On the abuse of the necessary *a posteriori*

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Please do not cite this version. The published version is: 'On the abuse of the necessary *a posteriori*', with N. Sabbarton-Leary, in Beebee & Sabbarton-Leary, eds., *The Semantics and Metaphysics of Natural Kinds* (New York: Routledge, 2010)

1. INTRODUCTION

Since Kripke famously argued that necessity and *a priority* can, in some circumstances, come apart, contemporary metaphysicians have increasingly appealed to the category of the necessary *a posteriori*. What they generally fail to do, however, is provide any *argument* for why the truths in question fall into this category. But arguments are needed. Even if we accept that Kripke's story holds for proper names and natural kind terms, it can by no means be taken for granted that the story extends to cover other cases. This paper rehearses the general argument that such arguments are indeed required, and discusses in detail one example of abuse of the necessary *a posteriori*: Brian Ellis's 'scientific essentialism' (SE), according to which the laws of nature are metaphysically necessary but knowable only *a posteriori*. Ellis grounds this alleged feature of laws in a conception of natural kinds that extends well beyond standard cases of molecular constitution and biological species ('water', 'gold' and 'tiger', to use Kripke's examples); we shall argue both that Ellis provides no convincing arguments for this extension, and that there are good reasons for thinking that no such arguments can be given.[1]

We shall proceed as follows. In §2, we draw out the consequences of Kripke's account of the semantics of natural kinds terms for anyone who wants to claim that the category of the necessary *a posteriori* is in fact much broader than Kripke suggests. In §3 we turn Brian Ellis's scientific essentialism (SE), and argue that there are clear cases of Ellisian 'natural kinds' that fail to fit Kripke's model, and hence cannot be thought to generate the *a posteriori* necessities that Ellis claims to hold for natural kinds in general. In §4, we

assess the consequences for SE, and argue that the lack of the relevant *a posteriori* necessities undermines Ellis's own account of *de re* necessity. Finally, in §5, we offer a brief diagnosis.

2. THEORETICAL IDENTITIES AND THE NECESSARY *A POSTERIORI*

Kripke argues that 'theoretical identity' statements, such as 'gold is the element with atomic number 79' and 'water is H_2O', are metaphysically necessary but knowable only *a posteriori*. As we pointed out in the introduction to this book, it is relatively uncontroversial that Kripke takes the terms on the left-hand sides of such 'identity' statements to be analogous to proper names such as 'Ehrich Weiss' and 'Harry Houdini' in that they are (i) non-descriptive, (ii) rigid, and (iii) introduced by ostensive baptism (or description, but where this description need have no bearing on the reference of the term). However, it is a matter of some controversy what Kripke thinks the semantic status of the terms appearing on the right-hand sides ('the element with atomic number 79'; 'H_2O') are. We favour an interpretation of Kripke that takes such terms to be a description of the essence of the natural kind in question, so that, for example, *having 79 protons in its nucleus* is the essence of gold, and *being constituted by molecules composed of two hydrogen and one oxygen atom* (perhaps along with some structural features of the molecules) is the essence of water. Thus the phrases that appear on the right-hand side of Kripke's paradigmatic theoretical identification sentences are (i) definite descriptions (used attributively), (ii) *de facto* rigid, and (iii) discovered and described by science rather than ostensively introduced.

The treatment of theoretical identifications as part of the category of the necessary *a posteriori* is thus – given the difference between expressions like 'the element with atomic number 79' and 'Harry Houdini' – not warranted by appeal to the similarities between proper names and natural kind terms alone. Insofar as Kripke offers any *argument* for the claim that facts like 'water is H_2O' are necessary yet knowable *a posteriori*, they are abbreviated analogues of Putnam's Twin Earth thought experiment (Putnam 1973): our initial identification of water was via its observable, characteristic

properties, for example its 'feel, appearance and perhaps taste' (Kripke 1980: 128), but as science improves we eventually discover that water is H_2O. Now Kripke invites us to imagine a scenario where there is a substance that has a 'completely different atomic structure from that of water, but resembled water in these [characteristic] respects' (*ibid.*); is this water? According to Kripke the answer is no. Just 'as there is a fool's gold there could be a fool's water' (*ibid*.). Given that water *is* H_2O, nothing lacking that atomic structure could be water.

The above interpretation of Kripke's account of natural kind terms is perhaps controversial. Nonetheless – and this is really all that matters for the purposes of this paper – it does at least show that Kripke provides the resources for two distinctively different routes for arguing that a given 'theoretical identity' statement is necessary *a posteriori*. One route is analogous to the route Kripke describes in the case of proper names. If one can plausibly maintain that the two terms in the 'identity' statement are *both* analogous to proper names (as perhaps 'gold' is, but 'the element with atomic number 79' clearly – we believe – is not), whose reference traces back to two distinct baptismal events which happen to name the same kind, then one has a good case for claiming that the relevant identity claim is necessary *a posteriori*. This route will play no role in what follows, since Ellis is explicitly concerned with essences.[2]

The other route is the route we attribute to Kripke above in the case of natural kind terms, and our starting-point for the rest of this paper. Here, the term on the left ('gold') is analogous to a proper name and names a natural kind, and the term on the right ('the element with atomic number 79') specifies the essence of that kind. But one must *argue* that one's alleged case of a necessary *a posteriori* truth fits this model, and such an argument would seem to require two specific components:

Necessity: Consider the case of water. Let's grant that water has a straightforward underlying nature: actual samples of water are samples of a substance that is composed of

molecules, each of which is composed in turn of two hydrogen atoms and one oxygen atom[3]. It does not follow, however, that 'water is H_20' is *necessary*, because it does not follow that the underlying nature is water's *essence*. For of course it might be, for all that has been said so far, that the term 'water' is not analogous to a proper name: it might have a meaning such as 'whatever potable liquid is typically to be found in rivers and lakes and falls from the sky', in which case the claim that water is H_20 would be contingent rather than necessary. In order to rule this possibility out, we have to run a Twin Earth-style thought experiment: it is only the fact that we (allegedly) intuitively judge that XYZ is not water, despite meeting the above description, that justifies the claim that water's underlying nature is its essence, and hence that 'water is H_20' is necessary.

A Posteriority: Even if we suppose that the relevant underlying nature *is* the essence of the kind in question, it still does not follow that we have a case of a necessary *a posteriori* truth. For it might be that the relevant rigid designator on the left of our theoretical 'identification' is introduced as a matter of stipulative definition, just as a bachelor is defined to be an unmarried man. Or it might be that it is what we shall call a 'descriptor':[4] a designator that has descriptive content that uniquely identifies the kind in question. Either way, the truth in question will be necessary but knowable *a priori*. Clearly this is not the case for 'water', since the word was around a long time before anyone knew the underlying nature of the substance the term refers to. But for many terms – and in particular for many of the terms typically assumed by essentialists to generate *a posteriori* necessities – it looks a lot more plausible that the term either is introduced as a matter of stipulative definition ('lepton' and 'Higgs boson', perhaps) or else is a descriptor ('ununseptium'). In order to rule this possibility out, then, one needs to provide an argument for the claim that the relevant term was not introduced by stipulative definition and is not a descriptor, so that it can plausibly be claimed that the essence of the kind is not simply the meaning of the kind term.

Kripke's own examples of natural kind terms, of course – 'gold', 'tiger', 'water' – are all a part of ordinary language, and (as we just saw for 'water') it would – by Kripkean lights anyway – be implausible to maintain that their meaning is the underlying essence of the kinds in question. Hence his argument focuses on Twin-Earth-style thought experiments, and he does not bother to argue explicitly for *A Posteriority* in the sense described above. The situation is rather different for many contemporary essentialists, who are largely concerned with the *fundamental* joints in nature, which are likely to be found in the classifications of physics rather than those of ordinary language-users. Given these philosophers' conception of natural kinds, hardly any natural kinds have ordinary-language names like 'gold' attached to them. Hence, as we shall see in the case of Ellis, the argumentative lacunae in their views tend to be found in the absence of any defence of *A Posteriority* rather than *Necessity*.

However, since an argument for *A Posteriority* involves arguing that a given term is not introduced by stipulative definition and is not a descriptor, such an argument will always open up the possibility described in *Necessity*: that what is discovered *a posteriori* is merely the underlying nature of the kind in question, rather than its essence; and this possibility will in turn need to be removed using a Twin-Earth-style thought experiment. So a complete argument for necessary *a posteriority* will, in the end, need to cover both bases.

3. ELLIS ON NATURAL KINDS AND LAWS

Brian Ellis's *Scientific Essentialism* (2001) presents a full-blown essentialist theory of the fundamental nature of reality. For Ellis, there are several kinds of natural kind: substantive kinds (proton, hydrogen atom), dynamic kinds or kinds of processes (β-decay, refraction, electromagnetic radiation), and property kinds (having a rest mass of two grammes, having spin ½). Natural kinds form a hierarchy, so that, for example, *nitrogen* is one 'infimic species' (and hence itself a natural kind) of the more general kind, *element*, and hydrogen atoms are members of one infimic species of the more general kind *atom*.

Natural kinds, for Ellis, ground laws of nature, and these laws are necessary *a posteriori.* Thus, for example:

> The laws of electromagnetism … must hold of electromagnetism in any world in which electromagnetic radiation may exist. The laws had to be discovered empirically, of course, so they are *a posteriori*, in the way that all empirical generalizations are. But what has been discovered is the essential nature of such radiation – that is, the properties and structure that any radiation must have if it is to be electromagnetic radiation. The laws of electromagnetism are thus necessary *de re*. (2001: 226)

Similarly for substantive and property kinds:

> … it is a necessary truth that a thing of kind *K* has the property *P* if *P* is an essential property of *K*. It is, of course, *a posteriori* what properties are essential to a given kind. Therefore, the proposition that things of the kind *K* have the property *P* is what I call 'really necessary'. If *P* is a natural dispositional property, then it is also a necessary truth that anything having the property *P* must be disposed to behave in certain ways in certain circumstances just in virtue of having this property. Of course, we have to discover empirically what kinds of dispositional properties exist. But if anything has the property *P*, it must be disposed to behave in a *P*-wise fashion, just in virtue of being a thing of this kind. Therefore, if the laws of nature are propositions stating facts of this sort, then they too are really necessary. (2001: 219)

The first point that needs to be made about Ellis's position is that he simply takes it for granted that it is '*a posteriori* what properties are essential to a given kind': the essential natures of natural kinds are for scientists to discover by empirical investigation. This is a very large assumption indeed. Granted that Kripke shows this to be so for the

kinds *gold*, *water* and *tiger* – and perhaps we can generalize to cover those basic chemical kinds and biological species for which we have names in ordinary language ('diamond', 'dog', 'charcoal' and so on) – we cannot massively expand the remit of natural kinds terms and assume without argument that what goes for Kripke's natural kinds goes for all natural kinds, given our expanded conception of them. After all, while Kripke is undoubtedly giving an account of natural kind terms, in effect for Kripke what *makes* something a natural kind term is the fact that it obeys the requirements of his theory. If one wishes to expand the extension of 'natural kind' to cover cases that are manifestly highly dissimilar from Kripke's examples (so that it covers, for example, leptons and refraction), one needs to *show* that the terms used to denote these kinds obey Kripkean semantics, if one wishes to preserve Kripke's claim about *a posteriority*. This is not something that Ellis does. Indeed, he explicitly says that his 'concerns are different from Kripke's. Kripke's essentialism was developed in relation to theories of reference and identity. Scientific essentialism [that is, Ellis's view] derives from an examination of the scientific practice of theoretical identification' (2001: 54). But of course if Ellis means something like what Kripke means by 'theoretical identification' – which he does, because he holds that that the relevant identifications will be necessary *a posteriori* – then Ellis should be just as concerned as Kripke is with reference and identity: without an argument that what goes for gold and water goes equally for leptons and refraction, his claim that natural kinds (as he understands them) *in general* generate *a posteriori* necessities is unwarranted.

Of course, the claim may yet be plausible or warrantable, even though Ellis himself does not make the argument himself. But consideration of some particular cases of chemical and process kinds will demonstrate that there are at least some natural kinds (in Ellis's sense) that manifestly do not generate *a posteriori* necessities. We shall focus primarily, in §3.1, on the case of natural kinds of substance, and deal only briefly, in §3.2, with process kinds.

3.1 Substance kinds

Recently (in June 2009) the International Union of Pure and Applied Chemistry (IUPAC) confirmed the discovery (or rather, manufacture) of element 112 by Sigurd Hoffman and his team at the Centre for Heavy Ion Research in Germany, which is soon to be added to the periodic table. Chemists concerned with nomenclature – the systematic naming of substances – have introduced a decisive system for the introduction of 'temporary designators'[5], used to name elements for which there is evidence they exist, but where that evidence falls short of conclusive proof. In such cases the IUPAC advise that an element name be 'derived directly from the atomic number of the element' (Connelly et al 2005: 47). Element 112 was first reported in the mid-90s, but IUPAC standards deem that a single reported discovery is insufficient to confirm the existence of a new element. Hence a temporary designator was introduced to refer to element 112. The systematic rules are based upon ten numerical roots. Each numeral of the atomic number of an element is replaced with the corresponding letters. Thus '1' is replace by 'un' for both the first and second numerals, and '2' is replaced by 'bi', and the series of letters is 'terminated by "ium" to spell out the name' (*ibid*.). Finally, following convention, the 'i' of 'bi' is elided to give us the element name 'ununbium'.[6]

Similar examples using descriptors are also available for more complex kinds. Consider the compound consisting of molecules of PCl_3. According to IUPAC there are three distinct systems of nomenclature that can be used to generate three distinct names for the same compound, and our choice of which to use is determined, in part, by how much information we are intending to convey with that name. The simplest *compositional nomenclature* employs a system that recommends names 'which are based solely on the composition of the substance' (Connelly et al 2005: 5) and stipulates certain grammatical rules 'to specify the ordering of components, the use of multiplicative prefixes, and the proper ending for the names of electronegative components' (*ibid*.: 6). On this system PCl_3 comes out as phosphorus trichloride. The second, more complex, system is *substitutive nomenclature*, and is 'based on the concept of a parent hydride modified by substitution of hydrogen atoms by atoms and/or groups' (*ibid.*). The nomenclature specifies rules for naming the parent compound and substituent atoms and/or groups of atoms. In this case PCl_3 comes out at trichlorophosphane. Finally, the most complex

system is *additive nomenclature*, where compounds are treated as the 'combination of a central atom or central atoms with associated ligands' (*ibid*.: 7). 'Ligand' is the term used to denote any substance, be it an atom or a molecule, that is bonded to the central atom. The grammatical rules of the *additive nomenclature* 'provide ligand names and guidelines for the order of citation of ligand names and central atoms names, designation of charge or unpaired electrons… [and] designation of spatial relations' (*ibid.*). On this system PCl_3 comes out as trichloridophosphorus.

Each of the names – 'phosphorus trichloride', 'trichlorophosphane' and 'trichloridophosphorus' – communicates some basic information even to laymen who are not familiar with the specifics of the grammar of each individual system. Take 'trichloridophosphorus', for instance. As complex as this name is, it only takes a passing acquaintance with the periodic table to know that the name refers to a compound consisting of three parts chlorine and one part phosphorus. More important, perhaps, is the function these names perform for those individuals who *are* competent with the grammar. Names produced using the additive system will allow someone *au fait* with the grammar to construct a representation of the molecule, including its charge and the spatial relations between the constituent atoms.

What both of these examples illustrate is that some – and indeed clearly most – chemical names are *not* introduced using a Kripke-style name-acquiring transaction. Rather, they are generated using a complex set of rules and grammar, and clearly encode descriptive information. In other words, they are descriptors. As a result, a theoretical identity sentence such as 'ununbium is the element with atomic number 112' and 'trichloridophosphorus is PCl_3' is something a chemist can come to know *a priori*. We simply could not have discovered that trichloridophosphorus was *not* PCl_3, given the way that the name was introduced, nor that ununbium was *not* the element with atomic number 112. Many natural kind terms, then, do not adhere to the orthodox Kripkean model.

Chemical terms derived from IUPAC rules are not the only names of putative natural kinds that fail to fall within the remit of the Kripkean story; there are plenty of other cases that, at the very least, cannot simply be assumed without argument to generate *a posteriori* necessities. Consider the Higgs boson. Clearly there was no initial baptism, akin to the naming of water, for the Higgs boson. Rather, the existence of the Higgs boson is a hypothesis designed to explain why the photon has no mass while the W and Z particles (responsible for weak nuclear force) have huge masses – a hypothesis that has yet to be confirmed, thanks to teething problems with the Large Hadron Collider at CERN. So, for example, the statement 'the Higgs boson (if it exists) is responsible for the masses of W and Z particles' would seem to be knowable *a priori*: we know *a priori* that any particle that is discovered that fails to account for the masses of W and Z particles will not be the Higgs boson but something else. The same goes for 'the Higgs boson has no spin': since a boson is *defined* as having no spin, we know *a priori* that any particle that is discovered that has spin will not be the Higgs boson.

Of course, there are plenty of things that physicists might find out *a posteriori* about the Higgs boson, assuming that they discover that it actually exists; and one might argue that such truths *will* be good candidates for members of the category of necessary *a posteriori* truths about the essence of the Higgs boson. For example, the Standard Model of particle physics does not predict the mass of the Higgs boson. So, say, 'the Higgs boson has mass 120 GeV (gigaelectronvolts)' is not knowable *a priori*. Unfortunately, however, it is not obviously *necessary*: we would need an *argument* in order to establish that the claim 'the Higgs boson has mass 120 GeV' is necessary if true. As we've seen, what would be needed in order to establish this would be a Twin-Earth-style thought experiment. But we cannot simply *assume* that the Higgs boson's mass is part of its essence, in the kind of full-blooded way that generates *a posteriori* necessity.

Thus at least some of the kinds identified by Ellis as 'natural' kinds turn out to have essences that are defined rather than discovered: our candidate 'theoretical identifications' are knowable *a priori*, and we have no grounds for thinking that those

underlying features that are plausibly taken to be discovered *a posteriori* (for example, the mass of the Higgs boson) are a part of the kind's essence.

It might be objected that the situation is not as clear-cut as we have suggested. The claim that 'ununbium is the element with atomic number 112' is knowable *a priori* entails that it could not be discovered to be false; however, this is disputable. Imagine, for example, that the element we were calling 'ununbium' turned out, long after the term had come to be widely used (and perhaps part of ordinary language because (what we had been calling) ununbium turned out to have properties that are important outside the chemistry lab), to have 113 protons rather than 112 protons in its nucleus. Surely in this case we would want to say that ununbium turned out not to have atomic number 112, in which case it cannot be *a priori* that ununbium is the element with atomic number 112, since we can imagine the theoretical identification turning out to be false. Hence, contrary to what we have argued, 'ununbium is the element with atomic number 112' is in fact necessary *a posteriori*.[7]

Such a claim would, of course, depart from Kripke's original meta-semantic story, since in the above case there is no name-acquiring transaction of the Kripkean variety. Rather, the thought would be that, whatever the genealogy of the name, at some later time it *comes* to, as it were, lose its descriptive content and become a name that directly refers to the element in question.

Our response is to accept the thought experiment, but deny that it shows that 'ununbium is the element with atomic number 112', *as the term 'ununbium' is currently used*, is known only *a posteriori*. Clearly if it was discovered, right now, that Prof. Hofmann and his team had actually manufactured samples of the element with atomic number 113, IUPAC would determine that what they had actually manufactured was ununtritium, and not ununbium at all, and that ununbium does not yet exist (or, if it occurs naturally, has never been discovered). Of course, this means that previously-uttered claims involving

'ununbium' would all turn out to be false. Or, if that seems implausible, one might say some such claims, in some contexts, involved a referential rather than attributive use of the term, so that 'Great, we've manufactured ununbium!' would be false, but, say, 'Here's that sample of ununbium you asked for' would be true. This would not undermine the claim to *a priority*, since the same holds for terms like 'bachelor': it is of course knowable *a priori* that all bachelors are unmarried, but one can, in certain circumstances (if Donnellan (2008: 268) is right, at any rate), use the term 'bachelor' referentially, as in the utterance of 'the bachelor in the corner is wearing a terrible suit', where it is clear which man the speaker intends to refer to, but they are mistaken about the man's marital status.

In other words, we can accept that the meaning of 'ununbium' (or for that matter, 'Higgs boson', and perhaps even 'phosphorus trichloride') could, in principle, change so that the term comes to be directly referential. But that does not undermine the claim that the term *actually* has descriptive content that renders the relevant theoretical identity statement knowable *a priori.*

3.2 Process kinds

Ellis holds that what (allegedly) goes for natural kinds of substance goes also for natural kinds of process. He says:

> A natural kind of process that is a display of a dispositional property has a certain real definition. And it is one of the primary objects of science to try to discover what the real definitions of the various natural kinds of processes are. In the case of any simple causal process, the real essence will be a dispositional property, and the scientific problem will be to specify precisely what this dispositional property is. In general, the real essence of a causal process of a given natural kind will be specifiable counter-factually by the kind (or kinds) of circumstance *C* in which it would be triggered, and the kind (or kinds) of outcome *E* which would … result, if there were no interfering

> or distorting influences. In the simplest kind of case … the dispositional property may be uniquely characterized by an ordered pair <*C, E*> where '*C*' denotes a kind of circumstance and '*E*' a kind of event. If *x* is an object that has this dispositional property, then *x* may be said to have the power, capacity, or propensity to *E* in circumstances *C*. However, it is not an *a priori* matter what the real essences of the natural kinds of processes are, and what is being determined is not the meaning of a dispositional term. (Ellis 2001: 124)

It is clear, then, that Ellis thinks that there are necessary *a posteriori* truths to be had in the domain of dispositional properties and the causal processes to which they give rise. A dispositional property *P* has an essence, *E* (so that, in the simplest case, for an object to have *P* is for it to be such that outcome *O* would occur, were the object to be placed in circumstances *C*), where it is an *a posteriori* matter, to be discovered by scientific investigation, that the essence of *P* is *E*, but where it is metaphysically necessary that *P* is the dispositional property with essence *E*. We shall argue, briefly, that the claim that the category of the necessary *a posteriori* can be extended to dispositional properties, and thereby to causal processes, in this way is highly implausible.

Recall our lessons from Kripke. We get theoretical identifications – the relevant class of necessary *a posteriori* truths – just when we have a general term (such as 'gold') on the left-hand side of the 'identity' statement that has no descriptive content or stipulative definition, and a specification of the essence of the kind thus named on the right-hand side.

Note first that in the passage just quoted, Ellis advances the claim that dispositions have 'real definitions' or 'essences' that are not knowable *a priori* without the slightest hint that a Kripkean story about the naming of dispositions is required in order to justify this claim. In his 'simplest case', our dispositional property 'may be uniquely characterized by an ordered pair <*C, E*>, and if object *x* has this property, then it 'may be said to have

the power, capacity or propensity to *E* in circumstances *C*'. This would appear to deliver the metaphysically necessary truth: 'an object with property <*C, E*> has the power to *E* in circumstances *C*', or perhaps 'the property <*C, E*> *is* the power to *E* in circumstances *C*'. Metaphysically necessary this may be, but knowable only *a posteriori* it most certainly is not: it is a matter of orthographical stipulation that property <*C, E*> *is* the power to *E* in circumstances *C*, and so this is uncontroversially knowable *a priori*. (Of course, whether such a property *exists* is not knowable *a priori*, but this is not what Ellis is claiming. He is claiming that the *essence* of the property is not knowable *a priori*.)

Many properties do, of course, have names that are not merely orthographically distinct ways of describing their essence. Take solubility, for example – a property that Ellis takes to be 'a real disposition, for the process of solution is a natural kind of process' (2001: 125). Let's say that the definition of solubility (in some substance *S*) is the power to form a homogeneous mixture with *S* with particle sizes at the molecular or ionic level. Grant, then, since this is our toy definition, that it is metaphysically necessary that this is so. The question is, is it knowable only *a posteriori*, or have we merely stipulatively defined what it is to be soluble, so that our metaphysically necessary truth is knowable *a priori*?

It is not obvious, straight off the bat, what the answer to this question is. One might argue, in defence of Ellis, that a Kripkean story can be told about solubility. For example, one can imagine ordinary language-users or proto-scientists noticing the (normally) observable difference between, say, what happens when one mixes salt with water (producing a solution), and what happens when one mixes sand with water (producing a suspension): in the second case but not the first, the resulting mixture is murky and its constituent substances separate out if you leave the mixture to stand. And one can imagine our proto-scientists dubbing the disposition to produce a mixture of the first kind 'Disposition *S*'. So we have a potentially Kripkean story here: an initial baptism based on observable features, where the underlying 'essence' of the disposition still waiting to be investigated by science (since one can – fallibly – successfully identify the effects of possession of Disposition *S* in the presence of its manifestation conditions without any grasp or knowledge of the fact that the essential difference between a solution and a

suspension is the size of the particles that constitute the mixture). So there is a prima facie case for thinking that Disposition *S* is solubility, and that there are *a posteriori* necessary truths to be had about its underlying nature (perhaps that Disposition *S* – that is, solubility – results in molecule- or ion-sized particles distributed homogeneously in a mixture).

So far so good. Unfortunately, however, matters are rather more complex than is suggested by the toy story just given. Solutions are often defined in terms of the size of the particles in the resulting mixture: up to 2 nanometers for a solution, and over 1000nm for a suspension. In between the two, there is the category of *colloid*: a mixture where the particle size is between 2 and 1000nm. Many colloids (unlike solutions) can be separated into their constituent substances by filtration (dissolved particles are too small for this), but unlike suspensions they do not separate out naturally, because the colloidal particles (like dissolved particles) are small enough for Brownian motion. Blood and mayonnaise, for example, are colloids. Also, solutions, colloids and suspensions need not be mixtures of solids and liquids, or liquids and liquids: carbonated water, water vapour in the air, and brass (an alloy of copper and zinc) are all solutions; pumice and smoke are both colloids. Now, which disposition did our initial baptism of 'Disposition *S*' denote, exactly? It seems highly unlikely that this question has a determinate answer – and if it does, it seems highly unlikely that the answer is 'solubility'. First, the observable features on the basis of which the initial baptism was made (the fact that salt, unlike sand, forms a transparent liquid that does not separate out on standing) are neither necessary nor sufficient conditions for something's being soluble. Of course, this is true of natural kind terms generally on the Kripkean story – it is neither necessary nor sufficient for something's being a sample of water that it is potable, found in a river or a lake, and so on. But such features are at least reasonably typical (as opposed to necessary) and distinctive (as opposed to sufficient) of water. In the case of solubility, the relevant features are neither typical nor distinctive: water vapour in air is not a transparent liquid, and nor is brass, but they are both solutions, and colloids as well as solutions fail to separate on standing. It is therefore hard to see how to make the case that the disposition denoted (if any) was solubility. This would be a little like claiming that someone who had

only ever been exposed to one kind of mammal – cats, say – and who baptised that kind of entity (pointing to a cat) '*M*', established that '*M*' denotes the kind *mammal*. If '*M*' refers to anything, then its most plausible reference is the kind *cat*.

Perhaps, by analogy with the cat case, one could argue that a more restricted disposition, in the right ballpark, was denoted – solubility in water, say. But solubility in water is not solubility. So if 'solubility' *simpliciter* is to count as a kind term capable of generating *a posteriori* necessary truths, this will not help.

Second, we have so far glossed over a difficulty for the very possibility of 'baptising' a disposition in the first place. One cannot, it seems to us, directly baptise a disposition, because dispositions – when they are not being manifested – have no observable features whatsoever (analogous to be a colourless, potable liquid, say), which one can use to fix the reference. I cannot point to a sample of salt and say 'let the dispositional property had by that sample be named "solubility" ', for of course it will then be completely indeterminate which dispositional property I am attempting to pick out. So it seems that the only way to baptise a disposition would be indirectly, via denoting the process, or perhaps the product of the process, that the disposition gives rise to. Indeed, this is how we told our toy story about solubility above: we start by picking out a process (dissolving), or perhaps the result of that process (a solution), and then denote the disposition by calling it the disposition to do something of *that* kind, or to produce something of the same kind as *that*. But this would seem to require not only that solubility is a natural kind, but also that both the process of dissolving and the result of that process – a solution – is also a natural kind. The latter mechanism for baptising solubility (or solubility in water) obviously requires this: if solubility is the disposition to produce something of *that* kind, then 'that' must directly and non-descriptively denote a kind – that is, it must denote a Kripkean natural kind. The former mechanism – where the process rather than the product is directly denoted – would also seem to require that *solution* is a natural kind; at any rate, it would be strange if both solubility (the

disposition) and dissolution (the process) were natural kinds but the product of the process (solution) were not.

This creates a serious problem for Ellis's account, because it is in serious tension with his 'hierarchy requirement': 'if anything belongs to two different natural kinds, these natural kinds must both be species of some common genus' (2001, 20). Consider the term 'water'. Most likely, all actual samples of H_2O have other substances dissolved in them (most obviously, chlorine in tap water and salt in seawater). So are these in fact (impure) samples of H_2O, or (pure) samples of solutions? The hierarchy requirement rules out the possibility of answering 'both' to this question, since of course there is no common genus of which *H_2O* and *solution* are both species. So the answer must be one or the other. But (most, and probably all) samples of (what we call) water just *are*, uncontroversially, solutions. But then, by the hierarchy requirement, they cannot also be samples of H_2O. And of course in that case it's going to turn out that 'water' does not in fact refer to the natural kind we thought it referred to: it refers to the natural kind whose essence is that it is a solution, and not the natural kind whose essence is that it is H_2O!

We conclude that the example of solubility – one of Ellis's examples of a 'real disposition' (2001: 125) – is not a kind of disposition that generates any interesting *a posteriori* necessities, because the term 'solubility' simply does not fit the required Kripkean story. Of course, it might be that Ellis should not have said that solubility in particular is a real disposition; he might be wrong about solubility but right that there *are* real dispositions and natural kinds of process about which there are metaphysically necessary truths that are knowable only *a posteriori*. Our point, as with substance kinds, is that this needs to be shown rather than assumed.

Before considering the consequences of the fact that some theoretical identifications are knowable *a priori* for Ellis's overall position, it is worth noting that it is arguably not merely *some* Ellisian natural kind terms that fail to generate the required *a posteriori*

necessities, but the vast majority. Kripke's own examples – 'water', 'tiger', 'gold' – all designate objects or substances that are easily observable and (fallibly) individuated by ordinary people, and this is what makes the claim that such terms are directly referential plausible. Very, very few Ellisian natural kinds – the allegedly natural joints in nature that scientists aim to uncover – fall into this category. Scientific investigation – particularly in physics and chemistry, where (given that Ellis hold that biological species are not natural kinds) most of the Ellisian kinds are to be found – rarely involves finding some unidentified object or substance, giving it a name, and *then* investigating its nature. This point also applies to alleged natural kinds of process and to the dispositions that allegedly give rise to them: 'solubility' is not at all like 'gold', and nor are 'refraction' or 'electromagnetic radiation'. So our claim is not that kind terms such as 'ununbium', 'Higgs' boson' and 'solubility' are counterexamples to a rule that holds in all but a few cases; rather that it is ordinary-language terms such as 'water' and 'gold' that are the exceptional cases.

4. THE CONSEQUENCES FOR SCIENTIFIC ESSENTIALISM

How much trouble does this make for Ellis's overall essentialist picture? Quite a lot, we shall argue, because the philosophical core of Ellis's position is the view that 'natural necessities' are 'grounded in the world' (2001: 248). His position thus contrasts with the Lewisian conception of modality, according to which necessity is an inter-world, rather than intra-world, phenomenon: the necessary status of a truth is grounded not in the nature of the actual world – in which, in and of itself, there is no necessity to be found – but in the relationship between the actual world and other possible worlds. So, for example, for Lewis the necessity of the laws of nature ('physical' necessity rather than metaphysical necessity) is secured by fiat: a proposition is physically necessary, by definition, just in case it holds at all possible worlds with the same laws of nature as the actual world. Ellis's position also contrasts with David Armstrong's, according to which, while natural necessity is a real, fundamental feature of the actual world, its existence – and which universals it relates – is contingent (see Armstrong 1983). So natural necessity

is, as it were, separable from the intrinsic natures of things: it is a kind of glue that binds things together.

Ellis, by contrast, says:

> To ground natural necessities in the world, it is necessary to develop an ontology of things capable of sustaining causal and other modal relationships. To do this, it is necessary to ground the laws of nature somehow in the world. To deal with the bulk of laws of nature – the causal and statistical laws that describe the powers and structures of things belonging [to] natural kinds – it is sufficient to recognize that these things have their kind essences essentially. (2001: 248)

For Ellis, then, natural necessity is grounded in essences: where the 'powers and structures' of things are essential to the kinds that those things are members of, those essences will sustain 'causal and other modal relationships. Natural necessity is thus, for Ellis, full-blooded, *de re* metaphysical necessity, or 'real necessity' as he sometimes puts it. Natural necessity arises out of the intrinsic, essential natures of the inhabitants of the actual world, and not from any relationship between the actual world and other possible worlds (as Lewis has it); nor is it (as Armstrong has it) an additional item of ontology – a kind of metaphysical glue.

The problem for Ellis arises when we ask what the argument is for the claim that there *are* essences – of substantive, property and process kinds – of the sort that will generate 'real' necessities. Ellis says:

> Analytic propositions are true in virtue in virtue of the meanings of words – that is, they depend for their truth on some conventionally established criterion for including something in some linguistically defined class. Metaphysically necessary

> propositions, on the other hand, are true in virtue of the essential natures of things – for example, they state correctly, or otherwise depend for their truth on, what makes something a thing of the natural kind it is. (2001: 235)

How are we to understand this claim in the context of the examples of chemical kind terms described above? 'ununbium is the element with atomic number 112' and 'phosphorus trichloride is PCl_3' are, we argued above, analytic: all that is needed in order to know the truth of these claims is some rudimentary knowledge of the mechanics of chemical nomenclature. But, given Ellis's characterization of the difference between analytic and metaphysical necessity, it would seem that he is committed to saying that ununbium and phosphorus trichloride are not natural kinds. Since the relevant truths depend merely on 'some conventionally established criterion for including something in some linguistically defined class', they are *not* 'true in virtue of the essential natures of things' and thus (since all natural kinds have essences) are not truths about (the essences of) natural kinds. Gold and water, by contrast, *would* seem to have essences and thus be natural kinds, since 'gold is the element with atomic number 79' and 'water is H_20' are not analytic.

This would be a curious position, to say the least, for Ellis to endorse: after all, gold and ununbium are both elements, and water and phosphorus trichloride are both compounds. So if gold is a natural kind with an essence that generates *de re* necessity, surely ununbium is too; similarly for water and phosphorus trichloride. And it is very clear that Ellis would want to endorse this claim. But the problem is that he cannot, apparently, endorse it, because he is committed to the view that analytic truths cannot be truths about essences.

In fact, Ellis goes on to offer a criterion for distinguishing between analytic and metaphysical necessity that, on the face of it, sidesteps this problem:

> … one technique is to abstract from the descriptive language used to refer to [some class of objects], and replace the general name used with an ostensive 'kind-referring'

> expression, such as 'stuff of this kind' or 'things of this kind'. If the necessity survives this process, then we know that it cannot be grounded in the descriptive language we had been using. 'Water is H_20', for example, clearly survives this test, because 'stuff of this kind is H_20', said pointing to a glass of water, is no less necessary than 'water is H_20'. If there is any doubt about it, then it can only be a doubt about what the intended object of reference is [e.g. about whether one is referring to the glass or its contents], or ignorance about what its nature is. (2001: 235-6)

Ellis's technique appears to solve the problem we just raised, since, arguably, what goes for water goes equally for phosphorus trichloride and ununbium: arguably 'stuff of this kind', said pointing to a sample of PCl_3, is no less necessary than 'phosphorus trichloride is PCl_3'.

So far so good. But now a new problem emerges: Ellis's technique for marking out the realm of real necessity is clearly far too permissive. The contrast he draws is with replacing 'bachelor' with 'a person of this kind', the idea being that the latter expression fails to fix reference to a particular class. And this is because 'bachelors are not bachelors in virtue of their intrinsic properties or constitutions': 'Examine any given bachelor as thoroughly as your please; you will never discover the intended reference of the word "bachelor" as a result of such an investigation' (2001: 236).

Unfortunately, however, Ellis here sets up a false dichotomy. It is, of course, true that bachelors are not bachelors in virtue of their intrinsic properties or constitutions. But plenty of members of other intuitively non-natural kinds *are* members of those kinds in virtue of their intrinsic properties or constitutions. Imagine, for example, that you point to a beaker containing a mixture of sulphuric acid and water. 'Stuff of *that* kind is a mixture of H_20 and H_2SO_4', said pointing to the contents of the beaker, is, it seems to us, necessary if 'stuff of that kind is H_20' is. Similarly, pointing at a liger, 'things of that kind

are the offspring of a male lion and a female tiger' would seem to be necessary (again, if 'stuff of that kind is H_20' is). But mixtures and biological categories are not, on Ellis's view, natural kinds: they do not have essences, and they do not carve nature at its natural joints.

The upshot is that Ellis does not have a story about what distinguishes *de re* necessity from other kinds of necessity – and in particular analyticity – that is consistent with his own view about what kinds of thing count as natural kinds. He cannot consistently say that no analytic truth is a truth about *de re* necessity – since that effectively rules out any kind for which there is no available term that meets Kripke's conditions on baptism from counting as a natural kind (as in 'ununbium is the element with atomic number 112'). And he cannot consistently say that the relevant distinction can be drawn by appealing to those kinds that can be referred to by ostensive definition and those that cannot, since many non-natural (in Ellis's sense of 'natural') kinds – such as mixtures of H_20 and H_2SO_4, and ligers – fulfil that criterion, if natural kinds do.

5. DIAGNOSIS

Our diagnosis of Ellis's predicament is that he is operating with two different conceptions of 'natural kind'. Early on in his book, Ellis appears to distance himself from Kripke: 'my concerns', he says, 'are different from Kripke's. Kripke's essentialism was developed in relation to theories of reference and identity. Scientific essentialism derives from an examination of the scientific practice of theoretical identification … Scientific essentialism is primarily concerned with the question of what makes a thing the kind of thing that it is, and so display the manifest properties and behavior it does. That is, real essences for us must not only be identifying, they must be explanatory' (2001: 54).

Ellis thus aligns himself with a more Lockean conception of natural kinds:

> The scientific task is to discover what makes a thing the kind of thing that it is and hence to explain why it behaves or has the properties it has. The scientific version of

> essentialism is therefore less concerned with questions of identity, and more with questions of explanation, than is the classical essentialism of Aristotle or the new essentialism of Kripke. Its closest historical predecessor is the kind of essentialism described by Locke. For Locke too was concerned with the question of what makes a thing the kind of thing that it is. He thought that if only we knew this, we should be able to explain why it has the manifest properties it has and behaves as it does. (2001: 55)

On the one hand, then, Ellis clearly wants to say that the natural kinds are those that carve nature at its joints, and that an investigation into the 'essences' of natural kinds is an investigation into the underlying natures of things that explain why they behave in the way that they do. On this conception of natural kinds, one is likely to find the natural kinds in the fundamental particles, the periodic table, and so on – that is, to the scientific practice of classifying on the basis of underlying nature, and explaining overt behaviour in terms of that underlying nature. But – crucially – such a conception of natural kinds requires no commitment to essentialism, or at least no commitment to Ellis's brand of essentialism[8]. One can quite happily hold that scientific classification aims to uncover the joints in nature, and that doing so is apt to lead to fruitful explanations and predictions of manifest behaviour, without being committed to any kind of 'real' necessity. And one can thus hold that 'phosphorus trichloride' picks out a natural kind, while 'raven-or-writing-desk' does not, without being an essentialist.[9]

On the other hand, Ellis is up to his neck in Kripkean commitments: when he talks about the 'scientific practice of theoretical identification', for example, it is Kripkean theoretical identification – the kind that generates *a posteriori* necessity – that he has in mind. 'Ours is not an *a priori* essentialism', he says on the previous page. 'We think that the laws concerning the behavior of the most fundamental kinds of things in nature are *a posteriori* necessary' (2001: 53). And, as we have seen, his account of the distinction between *de re* necessity – the defining feature of essentialism – and mere analytic necessity is driven by Kripkean intuitions concerning our ability to ostend a kind of stuff

without knowing its underlying nature. And Ellis's Kripkean commitments are absolutely vital to the essentialist enterprise, since, as we said above, without them we can happily endorse the view that there are natural kinds while eschewing essences and denying that the laws of nature are metaphysically necessary.

However – to return to our basic point – there is simply no *a priori* reason to think that the notion of 'natural kind' deployed by Kripke is coextensive with the notion of 'natural kind' that focuses on carving nature at its joints and the explanation of behaviour in terms of underlying nature. Such a radical extension of the Kripkean conception of natural kinds needs arguing for; Ellis, it seems to us, simply takes the extension for granted, because he fails to disambiguate between two quite different conceptions of 'natural kind'.

The aim of this paper has not been to show that there is anything wrong with essentialism as a metaphysical doctrine. Our aim has rather been to show that Ellis (and by extension other philosophers who extend the remit of the necessary *a posteriori* without argument) is not entitled to assume that truths about essences (if there are such things) are knowable only *a posteriori.* Moreover, in Ellis's case at least (although we believe the case can be made for other philosophers too), we have argued that that assumption is simply false. The temptation to extend Kripke's category of the necessary *a posteriori* is understandable, for it is precisely this extension allows scientific essentialists to uphold the two fundamental tenets of the view: first, that the world is not, at bottom, merely a Humean mosaic of matters of particular fact over which the laws of nature generalize, but rather a world in which the laws of nature are 'immanent' – part of the fundamental fabric of reality; and, second, that those laws are genuinely *discovered* to be true (and hence, given the nature of laws, metaphysically necessary). Our remit here has not been to show that these two theses are incompatible. It has merely been to show that appeal to the Kripkean story about natural kinds will not do the job.[10]

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Notes

[1] Other philosophers who have similarly failed to provide convincing (or indeed any) arguments for their claims about the necessary *a posteriori* status of truths that fall outside the narrow scope of Kripke's own argument include Alexander Bird (2007) and Adrian Heathcote and David Armstrong (1991). Bird, like Ellis, holds that the laws of nature (conceived by Bird as propositions that lay bare the underlying essences of fundamental dispositions) are necessary *a posteriori*; Heathcote and Armstrong hold that the relation of nomic necessitation is, as a matter of metaphysical necessity, identical with the causal relation, but that this identity can only be known *a posteriori*. We cannot substantiate the claim that the relevant arguments are lacking here, but we invite the sceptical reader to attempt to locate them for themselves.

[2] In the case of Heathcote and Armstrong's claim that 'causation is nomic necessitation' is necessary *a posteriori*, it is less clear whether they intend nomic necessitation to be the 'essence' of causation (this is suggested by their claim that 'investigation shows that causal sequences are essentially nomic' (1991: 67)) or whether they are thinking of 'causation is nomic necessitation' to be a genuine identity statement, analogous to 'Hesperus is Phosphorus'.

[3] We, like Mellor (1977), Zemach (1976) and, more recently, Needham (2000), object to the drastic oversimplification of the natural kind essence claims found in Kripke, Putnam and much of the subsequent literature. Our concern here, however, is not with essentialism itself, but rather that any potential essence claim, expressed on the right-hand side of a theoretical identity, must include so must empirical information that it is *obviously* an attributive definite description. Consider H_2O molecules: since H_2O molecules are made of hydrogen and oxygen atoms, and each type of atom has three

stable isotopes (atoms with the same atomic number, but a different atomic mass), there are 18 constitutional variations of an H_2O molecule. Furthermore, in order for collections to actually be molecules, the constituent atoms must bond together. Molecules of H_2O have a polar covalent bond: polar because of the way that the charge is distributed within the molecule, and covalent because each bond (of which there are two) is between two atoms maintained by a shared pair of electrons. The molecule also has a particular geometry: as the oxygen atom has 6 electrons, and only two have those are being shared with the two hydrogen atoms (which also contribute a single electron each to the two covalent bonds), the molecular geometry of an H_2O molecule is tetrahedral. However, although the standard bond angle of a tetrahedral molecule is 109°, and the bond angle in an H_2O molecule is 104.5°, owing to the mutual repulsion from the lone pairs of electrons.

[4] We have borrowed the term 'descriptor' from the Connelly et al (about which more below): 'The primary aim of chemical nomenclature', it says, 'is to provide methodology for assigning descriptors (names and formulae) to chemical species so that they can be identified without ambiguity, thereby facilitating communication' (Connelly et al 2005: 3). We shall have more to say about chemical nomenclature in the next section.

[5] A temporary designator is a type of descriptor. Broadly speaking, a descriptor is a name or a chemical formula that unambiguously refers to a chemical kind in virtue of encoding decisive descriptive information. A temporary designator is a descriptor that has been introduced, as the name suggests, temporarily, since the element in question has yet to receive a permanent name and/or symbol.

[6] Since element 112 has now been confirmed, the temporary designator will be replaced by a name suggested by Hoffman and approved by IUPAC. At that point – we would argue – the name for the element with 112 protons ('hoffmanium', perhaps) will stipulatively define the kind, rather than being a descriptor ('ununbium').

[7] Thanks to Jessica Pfeifer for pressing this objection, and to Josh Parsons for suggesting the response.

[8] See Leary 2009: 273-92.

[9] Of course, one needs to give an account of the difference between the natural and the non-natural kinds, but there are available theories to choose from, which do not require a commitment to essentialism. See for example Dupré (1986: 441-7, and 1995), Mellor (1977: 299-312) and Mumford (2005: 420-436).

[10] Thanks to audiences at the metaphysics of science conferences at Grenoble in December 2008 and Melbourne in July 2009, in particular Alexander Bird and Brian Ellis, for helpful comments and criticism; also to Robin Hendry.