# What are Natural Kinds?[1]

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## 1. Two Questions

Distinguish two questions about natural kinds. First, the naturalness question: what, if anything, makes a natural kind *natural*? Perhaps the members of a natural kind, unlike the members of an arbitrary group, stand in some natural similarity relation to one another. Perhaps they share an essence or some other natural feature. Or perhaps, as conventionalists argue, the boundaries of natural kinds do not correspond to distinctions in nature.

Second, the kindhood question: what, if anything, makes a natural kind a *kind*? The distinction between natural kinds and other natural groupings was noted by Mill (1843: 122–3), who remarked that horses formed a natural kind but white things do not. Mill's point is that, natural similarity among white things notwithstanding, leukocytes, chalks, white vans, clouds, comets, and degenerate (white) dwarf stars are too diverse a group to form a natural kind. If Mill is right, then investigating the difference between grue and green, for example, will not fully illuminate natural kinds, for neither green things nor grue things form a natural kind.

The naturalness question has dominated debate about natural kinds, at the expense of the kindhood question. One consequence of this dominance is that certain questions concerning the ontology of natural kinds have been obscured. Richard Boyd, for example, explicitly understands questions of the form 'is such-and-such a kind real?' to be questions concerning naturalness and integration with inductive practices ('accommodation'):

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> [W]hat is misleading about formulations in terms of the 'reality' or 'unreality' of kinds, or of 'realism' or 'antirealism' about them, is that they wrongly suggest that the issue is one regarding the metaphysical status of the families consisting of the members of the kinds in question – considered by themselves – rather than one regarding the contributions that reference to them may make to accommodation. Issues about 'reality' or 'realism about' are always issues about accommodation. (Boyd 1999: 159)

But there are two tasks: to distinguish natural from unnatural similarities – which will help explain 'accommodation' – and also to understand the metaphysical status of natural kinds, distinguishing the natural similarities that underpin natural kinds from the natural similarities that do not. In this paper, we take the kindhood question seriously, and we examine how best to develop a realist view of natural kinds. In particular, we will articulate a view of natural kinds as complex universals. We do not attempt to argue for the existence of universals. Instead, we will argue that, given the existence of universals, and of natural kinds, the latter can be understood in terms of the former, and that this provides a rich, flexible framework within which to discuss issues of indeterminacy, essentialism, induction, and reduction.

## 2. The Kindhood Question

Since our goal is to develop a realist view of natural kinds, we will set aside without argument the nominalism which denies that there are any such kinds. Once this is done, there remain several options for the ontology of natural kinds:

(1) Natural kinds are universals.

(2) Natural kinds are particulars.

(3) Natural kinds are *sui generis* entities, neither universals nor particulars.

We assume that all natural kinds fall into the same one of these categories. Thus we reject mixed views, for example the view that some natural kinds are *sui generis* while others are universals. Mixed views have a complexity that is currently unmotivated. Moreover, they deprive the category *natural kind* of ontological significance. The point of ontological categories such as *universal* and *particular* is to capture the most basic ontological difference there can be between entities. A category that cross-cuts these basic categories is unlikely itself to carry ontological weight.

In this paper, our main task is to examine the prospects for option (1), and so in this section we make just a few remarks about options (2) and (3). One version of option (2) identifies properties in general with sets – sets of tropes or sets of concrete possibilia – then identifies natural kinds with properties, and thus with sets. This is a potentially powerful picture, but one we will not develop here: our starting point includes the assumption that at least some natural properties are universals (Lewis 1983).

Another version of option (2) identifies each kind with the transtemporal fusion of all its members, a large concrete object composed of many individual organisms or molecules, say. The view that biological species are particulars is usually motivated by the ideas that (a) species are characterised by their extrinsic features, but (b) the defining properties of a nonparticular must be intrinsic rather than relational properties. As we will see, however, our view of natural kinds as complex universals allows for extrinsic characterisation of kinds.

Option (3) is exemplified by E.J. Lowe's 'four category ontology' of which kinds form one category (Lowe 2006). In this system, kinds are taken to be the subject matter of the laws of nature. But some laws of nature mention natural kinds ('salt dissolves in water') and others do not (Newton's law of gravitation). The former supervene upon the latter, and the progress of physics suggests that natural kinds will not feature in the basic (fundamental) laws of nature. The basic universals are the universals that feature in those laws. If we take the basic particulars, the basic universals, the pattern of instantiation of the latter by the former, and the basic laws of nature, then we have a supervenience basis for all else. (The Humean can agree with this even if she thinks that the addition of the basic laws of nature is superfluous.) Since the basic laws do not include the natural kinds, then the natural kinds do not appear in this supervenience basis, and so cannot be required in our basic ontology, the categories of which are supposed to capture all and only those sorts of thing that need to appear in our supervenience basis (cf. Bird 2011).

In this paper, we will concentrate on examining option (1): kinds are universals. Properties unify particulars: particulars which instantiate the same property have something in common. If properties are universals, then we can understand this unification quite straightforwardly: a universal is wholly present wherever it is instantiated, so particulars which share a property literally have some thing in common. The universal is wholly present in each of them. In this paper we will adopt a relatively sparse account of universals: if universals were abundant, it would be uncontroversial that each natural kind corresponds to a universal.

If kinds are universals, there are three subcategories of universal that a given kind *K* might fall into:

> (1a) *K* is a basic universal. If and when science uncovers the basic universals, for example, those required by the fundamental laws of nature, then *K* will be among these.
>
> (1b) *K* is a simple, but non-basic, universal. Arguably, there are universals that are not basic, since their existence supervenes upon that of other universals, but which are nevertheless not compounded out of those other universals. Simple non-basic universals may feature in emergent laws of nature; *K* is one of these.
>
> (1c) *K* is a complex universal. Arguably, there are universals that are somehow compounded out of other universals; *K* is one of these.

We can reject option (1a). If kinds are universals then we may distinguish between kind universals (the universals that are kinds) and non-kind universals (the universals that are not kinds). We argued above that kinds can be excluded from the supervenience basis. *A fortiori*, kind universals are not required in the supervenience basis, and so no kind is a basic universal. We will also set aside option (1b), as a fall-back option which needs to be considered only if (1c) fails – positing emergence should not be our first resort. Hence the option that needs to be considered in detail is (1c): kinds are compounded in some way out of other universals.

To motivate this view, consider the role of natural kinds in induction. Induction does not always rely upon natural kinds: much induction, such as that which produced knowledge of Newton's law of gravitation, does not refer to natural kinds at all.

Nonetheless, kinds are particularly powerful sources of induction, and our inductive capacities would be severely restricted if we confined ourselves to reference to non-kind universals. As Mill says:

> The class horse is a Kind because the things which agree in possessing the characters by which we recognise a horse, agree in a great number of other properties, as we know and, it cannot be doubted, in many more than we know. (1843: 703–4)

Natural kinds have this inductive power by managing to encapsulate many natural properties in one. A plausible way that natural kinds could achieve this is by themselves being compounds of the relevant universals, and this is the suggestion that we explore in this paper.

## 3. What are Complex Universals?

The most prominent contemporary defender of universals is D. M. Armstrong. Armstrong takes a sparse approach to universals: not every respect of similarity corresponds to a universal. Which similarities are underpinned by universals is a matter for empirical science not *a priori* philosophy. In contrast to Reinhardt Grossmann (1983: secs 58–61) who argues that there are only simple universals, Armstrong (1997: 31) argues that a metaphysics of universals will need complex universals as well. There are several reasons to accept complex universals. First, there may be no simple universals, just complexity all the way down (Lewis 1986a, although see Williams 2007). Second, if laws concern universals, and some laws concern non-fundamental properties, then there must be biological and chemical universals as well as the universals of fundamental physics. Third, if fundamental particulars compose non-basic concrete particulars, then those non-basic particulars will instantiate properties: these may include structural properties not instantiated at the basic level.

So what are complex universals? Consider *being red and round*, which is instantiated by all and only those particulars which instantiate both *being red* and *being round*. (Suppose for the sake of the example that *being red* and *being round* are both simple universals.) What is the relationship between the three universals *being red and round*, *being red* and *being round*?

A natural suggestion is that the first is the sum of the other two, that it is a mereologically complex universal with two universals as its proper parts (Lewis 1986a). If we accept this suggestion, we can explain a pattern of coinstantiation amongst the three universals. Why is it that, whenever *being red and round* is instantiated, so too are *being red* and *being round*? It's because *being red and round* is wholly present in each of its instances, and, quite generally, if an entity is wholly present, so too are its parts. Universals like *being red and round* are called 'conjunctive', and they can be understood as mereologically complex.

Conjunctive universals can account for many natural kinds, as we will show, but structural universals will also be required. Consider the universal *being a methane molecule*: for something to be a methane molecule, it must have four parts which each instantiate *being a hydrogen atom*, and a fifth part which instantiates *being a carbon atom*. Moreover those five parts must stand in the appropriate geometrical and physical relations to one another, i.e. they must instantiate the relevant relational universals in the relevant order. When a structural universal – like *being a methane molecule* – is instantiated by a complex particular, certain other universals are instantiated by the appropriate parts of that particular.

What relation holds between a structural universal and its correlates, between *being a methane molecule* and *being a hydrogen atom*, for example? Lewis (1986a) influentially argued that this relation is not parthood, that the correlate universals do not compose the structural universal. This is because, for Lewis, composition is unique, which is to say that there cannot be two distinct entities composed of the same proper parts. And we know that *being a methane molecule*, *being a butane molecule*, *being an isobutane molecule* and various other structural universals all have the same correlate universals. We might hope to differentiate these structural universals mereologically by counting an 'overall shape' universal amongst their parts, but this will not differentiate amongst universals which differ only in the order in which the correlates satisfy the relations.

Yet it is not compulsory to accept the Lewisian view that composition is unique: for example, in the realm of concrete particulars, uniqueness is denied by those who take the statue and its constituent lump of clay to be composed of the same parts (e.g.

Baker 2000). Hawley (2010) defends an account of structural universals in terms of nonunique composition. If structural universals have their correlates as parts, then the nature of the structural universal is not exhausted by the list of its parts, just as the nature of either statue or lump of clay is not exhausted by the list of its parts. (On this view, structural universals are not free of 'brute' modality, so cannot be used as the basis of a reductive account of modality, as some have hoped; but such an account is not our goal in this paper.)

As with conjunctive universals, this mereological picture enables us to explain a pattern of coinstantiation. Why is it that, wherever *being a methane molecule* is instantiated, so too is *being a hydrogen atom*? It is because *being a methane molecule* is wholly present in each of its instances, and, quite generally, if an entity is wholly present, then so too are its parts.

If both conjunctive and structural universals are mereologically complex, we can see the former as a special case of the latter. The correlates of a conjunctive universal are instantiated by entities which stand in the relation of identity to one another. Indeed, if we understand the relation of identity as the third proper part of the conjunctive universal, we can understand why conjunctive universals appear to satisfy the uniqueness of composition, even though this fails for complex universals more generally. The co-instantiation of *being red*, *being round* and *being identical* requires a single entity which instantiates both *being red* and *being round*, and there is only one way for this to happen.

We will refer to conjunctive and structural universals collectively as 'complex universals', and this complexity is to be understood mereologically. We have not been able to give a full justification of the claim that structural universals are mereologically complex. However, we have attempted to motivate the claim, and hope that its utility in understanding natural kinds will add extra support to this view of structural universals. Moreover, we will for the most part be focusing upon those natural kinds which we identify with conjunctive, rather than structural universals.

## 4. Natural Kinds as Complex Universals

We will discuss three varieties of natural kinds: precise structural kinds, precise conjunctive kinds, and indeterminate kinds. We will then discuss how kinds can permit exceptional members, which do not instantiate the properties usually associated with that kind.

### 4.1 Precise Structural Kinds

Methane molecules form a natural kind, and so, given the assumptions we have already made about kinds and universals, we identify that kind with the structural universal *being a methane molecule*. Notice that it is a matter for empirical discovery whether a given kind is a structural kind or not. For example, at present it appears that the kind *up quark* is not structural (i.e. up quarks are not mereologically complex), but it is at least epistemically possible that this is after all a structural kind.

### 4.2 Precise Conjunctive Kinds

Electrons form a natural kind of a different sort to methane molecules. To be an electron is to instantiate each of several specific properties (*having charge –1.602176487 x* $10^{-19}$ *C*, *having mass 9.10938215 x* $10^{-31}$*kg*, and *having spin 1/2*). We can thus identify the kind with a conjunctive universal, i.e. a complex universal with electron-mass, electron-spin, electron-charge and identity amongst its proper parts (we return below to discuss whether this list exhausts the proper parts). Each electron instantiates this conjunctive complex universal.

Regardless of whether a complex universal is structural or conjunctive, there is no requirement that its component universals be intrinsic properties of their bearers. If a kind – such as a biological species – is characterised extrinsically, then these extrinsic properties are components of the complex universal as we understand it. Indeed, in our discussion of the electron, there is no commitment to charge, spin or mass being intrinsic properties of the electrons which possess them.

Other kinds are not so narrowly defined as the electron. Some permit a range of values on some dimension: for example, different isotopes of the same element vary with respect to their atomic mass. Such kinds can nevertheless be identified with complex universals so long as determinables can feature amongst the components of such universals. Being a stable helium atom involves having mass number three or four, for example. Individual members of the kind may instantiate that same determinable kind property in different determinable ways. This is straightforward in precise cases. But where such range-properties or determinables cannot be specified precisely, we must grapple with indeterminacy.

### 4.3 Indeterminate Kinds

Many kinds are indeterminate in one respect or another. Sometimes this is because there is indeterminacy in which properties are the component properties of the kind. Sometimes it is because one of the component properties of the kind is itself a 'vague property' in some sense; these options are not mutually exclusive. Thinking of kinds as complex universals allows us to understand these sources of indeterminacy without positing vagueness in the extra-linguistic world, and without abandoning our realism about kinds.

Richard Boyd discusses kinds whose paradigm members all possess every property on some core list. Possessing all the properties on this list is sufficient for kind membership. Yet possessing all these properties is not a determinately necessary condition for kind membership: outlying individuals may lack one or more of the 'core' properties, without its being determinate that they are non-members of the kind.

> In cases…in which some of the properties in the cluster are absent or some of the mechanisms inoperative it will sometimes happen that neither theoretical nor methodological considerations assign the object being classified determinately to the kind or to its complement with the result that the homeostatic property-cluster definition fails to specify necessary and sufficient conditions for kind membership...the indeterminacy in extension of these natural definitions could not be remedied without rendering the definitions…scientifically misleading" (Boyd 1991, 142)

Boyd argues that biological species fit this pattern. In this section, we take up Boyd's concern with outliers which are borderline members of the kind. Different issues are raised by individuals which apparently lack a 'core' property, yet determinately belong to the kind; we will revisit these issues later.

Suppose that *K* is a kind of the sort envisaged by Boyd, and suppose that the main cluster associated with *K* consists of four properties, *P*, *Q*, *R*, and *S*. Consider an individual, *a*, which instantiates all four of these properties: *a* is a member of *K*. Now consider an individual, *b*, which instantiates *P*, *Q*, and *R*, but not *S*: according to Boyd, it is indeterminate whether *b* is a member of *K*. In such a situation, which complex universal is the natural kind *K*?

*K* cannot be identified with the complex universal *P+Q+R+S*: after all, *b* determinately does not instantiate this universal, yet it is indeterminate whether *b* is a member of *K*. Nor can *K* be identified with the complex universal *P+Q+R*: other borderline individuals (*c*, *d*, and *e* in the table below) determinately do not instantiate *P+Q+R*, but they are not thereby determinately excluded from *K*. The same goes, *mutatis mutandis,* for *P+Q+S*, *P+S+R*, and *Q+R+S*.

| | *P+Q+R+S* | *P+Q+R* | *P+Q+S* | *P+S+R* | *Q+R+S* |
|---|---|---|---|---|---|
| *a* (*P*, *Q*, *R*, *S*) | Yes | Yes | Yes | Yes | Yes |
| *b* (*P*, *Q*, *R*, lacks *S*) | No | Yes | No | No | No |
| *c* (*P*, *Q*, *S*, lacks *R*) | No | No | Yes | No | No |
| *d* (*P*, *R*, *S*, lacks *Q*) | No | No | No | Yes | No |
| *e* (*Q*, *R*, *S*, lacks *P*) | No | No | No | No | Yes |
| *f* (lacks *P*, *Q*, *R* and *S*) | No | No | No | No | No |

*Table*: complex universals are listed across the top row, whilst concrete particulars are listed down the first column, with the simple universals they instantiate bracketed . 'Yes' and 'no' indicate whether a given particular instantiates a given complex universal; by hypothesis, there is no indeterminacy in these facts about instantiation.

We can assimilate this puzzle to the 'problem of the many' which arises for complex concrete objects. Most ordinary concrete objects seem not to have sharp boundaries. Consider a cloud: some water molecules are clearly parts of the cloud, others are clearly not parts of the cloud, but there are plenty of molecules for which it is unclear whether they are parts of the cloud. How are we to understand this? Perhaps the cloud is a vague object. But the idea of metaphysical vagueness is repugnant to many: let us set it aside.

Instead, consider the many 'cloud candidates' in the vicinity, the many precise sums of water molecules which differ from one another only at their margins. A cloud candidate is a material object which would count as a cloud under some permissible precisification (sharpening) of the concept 'cloud'. But, absent any precisification, it is indeterminate which of the cloud candidates is the cloud. There are various options for addressing this indeterminacy, but we will focus on supervaluationism: a sentence is true iff it is true on all precisifications, false iff false on all precisifications, and otherwise neither true nor false (for an overview, see Keefe and Smith 1997, 23). So it's true that central molecules are parts of the cloud, because on any precisification of 'cloud', it is true that those central molecules are parts of the cloud. For each borderline molecule, it's neither true nor false that that molecule is part of the cloud, because for each such molecule, there are precisifications on which it is true that it is a part of the cloud, and precisifications on which it is false that it is part of the cloud.

Now, recall the complex universals *P+Q+R*, *P+Q+S*, *P+R+S* and *Q+R+S*. These are the rival candidates for the role of being the kind *K*. Paradigm kind-members such as *a* instantiate all of these precise complex universals. So it is true that *a* is a member of *K*, because on any precisification of '*K*', *a* is a member of *K*. In contrast, *b* instantiates *P+Q+R*, but does not instantiate any of the other candidate complex universals. So it is neither true nor false that *b* is a member of *K*, because on one precisification of '*K*' (where '*K*' picks out *P+Q+R*), it is true that *b* is a member of *K*, but on other precisifications, it is false that *b* is a member of *K*. This is the desired result: *b* is a borderline member of *K*, and it is neither true nor false that *b* is a member of *K*.

But then which complex universal is the natural kind *K*? Any determinately true answer to this question would have to invoke a metaphysically-indeterminate property. So if we reject metaphysical indeterminacy, then we must accept that there is no determinately true answer to the question. It is indeterminate which of *P+Q+R*, etc is the natural kind *K*, just as it is indeterminate which of the cloud-candidates is the cloud. Nevertheless, there are plenty of true claims and false claims we can make about *K*, just as we can about the cloud. It is true that *a* is a member of *K*, it is false that *f* is a member of *K*, and it is true that *K* has three component properties, though it is neither true nor false that *P* is among these three.

When we take natural kinds to be complex universals, we can assimilate the sort of indeterminacy Boyd has in mind to the sort of indeterminacy familiar from the problem of the many, and thus apply the sort of solutions which have already been developed in that context. This is a clear advantage of our mereological approach to natural kind universals.

We now turn to a second source of indeterminacy. According to the biological species concept, a species is an interbreeding natural population that is reproductively isolated from other such groups (Mayr 1942). There will be many borderline cases such that it is indeterminate whether individual *a* is a member of species *S* because it is indeterminate whether *a* is able to breed with members of *S*: perhaps some of *a*'s offspring with members of S are infertile, but others are not, perhaps *a* could breed successfully with members of *S* under artificial conditions but would never do so in nature (e.g. because *a*'s mating call isn't quite right, or because *a* inhabits a distant island). Consider *S* as complex universal which includes the universals (properties) mentioned above, which, it may be noted, include relational properties. Under some precisifications of these properties it is true that *a* is a member of *S* and under some other precisifications *a* will be excluded from *S*. These comments are not intended to endorse the biological species concept as the one true species concept; nor are they an argument that species are natural kinds. Rather they show that our account of natural kinds can accommodate species, as understood by the biological species concept, as natural kinds. The vagueness of the biological species concept is not itself any obstacle to regarding species as natural kinds.

Vague kinds exist elsewhere in the natural world. Chemical reactions create new molecules from old ones—as molecules engage in such interactions there will be intermediate forms which are borderline cases for belonging to the kind of the old molecule or the kind of the new molecule. The reaction of esterification takes, for example, acetic acid, $CH_3COOH$, and ethanol, $CH_3CH_2OH$ and produces ethyl acetate, $CH_3COOCH_2CH_3$ plus water, $H_2O$. In the process of reaction between a particular pair of molecules there will be a point when certain bonds are being broken and other formed when such that it is indeterminate whether we still have an acetic acid molecule or an ethanol molecule or indeterminate whether we yet have an ethyl acetate molecule. Yet determinately we still have a molecule, which is borderline for membership of these various kinds.

Our suggestion, then, is that kinds are complex universals: some conjunctive, some structural. This enables us to explain various types of indeterminacy affecting kinds and kind-membership, by drawing upon analogies with problems of indeterminate boundaries amongst concrete particulars.

**4.4 Exception-permitting Kinds?**

We have focused upon kinds which have borderline members – objects which neither determinately belong nor determinately fail to belong to the kind. A different puzzle is presented by 'freak' entities – these are objects which seem determinately to belong to a given kind, whilst determinately failing to instantiate what appears to be a core property of the kind. For example, we might think both that having four legs is a core property of the kind dog, and having six legs is a core property of the kind honey bee, but both dogs and bees can lose legs; and in a small number of unusual cases individual dogs can be born with five legs and bees likewise.

Sentences such as 'dogs have four legs' are *generics* and do not entail the corresponding quantified statement ('all dogs have four legs'). Arguably, what makes (some) generics true is the possession of a *disposition*—all dogs are in a sense disposed to have four legs. Thinking first about dogs who lose a leg in an accident or who are born with fewer than four legs due to some developmental aberration, then a disposition to have four legs may be genetically grounded. Those genes dispose a creature to have four legs, but that disposition may not be manifested due to environmental interference. In some cases, however, a dog may be born with more or fewer than four legs dues to a genetic mutation, in which cases its genes will not dispose it to have four legs. Nonetheless, the fact that the dog in question comes from the lineage *Canis lupus* does dispose it to have four legs. This of course will be an extrinsic disposition, grounded as it is in relational properties of the individual. Extrinsic dispositions are nothing strange (McKitrick 2003). And as remarked above, we see no reason to limit the universals that can compose a complex universal to non-relational universals.

In some cases the dispositions will be probabilistic, i.e. propensities; for example, the half-life of an isotope *I* will be part of the complex that is *I*—it is a propensity since it is the duration during which an atom of that isotope has a probability of 0.5 of decaying. Consequently some properties that we associate with a kind will not be parts of the complex of universals; rather, the propensity to have that property will be part of the complex. So it might be that the correct property that is part of the complex universal *Canis lupus* is the high propensity, under appropriate developmental conditions, to have four legs.

**Section 5: Complex Universals and Homeostasis**

We have argued that natural kinds are complex universals. But we should not maintain that every combination of simple universals corresponds to a natural kind: this would entail almost as many kinds as there are objects. Instead, we need restrictions at two levels. First, not every combination of simple universals composes a complex universal: composition is restricted. Second, not every complex universal is a natural kind.

The first restriction arises from our mereological treatment of complex universals, including structural universals. Acknowledging that different structural universals can be composed out of the same simpler universals (as with methane, butane and isobutane), we have denied uniqueness of composition for universals, and thus we have departed from classical extensional mereology in one respect. This does not entail that we must also deny unrestricted composition for universals, but it makes it very natural to do so. Moreover, universals – including complex universals – are posited to explain natural similarities amongst objects. Given our assumption of a relatively sparse account of simple universals, we would prefer a relatively sparse account of complex universals.

The second restriction arises from our treatment of indeterminacy, which follows the supervaluationist account of the problem of the many. On this picture, for each natural kind that is prone to indeterminacy, there is a range of precise complex universals which are candidates for being the natural kind. Thus the complex universals outnumber the natural kinds, at least in realms where indeterminacy is rife.

What might be the basis of restrictions of either sort? Recall that, according to Mill, natural kinds permit particularly powerful inductions. From just a few properties one may infer the kind, and from the kind one may infer other properties. For this to be the case, it must be the case that the combination of properties associated with a kind is frequently instantiated, relative to other nearby possible combinations. Furthermore, this clustering of properties must not be accidental – it must be explicable. Why do electrons have mass $9.1 \times 10^{-31}$kg, rather than $9.2 \times 10^{-31}$kg? The symmetry laws and the standard model do not permit the latter, but instead explain why there are particles with charge $-1.6 \times 10^{-19}$C, mass $9.1 \times 10^{-31}$kg. and spin ½. Thus the laws of nature explain why this combination of properties corresponds to a natural kind.

This includes structural properties: why do helium nuclei typically have two neutrons, sometimes one neutron, and never no protons? This is explained by the balance of the electro-weak and strong nuclear forces. The non-accidental combining of properties extends to other kinds, including biological kinds. Boyd (1991) argues that these can be understood as homeostatic property clusters. Here, the combination of properties is not brought about directly by the laws of nature but by mechanisms that make certain combinations of properties more frequently instantiated than other nearby combinations, perhaps because other combinations are developmentally unviable, or less biologically fit. For example, we said that the high propensity to have four legs is a universal is part of the complex of universals that is the kind *Canis lupus*. The homeostatic property cluster approach explains why this propensity is conferred by membership of *Canis lupus*: mutations (fewer or more than four legs) are less fit and quickly removed from the gene pool.

Thus we have naturalistic explanations of why certain combinations of properties are commonly found co-instantiated. In metaphysical terms, are these explanations of why certain combinations of simple universals compose complex universals, or are they explanations of why certain complex universals are natural kinds? That is, do they correspond to the first of our restrictions above, or to the second? There are a number of viable responses here; which response is preferable depends in part upon one's attitude to conventionalism about natural kindhood, an attitude which may vary across the physical, biological and social sciences.

The first restriction is a restriction on what exists: which complex universals are there? The second is a restriction on which entities of a given class (the class of complex universals) have the special status of being a natural kind. One appealing option, then, is to attach the naturalistic explanations to the first restriction: simpler universals compose a complex universal when there are appropriate law-based explanations of the ways in which they are commonly coinstantiated. In realms where there are many similar complex universals, we can, if we wish, see conventions or human interests as playing a role in determining which of the complex universals count as natural kinds. (This conventionalism is not compulsory: there might be natural facts about which of many similar complex universals is a natural kind.)

Indeed, whether a given complex universal is a natural kind may not be an all-or-nothing matter. Entities which belong to the same kind are importantly similar – similar in ways that support a rich pattern of inductive inferences. Such induction-supporting similarity has at least two dimensions, each of which permits degrees. One dimension concerns the precision of the induction: can we infer to precise values (e.g. the charge on an electron) or merely to imprecise ranges (e.g. the mass of an adult red squirrel)? The second dimension concerns the richness of the induction – knowing the kind, how many distinct properties can we infer? The inductive inferences relating to the electron are fairly few, whereas those relating to the horse, as Mill pointed out, are many. Chemical kinds have become the paradigm kinds because they combine a high degree of accuracy and precision with a high degree of richness.

These points can be understood given the framework of complex universals we have been working with. Richness is a matter of complexity: the more component parts a complex universal has, the richer the inductive inferences it can support. Moreover precision can be understood, as before, by allowing that some complex universals have determinable, rather than fully determinate, properties amongst their parts.

Our approach contrasts with that of Armstrong, who has a sparse conception of simple universals but is more permissive when it comes to complex universals: any conjunction of cointstantiated universals is itself a (complex) universal. For him, the natural combinations are ‘merely the more interesting sort of conjunctive properties’ (1997: 32); this suggests a conventionalist account of our second restriction, but an absence of anything corresponding to our first restriction.  There is apparently no place in Armstrong’s picture for naturalistic explanations based on homeostasis, symmetry or causal considerations.

But can we really offer naturalistic explanations of mereological facts about universals?  Such mereological facts might seem somehow trivial: how can we explain why a complex universal has a certain component, when the complex universal *just is* that component in addition to others?  But consider concrete objects and their parts.  It is perfectly reasonable to ask why a particular kitchen appliance has a plastic attachment on top, or why a particular tree has as many branches as it does.  In general, it is neither *a priori* nor analytic that a concrete object has the parts it actually has.  Similarly, we can ask why a complex universal has the components it does, without risking triviality: it is neither *a priori* nor analytic that the universal has those components.  We discuss necessity in our next section.

**6.  Essences of Natural Kinds**

So complex universals can provide an ontology of natural kinds, accounting for various sorts of precision and indeterminacy which arise in this context.  In addition, they allow us to make sense of various sorts of explanations which may provided in connection with natural kinds.  A further advantage of our realist approach to natural kinds is that it provides a framework for discussing essentialism about natural kinds, understood as an issue about the essence of the kind, rather than the essence of individual members of the kind.  Locke (1690: bk 3, c.3, section 15), for example, tells us that an essence is the being of some thing, whereby it is what it is.  Thus natural kind essentialists must find something for a natural kind essence to be the essence of.  The obvious candidate is that entity, the natural kind.

What can complex universals tell us about transworld identity conditions for natural kinds?  Do universals have essences that are of the right sort for being the essences of natural kinds?  Some philosophers regard universals, fundamental ones at least, as having dispositional essences, which is to say that the essence of the universal is given by its causal or nomic relationships with other universals (Shoemaker 1980, Ellis and Lierse 1994, Bird 2007). Other philosophers regard fundamental universals as quiddities, having no essence beyond a primitive identity (Lewis 1986b: 205; Schaffer 2005; cf Black 2000). But we have already argued that, if natural kinds are universals, then they are complex, non-fundamental universals.

So what about essences for complex universals? The term 'conjunctive' may suggest that conjunctive universals have all their components essentially; after all, the conjunction A&B could not have lacked A as a conjunct. Recall, however, that conjunctive universals are not logically conjunctive, but mereologically complex. So the question concerns mereological essentialism for complex universals: does a complex universal have its proper parts essentially?

We should not expect a univocal answer to this question. Consider the analogous question about concrete objects: does a given concrete object have any or all of its proper parts essentially? It seems evident that 'ordinary' objects such as organisms, artefacts, and mountains may often change some or all of their parts over time, and across possible worlds: for organisms, this change is not just permissible, it is required. This mereological flexibility does of course give rise to apparent paradoxes, such as the ship of Theseus, and – across worlds – Noah and Adam (Mackie 2006). In response, a few philosophers have denied the existence of mereologically flexible objects. But this is a desperate measure which requires us to explain away almost all of our everyday talk about such things. The more plausible alternative is to accept that there are mereologically flexible objects, instead of or as well as mereologically inflexible things such as masses or aggregates.

The same goes for mereologically complex universals: the very fact that they are mereologically complex does not determine their modal identity conditions. Universals, including complex universals, are wholly present wherever they exist, thus wholly present in more than one possible world. Yet this does not entail mereological essentialism for universals, just as the endurantists' claim that ordinary particulars are wholly present at each of many times does not entail that ordinary particulars cannot change their parts (Hawley 2010). Thinking of natural kinds in terms of complex universals does little to constrain our thinking about the essences of such kinds: in particular, it does not require us to think of every component of the complex universal as an element of the essence of the kind.

If, on the other hand, we have independent reason to think that some component is essential to the kind, this can be accommodated. Suppose that a kind-universal *K* is composed of universals *A*, *B*, *C*, *D* and *E*, but *E* plays a privileged role in explaining why these universals are frequently coinstantiated. *K*'s having *E* as a part explains why *K* has the other parts it does, given the actual laws of nature. For example, the atomic number of an element explains its other properties (e.g. whether it is a metal, whether it is gaseous at room temperature, how it reacts with other elements and so forth). Given that *E* plays this central role in explaining the existence and nature of *K*, it is a prime candidate for being or contributing to the essence of *K* (McGinn 1975).

This way of thinking about kind essences allows us to minimize an apparent disanalogy between kind essences and the essences of individuals. When E is an essential characteristic of X, and X is an individual, then E concerns the nature of X, what it is for X to be: a property without which X could not exist (Fine 1994). But when X is a natural kind, its essence, as understood by the recent, Kripkean tradition of natural kinds, does *not* concern what is it for X to exist; instead it concerns the (not necessarily essential) properties of the *members of* the kind X. From this perspective, it is unclear why natural kind essentialism is a species of essentialism at all, However, from the perspective developed here, there is a much closer analogy: when X is a kind, E is a part of X without which X could not exist. For both individuals and kinds, their essences concern the nature and existence of those entities. In the case of kinds, since the kind could not exist without property E as a part, it follows that necessarily everything which belongs to the kind has E. Hence Kripkean essentialism about kinds is a *consequence* of essentialism as applied to our claim that kinds are complexes of universals.

Finally, the distinction between the essential and non-essential parts of a kind raises questions about the distinction between what it is to be a member of a given kind (in the actual world) and the properties which are (actually) causally correlated with being a member of that kind. Take the biological cases: being a red squirrel is a conjunction of having the right mass, right colour, right ear shape, right evolutionary heritage, feeding on seeds, bushy tail, etc. These properties can be actual parts of *being a red squirrel* without being essential to that complex universal (i.e. kind). But there might be some temptation to think that some of these are merely consequences of being a red squirrel, not part of *being a red squirrel*, even contingently. This distinction will be hard to make out, however, if we are referring to causal homeostatic processes to explain why the complex universal has the parts it does.

We argued that the kind *electron* is a conjunctive universal with certain mass, spin and charge properties amongst its proper parts. But given the actual laws, electrons will systematically have other features in common with one another, common behaviours in common circumstances. Should we think of these further shared properties of electrons as parts of the complex universal *being an electron*? Once we appreciate that parthood does not entail essential parthood, this becomes a live option: we can take the kind universal to include *having spin ½* as a part in every possible world (along with other essential parts), but other parts which differ from world to world, depending upon the local laws.

## 7. Conclusion

We have not done enough to persuade the determined sceptic about natural kinds, or about universals to come over to our point of view. However, we have begun to explore the potential rewards of identifying natural kinds with mereologically complex universals, and thereby drawing upon a range of better-understood ideas about mereologically complex ordinary objects. Incorporating kinds into our ontology this way enables us to recognise their significance without having to posit an entirely new category of being.

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