. The Second Law of Thermodynamics plays a similar role in defining entropy. Poincaré (1905) has argued that a

number of laws have conventional aspects, and function like definitions. The necessity of these laws would follow from their analyticity, but they would be contingent, it might be held, because they do not have to be accepted if their linguistic context is rejected. This is analogous to sentences like "I am here now." This sentence is true whenever uttered (barring unusual meanings given to the words involved), yet it does not state a necessary truth⁵.

That there is something wrong with this account of the necessity of laws should be evident from the distinctly un-law-like character of "I am here now." Also, laws like Boyle's Law and Charles' Law do not seem to be in the least analytic. How can we explain *their* necessity, consistent with their contingency? The relevant form of necessity is *not* analyticity. An analytic statement must hold by meaning alone, but scientific laws are, presumably, empirical, synthetic statements. Any contingency involved in analytic statements derives from the circumstances of use of the terms or concepts involved. The contingency of scientific laws, however, is largely independent of how they are stated or conceived.

Another possible approach is to note that the necessity of laws holds only in worlds that are nomologically similar to ours. Presumably this would be the case for other necessary but contingent relations among natural kinds as well. There are two problems with this approach: First, without a clear criterion of nomological similarity, the approach merely reproduces the problem of defining the appropriate sort of necessity. It is unclear how to compare nomological similarity, e.g., do exceptions to laws count? if so, how much? Second, unless the properties corresponding to natural kinds exist

only in the nomologically similar worlds, the same property could both be and not be a natural kind, depending on world. It is impossible to give this objection much more flesh without a satisfactory account of nomological similarity across worlds.

The worlds approach does suggest a solution to the problem of nomological necessity, however. Laws hold in all and only those worlds in which the appropriate natural kinds exist. There will be worlds in which a given law does not hold, because the appropriate natural kinds do not exist. Thus it is contingent that a given law holds. However it is impossible for the law to be false; in this sense it is necessarily true. On this account there is no problem with the same properties determining natural kinds in one world, but not in another. We can eliminate possible worlds talk in this account by revising the description of the position to say that if a natural law were not to hold, then the natural kinds on which it depends would not exist (the contrary is not necessarily true).

It might appear that this approach to nomological, and hence causal, necessity is unduly restrictive for individual causal events. It appears that they could not be other than they are. This suggests that any causal event we are involved in, we must be involved in. While it is true that insofar as the causally relevant factors are concerned, any causal event could only happen as it did, this places little restriction on what can happen. It is still possible that other events could have happened instead, either like or unlike the ones that actually happened. Furthermore, the aspects of an event that are not essential to the necessity of causation could have been different in any case. It is true that a tight web of causal events might allow only one outcome, but that sort of determinism is not peculiar to present account of nomological necessity.

⁵ Extensive discussion of cases like this, together with explanation of the analyticity involved and the sense of metaphysical necessity are given by Kaplan (1979) and Stalnaker (1976, 1978).

It is important to be clear how the supervenience approach to necessity differs from essentialist accounts that place the contingency of laws only in the kinds of things that happen to exist in this particular world. On the essentialist account, natural laws are metaphysically necessary, but may hold vacuously. The biggest problem with this approach, other than the ontological exuberance of vacuous laws and natural kinds, is that metaphysical necessity implies that the laws should be discoverable *a priori*. No particular experience is required. This seems to run deeply against the grain of scientific methodology.

On my account, however (and also Lewis's account), since natural kinds and laws supervene on particulars, there is no need to postulate metaphysical necessity as well to explain the necessary relations of natural kinds. Laws hold if and only if the relevant kinds exist, and the relevant kinds exist if and only if the relevant particulars exist. Furthermore, we must discover the particulars in order to discover the laws, since the laws are abstractions from the relations of particulars⁶.

We discover natural kinds first by discovering that individuals of the kind exist, and then by determining that individuals of that kind bear certain necessary relations to those of other kinds, in virtue of their being members of the kind they are. Thus natural kinds are doubly empirical. They are contingent insofar as their existence is concerned, as required for the contingency of science, but they bear necessary relations that include the empirical scientific laws. It is this contingency that underlies the contingency of scientific laws. Because of the nature of the necessity of these laws, they cannot be false, but they do not necessarily need to be followed.

⁶ Generally, but not always by any means, the epistemological process will be more convoluted.

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