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S.I. : NEW DIRECTIONS FOR FUNDAMENTALITY

Natural kind fundamentalism

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Abstract
This paper defends Natural Kind Fundamentalism (NKF), the view that the ontological category of *natural kind* is fundamental. I develop a primitivist account of categorial fundamentality based on the Complete Categorial Basis (CCB) criterion, which requires that fundamental categories form a complete and minimal system irreducible to other categories through ontological dependence relations. I argue against bundle-theoretic reductions and in favour of the view that natural kinds are substantial universals serving as principles of unity for property clusters. This framework distinguishes between the metaphysical 'why' question (answered by substantial universals as unifiers) and the empirical 'how' question (concerning specific unification mechanisms). I demonstrate that natural kinds and properties exhibit mutual but asymmetric dependence: properties depend generically on kinds for instantiation, while kinds depend rigidly on their essential properties. The resulting formal ontological structure satisfies the CCB criterion and explains why certain property clusters are non-arbitrary without reducing kinds to properties or vice versa.

Keywords Natural kinds · Categorial fundamentality · Ontological categories · Substantial universals · Formal ontology · Essential dependence

1 Introduction

Natural kinds serve an important role in metaphysics and philosophy of science, but are they *fundamental*? More specifically, is the ontological category *natural kind* a fundamental category? To answer these questions, and indeed to specify what it

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would mean for natural kinds to be fundamental, we need a theory of fundamentality in general and *categorial fundamentality* in particular. Once we have an appropriate understanding of these notions, I will argue that the category of natural kind should indeed be understood as a fundamental ontological category. I call this view *Natural Kind Fundamentalism* (NKF).

In what follows, I will first outline my approach to ontological categories in general and then give a few examples from the literature regarding natural kinds and their role in categorial ontology, as well as some initial reactions for and against the idea that natural kinds could constitute a fundamental ontological category.

In the second section, I will proceed to outline my preferred approach to categorial fundamentality, developing a primitivist account that treats fundamentality as a basic notion characterized by the Complete Minimal Basis (CMB) criterion, which I extend to ontological categories through the Complete Categorial Basis (CCB) framework.[1]

The third section develops the central thesis of the paper by arguing against bundle-theoretic reductions of kinds to property clusters, offering a positive account of natural kinds as substantial universals within a neo-Aristotelian framework, and clarifying the explanatory division of labour between metaphysical and empirical questions regarding property unification. I distinguish between the 'why' question (answered metaphysically by substantial universals) and the 'how' question (addressed empirically through discovering specific unification principles). I also situate NKF within the broader landscape of natural kind realism, addressing challenges from Chakravartty (2023) and contrasting NKF with less robust forms of kind realism such as Dupré's (1993) promiscuous realism.

The fourth section examines how natural kinds fit within a complete categorial system, analysing the formal ontological relations between substantial universals and properties through essential dependence relations and demonstrating their systematic integration while preserving irreducibility. I also show how this framework satisfies the CCB criterion for fundamental categories.

I will now proceed to make some preliminary remarks about ontological categories.

1.1 Ontological categories

Before we can make any progress, we need to have some idea about what ontological categories are supposed to be. In my broadly neo-Aristotelian approach to ontological categories, I maintain that categories themselves are not additional, existing entities. On this line of thought, categories reflect their instances rather than existing as separate entities. When I develop a theory of ontological categories, I am effectively theorising about the most general features of the members of those categories, not about some additional realm of categorial entities floating above or beyond their instances. As Hakkarainen and Keinänen (2023: 1) put it, categories 'are not entities numerically distinct from their members.'

This approach aligns with principles like Armstrong's (1989) *principle of instantiation*, which denies the existence of uninstantiated universals in some Platonic heaven. On the present approach, ontological categories are categories of being, not

[1] Here I will be drawing on Tahko (forthcoming).

categories of thought (as in the Kantian tradition), but this does not mean the categories themselves constitute additional beings. It is important to be precise about this point. While the categories themselves do not exist as separate entities, the distinctions underlying them are real: they reflect genuine differences in the existence and identity conditions of the entities that fall under them. Some of these distinctions may well align with our fundamental epistemic categories – our most general ways of thinking about and classifying entities – but I maintain that this alignment is a *consequence* of our epistemic faculties tracking real ontological distinctions, rather than the categories themselves being epistemological in character. The success of science in identifying and employing natural kind classifications is evidence that our epistemic categories can latch onto mind-independent categorial structure, even if the categories as such are not additional beings in the world.[2]

To treat categories as entities would be to commit a category mistake – potentially even requiring a category of categories, threatening an infinite regress. Instead, categories are ways of understanding the fundamental divisions among what exists, individuated by the existence and identity conditions of their members. Accordingly, when I speak of *natural kind* as a fundamental category, I am not positing the existence of some entity called 'natural kind' over and above electrons, muons, hydrogen atoms, and any other presumed natural kinds; rather, I am identifying a fundamental way that certain entities, namely, the *members* of the category *natural kind* exist and relate to other entities in the world.

With this initial constraint of how I understand ontological categories made clear, consider a few examples from the literature, specifying how natural kinds might be conceived of as a fundamental category.

As a starting point, let me draw on Bird, who lists a few helpful ways to understand what he calls 'strong realism' about natural kinds:

> Are natural kinds:
>
> (a) Identical or straightforwardly reducible to entities of a more general nature, for example sets or (non-kind) universals?
>
> (b) Emergent entities, not reducible to other entities, but supervenient on them?
>
> (c) Fundamental, sui generis entities? (Bird, 2018: 1415).

It is Bird's option (c) that I favour, but with the important specification, as already noted, that it is not the entity 'natural kind' that we should consider a *sui generis* entity, rather, we may say that the members of that category are *sui generis* entities. Bird cites Lowe (2006) as a proponent of this view, and my own starting point is similar to Lowe's in many important regards. However, I explicitly employ a primitivist notion of fundamentality in my analysis, and I will go beyond Lowe's theory when

[2] The key point is that the *success* of our epistemic categories in tracking natural divisions provides evidence for the reality of those divisions, not for the reducibility of ontological categories to epistemic ones.

it comes to specifying the relationship between natural kinds and the properties that they are linked to.[3]

This brings us to the key question for any theory of natural kinds, namely how, or whether, natural kinds are distinct from the (natural) properties that are essential to them or definitive of them. Tobin writes about this distinction:

> [O]ne might argue that natural kinds and natural properties are distinct and that natural kinds could be considered as a sui generis type of entity. For example, one might hold that natural kinds require a distinct kind of universal, substantival universal, or sortal. (Tobin, 2013: 164).

Lowe's view aligns, again, with this description, since he holds that natural kinds are *substantial universals*, to distinguish them from *property universals*. It may be helpful to reproduce Lowe's famous 'ontological square' and four-category ontology at this point – a view inspired by Aristotle:

We shall return to the *formal ontological relations* such as instantiation and characterization pictured in Fig. 1 especially in § 4, but for now it is important to notice that even though the four categories in Lowe's ontology are intended to be fundamental, there are clearly some relations that stand between them. These formal ontological relations are typically regarded as *internal relations* which are not a further addition to being (see Hakkarainen & Keinänen, 2023 for a detailed discussion).

I shall conclude this introductory section with one more quote, from Bird and Tobin, which labels the view that I defend, namely, Natural Kind Fundamentalism (NKF):

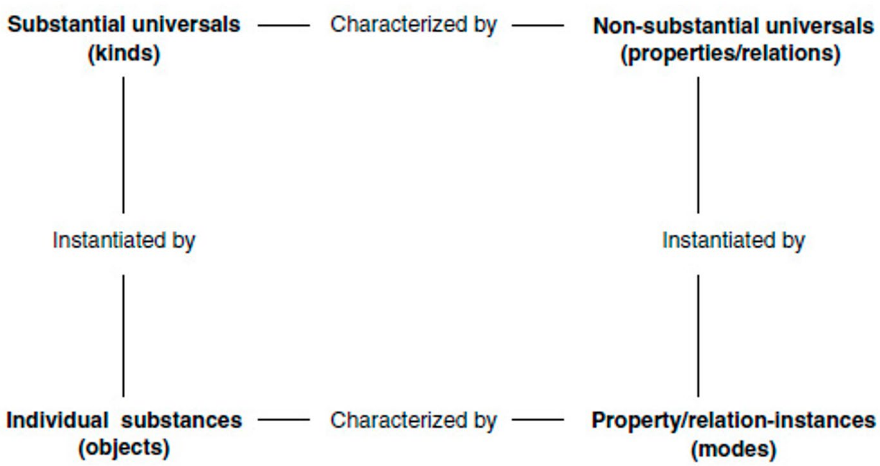

Fig. 1 The 'ontological square' (Lowe, 2006: 22)

[3] It's worth noting here that Bird (2012) himself has challenged Lowe's inclusion of natural kinds among the fundamental categories, contending that in addition to particulars, all we need is universals: kinds are not ontologically fundamental. His critique focuses on whether kinds are genuinely required for an adequate account of laws of nature. We shall return to Bird's criticism in § 3.4.

> [N]atural kind *fundamentalism*, which holds that not only are there natural kinds (as entities), but also that natural kinds find a basic and sui generis place in our ontology. (Bird & Tobin, 2024: 1.2.3.)

NKF as such leaves many questions open, but we can see that the idea of a *sui generis* or basic role for natural kinds is a key part of this view. This is importantly different from some popular formulations of what fundamentality itself amounts to – a difference between fundamentality in general and *categorial fundamentality*, which we turn to next.

Before proceeding, it is worth asking: why might one resist the idea that natural kinds are fundamental? Setting aside scepticism about the existence of natural kinds altogether, the most common motivation is parsimony. Many contemporary metaphysicians who accept that there are natural kinds do not regard them as a fundamental ontological category. Instead, they defend some version of bundle or cluster theory, according to which a natural kind is nothing more than a bundle of properties clustered together (see § 3.1 for detailed discussion). On such views, once we have properties and whatever relations hold between them, there is no further ontological work for a distinct category of natural kinds to perform. The attempt to get by with as few fundamental categories as possible is a perfectly legitimate methodological approach. Indeed, as we shall see, part of what motivates NKF is the recognition that bundle theory *cannot* adequately explain why certain property clusters are non-arbitrary. The argument of this paper is that the parsimony motivation is ultimately misguided in this case: natural kinds earn their place in a fundamental categorial system by performing explanatory work that no other category can supply. But the burden of proof rightly falls on the defender of NKF to demonstrate this, which is the task of the subsequent sections.

2 Categorial fundamentality

This section establishes the theoretical framework for understanding categorial fundamentality. The argument proceeds in two main stages. First, I develop a primitivist approach to fundamentality that treats it as a basic notion characterized by the Complete Minimal Basis (CMB) criterion (§ 2.1). This approach avoids the circularity problems that plague independence-based and grounding-based definitions while accommodating cases of mutual dependence among fundamental entities. Second, I extend this framework from individual entities to ontological categories through the Complete Categorial Basis (CCB) criterion (§ 2.2). The CCB requires that fundamental categories form a complete and minimal system where no category can be exhaustively reduced to others through ontological dependence relations. I conclude by examining the distinctive advantages of this approach, including its holistic orientation, avoidance of circularity, and empirical openness (§ 2.3).

2.1 A primitivist approach to fundamentality

Recent discussions of fundamentality have largely focused on defining it in terms of independence or ungroundedness (see Tahko, 2023a for an overview). On such views, an entity is fundamental if and only if it does not depend on anything else, or if it is ungrounded. While this is a very simplified reconstruction, it is clear that the usual independence or grounding-based approaches to fundamentality face significant challenges when confronting cases of mutually dependent entities that nevertheless seem to have some claim to fundamentality. As I will argue, categorial fundamentality must accommodate mutual dependence.

This, in part, leads me to adopt instead a *primitivist* approach to fundamentality, treating it as a basic notion that can be characterized but not reductively defined. On this view, fundamentality is not analysed in terms of other metaphysical notions but is understood through its explanatory role in our overall metaphysical theory. This approach has precedents in the work of Jessica Wilson (e.g., 2014, 2025) and others who resist defining fundamentality in terms of grounding or other dependence relations.

The core characterization I employ is the **Complete Minimal Basis (CMB)**: *x* is fundamental if and only if *x* belongs to a plurality of entities X and X forms a minimal complete basis that determines everything else.

This characterization has two essential components:

1. **Completeness**: The fundamental entities, taken together, provide a sufficient basis for everything else in reality. Once we have specified the complete basis, we have specified everything needed to determine all non-fundamental entities. Nothing is left out or unaccounted for.
2. **Minimality**: Ensures ontological parsimony by requiring that nothing in the fundamental basis is superfluous. The removal of any entity from the basis would render it incomplete. This connects to the idea of an *ontologically minimal* description of reality (cf. Tahko, 2018 – we include all and only what is needed).

The CMB approach, when used to characterize rather than define fundamentality, is itself quite neutral and can be combined with many or most accounts of fundamentality. However, when combined with the primitivist account, there are clear advantages. Unlike pure independence-based definitions, CMB + primitivism can accommodate cases where fundamental entities stand in various dependence relations to each other. Unlike grounding-based accounts, it avoids potential circularity in defining fundamentality by appeal to what is ungrounded. And unlike some other primitivist approaches, it provides clear criteria for evaluating proposed fundamental bases.

2.2 From entity basis to categorial basis

While CMB was originally formulated for entities, I extend it to ontological categories to arrive at what I call the **Complete Categorial Basis (CCB)** criterion. This move reflects the insight that just as we can ask which entities are fundamental, we can ask which ontological categories are fundamental to the structure of reality:

> **(CCB)** a system of categories is complete if and only if the plurality of all existing entities X are members of one and only one category in the system. The system is minimal if the existence and identity conditions of entities belonging to any of the categories cannot be exhaustively specified in terms of ontological dependency relations between those entities and entities belonging to other categories.

A system of ontological categories satisfies the CCB criterion if and only if it satisfies:

1. **Completeness**: Every existing entity belongs to exactly one category in the system. There are no categorial gaps (entities that belong to no category) or overlaps (entities that belong to multiple categories at the same level).
2. **Minimality**: The categories in the system are irreducible. Following Lowe (2006), this means that the existence and identity conditions of entities belonging to any category cannot be *exhaustively specified* in terms of ontological dependency relations between those entities and entities belonging to other categories.

This second condition requires careful unpacking. To say that a category is irreducible is not to deny that there are important relations between entities of different categories. Rather, it is to insist that membership in the category involves something over and above standing in various relations to entities of other categories. A category is fundamental if what it is to be an entity of that category cannot be fully captured by specifying relations to entities outside the category.

We should, however, allow for a *partial* specification of what a category is in terms of the relations that it stands in. Focusing on the category *natural kind*, we can see that in Lowe's four-category ontology an important specification for natural kinds is that they are characterized by properties. For instance, the kind *electron* is characterized by properties like *unit negative charge* and a *mass* of $9.1093837 \times 10^{-31}$ kilograms. But the properties that characterize the kind electron do not fully and exhaustively specify the identity and existence conditions of the kind. What else is needed then? Crucially, the kind *unifies* the properties that characterize it in its members. This important role for natural kinds will be discussed in more detail in § 3 and § 4.

2.3 Advantages of the CCB approach

The CCB framework offers several distinctive advantages for understanding categorial fundamentality, advantages that align with broader methodological developments in the analysis of ontological categories.

(1) **Holistic and System-Oriented Analysis.** Rather than asking whether individual categories are fundamental in isolation, the CCB approach evaluates entire categorial systems. This reflects the insight that categories come as a package and whether we regard them as fundamental depends on their role within a broader

categorial scheme. A category that appears reducible when considered alone may prove irreducible when we examine its systematic relationships with other categories. This holistic perspective prevents the kind of piecemeal analysis that can miss crucial interdependencies between categories.

(2) **Avoidance of Circularity.** The CCB approach avoids the potential circularity of approaches that define categorial fundamentality by appealing to fundamental formal ontological relations (see Hakkarainen, 2022, Hakkarainen & Keinänen, 2023 for a related account and Tahko, forthcoming for discussion). If we say that a category is fundamental because entities in that category stand in fundamental relations to each other, we risk circularity unless we have an independent account of what makes a relation fundamental. The CCB approach shifts focus from what *makes* a category fundamental to the structural and explanatory role it plays within a complete system.

(3) **Flexibility and Empirical Openness.** The CCB framework accommodates complex patterns of dependence between fundamental categories while remaining flexible enough to evaluate different proposed categorial systems. Unlike approaches that stipulate specific formal ontological relations as fundamental, CCB provides a criterion for evaluating whether any given categorial system successfully captures reality's fundamental structure. This makes the framework empirically open: new discoveries about the nature of reality could lead us to revise our views about which categories satisfy the CCB criterion. The CCB approach rejects the idea that categorial differences are arbitrary or merely conventional. Instead, it seeks principled criteria for determining when a categorial system successfully captures the systematic structure of reality.

The empirical openness of the CCB framework is worth illustrating with a concrete example that also serves to clarify the relationship between CMB and CCB. Suppose, for the sake of argument, that protons and electrons are both natural kinds. Is a hydrogen atom also a natural kind? If so, we must ask whether hydrogen is needed in the CMB – that is, whether its properties are fully determined by its natural kind parts (protons and electrons). If hydrogen is fully determined by its parts, then hydrogen as a fundamental natural kind is superfluous, satisfying minimality. If, however, hydrogen has properties that are not determined by its natural kind parts, then we appear to have emergent properties that require their own place in the CMB.

This is a genuine empirical question, and the CMB framework is designed to accommodate either answer. Indeed, there are serious arguments for the strong emergence of chemical kinds. Hendry (e.g., 2021), for instance, argues that chemistry is strongly emergent from fundamental physics, in which case chemical kinds such as hydrogen would presumably be part of the CMB rather than being reducible to more fundamental natural kinds. But if hydrogen does reduce to its constituent kinds – or rather, if the properties of the latter fully determine all of hydrogen's properties – then hydrogen will not be part of the CMB.

Crucially, the claim that natural kinds constitute a fundamental ontological *category* does not dictate any view whatsoever about which natural kinds themselves are fundamental or genuine. This is precisely the distinction between CMB and CCB that gives the present framework its flexibility. The CCB criterion tells us that the *category* of natural kind is fundamental; the CMB criterion, operating at the level of particular entities, tells us which specific natural kinds belong to the complete minimal basis. These are separate questions, and the framework remains empirically open on the latter by design. I use *electron* as a paradigmatic example of a natural kind throughout this paper, but it is of course possible that there is further substructure that is more fundamental than electrons. Should this turn out to be the case, the CCB criterion for the fundamentality of the natural kind *category* would be entirely unaffected.[4]

3 Natural kinds as a fundamental category

Having established a framework for understanding categorial fundamentality, we can now turn to the central thesis of this paper: natural kinds constitute an irreducible and fundamental ontological category. This section develops what I call Natural Kind Fundamentalism (NKF) – the view that natural kinds are substantial universals that provide the ultimate explanation for property clustering. The argument proceeds in three stages. First, I refute the bundle-theoretic reduction of kinds to mere collections of properties (§ 3.1). Second, I offer a positive account of natural kinds as substantial universals within a neo-Aristotelian framework (§ 3.2). I then clarify the crucial explanatory division of labour between metaphysical and empirical questions regarding property unification (§ 3.3) (for further discussion, see Tahko, 2022). Finally, I briefly consider some critical remarks by Bird, who questions the need for *sui generis* natural kinds in explaining laws of nature.

3.1 Against bundle theory: the ontological priority of kinds

The most prominent reductive challenge to NKF comes from various versions of bundle or cluster theory regarding kinds – a close relative of classic bundle theory which construes objects as bundles of universals or tropes. Bundle theory regarding natural kinds treats natural kinds as nothing more than systematic clusters of co-instantiated properties. On this view, the kind *electron* simply consists in the regular co-occurrence of unit negative charge, specific rest mass, and half-integer spin. The kind contributes nothing ontologically beyond what the properties themselves provide. Bundle theorists thus embrace what we might call the *property-first* approach: properties are fundamental, and kinds emerge as derivative patterns in their distribution. Rather than discussing specific versions of bundle theory about kinds in detail, I will give an overall analysis which captures the most prominent features of the view (for detailed examples, see e.g., Boyd, 1991, Millikan, 1999, Chakravartty, 2007, Oderberg, 2011, and Paul, 2017; Paul defends a version of classic bundle theory, see also Keinänen & Tahko, 2019 for discussion).

[4] This point also addresses the concern that using *electron* as a paradigmatic natural kind is problematic because there may be more fundamental entities constituting an electron. Even if this turns out to be the case, the argument for NKF as a thesis about the *categorial* status of natural kinds would be unaffected, we would simply revise our view about which particular kinds are fundamental.

This bundle-theoretic reductive programme faces a decisive objection stemming from the non-arbitrariness of natural kinds. Consider the distinction between genuine natural kinds (or at least one of our best candidates) like *electron* and arbitrary property clusters like *green and round things*. Both involve systematic property co-instantiation, yet only the former reflects an objective division in nature. The bundle theorist struggles to account for this crucial difference. If kinds simply reduce to property clusters, what makes some clusters natural while others remain artificial constructions?

The bundle theorist might respond by appealing to the *stability* or *lawlike regularity* of certain property co-instantiations. Natural kinds, they could argue, involve properties that cluster together across a wide range of circumstances, while arbitrary clusters lack such robustness. But this response merely pushes the fundamental question back a step. *Why* do the properties characteristic of electrons reliably co-occur while those defining green and round things do not? The bundle theorist has no principled answer beyond brute fact.

Here we encounter the core problem with bundle theory's explanatory strategy. Property universals alone – even supplemented with nomological relations between them – cannot account for the systematic clustering that characterizes natural kinds. Consider the properties definitive of electrons: unit negative charge (-*e*), rest mass (m), and spin quantum number (1/2). These property universals also occur in other contexts – muons share the charge and spin of electrons while differing dramatically in mass. What explains why these particular properties cluster together *specifically in electrons* rather than occurring in other combinations?

Bundle theory cannot provide a non-circular answer. Any attempt to specify which properties necessarily co-occur faces the problem that the same properties appear in different clusters across different kinds. The properties themselves underdetermine their own clustering patterns. We need something *beyond* the properties to explain why they unite in the specific ways that define particular natural kinds. Here, the bundle theorist might still appeal to *causal mechanisms* or *laws of nature* which do indeed go beyond the properties themselves. For instance, carbon atoms and hydrogen atoms come together in methane through covalent bonds, which are governed by the electrostatic interactions described by Coulomb's Law.

However, this approach will ultimately require an account of the relevant causal mechanisms or laws of nature that govern the clustering of properties, and it seems unlikely that it could apply in all cases and especially in cases such as that of *electron*, where no obvious mechanism or law is available. Accordingly, Chakravartty (2007, p. 171) suggests that fundamental natural kinds, such as electrons, have their core properties (mass, charge, spin) as a matter of brute fact.

This brings us to the fundamental insight underlying NKF: the kind is *ontologically prior* to the properties it unifies. It is *because* a particular entity is a member of the kind *electron* that it instantiates the systematic cluster of properties characteristic of electrons. The kind provides the unifying principle that explains property clustering, not the other way around. This directly addresses what I call the 'why' question of property clustering: *why* do certain properties systematically occur together in members of natural kinds?

The ontological priority thesis stands in sharp opposition to what Smith (e.g., 2005) has termed *fantology* – the reductive view that treats ontology as exhausted by individuals and predicates (the *Fa* structure of first-order logic). Fantology overlooks the crucial distinction between *sortal universals* (kinds) and *characterizing universals* (properties). Substantial universals like *electron* or *water* play a fundamentally different ontological role than characterizing properties like *negatively charged* or *liquid*. The former provides the principle of unity for the latter, determining which properties necessarily co-occur in the kind's instances. In a similar vein, Simons, albeit a nominalist, commends Lowe's resistance to fantology and the reduction of the traditional four-fold category structure to just two categories – individuals and properties:

> [S]uch a reduction is an impoverishment rather than a welcome simplification: it overlooks the difference between those kinds or universals which provide identity conditions for things that fall under them (sortal universals, kinds), and those which merely tell us what things are like (properties). (Simons, 2012: 127).

Once we recognise this distinction between kinds and properties, the bundle theory's reductive programme appears misconceived from the start. Natural kinds cannot be reduced to bundles of properties because they serve as the ontological ground for property clustering itself. The kind *electron* is not a collection of properties seeking a principle of unity—it *is* the principle of unity for its characteristic properties.

3.2 Natural kinds as substantial universals

Having rejected the bundle-theoretic reduction of natural kinds to properties, I now offer a positive account of natural kinds within a neo-Aristotelian framework. Natural kinds are best understood as *substantial universals* – entities that belong to a fundamental ontological category in their own right, irreducible to other categories like properties or individuals.

This proposal finds its most systematic development in Lowe's (e.g., 2006, 2015) four-category ontology, as illustrated by the ontological square in Fig. 1. I will briefly outline Lowe's theory here so that we have a point of reference, but I should emphasize that I do not necessarily subscribe to the full four-category picture that Lowe has developed. Lowe distinguishes four fundamental categories: individual substances, substantial kinds (or substantial universals), attributes (or property universals), and modes (or property particulars or tropes). Each category plays an indispensable role in a complete ontological theory, connected through formal ontological relations like instantiation, characterization, and exemplification. My interest here is primarily the relationship between substantial universals and attributes. I remain agnostic about substances, and I am inclined to resist the introduction of modes (see also Tahko, 2022).

In this framework, natural kinds occupy the category of substantial universals – entities that are instantiated in individual substances and characterized by attributes. The kind *electron*, for instance, is instantiated in particular electrons (individual substances) and characterized by properties like unit negative charge and specific rest mass (attributes). Particular electrons exemplify these attributes by being characterized by particular modes (specific instances of the relevant properties).

This neo-Aristotelian approach carries several important ontological commitments. First, it embraces *immanent realism* about substantial universals. Natural kinds exist where their instances exist, not in some Platonic realm separated from the concrete world. There are no uninstantiated natural kinds – every substantial universal must have instances to exist at all. The kind *electron* exists because particular electrons exist and instantiate it.

Second, the view treats substantial universals as *universals* in the strict sense – entities capable of being wholly present in multiple locations simultaneously through their instances. The kind *electron* is not spatiotemporally located in any specific place but exists wherever particular electrons exist. This allows the same kind to be instantiated by numerically distinct particulars while remaining ontologically unified.

Third, substantial universals are conceived as *substantial* in virtue of their role as principles of unity for the entities that instantiate them. Unlike property universals, which in Lowe's framework characterize their instances, substantial universals *constitute* the fundamental nature of their instances. A particular's membership in a natural kind determines its essential properties and provides the foundation for its modal and temporal identity conditions.

Fourth, substantial universals do not exist *in* time. This temporal feature distinguishes them sharply from both their instances (which exist in time) and their characteristic properties (which may be temporally located through their instantiations). This atemporality is not the transcendent atemporality of Platonic universals existing in a separate realm, but rather reflects their status as formal principles that structure temporal reality without themselves being subject to temporal passage. This feature has been the subject of some debate between Lowe and Kistler. Lowe (2004: 156) explicitly defends the thesis that universals 'do not exist "in" time at all' arguing that this distinguishes them fundamentally from their particular instances. Kistler (2004) objects to this temporal conception as part of his broader critique of Lowe's four-category ontology, questioning whether kinds can serve their supposed ontological role while remaining atemporal entities. The debate centres on whether substantial universals can provide genuine unification for temporal entities while themselves standing outside the temporal flow. I suggest that this atemporality or four-dimensional view of kinds is precisely what enables substantial universals to provide trans-temporal identity conditions for natural kinds – the kind *electron* remains the same kind across different temporal stages of its instances precisely because it transcends the temporal particularity that distinguishes one electron-stage from another.

These features provide a vindication for NKF. Natural kinds emerge not as derivative constructions from more basic categories but as irreducible constituents of reality's fundamental categorial structure. They play an indispensable explanatory role that no other category can fulfil – serving as the principles of unity that explain systematic property clustering. However, before we move on, I should acknowledge that this approach to substantial universals faces important challenges from those who question whether we really need universals at all. One of these, targeting Lowe's theory specifically, comes from Heil (2012) who questions how substantial universals could perform their supposed explanatory work. He asks what explanatory advantage there is to saying 'that instances of *aqua regia* have this power [gold-dissolving] because they are instances of *aqua regia*', arguing that this seems to posit 'an entity – the universal – where none is called for, then claiming an explanatory advance' (2012: 120). More substantially, Heil queries what universals actually explain and suggests that similarities among electrons might not require further explanation beyond the particular modes or tropes that individual electrons possess. Like Heil, I would prefer to get by with fewer than four ontological categories if possible, and I share his concern that universals should earn their ontological keep through genuine explanatory work rather than mere formal apparatus.

Fortunately, the account of substantial universals developed here provides clear answers to Heil's worries about their explanatory role. The question (to be discussed in more detail below) that substantial universals answer is not the trivial one Heil considers (why do instances of *aqua regia* dissolve gold? because they are instances of *aqua regia*), but rather the deeper question of why certain properties systematically cluster together in the first place. The kind *electron* does not explain why this particular electron has unit negative charge – that is explained by the particular's instantiation of the relevant property. Rather, the substantial universal explains why unit negative charge, specific rest mass, and half-integer spin invariably occur together across all electrons, forming a non-arbitrary natural grouping rather than a merely conventional classification. This unifying role cannot be performed by modes alone, since modes are particular property-instances that characterize individual substances, whereas systematic property clustering requires a universal principle that transcends any particular instance. The substantial universal thus provides the formal ontological foundation that makes possible the various empirical unification principles (laws of nature, causal mechanisms, etc.) that science discovers, giving universals precisely the kind of substantive explanatory work that Heil rightly demands.

3.3 Unification principles: the 'how' vs. the 'why'

NKF, as developed above, enables a crucial clarification regarding the explanatory division of labour between metaphysics and science. I distinguish between two fundamentally different questions about property clustering in natural kinds: the *why* question and the *how* question (cf. Tahko, 2022 and Bellazzi & Tahko, 2025).

The 'Why' Question (Metaphysical): *Why* do the properties characteristic of a natural kind cluster together systematically in the kind's instances? This is a question of formal ontology, concerning the basic structure of reality. NKF provides a direct answer: properties cluster together because the substantial universal unifies them. It is part of the nature of substantial universals to serve as principles of unity for their characteristic properties.

The 'How' Question (Empirical): *How* does a particular natural kind unify its characteristic properties? What are the specific mechanisms, laws, or principles through which the unification occurs? This is largely an empirical question for science to investigate. Different kinds may employ different *unification principles* (UPs) to integrate their properties.

This distinction proves crucial for understanding the relationship between metaphysics and scientific practice. NKF operates at the level of formal ontology, providing the general framework within which scientific investigation of specific unification mechanisms can proceed. Science seeks to discover the particular UPs operative in different domains, but metaphysics provides the foundational insight that there *must* be such principles, in virtue of the nature of substantial universals.

Consider some examples of how this division of labour works in practice. For biological kinds, science has identified various causal mechanisms as plausible UPs, like Boyd's (1991) homeostatic property cluster (HPC) theory suggests. The kind *Homo sapiens* maintains its characteristic properties through complex feedback systems involving genetic, developmental, and physiological processes. These mechanisms constitute the *how* of unification for this particular kind – assuming that one accepts biological kinds.

For chemical kinds, different UPs are operative. The kind *water* (H_2O) might unify its properties through the laws governing molecular structure and chemical bonding. The specific ways that hydrogen and oxygen atoms combine to produce water's characteristic properties – its boiling point, density, chemical reactivity – constitute the empirically discoverable UP for this kind.

For fundamental physical kinds like *electron*, the situation becomes more complex. Traditional causal theories like HPC theory struggle here because there are no obvious causal mechanisms connecting unit negative charge, specific rest mass, and half-integer spin. These properties appear to cluster as a matter of the kind's essential nature rather than through identifiable causal processes. There may be a yet to be discovered UP which might involve fundamental laws of nature or, in the limiting case, the essential nature of the substantial universal itself. Crucially, the *how* of unification remains an empirical question, but we do not need to postulate any additional brute facts to address the *why* question since the answer to that question is the same regardless of the kind in question.

This flexibility regarding specific UPs represents a significant advantage of NKF as I have developed it over reductive approaches. Bundle theory about kinds, in its various forms, typically commits to particular types of unification mechanisms – whether causal processes, nomological relations, or spatiotemporal co-location. When these mechanisms prove inadequate for certain kinds (particularly fundamental physical kinds), the theory faces explanatory gaps.

By contrast, NKF remains pluralistic about UPs while providing a unified metaphysical foundation. The substantial universal *always* serves as the ultimate source of unification, but this unification may be implemented through various empirically discoverable mechanisms depending on the specific kind in question. Some kinds may rely primarily on causal processes, others on fundamental laws, still others on essential natures that resist further empirical analysis, at least for the time being.

This explanatory strategy also clarifies the proper relationship between metaphysics and empirical science. Metaphysics does not compete with science by offering rival explanations of specific unification mechanisms. Rather, it provides the conceptual framework that makes scientific investigation of such mechanisms coherent in the first place. Without the metaphysical insight that natural kinds serve as principles of unity, the scientific search for UPs would lack proper theoretical foundation.

An important clarification is in order here. NKF does not claim that natural kinds are the *only* principles of unity that may be operative in the world. It is entirely possible that there are organisational principles which resemble UPs but which do not constitute objective unification principles in the sense required for genuine natural kinds. Consider biology, where there are multiple competing candidates for a unification principle for species – genetic, ecological, phylogenetic, and others. These are all principles of unity in some sense, but on closer inspection they may fail to constitute *objective* UPs that would ground a fundamental natural kind. The form of classification may be similar, but the metaphysical status of the organisational principle differs. NKF is compatible with the possibility that some domains feature organisational principles that fall short of the robust, mind-independent unification that characterizes genuine natural kinds, and indeed this is precisely what we would expect if some putative kinds in, say, biology turn out not to be genuine natural kinds (cf. Tahko, 2022).

The why/how distinction thus reveals NKF as providing precisely the type of foundational theory that categorial fundamentality requires. It identifies natural kinds as playing an irreducible explanatory role – answering the core metaphysical question of why property clustering occurs – while remaining appropriately open to empirical discovery regarding the specific mechanisms through which this clustering is implemented in particular cases.

This explanatory strategy also addresses a sophisticated recent challenge to natural kind realism from Chakravartty (2023). Chakravartty argues that natural kind realism faces a 'fatal dilemma' (2023: 65) once we acknowledge the central role that inductive success plays in identifying and theorizing about natural kinds. On his analysis, the epistemic centrality of kinds, namely, their capacity to 'facilitate human epistemic (and other) interests via inductive inference' (2023: 63), renders traditional mind-independence claims untenable.

Chakravartty's dilemma arises from attempts to update traditional realism by incorporating epistemic interests while preserving mind-independence. Such 'hyperrealist' approaches must either stipulate proxies for naturalness (which remain inherently anthropocentric) or refuse to stipulate restrictions entirely (which provides no principled way to distinguish mind-independent from mind-dependent kinds). Either horn of the dilemma, he argues, collapses the distinction that realism requires.

The why/how distinction developed here provides a response to this challenge. Chakravartty's dilemma gains its force by conflating the metaphysical question of *why* property clustering occurs with the epistemic question of *how* we identify and theorise about particular natural kinds. The substantial universal provides the metaphysical answer to the why question: properties cluster because kinds serve as principles of unity. This is the case regardless of the epistemic story about how we come to discover or theorise about specific kinds and their unification principles.

This separation preserves genuine mind-independence at the categorial level, i.e., at the level of the unification principle itself, while acknowledging the legitimate role of epistemic interests in scientific practice. The category of natural kind is fundamental because substantial universals play an irreducible unifying role for properties. But *which* particular kinds exist and *how* they achieve unification remains open to empirical investigation guided by inductive success and other epistemic considerations. Chakravartty's challenge thus targets the wrong level of analysis, as it shows that our *identification* of natural kinds involves epistemic interests, but this does not undermine the mind-independent *existence* of the categorial structure that makes such identification possible in the first place.

It is worth situating the present discussion within the broader landscape of natural kind realism, since views that travel under the label 'natural kind realism' differ significantly in their metaphysical commitments (cf. Bird's 'strong realism' discussed in § 1.1). NKF is certainly a version of natural kind realism, properly understood, but that label is also used for views that do not regard natural kinds as a fundamental ontological category. A particularly instructive case is Dupré's (1993) *promiscuous realism*, which holds that there are 'countless legitimate, objectively grounded ways of classifying objects in the world' (Dupré, 1993: 18). While promiscuous realism purports to be a realist view, its taxonomy is ultimately driven by a commitment to the plurality of human interests. Moreover, Dupré's underlying process ontology (Dupré, 2012) sits uneasily with the kind of mind-independent categorial structure that NKF defends. Carr (2023) has recently argued persuasively that Dupré's promiscuous realism, when assessed against the key conditions for natural kind realism derived from Chakravartty's three dimensions of commitment for scientific realism, fails to satisfy at least one of these conditions. Therefore, it should be classified as an antirealist view of natural kinds. This conclusion is consonant with the present framework: from the perspective of NKF, promiscuous realism lacks the commitment to mind-independent substantial universals that genuine natural kind realism requires.[5]

3.4 Natural kind fundamentalism and laws of nature

Before turning to examine how natural kinds fit into a complete categorial system, we should address an important challenge to the fundamentality of the natural kind category itself. Bird (2012) argues that natural kind approaches like Lowe's, where a key task for natural kinds is that they feature in laws of nature, face a serious limitation: some scientifically important laws appear not to feature fundamental natural kinds. Coulomb's law, for instance, applies to all charged particles rather than any specific kind, leading Bird to question whether kinds are genuinely necessary for understanding laws of nature.

I contend that rather than undermining NKF, this observation reveals something important about the scope and limits of categorial fundamentality. The fact that some laws do not feature fundamental natural kinds need not threaten the fundamental status of the natural kind category – it may simply reflect different grades of necessity operating in nature. Following insights developed elsewhere (Tahko, 2015), we can distinguish between laws that are metaphysically necessary because they flow from

[5] See also Creţu, 2018 for critical discussion of the main arguments for natural kind realism, and Gentile & Lucero, 2024 on the explanatory power that a more robust realist framework can provide. There is of course much more to be said about the relationship between NKF and the broader landscape of natural kind realism. I have engaged with these issues in more detail elsewhere (Tahko, 2021), and a full treatment would require a separate discussion. The present point is simply that NKF provides principled resources for distinguishing genuine natural kind realism from views that, while employing realist vocabulary, lack the commitment to mind-independent categorial structure that robust realism requires.

the essential natures of fundamental kinds, and laws that are nomologically necessary but metaphysically contingent because they concern other structural features of reality.

Consider the contrast between the Pauli Exclusion Principle (PEP) and Coulomb's law. The PEP states that no two fermions can occupy the same quantum state simultaneously, a constraint that appears to flow directly from the essential nature of fermions as particles with half-integer spin. This suggests the PEP may be metaphysically necessary, grounded in what it is to be a fermion. Coulomb's law, by contrast, governs the behaviour of all charged particles without being grounded in the nature of any particular kind.

One might object that the very generality of laws like Coulomb's law, which apply across multiple natural kinds, suggests that there are important commonalities between natural kinds that are better explained by property clustering than by the kinds themselves. After all, if unit negative charge is a property shared by electrons and muons, and Coulomb's law applies to all charged particles in virtue of this shared property, does this not support a property-first rather than kind-first picture? I think not. NKF fully agrees that properties are definitive of kinds – indeed, as analysed in detail in § 4, natural kinds rigidly depend on their essential properties. Where the same property occurs in multiple kinds, as unit negative charge occurs in both electrons and muons, it is entirely to be expected that laws governing that property will apply equally to both kinds. But this is perfectly compatible with NKF: the substantial universal *electron* unifies unit negative charge with specific rest mass and half-integer spin, while the substantial universal *muon* unifies unit negative charge with a different rest mass and half-integer spin. The shared properties explain why certain laws generalise across kinds, but they do not explain why each kind has the *particular cluster* of properties that it does. That explanatory work remains the province of substantial universals.

This framework preserves what is perhaps the most compelling feature of Lowe's theory about natural kinds, namely, its ability to ground metaphysically robust laws in the essential natures of kinds, while acknowledging that not all scientifically important regularities need flow from natural kinds. The category of natural kinds remains fundamental because it provides the ontological foundation for metaphysically necessary laws, even if other categories ground weaker but still genuine forms of nomological connections. This gives us a principled criterion for distinguishing the metaphysically necessary laws from more contingent regularities, without forcing all laws into a single modal category.

A related question concerns the modal status of natural kind instantiation itself. If the instantiation of fundamental kinds is metaphysically necessary, then the laws that flow from the essential natures of those kinds will inherit this necessity. Weaker laws or regularities – those that do not flow from the essential natures of fundamental kinds – may depend on other features, such as contingent property distributions or structural arrangements. I am sympathetic to a relatively sparse view of which kinds are genuinely fundamental, which would restrict metaphysically necessary instantiation to a comparatively small number of kinds. But the framework developed here is designed to retain openness on this score. Whether a given kind is fundamental, and what modal status its instantiation possesses, are questions that the CCB framework leaves to the interplay between metaphysical theorising and empirical investigation. The key point is that adopting a sparse or a less sparse view of natural kinds does not affect the argument for NKF as a thesis about the fundamentality of the category; it affects only which particular kinds fall within the scope of the strongest modal claims.[6]

This completes the case for treating natural kinds as irreducible unifiers deserving recognition as a fundamental ontological category. They provide metaphysically indispensable explanations that no other category can supply, while maintaining the proper relationship with empirical investigation of their specific implementation in the natural world.

4 Natural kinds as part of a fundamental categorial system

Having argued that natural kinds constitute a fundamental ontological category, this section examines how they integrate within a complete categorial system. The analysis proceeds through several interconnected stages. First, I clarify the formal ontological relations that structure the relationship between natural kinds and properties, focusing on essential dependence relations (§ 4.1). Second, I provide a precise formal analysis showing how kinds and properties exhibit mutual but asymmetric dependence: properties depend generically on kinds while kinds depend rigidly on their essential properties (§ 4.2). Third, I explain how this asymmetric dependence structure reveals the ontological priority of substantial universals over properties despite their mutual dependence (§ 4.3). Fourth, I clarify how this framework distinguishes essential from accidental properties through the dependence structure (§ 4.4). Finally, I demonstrate how natural kinds and properties together satisfy the Complete Categorial Basis criterion, forming an integrated system of fundamental categories characterized by irreducibility, systematic integration, and mutual determination (§ 4.5).

4.1 Formal ontological relations and ontological dependence

The fundamental insight underlying NKF is that substantial universals and properties exhibit systematic interconnections that reflect the overall categorial structure of reality. In Lowe's four-category ontology, individual substances depend on substantial universals for their identity as the kinds of substances they are. Substantial universals depend on attributes for their characterization – the kind *electron* would not be the kind it is without being characterized by specific charge, mass, and spin properties.

These dependencies between the members of the categories are *formal ontological relations*. As *internal relations*, they are structural features of reality itself, not additional entities populating our ontology. They reflect the essential interconnectedness of the fundamental categories while preserving the irreducible character of each. Natural kinds cannot be reduced to properties, but they necessarily relate to properties through the formal ontological structure of reality.

[6] I develop the connection between natural kind fundamentalism and the modal status of laws of nature in more detail in Tahko (2015).

The notion of formal ontology has Husserlian origins, where formal ontological relations are understood as 'formal structures' among objects and their parts (see Smith & Mulligan, 1983 and Hakkarainen & Keinänen, 2023 for more detailed discussion). These relations hold necessarily, given the existence of their relata, and determine the categorial structure of reality.

While Lowe's ontological square in Fig. 1 provides a helpful illustration of how fundamental categories might be systematically related, our focus here is specifically on the relationship between substantial universals and properties. We need not commit to the full four-category framework to recognise that kinds and properties stand in formal ontological relations that structure this portion of reality.

To formalise the relationship between natural kinds and properties, we must employ the tools of formal ontology, specifically the hyperintensional notion of *essential dependence*.[7] This approach, building on the work of Fine (1994), Lowe (1998), and others (e.g., Correia, 2005, Koslicki, 2012, Tahko & Lowe, 2025) provides the precise conceptual machinery needed to articulate how natural kinds relate to properties.

Let us define two key notions of ontological dependence that are crucial for understanding kind-property relations:

Rigid Essential Dependence (E-RIG): x depends essentially for its existence upon y if and only if it is part of the essence of x that x exists only if y exists.

This relation can be symmetric or asymmetric. In the context of natural kinds, we find asymmetric rigid dependence: substantial universals depend essentially for their existence on the specific properties that define them. The kind *electron* depends rigidly on the properties of unit negative charge, specific mass, and spin – these particular properties, not merely some properties or other. The dependence is *rigid* because the kind requires these exact properties to be the very kind it is.[8]

Generic Essential Dependence (E-GEN): x depends essentially for its existence upon Fs if and only if it is part of the essence of x that x exists only if some F exists.

This relation expresses a more flexible form of dependence. Property universals depend generically on there being some kind that instantiates them, but not on any particular kind. The property of unit negative charge could exist through instantiation in electrons, muons, or other negatively charged particles. The dependence is *generic* because what matters is that some kind or other bears the property, not that any specific kind does so.

[7] For further details regarding my preferred analysis of *essence* itself, see Tahko (2023a).

[8] It is worth noting that while natural kinds on the present account are rigidly dependent on their essential properties, this is compatible with the causal or historical methods of reference that are operative in scientific practice. Scientists can identify and successfully refer to a natural kind through causal/historical chains of reference even before discovering (all of) the kind's essential properties. This is precisely what enables science to *learn more* about a natural kind after its initial discovery – one can have identified and referred to the kind prior to discovering its full essential characterisation. This observation further supports the division of labour between science and metaphysics developed in § 3.3: the metaphysical account specifies the essential dependence structure of natural kinds, while science employs whatever referential and investigative methods are needed to discover the content of that structure.

4.2 The formal structure of kind-property relations

With these conceptual tools in hand, we can now provide a precise analysis of how natural kinds relate to their properties. The relationship is characterized by a distinctive pattern of mutual but asymmetric dependence relations that explains both the unity of kinds and the sense in which we can regard them as ontologically prior to properties:

(1) **Properties generically depend on kinds (E-GEN)**: Each property universal depends for its existence on there being some natural kind that either essentially or accidentally instantiates it. This reflects the immanent realist commitment that there are no uninstantiated universals – properties exist only insofar as they characterize natural kinds.
(2) **Kinds rigidly depend on their essential properties (E-RIG)**: Each natural kind depends for its existence on the specific properties that define its essence. These are not merely properties the kind happens to have, but properties that are constitutive of what it is to be that kind.

This dual structure of dependence relations provides the formal ontological foundation for answering the fundamental 'why' question of property clustering. Natural kinds unify their associated properties precisely because these properties generically depend on the kind for their existence, while the kind itself rigidly depends on its essential properties for its identity. The kind serves as an ontological focal point that both necessitates the existence of its properties and derives its own identity from its essential characterization via these properties.

The formal structure can be illustrated as follows: a natural kind *K* unifies a certain set of properties because, on the one hand, these properties generically depend on *K* (or some kind like it), and on the other hand, *K* rigidly depends on its essential properties. Properties that are accidental to *K* may be essential to other kinds, but all properties depend generically on there being some natural kind that bears them. Figure 2 illustrates this structure:

4.3 Asymmetric priority within mutual dependence

The dependence relations between kinds and properties exhibit a subtle but crucial asymmetry that reveals the ontological priority of substantial universals. While kinds and properties are mutually dependent, the *direction* of these dependencies differs in ontologically significant ways.

The generic dependence of properties on kinds is *existential*: properties require some kind or other for their instantiation, but they are not essentially tied to any particular kind. A property like unit negative charge can be instantiated by different kinds (electrons and muons) without losing its identity. This flexibility reflects the ontological dependence of properties on the category of substantial universals as such.

By contrast, the rigid dependence of kinds on their essential properties is *constitutive*: these specific properties are not merely required for the kind's existence but

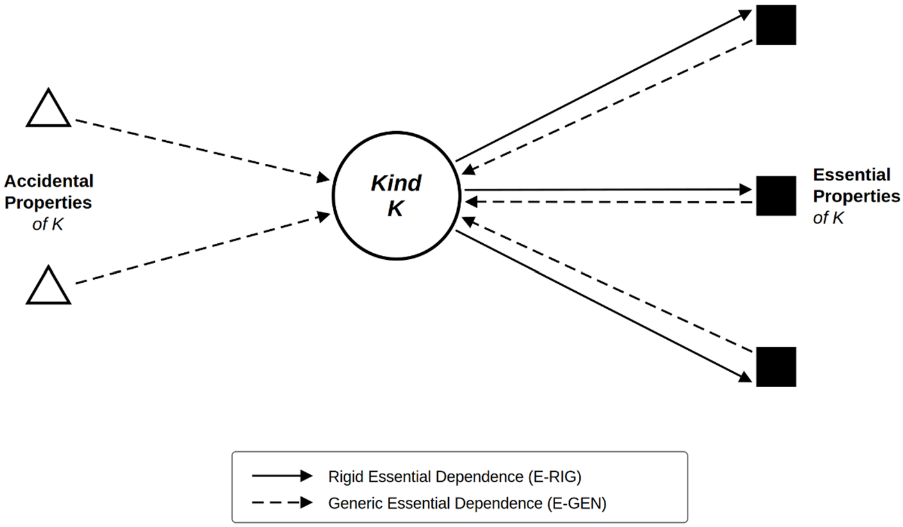

Fig. 2 Ontological dependencies between a kind and essential/accidental properties

partially constitute what it is to be that kind. The kind *electron* is not merely something that happens to have unit negative charge; rather, having unit negative charge is partially constitutive of being an electron.

This asymmetry explains why substantial universals, rather than properties, serve as the fundamental unifying principle. Properties cluster together not because of intrinsic relations among themselves, but because they are unified by their common relation to a substantial universal. The substantial universal provides the ontological 'glue' that holds together what would otherwise be an arbitrary collection of properties.

The asymmetric priority of kinds over properties thus provides the metaphysical explanation for why certain property clusters are non-arbitrary. It is because particulars instantiate the substantial universal *electron* that they systematically exhibit the properties of negative charge, specific mass, and spin. The clustering is not a brute fact but reflects the formal ontological structure whereby properties depend on kinds for their unification.

4.4 Essential vs. accidental properties in the dependence structure

The formal ontological framework helps clarify the distinction between essential and accidental properties of natural kinds. Essential properties are those on which the kind rigidly depends. Without these specific properties, the kind would not be the kind it is. Accidental properties are those that may characterize instances of the kind without being constitutive of the kind's identity.

Both essential and accidental properties generically depend on substantial universals for their existence, but they relate differently to the rigid dependence structure. Essential properties of kind K are those properties P such that K rigidly depends on

P. Accidental properties of *K* are those properties that characterize *K* (or instances of *K*) but on which *K* does not rigidly depend.

This distinction is ontologically robust rather than merely epistemic. Whether a property is essential or accidental to a kind is determined by the formal ontological relations of dependence, not by our knowledge or conceptual schemes. The kind *water* plausibly rigidly depends on the property of containing hydrogen and oxygen in certain proportions, making this an essential property, while it does not rigidly depend on properties like raining from the sky or filling the lakes, making these accidental. Alternatively, we could here resort to the Finean (1994: 276) distinction between *constitutive* and *consequential* essence, whereby properties entailed by the constitutive essence could be regarded as part of the consequential essence (rather than as accidental as above). Arguably, some properties that may not be obviously essential, such as the property of water being a liquid at room temperature, could be regarded as being entailed by the essential properties of water, and hence part of its consequential essence. This distinction is not without its problems though and Fine himself prefers to define essential dependence in terms of the constitutive essence. Either way, we can formalise the relevant dependence structure with the tools at hand.

Importantly, properties that are accidental to one kind may be essential to another. The property of having atomic number 79 is accidental to the kind *metal* but essential to the kind *gold*. This reflects the systematic character of the dependence relations: the same property can participate in different patterns of rigid and generic dependence with different substantial universals.

4.5 Natural kinds within the complete categorial basis

The formal ontological analysis reveals how natural kinds and properties together can satisfy the Complete Categorial Basis (CCB) criterion for fundamental categories. While I remain agnostic about the full scope of fundamental categories, the systematic relationship between kinds and properties demonstrates how they form an integrated part of any complete categorial system. We may summarise this with three points:

1. **Irreducibility**: Neither natural kinds nor properties can be eliminated in favour of the other. Natural kinds cannot be reduced to bundles of properties because this cannot explain why certain property clusters are non-arbitrary. Properties cannot be reduced to aspects of kinds because kinds themselves depend on properties for their characterization. Each category plays an irreducible role in the formal ontological structure.
2. **Systematic Integration**: Natural kinds and properties are necessarily related through formal ontological relations of essential dependence. These relations are not contingent additions to otherwise independent categories, but essential structural features that define how kinds and properties function together.
3. **Mutual Determination**: The categories of natural kinds and properties jointly determine a significant portion of reality's structure. Every property exists only through instantiation in some substantial universal, and every kind exists only

> through characterization by properties. Together, they provide the framework for understanding the systematic clustering of properties that characterizes reality.

This analysis supports (at least) a two-category fundamentalism focused on substantial universals and properties, without necessarily requiring commitment to additional categories like individual substances or modes. The formal ontological relations between kinds and properties are sufficient to ground the explanatory work that NKF seeks to accomplish.

However, a natural question arises regarding what instantiates the natural kinds. If kinds are neo-Aristotelian substantial universals subject to the principle of instantiation, then our fundamental categorial ontology should include whatever it is that instantiates the kind. The straightforward solution is to commit to individual substances, completing (at least part of) Lowe's four-category ontology. But the challenge of developing an ontology without substances is intriguing, and there are proposals in the literature that attempt to do so while retaining natural kinds as a fundamental category. One such proposal is the bundle theory with kinds developed by Keinänen and Tahko (2019), which outlines an ontology with just kinds and properties – where particulars are construed as 'caboodles' of properties that instantiate substantial kind universals, without requiring a separate category of individual substance. I do not wish to commit to any particular solution here, but I note that the framework developed in this paper is compatible with several approaches to instantiation. Crucially, the question of what instantiates natural kinds is orthogonal to the question of whether the category of natural kind is itself fundamental – the latter is the thesis of this paper. What matters for NKF is that kinds and properties form an irreducible pair of fundamental categories; how to complete the categorial picture with respect to particulars and their instantiation of kinds, while important, is a further question that can be addressed independently.

5 Conclusion

The formal ontological framework presented in this paper provides a sophisticated foundation for the role of natural kinds in categorial systems. Natural kinds emerge as ontological unifiers that explain property clustering without collapsing into mere property bundles.

The systematic character of the kind-property relationship means that explanations invoking natural kinds are not ad hoc appeals to mysterious entities, but applications of a general theoretical structure that governs fundamental ontological relations. When we explain why electrons have the properties they do by appealing to the substantial universal *electron*, we are invoking a specific instance of the general formal ontological structure that relates kinds to properties throughout reality.

The asymmetric dependence structure provides the ontological foundation for scientific essentialism while remaining compatible with empirical discovery. The formal ontological framework specifies that natural kinds rigidly depend on their essential properties, but it does not dictate a priori which properties are essential to which kinds. This remains a matter for empirical investigation guided by scientific theory.

Moreover, the framework respects the division of labour between metaphysics and empirical science. Formal ontology specifies the general structure of kind-property relations – that kinds unify properties through patterns of essential dependence – but it does not dictate which specific kinds exist or which properties characterize them. The discovery of particular natural kinds and their properties remains an empirical matter.

This division of labour enables Natural Kind Fundamentalism to maintain its explanatory ambitions while respecting the importance of scientific inquiry. The metaphysical thesis that natural kinds are fundamental provides the conceptual framework within which scientific discoveries about specific kinds and their properties can be understood, without constraining the content of those discoveries.

Natural kinds emerge not as isolated theoretical posits, but as irreducible elements within the fundamental structure of reality, essentially connected to properties through relations of mutual but asymmetric dependence. This framework provides the metaphysical foundation for understanding why the natural world exhibits the systematic property clustering that science investigates, while remaining open to empirical discoveries about the specific character of natural kinds and their properties.

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