

Essential Properties are Super-Explanatory: Taming Metaphysical Modality

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1 Introduction

This paper aims to build a bridge between two areas of philosophical research, the structure of kinds and metaphysical modality. Our central thesis is that kinds typically involve *super-explanatory* properties, and that these properties lie behind all substantial cases of metaphysical necessity.

Philosophers of science who work on kinds tend to emphasize their complexity, and are generally suspicious of any suggestion that they have “essences”. The complexities are real enough, but they should not be allowed to obscure the way that kinds are typically unified by certain core properties. We shall draw on the work of Ruth Millikan in explaining this. Millikan herself has never been much concerned with issues of metaphysical modality, but we shall show that her analysis offers a natural account of why certain properties are metaphysically essential to their possessors.

2 Kinds

Some categories have a rich structure, in that their instances share a great many properties.

For example, all horses are alike, not only in being horses, but in eating grass, growing manes, having uncloven hooves, and sharing a great number of other behavioural, anatomical and physiological features.

Following J.S. Mill, we shall call this sort of category a “Kind”¹. The defining characteristic of Kinds is that any Kind *K* will enter into a plurality of informative² generalizations of the form: *All K are G*.

Note that by no means all properties pick out Kinds. For example, square things, or soft things, or small things, do not form Kinds. There are no informative generalizations of the form: *All square/soft/small things are G*.

Biological species are not the only Kinds. Chemical substances are also Kinds. All samples of sulphuric acid have the same melting and boiling point, the same propensity to combine with other substances in fixed proportions, the same liquid density, electrical and thermal conductivity, and so on.

¹ As J S Mill put it “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 properties, as we know, and, it cannot be doubted, in a great many more than we know” 1843, 703-4.

² Our requirement for informativeness is that it be possible to know that something is *K* without already knowing it is *G*. Some Kinds are thinner than other, in supporting fewer generalizations. But any Kind supporting a plurality of generalizations is worthy of note. In footnote 11 below we shall distinguish between genuine Kinds and *accidental* Kinds, like jade. The generalizations associated with many Kinds, especially biological taxa and social categories, admit of exceptions. Nothing in what follows will hinge on this, though we shall return to the point in footnote 23.

Higher biological taxa, as well as species, also form Kinds. For example, all mammals have fur, sweat glands, milk glands, and other distinctive anatomical features. Note how the features common to some higher taxon will be a subclass of those common to its subordinate taxa. The features common to all mammals are among the features common to all horses.

Astronomical objects also fall into Kinds. All main sequence stars (those powered by hydrogen fusion) are spherical, in hydrostatic equilibrium, radiate energy of certain wavelengths, and so on. Other astronomical Kinds include red giant stars, white dwarf stars and supernovae. Further types of Kinds include meteorological categories and geological formations.

3 Kinds are Useful but not Anthropocentric

The rich structure of Kinds is very useful to human beings.

For one thing, we can normally ascertain that something is an instance of some Kind *K* by observing just one, or some few, of its characteristic *G*s. For example, you can identify horses by the characteristic shape of their heads, or gold by its characteristic electrical conductivity. And then, if you are appropriately informed, you can infer all the other characteristic *G*s from this.

For another thing, there are often short-cuts to becoming appropriately informed about the *G*s that are characteristic of some Kind. This is because Kinds fall into Types that specify *which* properties will be shared by all the instances of Kinds of that Type.

So, for example, vertebrate species are one Type of Kind, in that all the animals in any given vertebrate species will share morphology, anatomy, physiology, diet, reproductive behaviour, and various other properties (but not injuries, learned behaviours, . . .) Of course, the determinate morphology, anatomy, and so on, of any one vertebrate species will be different from that of the others; still, the different vertebrate species will all coincide in each being characterised by determinates of the same set of determinable properties.

Similarly, chemical substances are another Type of Kind. All samples of any given chemical substance in a given state of matter will typically have the same colour, taste, odour, density, electrical and thermal conductivity, . . . (but not the same shape, size, . . .)

If you know the “template” of determinable properties for a certain Type of Kind, as Ruth Millikan has put it³, then you are in a position to make *one-shot inductions*. From a traditional perspective, it can seem puzzling that that one experiment on one piece of gold can tell you when all gold will melt, or that one dissection of a hippopotamus can tell you about all hippopotamus bladders. However, once you know the template for chemical substances, or for vertebrates, then these inferences are secure.

³ Millikan 2000: ch. 1.8.

All in all, then, facts about Kinds are very useful for people to know. But it would be a mistake to infer from this that the structure of Kinds is somehow anthropocentric, that it is something we project onto reality because of our particular human interests.⁴ On the contrary, the structure of Kinds is part of objective nature, and useful to us precisely because of that. Kinds would be structured in just the way they are even if no people or other intelligent beings had ever evolved to know about them.⁵ (Indeed it is likely that many of our distinctive intellectual powers evolved specifically to enable us to discern the pre-existing structure of Kinds.)

4 Super-Explanatory Properties

When we have a Kind *K* whose instances share many different properties *G*, there will typically be some single property *E* of their instances that explains this multiple commonality. Our eventual aim in this paper is to show that such “super-explanatory” properties are also essential in the modal sense of being possessed by Kind instances across all possible worlds. But that is for later. Our first task is to explain the role of super-explanatory properties in the actual world.

For example, the *atomic constitution* of gold explains why all samples of solid gold have the same density, electrical and thermal conductivity, melting and boiling point, . . . More generally, the *molecular constitution* of any given chemical substance will explain why its instances share many corresponding properties.⁶

Similarly, the internal physical constitutions characteristic of the various Kinds of astronomical objects explain why the instances of such Kinds (the main-sequence stars, the white dwarfs, the red giants, . . .) share their many other common properties.

Moreover, as we shall see, the members of any given biological taxa will also share a single property that explains their multiple commonalities – though in the biological case, we shall argue, this will not be a shared intrinsic property, as it is with chemical or astronomical Kinds.

We can view such “super-explanatory” properties as illustrations of the Principle of the Common Cause. In general, when we find some *A* and *B* are correlated (in the sense that they are *co-instantiated* more often than we would expect given their separate probabilities

⁴ Of course, our interests will determine *which* Kinds we attend to, and indeed might often direct our attention to categories that are not Kinds at all (cf. Dupre 1993).

⁵ Exceptions are the social Kinds that we shall touch on briefly below. These do of course depend on people, and moreover, in the special case of Ian Hacking’s “looping kinds”, on people’s knowledge of them (Hacking 1995).

⁶ Some complications: it is the molecular *structure*, not chemical formula, that explains the properties of chemical compounds (isomers can be very different from each other); isotopy makes a difference to some (but not all) of the properties of elements and compounds; some chemical mixtures are Kinds in their own right. A rich literature explores the complexity of chemical and other natural Kinds (inter alia Hendry 2008, Needham 2008, Khalidi 2013, Häggqvist and Wikforss forthcoming). We take this literature to show that there are more Kinds than you might initially suppose, often nested within each other, each with their own super-explainers for their shared properties.

of occurrence), then it will be the case that either A causes B, or B causes A, or both A and B are joint results of some common cause.

Kinds are in effect rich complexes of correlations. All the many Gs characteristic of a Kind are correlated with each other. As soon as we know that something has one such G, this typically makes all the other Gs much more likely. However, at least in the cases we have considered so far, the different correlated Gs don't cause each other. The melting point of gold doesn't cause its density. The bladders of hippopotami don't cause their ears. So correlations between properties like these must be due to some common cause, some super-explanatory property of the instances that is responsible for their all sharing so many other properties.⁷

Do all Kinds conform to this common-cause model? *Functional* Kinds are an interesting case. Consider the Kind *aerial insectivore*. All the swallows, martins, swifts, insectivorous bats, and other flying insect-eaters share a range of properties, including acute sensory systems, ability to swoop, and pointed beaks or mouths. Kinds like this are the result of convergent evolution. The aerial insectivores all belong to species that have been shaped by similar selective pressures.

Some are suspicious of Functional Kinds, on the grounds that they only share a few superficial properties, by comparison with the multitude of properties shared by the members of any biological taxon.⁸ While this is certainly true, and indeed a point to which we shall return below, we are happy to accept Functional Kinds as genuine Kinds, albeit of limited informativeness. In line with this, we would say that the common selective pressures that give rise to Functional Kinds are themselves a super-explanatory common cause for the shared properties of those Kinds.⁹

We don't completely want to rule out Kinds that don't in any sense have a super-explanatory core property. Maybe there are Kinds where the shared Gs *do* cause each other, rather than stemming from some common cause. Perhaps some meteorological categories are like this. (For example, *tropical cyclones* might be seen as occurring when strong winds, heavy rain, spiralling thunderstorms and a low-pressure centre all reciprocally reinforce each other.)¹⁰

As with Functional Kinds, one might feel that there is something rather thin about Kinds like tropical cyclones that gain their common properties from cycles of reciprocal causation. We shall not push this point, however. Nothing in our arguments will depend on the claim that

⁷ Some doubt that the Principle of the Common Cause can be defended in any general form (Arntzenius 2010). We disagree, but need not pursue the issue here. The more important point is that Kinds typically have super-explanatory cores, not whether this has a principled basis.

⁸ Thus biologists typically attach more weight to *homologies* between traits with a common ancestry than to *analogies* resulting from common evolutionary pressures (cf. Brigandt and Griffiths 2007). See also Godman 2015.

⁹ Perhaps artefacts (like *cars*, as opposed to makes and models like *Vauxhall* and *Zafira*) also form Kinds, with their common features stemming from the shared intentions of their makers.

¹⁰ Cf. Millikan 2017: ch. 1. Richard Boyd (1991, 1999) has argued that Kinds are "homeostatic property clusters". While we certainly agree that properties cluster in Kinds, homeostasis matters to at most a few Kinds. We feel that Boyd's analysis has obscured the importance of super-explanatory properties.

all Kinds have instances that share some super-explanatory property. Rather, we are interested specifically in analysing those Kinds that *do* have super-explanatory properties. If there are Kinds which lack such a property, so be it. The claims which follow will not apply to them.¹¹

5 Historical and Eternal Kinds

In the next section we shall ask what plays the role of super-explanatory properties for biological taxa. But first we need to discuss something else.

Consider a rather different type of Kind from those discussed so far – all the different copies of *Alice in Wonderland*. This qualifies as a Kind all right. The copies share a multitude of properties. Each copy tells the same story, with same characters and scenes. Indeed they all tell it in the same way, with the same first word, the same second word, and so on, until the end.

The car model *Vauxhall Zafira* forms another Kind. All cars of this model have the same ingenious system of extra folding seats, the same undercar spare wheel holder, the same type of carburettor, and so on.

The correlations between the properties of these Kinds are not explainable by some intrinsic common physical property, like molecular structure or stellar composition. Different copies of *Alice in Wonderland* can be physically quite different (paper, magnetic tape, . . .) And even if all *Zafiras* are physically similar, there is no one aspect of this similarity that provides a common explanation for all the other shared properties of *Zafiras*.

Rather, the super-explanatory feature shared by the members of these Kinds is their common origin. All the many instances of *Alice in Wonderland* have been replicated in one way or another from Lewis Carroll's original manuscript. All the many *Zafiras* have been manufactured in line with the designer's original blueprint. That's why these instances all share a multitude of properties.

Ruth Millikan has coined the term "Historical" for Kinds whose shared properties are due to their instances all being copied from some common source (1999). She contrasts these with "Eternal" Kinds whose shared properties are explained by the instances having some common *intrinsic* physical property. (The term "Eternal" is perhaps not ideal, given that instances of Eternal Kinds can be in flux and short-lived (supernovae, decaying elements), but we will stick with it.)

¹¹ Some categories technically fit our definition of Kinds, in supporting a plurality of generalizations, even though there is *no* unified explanation for the correlations involved, not even in terms of reciprocal causation. For example, jadeite and nephrite are traditionally lumped together as *jade*, on account of their similar colour, hardness and density, even though they are two quite different minerals. Cf. Bird 2010. Let us say that a Kind is *genuine* if its correlations have a unified causal explanation, and *accidental* when it results from two or more genuine Kinds fortuitously coinciding in some of their properties. Accidental Kinds are by their nature rare; we shall put them to one side in what follows. To summarize our taxonomy, then: any category supporting a plurality of generalizations is a *Kind*; only those with a unified causal explanation are *genuine*; for most but not necessarily all genuine Kinds, that explanation involves a *super-explanatory* common cause.

Literary works and car models might seem somewhat frivolous examples of Kinds. But consciously designed items like these are not the only Historical Kinds. Various types of social category can also be seen in this light: the many beliefs and behaviours characteristic of *Christians*, say, or *molecular biologists*, or *Japanese women*, are arguably shared because they are copied from prior models (cf. Godman 2105, forthcoming). In addition, as we shall now argue, biological taxa are also Historical Kinds.

6 Biological Taxa

What sort of Kinds are biological taxa? A first thought might be that they are Functional Kinds, with their shared properties accounted for by common selective pressures. But this fails to do justice to the rich structure of biological taxa. The members of any biological taxon typically share a wealth of features that are not explainable by the selective pressures that shaped that taxon. This is because natural selection does not design ideal organisms, but builds on what went before, is limited to materials thrown up by mutation, and is buffeted around by genetic drift. This ensures that biological taxa standardly share any number of non-functional features. We need to look beyond selective pressures to capture the nature of biological taxa.

Michael Devitt (2008, 2010) has recently argued that we need to recognize intrinsic biological “essences”, in the form of shared genomic material and associated developmental mechanisms, precisely in order to account for the many characteristic phenotypic commonalities displayed by the members of any given biological genus. (We have put “essences” in scare quotes to repeat the point that at this stage we are still not concerned with any modal issues, but simply with the explanatory role of genomic mechanisms in the actual world.)

Devitt’s position might suggest that we should assimilate biological taxa to Eternal Kinds, taking their shared genomes and developmental mechanisms to play the role of super-explanatory intrinsic properties. However, this is not the only possible way of fitting biological taxa into our analysis. An alternative option is to view biological reproduction and ontogeny as a copying mechanism which produces new members of biological taxa from old ones. This would then render biological taxa as Historical Kinds.

Does this have to be an either/or issue? The examples offered so far might have suggested that Eternal and Historical Kinds will always be mutually exclusive. We have considered Eternal Kinds, like chemical substances and stars, whose instances have had no causal connection to each other, but have simply arisen whenever the conditions were right. By contrast, the instances of Historical Kinds are necessarily causally connected to each other, related by descent through copying.

Still, the definition of an Eternal Kind as having a common intrinsic core does not itself preclude its instances from being causally connected to each other. So it remains open that some Kinds might be *both* Eternal and Historical, in the sense that their instances share some common intrinsic property *and* reproduce by copying.

Biological taxa could be a case in point. We could view them both ways. We could focus on the genomes and developmental mechanisms, and view reproduction as simply a part of the process which creates items with that intrinsic nature. Or we could focus instead on the reproduction, and view the genomes and development as simply a part of the process by which new instances are copied from old ones. The two perspectives are obviously compatible. This suggests that biological taxa are akin to both Eternal and Historical Kinds.

Nevertheless, we want to argue that biological taxa should be counted as Historical and not Eternal Kinds. In an earlier paper two of us pointed out that (a) even in sexually reproducing taxa, a significant number of taxon-typical biological characteristics are not inherited through the sexual bottleneck via intrinsic genetic properties of the zygote, but via non-genetic influences like behavioural imitation, and (b) in single-celled non-sexual taxa like bacteria, genomic material does not play any super-explanatory role, but is just one of the features copied in mitosis. On this basis, we argued that a uniform account of biological taxa should treat them as Historical rather than Eternal Kinds (Godman and Papineau forthcoming).

It now strikes us, however, there is a more fundamental objection to viewing biological taxa as Eternal Kinds. It's not just that this position fails to deal with non-genetic inheritance and non-sexual reproduction. Rather, even if we stick solely to genetically inherited traits in sexual species, it never offers the right kind of super-explanation at all.¹²

Remember that we are looking for some common-cause explanation of the multiple correlations between the many characteristic phenotypic features of biological genera. However, the genomic material common to the members of a taxon will typically not be suited to play this role. This is because it will normally be a *conjunction* of different genetic properties, each one of which explains a different phenotypic feature. So we don't have *one* intrinsic property acting as a *common* cause for many phenotypic properties, but simply a list of different intrinsic genetic properties explaining different phenotypic properties. And this thus leaves us once more with an unexplained multiple correlation. Why are all those different intrinsic genetic properties found together?

By way of comparison, note that it would not be much of an explanation of why all gold, say, has a distinctive colour, density, electrical and heat conductivity, . . . to be told that gold contains an intrinsic property I_1 that determines its colour, a different I_2 that fixes its density, another I_3 for its electrical conductivity, and another I_4 for its heat conductivity . . . We would still want to know why all these intrinsic I-properties occur together in any sample of gold.

By the same coin, it is no explanation of the many features common to all horses, say, to say that horses all have some genetic material that determines manes, and some other genetic material that determines uncloven hooves, and some other genetic material that determines their head shape . . . We wouldn't yet have explained why all these different genetic features are found together in horses.¹³

¹² We would like to thank Nicholas Shea for this objection.

¹³ It might seem that this argument assumes a strong version of "bean-bag" genetics according to which genomes are composed of separate "genes" each of which independently determines some phenotype, when

In the case of gold and other chemical substances, of course, it is molecular structure that provides the requisite common cause. The different features of gold all stem from one common source, its atomic structure, and not from a number of different intrinsic properties. But in the biological case the different genetic elements in some taxon's genome are not tied together in this way.¹⁴

To find a property that explain why all the different phenotypic features of a biological taxon are instantiated *together*, we need to turn away from ontogenetic development and view the taxon as a Historical Kind. The reason the phenotypic features of a taxon are found together is that its members are all descended from common ancestors who had those features. Biological reproduction is a copying process – offspring share the heritable features of their parents.¹⁵ So a set of properties that are conjoined in an ancestral population will be found together in the descendants too.

One last point before turning to modal matters. Ernst Mayr introduced a well-known distinction between proximal and ultimate biological explanations (1961). A proximal explanation tells us how an individual organism develops the phenotypic features that are characteristic of its species. An ultimate explanation tells us why that species came to have those characteristics in the first place. Proximal explanations will refer to the developmental program that enables the zygote to develop into a mature organism. Ultimate explanations will appeal to the historical circumstances that shaped the species, including selective pressures.

Devitt explicitly relates his analysis to Mayr's distinction. He observes that his intrinsic essences answer Mayr's proximal question, in that they explain individual development in terms of genetic material and associated developmental mechanisms. He also responds to Mayr's ultimate question, by adding a further historical element to biological essences. So Devitt's overall view is that taxon essences are partly intrinsic and partly historic: the intrinsic component explains proximal issues of individual development, while the historic component explains ultimate issues of taxon origins (Devitt 2010).

It is worth making clear that our analysis of biological taxa is motivated by a question that is quite distinct from both of Mayr's questions. We are interested specifically in explaining

in truth different parts of genomes combine in complex ways in producing any given phenotype. Our argument only requires, however, that genomes display some level of modularity, and this much is widely agreed to be a prerequisite of evolution by natural selection.

¹⁴ The trouble with taxon genomes as super-explainers is not that they are *conjunctions* of properties. Plenty of legitimate super-explainers, like molecular structures say, can be analysed as conjunctions of properties. Rather the objection is that the conjunction of properties in a genome do not *all* play a part in explaining *each* of the taxon's characteristics Gs, and so fails to identify the source of their correlation. We would like to thank Julien Dutant for pressing us on this issue.

¹⁵ In sexual taxa, offspring are only partial copies of their parents, due to sexual dimorphism and the sexual mixing of traits. We shall take these complications as read when we refer to the members of a sexually reproducing taxon as being "copied" from a common source. With clones like Dolly the sheep, on the other hand, we do have full copies of parents. Sometimes people wonder whether such clones properly belong to the relevant biological species. That depends on exactly what hangs on "species membership", but we would certainly count clones as belonging to the same Historical Kinds as the parents they are copied from.

why so many different properties are tightly *correlated* in the members of any given biological taxon, not in how those properties develop as those organisms mature from zygotes, nor in why the taxon came to have those properties in the first place.

It is clear enough that we are not addressing Mayr's first proximal question. When we explain the clustering of a taxon's properties in terms of the common ancestry of its members, we simply take developmental mechanisms for granted. We assume that offspring will resemble their parents, and use this to infer that all taxon members will share the properties that were originally displayed by the founding population. From our perspective, the development of mature organisms from fertilized zygotes is not explained, but rather presupposed as part of the copying mechanism that ensures the resemblance between parents and offspring (a resemblance, remember, that is differently accomplished in non-genetic inheritance and in non-sexual taxa).

Nor are we answering Mayr's ultimate question. Even though our biological super-explanatory are historical, they do nothing at all to address Mayr's ultimate issue. By way of analogy, note that when we explain why all the copies of *Alice in Wonderland*, or all the *Vauxhall Zafiras*, share so many correlated properties, in terms of their all being copied from a common source, this doesn't even start to explain why *Alice* and the *Zafira* were designed as they were in the first place. While these are certainly questions worth asking, we do nothing to answer them, but simply take the features of the originals as given, and explain the commonalities in the copies by that alone. Similarly, when we explain why horses share so many common features, say, we start from the fact that some few original horses had those features, and explain the correlations by that alone, without wondering where those original features came from.

So our question is different from both of the questions traditionally addressed by biological theorists. Where they are interested in ontogeny and phylogeny, we are interested in explaining correlations. Moreover, our approach simply assumes answers to the traditional questions, taking as given both the machinery that allows offspring to resemble their parents, and the original traits of founding populations.

Still, even if our question is not one that has traditionally concerned biological theorists, this does not mean it is not philosophically important in its own right.

In this connection, note first that our correlational question is the one we need to focus on if we want to uncover some notion of "core property" that applies to Kinds in general, and not only to biological taxa. All Kinds involve correlations that call for explanation in terms of super-explanatory properties. But they do not all have ontogenies or phylogenies about which to ask Mayr's proximate and ultimate questions. Chemical samples, for example, do not develop ontogenetically from seeds, nor do their shared properties result from evolutionary processes.

Moreover, in our view it is specifically correlation-explaining super-explanatory properties that hold the key metaphysical modality. If we want a species of "essence" that is invariant across metaphysically possible worlds, we need to focus on super-explanatory properties, rather than developmental machinery or evolutionary origins.

7 The Necessity of Super-Explanatoriness

We now turn to modal issues. The central thesis of this paper is that super-explanatory properties are the source of all substantial cases of metaphysical necessity.¹⁶

Take chemical substances. As we have seen, molecular structure plays the super-explanatory role for chemical substances. In line with this, chemical substances have their molecular structure necessarily. There are no metaphysically possible worlds where water is not H₂O. Moreover, in any possible world, anything that is H₂O is water.

It works similarly with biological taxa and other Historical Kinds. Here the super-explanatory property is shared origin. Accordingly, you can't possibly be a tiger unless you are part of the lineage that starts with the original tigers, and necessarily anything that is part of that lineage (without too many modifications) is a tiger. You can't possibly be a copy of *Alice in Wonderland* if your provenance doesn't trace back to Lewis Carroll's original manuscript, and necessarily any reasonably faithful copy with such a provenance is a copy of *Alice in Wonderland*.

As we said, Functional Kinds tend to be less rich than other Kinds. But even so it is natural to regard the selective pressures that super-explain their shared properties as modally necessary and sufficient for Kind membership. You can't possibly be an aerial insectivore unless natural selection has shaped you to catch insects, and necessarily anything so shaped is an aerial insectivore.¹⁷

It is not hard to understand why we should take super-explanatory properties to have this kind of modal significance. Metaphysical modality gains its significance from its connection with counterfactual thinking. Many everyday concerns call for us to consider what would have happened under some counterfactual supposition. When we counterfactually suppose that some item lacks some property, we naturally hold most of its other actual properties fixed. (. . . Suppose Nixon had lost the election . . .) But when we suppose that some item lacks a super-explanatory property, all bets are off. Counterfactually supposing away a cause requires us to suppose away its effects too. So when we suppose away the super-explanatory core of some item, we therewith suppose away all the many correlated properties that made the item worth recognising in the first place. The natural reaction is that we have thereby supposed away the item altogether.

This is not to deny that there are possible worlds where a liquid with the superficial properties of water (odourless, colourless, tasteless, . . .) is not H₂O, and where a species with the superficial properties of tigers (striped, solitary, carnivorous, . . .) is not descended from the original tigers. But that liquid would not be *water*, nor that species *tigers*, precisely because their correlated properties do not stem from the same super-explanatory source as in the actual world. We don't count them as the same Kinds, despite their superficial

¹⁶ Mallozzi forthcoming also defends this assumption, and in particular explores its epistemological implications, focusing on examples of eternal Kinds.

¹⁷ And artefacts will have the intentions behind them essentially. Necessarily something is a watch if and only if it has been designed to be a personal portable chronometer.

resemblance, because they have been put together in a different way. They don't have the crucial property that pulls together the categories that exist in the actual world.

So far in this section we have argued that modal necessity goes with super-explanatoriness for Kinds. We think the same account also applies to the essential properties of particulars like humans, other animals and inanimate objects. Ruth Millikan has shown how such *Individuals*, as we shall term them, have structures that are analogous to those of Kinds in various respects. In the final sections of this paper we shall explore this analogy further, arguing that certain properties of Individuals also play a super-explanatory role, and that this offers an attractive account of the distinction between the essential and accidental properties of Individuals.

Before proceeding, it will be helpful to add some precision to our arguments. We have on occasion drifted into talking of super-explanatory of Kinds, and of Kinds possessing those properties in all possible worlds. But in the case of Kinds (and an analogous point will apply to Individuals), it is not strictly the Kinds themselves that have the super-explanatory properties, but their instances; and correspondingly what's strictly necessary isn't that the Kind has the essential property, but that any instance of the Kind does. Thus:

(1) $(K)(E)(x)((K \text{ is a Kind, and } E \text{ super-explanatory with respect to } K) \rightarrow \text{nec } (Kx \rightarrow Ex))$

There is also the converse implication (though here the analogy will break down for Individuals):

(2) $(K)(E)(x)((K \text{ is a Kind, and } E \text{ super-explanatory with respect to } K) \rightarrow \text{nec } (Ex \rightarrow Kx))$

Principle (1) says that any super-explanatory *E* is *required* for Kind membership across possible worlds. *E* is an "essential property", in that you can't belong to the *K* if you lack it.

Principle (2) says that any super-explanatory *E* is *sufficient* for Kind membership across possible worlds. *E* constitutes an "essence", in that you must belong to the *K* if you have it.¹⁸

Note that it doesn't follow from (1) and (2) that a property that's essential to, or an essence of, some Kind must be essential to, or an essence of, the individuals that belong to that Kind. *Having professional accreditation* is essential to and the essence of *being a medical doctor* – necessarily you have the accreditation if and only if you are a doctor. But that accreditation is not essential to (and still less is it the essence of) individual doctors *being who they are*. Any doctor could have failed to be a doctor; indeed no doctor was always a doctor, and many doctors cease to be doctors.

¹⁸ Many theorists (Rieppel 2010, Ereshefsky 2010) who are suspicious of Kind "essences" take it as definitional that they must be *intrinsic* properties. Many essentialists like Mark Ellis also view historical essentialism with suspicion, suggesting that historical essentialists "creatively revive the illusion of species essentialism" (Ellis 2011: 670). Given our view of Historical Kinds, we obviously think a meaningful sense of historical essentialism can survive these critiques (see also LaPorte 2017, Godman and Papineau forthcoming).

It has been put to us¹⁹ that super-explanatory properties do not really involve *metaphysical* modality, but only highlight certain aspects of *nomological* modality. After all, super-explanatoriness depends on nothing more than nomological relations between properties in the actual world, and so doesn't have to be seen as taking us beyond actuality.

We agree that our account of modally essential properties gives priority to the actual world. Super-explanatoriness is fully determined by actual-world nomological relations. But we don't think that this disqualifies it as an account of metaphysical modality. After all, super-explanatoriness involves a quite specific kind of nomological structure. It's not just a matter of one property being nomologically related to another, as gas pressure, say, is related to temperature. Rather, it involves a given property being the *common cause* of a *multitude* of other properties, and thereby explaining why those other properties are so tightly *correlated together*.

Our proposal is thus not to *eliminate* metaphysical necessity in favour of nomological necessity, but rather to *reduce* the kind of cases of metaphysical necessity that are familiar from the Kripke-Putnam literature to a specific kind of nomological structure. Whenever we find the structure characteristic of a super-explanatory property, then that property will be possessed in all metaphysically possible worlds.

To drive the point home, note that it is a consequence of our view that essential properties will stay fixed even in possible worlds where the relevant laws of nature were different. Even if variation in laws of nature meant that H₂O is no longer odourless, colourless, tasteless, . . . it would still be *water*. We might be explaining modal essentiality in terms of this-world super-explanatoriness. But even so our account clearly implies that modal connections transcend nomological ones.²⁰

On our view, then, super-explanatory properties provide a kind of bridge between the actual world and the modal realm. Super-explanatoriness depends on nothing beyond a specific kind of causal role in the actual world. But the specific structure of this causal role means that we are committed to super-explanatory properties remaining invariant across all possible worlds.

8 Identity and Super-Explanatoriness

It has been put to us²¹ that the modal consequences of (1) and (2) follow directly from the necessity of identity, and therefore that super-explanatoriness is not needed to explain them.

The thought is that such identities as *water* = H₂O, and *tigerhood* = *being descended from the original tigers*²², and so on, together with the necessity of identity, are themselves

¹⁹ In particular by Graham Priest.

²⁰ As it happens, we are not committed to the contingency of laws of nature. But it enough for our point that modal connections would come apart from nomological ones *if* the latter were contingent.

²¹ In particular by Paul Horwich and Stephen Neale.

²² Perhaps it would be better to frame these as generalized identities rather than as simple equalities between properties (cf. Correia 2010, Rayo 2013, Dorr 2016, Correia and Skiles forthcoming). And ideally we should be

enough to ensure the necessary coextensiveness specified in the consequents of (1) and (2), without any help from the super-explanatoriness referred to in the antecedents.

We agree that the modal consequences of (1) and (2) follow from Kind identities like *water* = H_2O , and *tigerhood* = *being descended from the original tigers*, together with the necessity of identity. But we think that such Kind identities are themselves a consequence of (1) and (2). The reason that we identify water with H_2O is precisely that this molecular structure is super-explanatory of the many shared properties of water. Because of this super-explanatoriness, we regard water and H_2O as necessarily coextensive, and this then leads us to identify them.

After all, there are theorists who don't agree that *water* = H_2O . (Let us stick to water. Everything that follows in the section applies would apply equally to tigerhood.) These theorists reject an externalist account of the concept *water*, and instead hold that it refers to anything that satisfies such nominal requirements as *odourless, colourless, tasteless, freezes at 0°C, etc.* They allow that all the actual water is in fact H_2O . But they see no reason why this property should have a privileged role in relation to the nature of the Kind *water*, at the expense of the properties by which we recognize the Kind. They thus maintain that *water* = *odourless, colourless, tasteless, freezes at 0°C, etc.* and deny that *water* = H_2O .

In line with this, they hold that it is by no means necessary that water is H_2O , or indeed that H_2O is water. They think that there are possible worlds in which water – the odourless, colourless, etc. liquid – is not H_2O , and worlds in which H_2O is not water – not odourless, colourless, etc., due to different types of observers or different laws of nature.

Now, we of course think that these anti-externalists are wrong about water (and we would say the same about similar anti-externalist views about other Kinds). But the interesting question is *why* they are wrong.

Note that nothing is extensionally amiss with their account. They will classify just the same actual liquids as water as anybody else.

In our view, the reason for identifying *water* with H_2O , rather than with *odourless, colourless, tasteless, freezes at 0°C, etc.* is precisely that H_2O is super-explanatory with respect to water, in a way that the nominal features of water are not, despite their extensional adequacy.

A super-explanatory property of a Kind plays a special role. It is a single property that pulls together all the many other common features of the Kind. None of the Kind's other nominal features have this role. They are simply effects of the common super-explanatory core.

This is why we take super-explanatory properties to be constitutive of Kinds. An instance with a super-explanatory property has the feature that causes all the other distinctive

more explicit about the types involved: for example, by equating *being water* with *being made up of H_2O molecules in a certain way*. Still, we trust that our simplifications will not affect our arguments.

properties of the relevant Kind. And so possible (or indeed actual²³) instances still count as of that Kind, even if they lack some of the nominal features of the Kind.

Conversely, if we posit an instance that has all the nominal features, but not the super-explanatory essence, it doesn't count as a member of the relevant Kind. As we observed earlier, a liquid that was odourless, colourless, tasteless, etc, but was not H₂O, would not be water, despite its superficial resemblance. The category would have been put together by hand, so to speak, rather than deriving its shared features from the core property that pulls them together in the actual world.

So, yes, once we are given such identities as *water = H₂O*, and *tigerhood = being descended from the original tigers*, then it will follow that the properties that flank the identity sign are necessarily co-extensional. But the reason for embracing these identities in the first place is precisely that the properties on the right-hand sides are super-explanatory essences.

9 Types of Metaphysical Necessity

Our central thesis is that super-explanatoriness lies behind all *substantial* cases of metaphysical necessity. We will now explain why we have qualified our thesis in this way.

There are certainly some metaphysical necessities that owe nothing to super-explanatoriness. In particular, logical necessities do not, nor do many ordinary necessities of identity. These necessities fall out of the framework of modal discourse itself, and so they are generally regarded as philosophically unpuzzling. The more interesting necessities are those that depend on something else.²⁴ It is these that we want to explain in terms of super-explanatoriness. We distinguish them as "substantial" because they are not simply corollaries of logic and the necessity of identity.

It will be helpful briefly to comment on the necessity of identity. As it familiar, this is forced on us simply by the legitimacy of de re modal constructions (. . . Nixon might have lost the election . . .), together with the premise that $(x)(nec(x = x))$ (or alternatively $nec(a = a)$). These lead quickly to the principle that

$$(x)(y)((x = y) \rightarrow nec(x = y))$$

(or alternatively to the schema $(a = b) \rightarrow nec(a = b)$).

The necessity of identity then ensures the necessity of such claims as that *Marilyn Monroe = Norma Jean Baker*, or *Hesperus = Phosphorous*. Identity claims like these certainly count as metaphysically necessary even though super-explanatoriness is nowhere involved.

²³ In Kinds with generalizations that admit of exceptions, such as biological taxa, there will be real cases like this, like albino tigers without stripes. Here the knowledge that the instance still belongs to the Kind can inform our actual-world inductions as well as our counterfactual conclusions.

²⁴ Some philosophers of modality take all necessity to depend on nothing beyond logic and conceptual structure. We take the arguments of this paper to show that this attitude is deeply misguided, for reasons spelled out in Mallozzi 2018.

In the last section we showed how Kind identities do follow from considerations of super-explanatoriness. But this does not hold for all identities. Ordinary identities involving Individuals like Marilyn Monroe or Hesperus don't depend on anything being super-explanatory.²⁵

The same applies to logical necessities. We take these to be a subclass of metaphysical necessities. But there is no reason to think of them as depending in any way on super-explanatoriness.

So we are happy to recognize a range of metaphysical necessities that do not derive from super-explanatoriness. However, as we said, these cases are not generally regarded as philosophically noteworthy, but rather as part of the framework of modal discourse. The more substantial issues are raised by metaphysical necessities that are not so guaranteed. Why is molecular structure necessary to water, while being tasteless is not? Why are my parents necessary to me, while my birthplace is not? There are no agreed answers to these questions, and indeed a significant number of philosophers are sceptical about the necessities they presuppose. It is these substantial questions that we aim to answer by appeal to super-explanatoriness. We have already shown in previous sections how this can work in connection with Kinds. In the remaining sections we shall apply the same strategy to the substantial necessary properties of Individuals.²⁶

Kit Fine has argued that necessary truth across all possible worlds is never brute, but always a consequence of *essences*. While we have talked of essences and essential properties, and are entirely happy to agree with Fine that necessities are never brute, we are uneasy about trying to force all metaphysical necessities into the single mould of essences.

For a start, there is the necessity of logic itself. This is not the place to explore its basis, but there is no obvious reason to suppose that this will hinge on the essence of anything.

Then, even where talk of essences is formally appropriate, in the sense of features that are both necessary *and* sufficient for certain items across possible worlds, there are cases and cases. We might think of an Individual's identity as itself such an essence, but such trivial essences add nothing to our understanding of necessity. It strikes us as unhelpful to us to run these cases together with necessities involving Kinds, where the essences depend on super-explanatoriness, and not just the structure of modal discourse.

And, finally, a number of non-brute necessities resist explanation in terms of essences simply because they don't involve anything being *sufficient* for anything across possible worlds (as opposed to merely being *required*). We are thinking here of properties of Individuals that are essential but not unique to them. We agree that these necessities are not brute. But this doesn't mean that they have to be explained in terms of *essences*. In our

²⁵ Perhaps we should also mention here identities involving properties that are not Kinds. But it is hard to think of examples of these that are not conceptually a priori, and so reducible to logical truths of the form $F = F$.

²⁶ Will not the relationships between parts and wholes underpin further necessities, beyond those that can be accounted for by identity, logic and super-explanatoriness? We doubt this, but recognize that the issue calls for detailed analysis.

view, they can be explained directly in terms of super-explanatoriness, without bringing essences into it. We turn now to essential properties of Individuals.

10 Individuals as Historical Kinds

Many of the most striking examples of essential properties involve Individuals rather than Kinds. This lectern could not have been made from a material other than wood. Queen Elizabeth could not have had a different father from George VI. Our proposal is intended to cover these cases too. The next two sections will explore how this might work. Our aim is not so much to provide a definitive account of which properties are and are not essential to Individuals, but rather to display how such issues can usefully be viewed through the lens of super-explanatoriness.

Ruth Millikan has long emphasized that Individuals are akin to Kinds in a number of respects. To see how this works, think of the “instances” of an Individual as its temporal stages. For many Individuals, these temporal stages will share a multitude of properties. For example, all the temporal stages of the rock by the pond in Jane’s garden share the same size, shape, mass, markings, smoothness, hardness, and so on. All the temporal stages of Jane herself share the same physiognomy, gait, distinguishing marks, vocal timbre and accent, brown eyes, and so on.

The analogy with Kinds is close. We can normally identify an Individual from just a few of the many Gs that are shared by all its stages, and use that identification to infer the many other properties it will currently display. (You recognize Jane from her gait, and immediately anticipate a wealth of further features.) Moreover, we can typically use one-shot inductions acquire knowledge of the properties common to the stages of Individuals. Since we know which properties people, and rocks, and many other things, retain over time, observing a property in one stage can tell us it will be displayed by the others. (You note someone’s eye colour, and infer they will always have it.)

Note how Individuals are different from events in just this respect. Events like storms and car crashes and sporting contests do not maintain a large suite of properties over time, but are in general flux.

Some philosophers take this difference to mark some deep metaphysical difference, with implications for the nature of time and change. (Objects but not events, these philosophers say, are “wholly present” at any time that they exist.) We think that is over-inflating the point. No doubt the difference in property stability between ordinary objects and events is the reason why we talk about them differently, and in particular are far readier to recognize temporal parts of events (the “first half” of the match) than temporal parts of objects. After all, what would be the points of identifying a “Tuesday-rock” as distinct from a “Wednesday-rock”, given that they are so very similar? But beyond that we see nothing wrong with viewing both objects and events as “four-dimensional worms” occupying regions of spacetime. (For those philosophers who remain uneasy about “temporal stages” as parts of persisting objects, feeling that such talk is insufficiently sensitive to the difference between objects and events, we suggest that they simply understand our talk of stages as referring to possible *encounters* with objects at different times.)

From now in this paper on we shall restrict our attention to particular objects with stable properties, and will understand the term “Individual” in this specific sense.

In our view, Individuals bear a close analogy to Historical Kinds. The reason that all their stages share so many properties is that they all stem from the same origin. In effect, each stage is copied from the one before, and so eventually from the Individual’s original state, and this is why the stages all resemble each other in so many respects. (It might seem somewhat forced to say that each stage of a stone is copied from the one before, but even simple persistence is a causal process that accounts for the preservation of properties over time.)

Accordingly, we take the original stage of any Individual to be essential to it. Necessarily, something is a stage of a given Individual only if it descends from that particular origin. If we suppose away that origin, we suppose away the source of the many shared features displayed by the stages of that Individual.²⁷

Before going into details, it will be worth pausing to emphasize a disanalogy between Individuals and Kinds that has been noted at various points earlier. With Kinds, super-explanatory properties are not only *essential* (required across all possible worlds for an instance to belong to the Kind, in line with (1)) but also *essences* (sufficient across all possible worlds for an instance to belong to the Kind, in line with (2)). With individuals, by contrast, super-explanatory essential properties need not yield essences.

In most cases, it is true, the particular original stage which instigated the history of an Individual will be plausibly be peculiar to it. No other possible Individual could stem from that particular origin. But there are exceptions. Identical twins, for example, share the same initial state, but are distinct individuals. The same goes for all the bacteria in a given lineage. More generally, the point will apply whenever we have Individuals that overlap in their initial stages, but later separate by fission.

The reason for the disanalogy is clear enough. Individuals are localised in spacetime in a way that Kinds are not. They are bounded by connected spacetime worms. Because of this, we count stages in different such worms as parts of different Individuals, however alike those stages might otherwise be. No doubt we type Individuals like this because of the human significance of interactions with specific Individuals, even in cases where those Individuals have qualitatively identical doppelgangers.

11 Necessities of Individual Origin

As we said, the particular origin of any Individual is essential to it. If we suppose away that particular origin, all bets are off. We have removed the thing that is responsible for the many stable properties that the Individual displays over time.

²⁷ Of course some of the properties displayed by many successive stages of an Individual will be due to changes that happen in its lifetime (like the scar on Jane’s arm) and not to the Individual’s origin. But such innovations are different, in that they account for a single shared property of stages, rather than a whole battery thereof.

This is not to say that every feature of that particular origin is essential to it, and so to the Individual that results. The carpenter could have constructed this lectern a little differently, making it a quarter of an inch taller, say, and yet it still have been the same lectern. The fertilized zygote from which Jane developed could have been affected by a cosmic ray, giving her blue rather than brown eyes, yet she still would have been Jane.

So the particular origin of any Individual could have varied in at least some respects.²⁸ It is the *particular* origin that is essential to the Individual, not all its qualitative features.

How much can the particular origin of some Individual differ, and yet still remain the same particular origin? We doubt that there is any general and principled way to answer such questions. There will be cases and cases. How we answer them will depend on the sort of Individual at issue, and on what sort of salient stable properties it displays over time.

In many cases, for example, it is natural to hold that the *type* of material from which some Individual is made is essential to its origin. These will be cases where many of the salient stable properties of the Individual depend on what type of material went into its construction. Thus any ordinary wooden lectern will display a range of properties that it would lack if it were made of ice rather than wood: surface appearance, tactile texture, combustibility, thermal conductivity, sonorosity, . . . Similarly, the vase on my desk displays many constant properties over time because of the kind of clay that it is made of. Many permanent features of single-handed Laser sailboats derive from their being made of glass reinforced plastic. And so on. With Individuals like these, we view material constitution as essential to the particular original state, precisely because so many of the characteristic permanent features depend on this constitution.

This does not necessarily apply to all Individuals. Perhaps there are Individuals whose significant lasting features are independent of what material they are made of. This seems plausible for Individuals whose shape, design and use are more salient than their basic physical properties. Think of buildings or statues. It is not obvious that Buckingham Palace would be a different building if it had initially been made of stone and not brick.

Even with Individuals where the type of material used *is* essential to the particular origin, it is a further question whether the *specific* piece of stuff used to construct the Individual is essential to that origin. In *Naming and Necessity*, Kripke argues that a lectern made from a given piece of wood couldn't possibly have been made from a different piece. But his argument is less than compelling. Kripke points out that it was always possible that a *different* lectern could have been made from any *other* piece of wood. True enough, and in *that* case the original lectern certainly couldn't *also* have been made from that other piece of wood. But this doesn't prove that it couldn't have been made from that other piece of wood if that piece *weren't* used to make another lectern. (Just imagine that the carpenter's assistant had fetched a different indistinguishable piece of wood from the store for the

²⁸ Similarly, the particular organisms from which a given biological taxon descends could have been different in various ways. The original tigers, and so the whole species, could have lacked stripes, if certain mutations hadn't occurred. Note here the difference from Devitt. Since he makes intrinsic *properties* essential to biological taxa, rather than *particular* origins, he has difficulty allowing any qualitative variation to be non-essential.

carpenter to make the original lectern from. Would that really have led to a different lectern?)²⁹

Still, in some cases, it may well be that the specific bit of stuff used is indeed essential to an Individual's origin. For instance, it is plausible that Michelangelo's David is not only essentially made of marble, but moreover that it is essentially made from the particular block of marble that Michelangelo used. This is because the overall shape and many of the details of Michelangelo's masterpiece no doubt trace back to the idiosyncracies of the block of marble he started with. The sculpture would have come out differently if the artist had used a different block. In this respect the statue of David is different from normal lecterns or vases. None of the salient features of lecterns or vases will be due to the specific bit of material they are made from. We expect their makers to be able to produce indistinguishable products from different bits of wood or lumps of clay.³⁰

In general, then, when many of the characteristics inherited from an Individual's initial state depend on the specific bit of stuff that was constructed from, that bit of stuff counts as essential to the Individual. It wouldn't have been David if it had been made from a different bit of marble.

It works similarly with organisms and their parents. The formative features of the zygote depend crucially to the distinctive features of the parents. With a different parent, the zygote would have come out very differently. Because of this, parents count as essential to their offspring. If we suppose away a parent, we no longer have the particular fertilised zygote from which the Individual inherits a wide range of its stable properties.³¹

By way of further confirmation of this line of argument, consider a thought experiment due to Christopher Belshaw³². Imagine a world in which all zygotes are genetically the same. All paternal sperm are identical, as are all maternal eggs. Once a couple have produced a zygote, they take it off to the government laboratory to be genetically customised according to the national population plan.

Now, in this world, we would no doubt still feel that no one could have come from a different processed zygote. The nature of any person would still depend very much on which customised zygote they developed from. But we wouldn't have any difficulty with the idea that you could have had a different father (or mother). (Just imagine that the assistant in the laboratory had fetched a different blank zygote from the store for the technician to make you from.) Since none of your details would depend on which parents you came from, we would cease to think of parents as essential to people.

²⁹ We would like to thank Martin Smith for pressing us about Kripke's argument.

³⁰ In much of the philosophical literature, "origin essentialism" means essentialism about the specific bit of pre-existing stuff out of which something is constructed. This is not the view we are defending. We hold that the first stage of an Individual is essential to it. It is a further question whether or not that first stage had to stem from the bit of pre-existing stuff actually used to make it.

³¹ By the same coin, we take it that their species and other biological taxa are essential to organisms.

³² Belshaw 2006. The last section of our paper has been much influenced by Belshaw's article.

12 Conclusion

The analysis of this paper leaves many questions unanswered. We are happy with that. Our aim here has not been to resolve all debates about metaphysical necessity, but rather to persuade readers that central aspects of it depend on questions of super-explanatoriness. (Of course, even after we bring in super-explanatoriness, some of those aspects will remain indeterminate, if for no other reason than that super-explanatoriness is itself not always a cut-and-dried matter. But, if so, that is probably as it should be.)

Philosophers of science who study Kinds have over-emphasized their complexities and downplayed their many important shared features. Metaphysicians who study metaphysical modality have spent too much time laying out options and soliciting intuitions, without considering whether science can help resolve their questions. It is time to link up the two areas of research.³³

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³³ We would like to thank Alexander Bird, Ned Block, Paul Boghossian, Michael Devitt, Julien Dutant, Jani Hakkarainen, Paul Horwich, Muhammad Ali Khalidi, Boris Kment, Jaakko Kuorikoski, Jessica Leech, Tim Lewens, Matteo Mameli, Caterina Marchionni, Ruth Millikan, Stephen Neale, Daniel Nolan, Graham Priest, Jesse Prinz, Samuli Reijula, Jonathan Schaffer, Martin Smith, Nick Shea, Barry Smith, Michael Strevens and Anand Vaidya.

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