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Necessities and Universals in Natural Laws

1 | Prologue

How do laws of nature differ from cosmic coincidences? This is a question very familiar to philosophers of science, and answers of two sorts still vie for their allegiance. One sort locates the difference in what laws say, the other "in the different roles which they play in our thinking", as Braithwaite's *Scientific Explanation* put it (1953: 295). In Chapter 9 of that book, Braithwaite developed and defended a classic answer of the second sort: the difference, he says there, lies in why we believe laws, not in what they say. In the quarter century since then, other answers of the same sort have been devised: Hesse presents one in [Hesse (1980)]. But since then also, answers of the first sort have again come into fashion. The revived fashion has mostly been for reading laws as saying how things must be; but some, more recently, have read them instead as relating not things but properties of things to each other. Hesse notes these fashions and rejects them, to my mind rightly, but she does not elaborate her reasons. It seems to me therefore that I can best complement her article by inspecting these fashions' argumentative cut, to see if they do indeed fit better than her and Braithwaite's Humean gear. Only first I shall build the problem up in my own way, to provide a lay figure to hang the garments on.

2 | The Problem

Certified laws of nature are the primary products of scientific thought and observation. They embody the generalized knowledge which science yields; they supply explanations and predictions of events; and they un-

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derlie the design of most modern artefacts. To take just three obvious examples: our human life has been much altered in this century by the discovery and applications of laws governing plant genetics, aerodynamics and electromagnetic radiation.

Laws differ widely in their subject matter, importance and complexity. What they have in common is generality. A law says that *all* things or events of some kind have a certain property or are related in a certain way to something else. If the law is statistical, the property is having a chance of having some other property or of being related to something else. It is, for example, a law that all light has the property of going at the same speed in a vacuum; and it is a statistical law that all atoms of the most common isotope of radium have the same chance (fifty-fifty) of turning into something else within their half life of 1622 years.

What needs certifying about a law is its truth. We cannot know that all light goes at the same speed in a vacuum unless it truly does so. Its constant speed will not serve to explain or predict anything if its speed is not in fact constant. And it is unsafe to base the design of artefacts on what is not the case. We know of course that even a certified law may turn out to be false. But without good reason to think it true, we lack good reason to employ it as we do. This is why we do not call something a law unless we think it true, so that a false generalization cannot be a law, although it may be "lawlike": *i.e.* such that it would be a law if only it were true.

Certifying the truth of some laws presents no problem. These are the analytic laws, those whose truth follows from the meanings of the terms they are couched in. There are more reasons than one for laws being analytic. A law may be analytic because it is used to define one of its terms. Newton's laws of motion, for example, may well be analytic because between them they define the Newtonian concepts of force and mass. Or a law, not originally analytic, may become so successful and theoretically important that its terms change their meaning to make it analytic. For this reason it is now arguably analytic that light is electromagnetic radiation, although that could not have been the case when the electromagnetic theory was first conjectured to apply to light. Then, we could easily have envisaged observing light to go faster or slower, for example, than the theory can be shown (by measuring the ratio of electromagnetic to electrostatic units) to require electromagnetic radiation to go. Nowadays we should take such an observation to show some error in the theory rather than question the law that light is electromagnetic radiation.

But even if some laws are analytic, most laws are not, and these are the ones that concern me. It does not follow from the meanings of the terms involved that radium's half life is 1622 years, nor that benzene is as insoluble in water as it is. Nothing semantic prevents a little more benzene sometimes dissolving in water, or some piece of radium having a rather different half life. How then can we certify the truth of what the law says, namely that these things never happen? We cannot see that they never do, if only because at no time can we see that they never will do in the future. We cannot directly perceive the truth of nonanalytic laws. At most, our senses can show us some of a law's past instances, and then only instances of laws about relatively observable properties of things and events. We can observe the speed of this or that ray of light and, perhaps indirectly, the half life of this or that piece of radium; but not all the things and events, past, present and to come, to which the law applies.

The problem then arises why a supposed law should be expected to hold in instances as yet unobserved; in short, Hume's problem of induction. Unlike Popper and his followers, I believe that induction does present a genuine and serious problem, which needs solution and has not yet been solved; although I believe Braithwaite's (1953: Ch. 8) attempted solution is along the right lines.* But wherever its solution lies, Hume's problem does not arise only incidentally for laws of nature. On the contrary, it is an inevitable concomitant to their role in supplying predictions. To make a prediction is to anticipate, rightly or wrongly, the result of making an observation; to say or just to expect, for example, that a bomb will explode before we see it do so. Whatever purports, as a law does, to justify such an expectation necessarily arouses Hume's problem. Only a generalization certified by observing all its instances would be free of inductive pretensions, and such a generalization is not much use for predicting things. It might indeed have some use: one might accept it on someone else's authority and use it to predict some instances one had not observed oneself. But real laws are used amongst other things to predict the results of future observations, and these are not yet available to anyone to certify the law with (see Mellor 1979). Real laws therefore undeniably need inductive support.

The other philosophical problem which laws of nature present is the one that concerns us. It is less obvious than the problem of induction, but perhaps more tractable: what exactly do laws say? I have taken them to be generalizations, and there is not much doubt of that. The debatable question is whether laws are more than generalizations, and if so, what more. Now if giving laws one content rather than another made the problem of induction soluble for them, this would be a strong argument for giving them that content. But since I believe no such solution is presently available for any credible content, I must look to other arguments. Hume's problem does, however, provide a reason for preferring weak readings of

* The problem of induction is discussed in the readings by Lipton and Popper in chapter 4 and in the accompanying commentary. For Mellor's more recent views on induction, see D. H. Mellor, "The Warrant of Induction," in *Matters of Metaphysics* (Cambridge: University of Cambridge Press, 1991), 254–68.

natural laws. The less a law says, the less there is to be certified in claiming it to be true.

The weakest reading seems to be the obvious one I have already given:

1 All *F*s are *G*s,

where *F* and *G* are properties of things or events. They may be relational, comparative or quantitative properties; in statistical laws *G* will be some determinate chance of having another property. (1) is of course a very simple form of law, but it will do; it has all the relevantly problematic features of more complex forms. But before discussing its supposed deficiencies, some preliminary points need to be made clear.

First, as my examples have already illustrated, the 'are' in (1) is to be taken tenselessly. The law applies to all *F* items in the universe, past and future as well as present. The laws of radioactivity do not just give radium's present half life; they say what it always was and always will be. Now some of what we take to be physical constants, such as the half life of radioelements, might indeed turn out to depend on the age of the universe. But then the true laws of radioactivity would say what the dependence was. Those laws would, like all other true laws, apply at all times; the values of our supposed constants at particular epochs being merely special cases of the general laws.

Secondly, I take it that anything in the universe is definitely either *F* or not *F*, either *G* or not *G*. This is not an uncontentious claim. Some have been led to deny it of so-called "vague" properties like being bald, because of its seemingly absurd consequences (for example, that at some point adding just one hair to a bald man's head gets rid of his baldness). Others have been led to deny it of some things and events in the future, either because they want the future to be open, at least in some respects, to being made definite by human decision and consequent human action or because of problems raised by quantum mechanics. They think it cannot now be the case, for example, that I shall definitely either be dead or be alive next year, if it is still open to me and others to settle the matter by what we decide to do between now and then. I think that these are both inadequate grounds for denying that everything is definitely *F* or not *F*, but I shall not argue the point here. (On the first, see Cargile 1969; on the second see Mellor 1981. I also think my being wrong in either case would make little difference to the ensuing discussion, but I shall not argue that either.)

Thirdly, I exclude from the range of *F* and *G* factitious properties such as Goodman's (1965) notorious "grue" (= green if the item is inspected before a specified time, otherwise = blue). I hope and believe criteria can be given to rule out these phoney properties (see for example Hesse 1974: Ch. 3); but in any event all parties agree that they are phoney, and I shall take their exclusion for granted.

I should however emphasize that I do not mean to restrict *F* and *G* to physical, as opposed to psychological or social, properties. Some philosophers (*e.g.* Davidson 1970; McGinn 1978) deny the existence of laws relating nonphysical properties; but largely because they mistake laws to involve necessities of the kind I shall be concerned to dispute and which they correctly perceive to be absent from mental and social generalizations. Anyway the point should be left open here; so if I stick to physical examples, it is only to avoid irrelevant controversy, and not because I think there are no others.

With this preamble, we may now ask what, if anything, is wrong with (1) as a reading of laws of nature. To see what seems to be wrong, we must look at (1)'s consequences in special cases, particularly the case, on which Braithwaite concentrates, where nothing in the world is *F*.

One might imagine that it did not matter what follows from (1) when nothing is *F*, but it does. Let us call a law 'vacuous' in that case. Many important laws are vacuous in this sense. The most famous one is Newton's first law of motion, that bodies acted on by no forces are at rest or move at a constant speed in a straight line. The law is central to Newtonian mechanics, but Newton's own gravitational theory implies its vacuity, since the theory says that all bodies exert gravitational forces on each other. No doubt Newton's laws of motion are peculiar, since as already remarked they may well be analytic. But Newton's first law illustrates a vacuity which is shared by many laws that are in no way analytic. There is in particular a multitude of nonanalytic laws quantifying over determinate values of continuously variable determinables: for example, the laws relating the vapour pressure of substances to their temperature. Each determinate value of these determinables yields another law as a special case, such as the law giving the boiling point of water at atmospheric pressure. Now there are infinitely many different temperatures and pressures, and hence infinitely many of these derived laws, all with mutually incompatible antecedents (nothing can be wholly at two different temperatures or pressures at the same time). Although the temperature and pressure of any given mass of water will vary continuously with time, there are many temperatures which no mass of water ever reaches: temperatures, for example, so high that water would decompose before it reached them. At any rate, so far as these derived laws are concerned, it is entirely accidental whether any water ever is at the temperatures and pressures they apply to. Consequently they must certainly be so construed as to make equal sense whether they happen to be vacuous or not (*cf.* Ayer 1956: 224–5 [818]).

In particular, it seems obvious that mere vacuity should not settle the truth of a law regardless of its content. But a lack of *F*s makes 'All *F*s are *A*s' true for any *A*, including both *A* = *G* and *A* = not-*G*. If there never is any water at some temperature *T*, statements crediting all water at that temperature with any pressure whatever all come out true. That seems

absurd; so vacuous laws should be read as saying something other than 'All *F*s are *G*s'. The question is what.

The obvious answer is that a vacuous law says

2 If there were *F*s, they would be *G*s.

But there are objections to (2). One is that it appears to imply that there are no *F*s, whereas laws, even if they happen to be vacuous, certainly do not claim to be. We could in reply say that (2) is not to be read as having this implication; and this stipulation can indeed be given some independent rationale. A case can be made for saying that the implication is not part of what (2) says, but follows rather from applying general rules of discourse: namely, not to mislead, and to be as informative as possible (see Mackie 1973: 75–7). These rules dictate that one should not say (1) when the law is known to be vacuous, since (1) is no more true then than is any other generalization starting 'All *F*s are . . .'. To pick out as a law the generalization which relates *F* especially to *G* in these circumstances, one must have some reason other than its truth. The reason may not be specified, but the fact that there is one is signalled by using (2) instead of (1). Consequently, even if the law says no more than (1), (2) would normally be used when, but only when the law is known to be vacuous. So (2) will indeed signal its user's knowledge of the law's vacuity, even though that is no part of what (2) is being used to say.

This is one of the arguments which can be used to defend Humean accounts of laws as saying no more than (1). It still leaves the problems of saying what reason there is to link *F* and *G* as a law does when there are no *F*s, and why (2) should be the right way to signal this reason. These are among the problems that have exercised Braithwaite and his Humean successors. But since my concern here is with their rivals, I shall concentrate instead on recent attempts to solve the problem of vacuous laws by giving (2) some assertible content over and above (1).

Laws, I have remarked, do not claim to be vacuous, even if they are; and ideally, they should say the same thing whether they are vacuous or not. It will hardly do to make laws say (2) if they are vacuous and (1) if they are not. A law cannot say (1) in both cases, we are supposing; can it say (2)? We have dealt with the obvious objection by removing (2)'s counterfactual implication (that there are no *F*s), which would have made all nonvacuous lawlike generalizations false regardless of their content. What can be said positively in favour of the suggestion?

Consider the universe of non-*F* things or events of which a vacuous law says that if they were *F*s they would be *G*s. It is surely immaterial to this supposed fact about these things or events that there happens to be nothing else which is *F*. So perhaps we should take the *non*vacuous law also to say of every non-*F* thing or event that if it were *F* it would be *G*. But again, the law itself does not assert that these things or events are not

F. It should say the same of all things or events, whether they are *F* or not. Let us therefore take a law to say of every thing or event *x* that

3 If *x* were *F* it would be *G*.

(Those who believe in possible as well as actual things and events may take '*x*' to range over them too.) I shall take the problem for our non-Humeans to be that of saying what (3) means in this case.

I shall not demand of them a general analysis of so-called 'subjunctive' or 'counterfactual' conditionals like (3). A general analysis would of course have to cover those that we are supposing to give the content of natural laws. But I am not convinced that other uses of these conditionals are homogeneous enough with this one to shed much light on it. In most other uses, for example, (3) might very well imply that *x* is not *F*, which we have seen it cannot do here. Or again, to make (3) true of an *x*, it may often suffice for that *x* to be *F* and also *G*. Lewis's influential analysis, for example, takes this more or less for granted, and the way he reluctantly accommodates possible exceptions (1973: 29) will certainly not cope with natural laws. Yet natural laws must be exceptions: it might be a coincidence that an *x* is both *F* and *G*, and not a matter of natural law at all. So in this case it must take more than that to make (3) true of any *x*. And as our consideration of vacuous laws has shown, the extra cannot be that all other *F*s are *G*s too, for there might just as well be no other *F*s. So whether the law is vacuous or not, the truth of (1) will not suffice to make (3) true of everything. But what more than (1) can a law say?

3 | Possible Worlds

The traditional non-Humean answer is that natural laws are or express necessities of some kind: what makes (3) true of everything is that *F*s not merely are *G*s, they have to be; (1) is not merely true, it is necessarily so. Conceptions of law as what Kneale (1949) called 'principles of necessitation' are of course by no means new. The problem with them is to justify the idea of necessity they invoke and to show how it explains the universal truth of (3). Of late years, the development of so-called "possible world semantics" has made that problem look more tractable, and thus encouraged a revival of the idea that natural laws are necessary truths. It has done this by providing a systematic way of saying what makes statements of necessity (and of possibility) true. So in particular we might hope to find in it an acceptable way of saying what makes necessary natural laws true.

The basic concept of this semantics is that of a possible world. A possible world is a way the world might be, or might have been. There are many such ways, and therefore many possible worlds, of which the actual world is just one. Possible worlds are distinguished by what the facts are supposed to be in them: if the supposed facts differ at all, so do the worlds. I might, for instance, die in various ways, and, for each way, at various ages. So there are many possible worlds in which I expire of, say, cirrhosis (or my counterpart in that world does so; see Lewis 1973: 39), and these differ amongst other things according to my or my counterpart's age at the time. In general, a statement which might be true, but fails to specify every detail of the universe, will be true in many possible worlds, differing amongst themselves in the details left unspecified.

Having in some such manner as this grasped the idea of possible worlds, and reified them, one can turn round and give, as the truth conditions of a statement, the set of possible worlds in which it is true. That is how possible world semantics offers to give the meaning of various kinds of modal statements, and in particular of statements of necessity and possibility. How enlightening this conceptual round trip is, from what might be the case, to what is the case in a possible world, and back again, is a very moot point, but one that can be waived while we see how well the concept copes with the supposed necessity of natural laws.

It follows at once from the definition of a possible world that a statement which might be true is one that is true in some possible world. Hence statements which have to be true are those which are true in all possible worlds. In particular, for (1) to be necessarily true is for it to hold in all the worlds there might be or might have been. Is that really what a natural law claims?

Suppose it is: does that solve the problem of vacuous laws and explain (3)'s being true of everything in the actual world? Consider again the case where there are no actual *F*s. The law does not say there are none, and it is tempting to suppose there always might have been. If that were so, then, on this view of laws, (1) would have to be true not only in this world, but also in worlds containing *F*s where its truth would not be the trivial consequence of vacuity it is here. And that would certainly distinguish (1) as a law from other vacuously true generalizations.

But this account depends on the possibility of there being *F*s; and, on this view of laws, there will often be no such possibility. I have cited the example of high temperature instances of the vapour pressure law for water that are vacuous because water decomposes before it reaches those temperatures. Now, that water decomposes below these temperatures is itself a natural law and so, on this view of them, necessary. Consequently these high temperature instances of the vapour pressure law not only are vacuous, they have to be. There could be no water at such temperatures. But that is to say there are no possible worlds in which these instances are not vacuous; and therefore none in which the truth of this instance of (1) is other than a trivial consequence of vacuity.

So the idea of laws being true in all possible worlds does not solve the problem of vacuous laws. Nor, for much the same reason, does it explain why (3) is true of everything in this world. Again, it would if anything, *a*, in this world might have been *F* even if it isn't. Then there would be possible worlds in which *a* (or some counterpart of *a*) is in fact *F*; and in all these worlds it, like every other *F*, is *G*. Where that is so, it seems to me undeniable that (3) is true of *a*. However, for any *F* there will be many *as* of which it is quite incredible that they might have been *F*. Take the law that in a vacuum all light goes at a constant speed—which is to say that all photons do. It is true then, of anything at all, that it would go at that speed in a vacuum if it were a photon. But this is not to say of everything that it might have been a photon. There is no possible world in which I am (or any counterpart of me is) a photon; and *a fortiori* none in which, as a photon, I (or any counterparts of me) travel at the speed of light. That is not, I believe, what makes this instance of (3) true of me. Yet I believe it is true of me, since I believe the law; and there is surely no inconsistency in my combining these beliefs.

For subjunctive conditionals like (3) to be true, their antecedents do not have to be possible. This is blatantly obvious in *reductio ad absurdum* proofs, where the truth of a subjunctive conditional is actually used to prove that its antecedent is *not* possible. One and one cannot make three precisely because, if they were to, something impossible would be the case. It should be almost as obvious that conditionals which give the content of natural laws likewise do not imply the possibility of their antecedents being true. The vapour pressure example shows at least that they cannot both do this and themselves be necessary truths. And I have given elsewhere (1974: 173) the example of safety precautions at a nuclear power station, which are supposed to make impossible the conditions under which, as a matter of natural law, the fuel would explode. It is ridiculous to maintain that the success of these precautions would disprove the very law that makes them necessary.

I am not sure why (3) should be so often thought to imply that *x* might be *F*. The reason may well be the same for taking (3) to imply that *x* is not *F*: namely, that it is customary to reserve subjunctive conditionals for use when their antecedents are believed to be false but possible. We see, however, that this custom is not invariable, and have in any case seen reason (see p. 851) not to make such a custom part of a conditional's meaning. So however natural the thought may be, it is mistaken, at least of the conditionals implied by natural laws. But the mistake is very widespread and of long standing, and it has had serious consequences. It has bedevilled the analysis of disposition statements, as I argued in §9 of my (1974). It has likewise afflicted discussions of free will, in which 'I could have done *X*' is frequently equated with 'I would (or could) have done X had I chosen to'. But it obviously does not follow from the latter that I could have done X, since it obviously does not follow that I could have chosen to.

The common confounding of conditional statements with statements of possibility has thus had ill effects in more than one area of philosophy.

The ill effect here has been that possible world semantics have been mistakenly thought to give sense to the idea that natural laws are, or assert, some kind of necessity.

4 | Natural Necessity

Laws might however still be necessary even if possible world semantics fails to say what makes them so. What makes (3) true of everything might still be that nothing could be both *F* and not *G*, whether or not it could be *F*. But it is not at all obvious that this is so. Subjunctive conditionals are not in general made true by necessities. Suppose that if I were to go to London I would go by train. This does not mean that I could not go any other way, merely that I would not. Lewis's (1973) treatment of subjunctive conditionals recognizes this fact about them: the consequent does not have to be true in all the possible worlds the antecedent is true in, only in those most like the real world.

Still, I have insisted that conditionals like (3) which follow from laws are a special case. In particular, it does not suffice for their truth that their antecedents and consequents are true; whereas my going to London by train may well make it true that, were I to go, I would go that way. So perhaps (3) does need some necessity to make it true of everything, even if conditionals in general do not.

But most natural laws seem to be contingent. Apart from those that are definitions, and those whose success has made them analytic, any law might have been false. We could have come across a counterexample to it; and we still could, even if we never will or would. That seems at any rate to be why we need to test our supposed laws by observation: things could be other than the law says, so we need to look and see whether or not they are. I believe, for example, that light could have gone in a vacuum at other than its constant speed, even if no photon ever does and even if nothing, were it a photon, ever would. So on the face of it, conditionals like (3) no more exhibit necessity than does the conditional about my going to London by train.

Attempts have been made to explain away the apparent contingency of natural laws. One attempt, which need not detain us long, distinguishes logical necessity and possibility from their natural or physical counterparts. It is logically possible for *F*s not to be *G*, but not naturally or physically possible. But all 'physically possible' means is 'consistent with natural law'. So to say that something is physically necessary is merely to say that some law entails it. Whether the law says it has to happen, and whether the law itself has to be true, remain entirely open questions.

A more serious attempt distinguishes between metaphysical and epistemic necessities (Kripke 1971: 150–1; Dummett 1973: 121); that is, between being necessary and being knowable *a priori*. Laws appear to be contingent because they cannot be known *a priori*. They cannot be proved in the way the truths of logic and mathematics can. We need to look and see what the world's laws are, and it may always turn out that what was thought to be a law really is not one. The *F*s we have seen to be *G* may mislead us into believing they all are, even though some future ones are not. It is consistent with all we have seen that there should be *F*s which are not *G*. That is the epistemic possibility of a supposed law being false; and something like it exists in mathematics. There too, special cases may mislead us into believing a mathematical generalization to which there are in fact counterexamples. Now, recognizing this possibility in mathematics does not diminish our belief in the necessity of mathematical truths: if the generalization *is* true, it could not have been otherwise. It is likewise conceivable that natural laws, if true, are necessarily so, even though we may be mistaken in what we suppose the true laws to be.

The apparent contingency of natural laws could undoubtedly be explained away like this if there were good reason to think them necessary: but is there? The analogy with mathematics certainly does not give one. If Goldbach's conjecture proves true, any attempt to suppose it false will eventually lead to contradiction (that of course being one way of proving it). In that case no consistent description could be given of a world in which the conjecture was true. That is, there is no such possible world. We might therefore explain the conjecture's necessity, if true, as truth in all possible, *i.e.* coherently conceivable worlds; since conceivability is a notion arguably more basic than necessity and intelligible independently of it. But no such case can be made for the corresponding conception of natural necessity. As Hume insisted, there is no difficulty in conceiving a natural law to be false: since it is not analytic, no contradiction ensues. A perfectly coherent description can be given of a world containing *F*s that are not *G*. The only ground for thinking such a world impossible would be that the law which would be false in it is not only true but necessary; and this is the very fact that needs to be established and explained.

5 | Essences

Arguments have recently appeared for the metaphysical necessity of some laws, namely those specifying essential properties of natural kinds. An essential property of a kind is one which nothing of that kind can lack. So if being *G* is of the essence of a kind *F*, the law that all *F*s are *G*s will be a necessary truth. The exemplars most widely touted by advocates of essences concern the microstructure of kinds: the atomic number of gold, the molecular constitution of water, the genetic makeup of plant and animal species, and the mean kinetic energy of gas particles at a given temperature. The question is: why suppose that these, or any other, properties of kinds are essential?

Two sorts of arguments have lately been adduced for essences, and hence for the necessity of the corresponding laws. Both employ possible world semantics; neither therefore proves more than that some generalizations hold in all possible worlds, and we have seen in [section] 3 that this is not enough to serve our turn. But the arguments repay scrutiny nonetheless, since there is more to them than the possible world jargon they are couched in.

One argument, due to Putnam (1975), infers essences from a mechanism for fixing what things or events a kind predicate ('*F*') applies to, *i.e.* its extension. This mechanism fixes what things are, or might be, *F*s in two stages. First, there are archetypal actual *F*s (*e.g.* paradigm specimens of gold or water): things that have to be *F* if anything is. Second, to be *F*, anything else has to have a suitable 'same-kind' relation to these archetypes. What this means is that it has to share some property with them—apart of course from the property *F*. What the same-kind relation is, for any category of kinds, it is for empirically testable scientific theories to say. The relations are not discoverable *a priori*, and in particular they do not follow from the meanings of the predicates involved: the laws giving the essences of kinds are not supposed to be analytic. But any shared property *G* which a same-kind relation picks out will be an essential property of the kind since, Putnam assumes (1975: 232), the relation is an equivalence relation holding across all possible worlds. Thus not only are actual *F*s all *G*s, all possible *F*s are: so (1) in this instance is true in all possible worlds.

I have elaborated elsewhere (1977) my reasons for rejecting this argument. Briefly, the extensions of real natural kinds do not in the first place depend on archetypes in the way Putnam's mechanism requires. And, in the second place, even if they did, his mechanism would still not produce essences. To produce an essence, the same-kind relation must be transitive, in order to ensure that all possible *F*s share the *same* property *G* with each other. But the mechanism does not need a transitive relation, since what makes things *F*s in other possible worlds is their sharing some property other than *F* with the archetypal *F*s in this one, and there is nothing to say this shared property must be the same in every possible world. For Putnam to claim the same-kind relation to be transitive, which he does in taking it to be an equivalence relation, is for him gratuitously to assume the essentialist conclusion he is out to prove. His mechanism in fact gives us no reason to think any instance of (1) true in all possible worlds. And since in any case only those giving essences are in question, Putnam's theory, even if it worked, would not solve the general problem of distinguishing laws from universal coincidences.

The same of course is true of Kripke's (1971, 1972) argument for essences; but that too we must look at, since solving our problem for some laws would at least be better than solving it for none. Kripke's argument is quite different from Putnam's. Kripke takes laws giving essences to be identity statements: the law 'Water is H_2O' he takes to say not merely that anything, were it water, would be H_2O, but that being water and being H_2O are one and the same property. But identity is a necessary relation, in the sense that nothing could fail to be identical to itself. So being water and being H_2O are the same property in all possible worlds, not only in this one. Nothing that could be water could fail, were it water, to be H_2O.

This of course is the merest sketch of Kripke's argument. He has, for example, also to show that 'water' and 'H_2O' are what he calls 'rigid designators', *i.e.* that they refer to the same stuff in any possible world it exists in. Otherwise the identity statement, since it is not analytic, might be true without being necessary, as for example 'Water is the most powerful solvent' is. ('The most powerful solvent' is not a rigid designator: it refers to whatever the most powerful solvent is, which in a world restricted largely to oil products would not be water.) As I have abbreviated Kripke's argument, so I shall abbreviate the objections raised in my (1977). The chief objection is that the argument, like Putnam's, blatantly begs the question: for being water and being H_2O to be the same property at all, never mind necessarily, the predicates '. . . is water' and '. . . is H_2O' must already be coextensive in all possible worlds. This is not a conclusion to be derived from the necessity of the identity: it is built into the identity as a premise. Granted, 'Water is H_2O' states a true law, and it has the form of an identity statement. But it is clearly only a variant of 'All water is H_2O', which does not have that form. At any rate, the identity of these properties only follows if 'water' and 'H_2O' are rigid designators, *i.e.* could not refer to different properties. But to believe this, one needs already to believe what the argument from this premiss is supposed to show: namely, that there could not have been some samples of water of a different molecular constitution.

Kripke, like Putnam, fails to establish the existence of essences. The microstructural exemplars which give their doctrine its spurious appeal indeed have a special status in science, but not the status of essences. They are special because they are central to our current scientific theories; but that, I have argued elsewhere (1977: §7), is quite a different matter from being necessary features of the world.

6 | Universals

The properties of being water and being H_2O do not stand in the necessary relation of identity. Perhaps, however, as Armstrong (1978a: Ch. 24), Dretske (1977) and Tooley (1977) have suggested, these universals stand in some contingent relation which makes it a law that all water is H_2O. This relation, that is to hold between the properties *F* and *G* whenever 'All *F* are *G*' is a law, Armstrong and Tooley call 'nomic necessitation'; I shall

call it 'N'. *F* and *G* have to be differently related if the law is that no *F* are *G* or that all *F* have a chance *p* of being *G*. But N will do for now: if it works, the other relations will; if not, nor will they.

This suggestion requires a realist view of at least those universals which are related by natural laws: for N to relate *F* and *G*, these properties must exist. That of course is debatable, but suppose for the moment it is true. Then *FNG* is by definition the fact that makes 'All *F*s are *G*s' a law. This is a contingent fact, and not only because *F* and *G* might not exist. *F* and *G* could quite well exist without 'All *F*s are *G*s' being a law: laws do not relate every property to every other property. Being water and being at 100°C, for example, are properties that enter into laws, yet no law relates them to each other. But though it is not, it might have been a law that all water is at 100°C; just as it might not have been a law that all water boils at that temperature at atmospheric pressure. Apart from analytic laws, therefore, it is quite contingent that N relates any particular *F* and *G*.

To do its job, N has not only to make *G*s out of actual *F*s, it has to make (3) true of everything, *i.e.* to be such that anything, were it *F*, would be *G*. Since this is all it has to do and be, one might think that postulating N is more a relabelling of the problem than a solution to it. But that would not be a fair response. There is a dearth of candidates for making (3) universally true, as we take it to be. If *F*, *G* and N would between them make it true, that may well, as Tooley (1977: 262) urges, be reason enough to believe in them.

After all, we already invoke properties to make conditionals true. The inertial mass, *m* kilogrammes, of a thing *a* at time *t* makes true all the conditionals of the form

> 4 If *a* were subjected at *t* to a force of *f* newtons, it would then accelerate in the direction of the force at *f*/*m* metres/second^2.

Any of these conditionals is in fact a generalization about events, namely that, if they were subjectings of *a* to a (specific) force *f* at *t*, they would be (or be shortly followed by) accelerations of *a* of magnitude *f*/*m*. These generalizations are just like the conditionals (3) entailed by laws, except that they are restricted to the individual *a*. We think them true, and a fact is needed to make them so: and the requisite fact is that *a* has mass *m* at time *t*. This is all the property of inertial mass amounts to: a truth-maker, as Tooley puts it, for conditionals like (4); and I have argued elsewhere (1974) that all properties of things are just truth-makers for such conditionals. But if we believe in properties *F* and *G* because they are needed (and suffice) to make conditionals like (4) true, why jib at accepting N when it is likewise needed and (with *F* and *G*) suffices to make conditionals like (3) true?

Here, however, the crucial difference between (3) and (4) emerges: (4) entails that *a* exists. Without *a*, '*a*' would have no reference, and I do not see what (4) could then mean, nor how in particular it could be true.

So if (4) is true, *a* exists; so the fact that *a* has mass *m* is always available to make (4) true. But it is by no means so clear that *F* and *G* exist whenever (3) is true of everything. The law that all *F* are *G*, it is agreed, may be vacuous: and if it is, there are no *F*s. Now if, as many (including Armstrong) suppose, properties and other universals need instances, then without *F*s there will be no *F*. But without *F* there will be no fact *FNG* to make (3) true of everything; and the problem of accounting for vacuous laws will remain unsolved.

Perhaps then universals need no instances. Concepts certainly do not: we can have the concept of a unicorn without there being unicorns. But universals are not concepts: concepts, if anything, are parts of our thought or our language; whereas universals, if anything, are parts of the world whether or not it contains any thought or language or concepts. No doubt concepts are closely related to universals, but it is not safe to assume that universals can dispense with instances just because concepts can. That remains an open question.

Tooley takes it for granted that universals need no instances, since he uses a particular example of a vacuous law to argue by elimination "that it must be facts about universals that serve as the truth-makers for basic laws without positive instances" (1977: 672), going on to ask rhetorically: "if facts about universals constitute the truth-makers for some laws, why shouldn't they constitute the truth-makers for all laws?" Armstrong, by contrast, holds a "Principle of Instantiation: For each N-adic universal, U, there exist at least N particulars such that they U" (1978: 113); but he offers nonetheless to cope with Tooley's example of a vacuous law. Now if Armstrong really can supply enough universals to make vacuous laws true, without violating his principle of instantiation, we may not have to decide whether universals do in fact need instances; but can he?

In Tooley's example, as Armstrong puts it, just two out of several types of particle happen never to meet; so the law governing their interaction is vacuous. Nevertheless particles of other types meet, so that the universal, meeting (M), exists; as do these two mutually evasive particle types (A and J). Armstrong can claim therefore that the law, despite being vacuous, "holds in virtue of the universals [A, J, M] being what they are" (1978a: 157). This solution, however, is only available for special cases of vacuous laws. For a start, it only works here because particles of other types do meet, thereby ensuring the existence of the universal M. Now if the law governing A and J particle interactions does not ensure their meeting, it can hardly ensure the meeting of other types of particles; and if A and J particles can fail to meet, so can others. If no particles ever met, the laws of all their interactions would still be true, but the universal M would not, for Armstrong, exist to make them so.

More seriously, not only might there be no meetings, there might be no A or no J type particles. Yet the law could still be true and important, even if there were nothing it applied to. We have seen that to be the case

with Newton's first law of motion, and the vacuous instances of vapour pressure laws. For these, and indeed for the bulk of vacuous laws, Armstrong's principle of instantiation does deprive him of the universals he needs as truth-makers. The Tooley case he discusses happens to be of the only sort he can cope with, and it is worth drawing out what makes cases of this sort amenable to Armstrong's treatment: namely, that in them there exist things with properties which make certain generalizations true. These are in fact generalizations of conditionals like (4) above. Consider that for many determinate values of the determinable force *f*, (4) is vacuous: *a* can only be subjected to one (net) force at any one time, and there will be many forces *a* never experiences. Yet *a*'s always having mass *m* suffices to make all these vacuous generalizations true. And so it is with Armstrong's A and J particles. While they exist, they are disposed to interact as the law says, whether they ever actually meet or not. Armstrong's universals A and J are just conjunctions of such dispositions (see Mellor 1974), and can thus be truth-makers for those laws whose vacuity results merely from the dispositions of actual things failing to display themselves. But not for the more important cases in which laws are made vacuous by the non-existence of the things themselves; and hereafter I will reserve the term 'vacuous' for such cases.

Since vacuous laws will in fact defeat the Armstrong-Dretske-Tooley account if universals need instances, we have after all to consider whether they do. I follow Ramsey in taking particulars and universals to be simply parts of facts picked out in order to generalize. For example, "It is not '*aRb*' but '(*x*)*xRb*' which makes *Rb* prominent. In writing '(*x*)*xRb*' we use the expression '*Rb*' to collect together the set of propositions *xRb* which we want to assert to be true" (Ramsey 1925: 28–9). To recover a proposition from this set, we need to know what an instance of *xRb* is, *i.e.* we need criteria for identifying the items, such as *a*, which have been quantified over. But we do not need separate criteria to identify *Rb*. Given *a*, *Rb* is just the remainder of the fact *aRb*. If it were an independently identifiable constituent, then, as Ramsey says (1925: 23–4), *a*(*Rb*) would differ from (*aR*)*b* and *a*(*R*)*b*, because these facts would have different constituents; and this is absurd.

Similarly, if we form the doubly general '(*x*)(*y*)*xRy*', we must regard the universal *R* as just the common part of all the facts thus collected: the fact *aRb* minus *a* and *b*. And since in forming the law that all *F*s are *G*s we at least collect whatever facts such as *Fa* there may be, the universal *F* must likewise just be the common part of all such facts. At least in laws, therefore, a universal must be regarded as derived from the particulars which are its instances and the facts that they are so. To regard them, as extreme realists do, as a primitive kind of entity, distinct from particulars but able to combine with them to yield facts, is to put the universal cart before the factual horse. It does nothing but pose such ancient but manifestly dotty conundrums as: why there are these two different kinds of entity, particulars and universals, and what the difference between them is; why two entities of the same kind (two particulars or two universals) cannot combine to form a fact; what the relation is between a particular and a universal that are so combined. The last question on its own is fatal to this view, since any answer to it immediately generates Bradley's (1897: Ch. 3) notoriously vicious regress; a regress not avoided just by Armstrong's ingenuous device of calling the relation in question a "union . . . closer than relation" (1978a: 3).

The fact is, as Ramsey showed, that we have no *a priori* reason to suppose that universals are fundamentally different in kind from particulars. What we think of as particulars are merely the kinds of entity we can most readily individuate, typically by appeal to their spatio-temporal location (*cf.* Braithwaite 1926); and a universal is just the common residue of a set of facts about such individuals. So there is really no mystery about what relates particular to universal in a fact, nor about why a fact has to contain at least one of each. Nor is there any general reason why residual universals cannot themselves be individuated and so admitted in their own right as entities to be quantified over—thus, for example, leaving the particular *a* as the common residue of a set of facts about *a*'s properties. Nominalism therefore is not the only, nor the most sensible, alternative to an extreme realism about universals.

From this Ramseyan account of universals it does however follow that they need instances: Armstrong's principle of instantiation is quite right. In the law that all *F*s are *G*s, the property *F* is just the residue of such facts as *Fa*. If the law is vacuous, there are no such facts; and no facts leave no residue. If there are no *F*s, there is no *F*. So there will be no fact *FNG* to make such a vacuous law true, and the Armstrong-Dretske-Tooley theory fails. Whether there are "real connections of universals", as Ramsey put it, I do not know: like him, "I cannot deny it; for I can understand nothing by such a phrase; what we call causal laws I find to be nothing of the sort" (Ramsey 1929: 148).

7 | Epilogue

I have considered two attempts, seriously undertaken of late years, to make natural laws say more than generalizations; both fail. The law that all *F*s are *G*s is given the force it needs neither by taking it to say that 'All *F*s are *G*s' is true in all possible worlds or is in some other sense necessary, nor by taking it to assert a contingent relation between *F* and *G*. Neither construal can cover the crucial case of vacuous laws which Braithwaite rightly stresses. There are no doubt likewise aspects of the problems of laws which solutions of Braithwaite's Humean cut also have difficulty covering; only they, to my mind, are more readily patched up. Those patches, however, must be woven elsewhere.[1]

Notes

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