

Editor's introduction

Activities of *kinding* in scientific practice

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It seems obvious that the sciences do not simply produce piles of unrelated bits of knowledge, but it is much less obvious *how* they provide us with explanations, and how these explanations yield understanding about the processes, causes, and contents of the natural world. Perhaps the sciences explain by classifying the contents of the world into natural categories of being or what might be called 'natural kinds'. Knowing what kind something is would then greatly inform us about what other information we can infer about it, for example knowing what natural kind it belongs to means that we know what inferences we can make about it and what generalizations apply to it as a member of that kind. Discussions over whether these natural kinds exist, what is the nature of their existence, and whether natural kinds are themselves natural kinds aim to characterize not only the kinds of things that exist in the world but also what knowledge of these categories can provide.

Although philosophically critical, much of the past discussions of natural kinds have often answered these questions in a way that is unresponsive to, or has actively avoided, discussions of the empirical use of natural kinds and what I dub 'activities of natural kinding' and 'natural kinding practices'.¹ The natural kinds of a particular discipline are those entities, events, mechanisms, processes, relationships, and concepts that delimit investigation within it – but we might reasonably ask, How are these natural kinds discovered? How are they made? Are they revisable? and Where do they come from? A turn to natural kinding practices reveals a new set of questions open for investigation: How do natural kinds explain through practice? What are natural kinding practices and classifications and why should we care? What is the nature of natural kinds viewed as a set of activities? and How do practice approaches to natural kinds shape and reconfigure scientific disciplines?²

Contributors to this volume answer these questions using empirically informed evidence-based approaches to natural kinds. They investigate natural kinds using practice-based approaches to explore the nature of kindhood and the activities of kinding within linguistics, chemical classification, neuroscience, gene and protein classification, colour theory in applied mathematics, homology in comparative biology, sex and identity theory, memory research, race, extended cognition, symbolic algebra, and geographic information science. Rather than offering a recapitulation of traditional or generalist approaches to the nature of kindhood, this

volume seeks to open up an as-yet-unexplored area within the emerging field of philosophy of science in practice, in the natural kinds literature, and in the studies of scientific classification.

Natural kinds

Natural kinds have traditionally been discussed in terms of how they classify the contents of the world. The metaphysical project has been one which identifies essences, laws, sameness relations, fundamental properties, and clusters of family resemblances³ and how these map out the ontological space of the world. But actually *how* this is done has been less important in the discussion than the resultant categories that are produced.

Much of the literature on natural kinds assumes that in order for kinds to be natural, they must be mind-independent.⁴ The standard view of natural kinds and of scientific classification is that the source of their *naturalness* is to be separate from human inquiry and activity. For instance, Robin Andreasen's (1998) version of natural kinds grants naturalness to classes only in virtue of their independence from classifiers: 'natural biological classification . . . exists independently of our classifying activities'⁵ Alexander Bird and Emma Tobin's (2015) most recent account exemplifies this standard view:

To say that a kind is natural is to say that it corresponds to a grouping that reflects the structure of the natural world rather than the interests and actions of human beings . . . The existence of these real and independent kinds of things is held to justify our scientific inferences and practices.⁶

To talk of natural kinds has been taken to commit oneself to a certain brand of naturalism. To be natural is to correspond to the way the world is structured according to its natural partitioning – a world structure that excludes the influence of human scientific activity. It should come as no surprise – given its title *Natural Kinds and Classification in Scientific Practice* – that the present volume rejects this reading of *naturalness*.

To say that there are natural kinds may commit one to some sort of naturalist position – that the things to which the kinds refer actually obtain and are adequate characterizations of the structure of epistemic space or are accurate representations of the ontology of the field within which they are used.⁷ But this commitment does not license the assumption that some univocal understanding of the naturalness of natural kinds exists or that to be objective requires they be independent of human classifying activities. I contend that natural kinds are thought to provide an accurate understanding of the contents of the world conceived of as natural in at least three different ways: (1) that there are natural groupings, classifications, or methodologies that exist; (2) that natural kinds pick out these natural groupings; and (3) that theories of natural kinds specify the naturalness of kinds in their descriptions of the contents of the world. These claims needn't be a package deal. A claim that natural kinds are real may be to hold that the taxonomy of kinds

within that field obtains, for example is veridical or realist. But there may be other orthogonal notions of natural kinds as being natural that refer to the method of investigation, for example it is a natural method if it is the one most appropriate to use to investigate the subject matter of our inquiry.

Richard Boyd's Homeostatic Property Cluster (HPC) Theory⁸ offers an alternative approach that does not ground natural kindhood on mind-independence but instead on 'epistemic reliability'.⁹ For Boyd, a theory of natural kinds is a theory of explanatory fit-ness. Natural kinds are those categories and classifications that fit the knowledge-seeking questions we ask and aim to answer. They are part of the methods we use to describe, categorize, and predict. According to the HPC Theory, a theory of natural kinds answers the question, why are these methods, classes, or categories epistemologically successful?¹⁰ But, despite widespread acceptance of the HPC Theory, if the kinds it claims are successful kinds in science are actually not, or if it fails to account for kinds that are, then its promise of providing an alternative approach to natural kinds that is responsive to scientific practice may be wanting.¹¹ Judgement of these kinds as natural kinds seems to demand empirical investigation of actual scientific practices as well as inclusion of some type of normative assessment about kinds in use to judge between natural (or at least useful) kinds and not natural (or unuseful) kinds?

The practice turn

The project of the present volume is to shift philosophical investigation of the naturalness of natural kinds to how they are used, discovered, or made. This shifts metaphysical inquiry of natural kinds from the contents of the world to the activities of partitioning, conceptualizing, comparing, and categorizing – that is to *ontologizing practices*. Instead of bracketing conceptualizing, comparing, and classifying as belonging to *theory* – a domain exclusive of and dichotomous with that of *practice* – theorizing in general and conceptualizing in particular are conceived of as practices. To put it boldly: if there is a category of scientific practices, theorizing – insofar as it is a practice of mind – is included within it.

Focusing on scientific practice takes the empirical and experimental re-examinations in history and philosophy of science (HPS) and in science and technology studies (STS) as catalysts for a broader understanding of what it is that we do when we explain and how this allows us to understand that which is explained. As such, it can be characterized as part of what has been referred to as *the practice turn*.¹² We can best understand this turn to be a turn of our attention to scientific action. Justification for this attention to action comes from the recognition that 'all scientific work, including pure theorizing, consists of actions, of the physical, mental, and "paper-and-pencil" operations, to put it in Percy Bridgman's¹³ terms'.¹⁴ This refocusing of science on scientific practices highlights the activities that are revealed when we look at the processes and doings of science by scientists and scientific communities (e.g. hypothesizing, testing, experimenting, theorizing, measuring) rather than exclusively on the products of science (e.g. knowledge, equations, theories).

The practice turn in philosophy of science is not an apologetic for an *and-practice-too* approach to the metaphysics of science. So-called pure theoretic approaches that omit reference to practice succeed in doing so only by assuming science and knowledge acquisition to be a subjectless state of affairs – activities with no actors, understanding with no one who understands, and modelling with no modellers. Hasok Chang¹⁵ suggests that the solution to this problem is for us to go against the convention of avoiding the second person familiar ‘you’ in our discourse, explanations, and discussions. We should (as philosophers and scientists) recover the importance of what knowledge is as something you or I understand or explain, rather than as disembodied subjectless answers to questions.¹⁶ It is also what I have referred to elsewhere¹⁷ as a turn to a context-driven naturalistic agent-based approach or extended agency. Knowledge and adjudication of methods of investigation (whether epistemological, metaphysical, or valuative) are the result of loops of reflectiveness that – in a multi-agent system – construct the grounds for objective knowledge through intersubjective judgements.

Simply put, evaluations rely on what people think, what they do, how they do it, and how they communicate it to others. These evaluations are dependent on the epistemic capabilities of individuals and are multiply instantiated within systems of practice. In the biosciences, these systems of practice include human agents, but also extend to their physical manipulations (e.g. measuring, weighing, running gels), mathematical modelling, proxied or remote tool use, objects of study and their modification (e.g. chassis organisms, BioBricks), and the spatially and temporally distributed social communities that they work within (e.g. International Human Epigenome Consortium [IHEC], Genome Consortium for Active Teaching [GCAT], International Genetically Engineered Machine [iGEM] Competitions).¹⁸

Questions posing oppositional alternatives – Does knowledge come from theory and inform practice or vice versa? Is science idea driven, data driven, tool driven, or practice driven? – frequently devolve into chicken-and-egg arguments over causal or at least temporal priority. Underlying these is the assumption that there is a unidirectional mode of inquiry – one whose existence could be either characterized as dependent upon us (socially constructed v. antirealist) or independent of us (realist v. naturalist). Philosophy of science in practice evaluates these metaphysical assumptions through critical assessment. That is, we can evaluate concepts in the tinkering (Jacob 1977¹⁹), intervening (Hacking 1983²⁰), retuning (Pickering 2005²¹), re-engineering (Wimsatt 2007²²), measuring (Chang 2004²³), kludging (O’Malley 2011²⁴), and in the verbing (Chang 2011²⁵) of science.

Natural kinds after the practice turn

A quick survey of the philosophical terrain of the traditional natural kinds literature would lead one to think that it is a limited ontological universe – populated by tigers, gold, and H₂O – objects of classification that have been considered quintessential kinds. Chemical kinds in particular remain the go-to natural kind if metaphysicians seek what they perceive to be unproblematic, real, objective kinds free from mind-dependence. A criticism of traditional metaphysical discussions of natural kinds is that they often ignore what science is actually doing when it dubs

things as natural kinds and simply assumes (or hopes) that the a priori categories of metaphysics coincide with those used in the sciences.²⁶

So what of the concepts traditionally understood as being based on a priori or purely theoretic approaches independent of our classifying activities, when we take the practice turn seriously? Does the practice turn in philosophy of science lead to a new practice-based metaphysics with practice-based notions of kindedness? If so, this would suggest a conception of natural kinds in direct opposition to traditional accounts of natural kinds that rely on essences or laws, as well as those based on the widely held view that natural kinds must be mind-independent, including those of Andreassen,²⁷ Bird,²⁸ and Tobin mentioned earlier.

Natural kinding practices and discipline-making

You, reader, might be thinking: okay, I know what natural kinds are, but what does it mean to *natural kind* something, and what in the world is *natural kinding*? I'll offer a fairly simple answer in response. '*Kinding*' and '*to natural kind*' are verbs (e.g. classifying, grouping, identifying, explaining, conceiving, representing, hypothesizing, tracking, intervening, measuring, testing, modelling, drafting, orienting, structuring, comparing, mapping, recording, representing, charting, etc.) – words that assert or convey activities or modes of being. They connect the subject with the predicate by expressing an action or state of the subject in relation to the predicate.

There is also a normative claim concerning methodology. Questions of metaphysics are best answered by grappling with the science itself, rather than relying on toy examples that have been shown to contravene actual scientific practice. If understanding the nature of kinding and classifying activities is the aim, we should begin by replacing (or at least augmenting) our toy examples with real activities within the specific discipline. Exploring the role of these scientific activities enables critical examination of how (and if) these affect the acquisition of knowledge, the context of discovery, and the categorization of the contents of the world.

What might this look like? An introductory example may help.^{29,30} Species have long been discussed as quintessential natural kinds. Whether they are remains a topic of much debate. To answer the question of whether species are (or are not) natural kinds, we would need to decide what the nature of kindhood for species is.³¹ This would involve a consideration of kinding and classifying practice within biological classification. Many (but not all) species concepts aim to define the species category in terms of natural lineages and groupings. Addressing the naturalness of these lineages and groupings in terms of the practices of natural kinding might involve a critical evaluation of the inclusion of ecological models into the current extension of ecological evolutionary developmental (eco-evo-devo) biology, the use of embryological tables to determine developmental stages in characterizing life cycles,³² or the use of G-C (guanine-cytosine) composition for the determination of phylogenetic distance. The use of models and measurements employed to track the resultant natural groupings and lineages may prove to affect the identification of species defined using them. These methods may result in non-concordant groupings. Insofar as species concepts aim to define the

species category, critical examination of how the use of these measurements and models may affect the categorization of species would provide insight from practice that may reconceive *species* and *naturalness*. In a recent paper,³³ I make an initial attempt to outline a practice approach to natural lineages based on the use of epigenetic, behavioural, cultural, and ecological inheritance systems,³⁴ rather than exclusively genetic inheritance. In that paper I ask what constitutes a natural grouping or lineage if evolution is conceived of as a multidimensional process that proceeds by means of multiple routes of inheritance. I suggest that if we take this multidimensional approach to lineage seriously, it ultimately affects how we conceive of species by extending the kinds of things (i.e. actions, processes, events, interactions, causes) that are evolutionarily significant in understanding and explicating those things that are considered to belong within the species category.³⁵ This re-conception of species comes from and is informed by the multiplicity of natural kinding practices that are used to track the varied systems of inheritance and the lineages that result from these.

Aim and structure

The aim of the volume is to turn past discussions of natural kinds on their head. Instead of presenting a metaphysical view of kinds based largely on an unempirical vantage point, it pursues questions of kindedness which take the *use* of kinds and activities of kinding in practice as significant in the articulation of them as kinds. It brings philosophical study of current and historical episodes and case studies from various scientific disciplines to bear on natural kinds as traditionally conceived of within metaphysics. Focusing on these practices reveals the different knowledge-producing activities of kinding and processes involved in natural kind use, generation, and discovery.

An evidence-based approach to natural kinds in scientific practice that is responsive to empirical practice requires specialists with intimate knowledge of their subject matter. This motivated my choice of contributors to this volume. I chose contributors who would explore the impact of the practice turn in philosophy and the conceptual consequences of it on the nature of kindhood using detailed case studies that exemplify kinding in use. I commissioned these papers to be written specifically for this volume, inviting the contributors to focus on an area of research that they were familiar with and engage with the activities of kinding. Their chapters address the nature of kinds, kindhood, kinding, and kind-making in physical chemistry, engineering, critical race theory, mathematics, developmental biology, molecular biology, computational neuroscience, cognitive science, linguistics, cartography, and sex and gender studies. Contributors use evidence, episodes, examples, and case studies rather than idealized toy examples to evaluate scientific practices of classification.

The volume is arranged over four overlapping themes:

- I. Explaining practices
- II. Kinding and classification

- III. The nature of natural kinds
- IV. Shaping scientific disciplines

The papers within each section engage with the theme and related questions within different disciplines. Part I, *Explaining Practices*, focuses primarily on the epistemic import of natural kinds and kinding practices. Bernhard Nickel, Hasok Chang, and Jackie Sullivan use linguistics, chemistry, and neuroscience (respectively) to show how kinds produce knowledge. Their concentrated discussions of the epistemology of practice and kinds as epistemic tools reveal a diversity of explanatory aims and approaches to understanding natural kinds. In 'Explanatory Strategies in Linguistic Practice', Nickel carefully identifies the relationship between explanatory strategies and the phenomena that are circumscribed as belonging to the study of linguistics. For instance, if syntactic theory is used to assess ungrammaticality, only certain kinds of perceived ungrammaticality will be detected. Nickel argues that a discipline is identified through its practices, in particular, its explanatory strategies. He provides a focused discussion of how this works through attention to three transitions in the history of linguistics. Nickel suggests that linguistic kinds are delimited as such through practitioners' use of epistemically sensitive and empirically reliable strategies. He argues that these explanatory strategies satisfy the Putnam (1975) and Evans (1982) requirement of deference to the world, rather than through the extension of natural kind terms.

Chang's approach to natural kinds in 'The Rising of Chemical Natural Kinds through Epistemic Iteration' is in direct opposition to the standard accounts which take the naturalness of natural kinds to be in their independence from human inquiry. He reveals the developmental framework through which science progresses – through knowledge-building stages of 'epistemic iteration' is human dependent. Chang investigates episodes in the history of chemical classification that provide detailed evidential support for his position that it is this epistemic iterativity rather than the popular natural kind essentialism that underpins the kindhood of chemical kinds. Chang's practice-based naturalism offers a compelling and empirically responsive alternative to the misinformed use of chemical kinds in the natural kinds literature. Chang offers a beta-test type 'suck it and see' approach as a practice-based replacement for the essentialist's cleaver (used for carving nature at its joints). He argues that the nature of chemical kind concepts (element, acidity, and phlogiston) is not in the immutable properties of objects (e.g. gold = atomic number 79), but in the revisability of their classificatory concepts and resilience in use over epistemic iteration.

Sullivan questions the assumption that the neurosciences will uncover natural kinds in 'Neuroscientific Kinds through the Lens of Scientific Practice'. Explanations within cognitive neuroscience are not developed as explanations for the purposes of providing linked-up accounts of causal processes or mechanisms. They are by-products of neuroscientists' conceptual and experimental practices. She argues that they are not intended to delimit kinds and do not attempt to represent the world or its joints as they are. Sullivan suggests that the aim of these practices is to understand cognitive capacities and which parts of the brain are involved in

the performance of these, for example things like face recognition and attention. Sullivan is critical of the view that natural kinds will be found as well as of the ontic view of mechanism that deemphasizes the role of scientific practice. Proponents of this view claim that mechanisms themselves – rather than scientists – are the ones that do the explaining. Sullivan argues that taking the role of conceptual, integrative, and experimental practices of neuroscientists on their own terms suggests an antirealism about cognitive kinds.

Part II, *Kinding and Classification*, is comprised of papers focusing on kinding practices and asks both what they are and why we should care about these activities of classification. Thomas Reydon, Joyce Havstad, Jordi Cat, and I (Catherine Kendig) explore classification practices in case studies in diverse sub-disciplines of history and philosophy of biology and applied mathematics (including nineteenth-century colour categories). Reydon shows how the practice of kinding impacts the natural kind conceptions we use in ‘From a Zooming-In Model to a Co-Creation Model: Towards a More Dynamic Account of Classification and Kinds’. Two models of conceptual kinding: zooming in and co-creation are evaluated. These are best understood as different kinding strategies. By focusing on our activity and the production processes required for kind creation, he builds on Boyd’s HPC Theory and on the work of Hacking (1995, 2007a) and in particular, his conception of *interactive* kinds. Reydon analyzes how these kinds of kinds are constrained and shaped by nature and by us in his support of a co-creation approach. He suggests that kindhood is ultimately kind-making reliant on practices in a co-created system where there is causal parity between our contribution and that played by nature in kinding the world and its contents. Reydon employs examples from practices used in tracking sociological classifications and gene classification to endorse the co-creation model.

Havstad’s ‘Protein Tokens, Types, and Taxa’ presents a nuanced account of the different protein classifications used within scientific practice – those characterizing the concept, identifying the type (or token), and those resolving taxonomic hierarchies. She shows that these protein classifications are orthogonal. Past accounts assuming protein classification to be pluralist do so by ignoring the diversity of practices and the objects of classification. Whereas practices of protein organization are pluralist, the protein individuation practice is monist. She argues that to make this judgement requires knowledge of the actual practices of protein classification. Havstad shows how the activities and practices of different classificatory schemes grant different suites of capabilities.

In ‘The Performative Construction of Natural Kinds: Mathematical Application as Practice’, Cat explores the tangle of practices and the dynamism embedded in kind construction, formal systems, and classification. He shows how practices are sources of norms and principles using case studies from nineteenth-century colour classification and fuzzy-set categorization. Rule-based colour research such as Maxwell’s (1856/1890) rested on a system of properties, formalizations, and algebraic models that were embedded in, as well as sustained by, those empirical practices. In turn, these practices provided justification for their use in the categorization of colour. Cat calls these embedded dynamic arrays ‘projects’; these are

the units of scientific conduct, vehicles of empirical knowledge acquisition, and the locus of practice.

My 'Homologizing as Kinding' takes homology to be a natural kind term and examines the changing historical and current practices used to identify homologues through the sets of activities that kind them. I suggest the concepts used within comparative biology are tuned by these *homologizing* activities which reciprocally are retuned by a new concept of *homology*. Recent research practices in developmental biology and the revised multidimensional approach to evolution provide evidential support for my suggestion. I evaluate the applicability of standard, linear accounts that disallow partial homology. These accounts favour an all-or-nothing conception of homology that take two or more traits being compared as either homologous or not. I suggest that if we take the multidimensional approach and comparative research practices seriously, these impact what constitutes an inheritance *lineage*. The upshot – those natural kinding conceptions of homology based on lineage require retuning to accommodate this kind of multidimensional homology thinking.

In Part III, The Nature of Natural Kinds, Sally Haslanger, Samuli Pöyhönen, and Quayshawn Spencer investigate the nature of natural kinds as kinds within the frame of practice. They question the widely held standard view that natural kinds are real and their reality is the result of them being mind-independent. Haslanger rejects the traditional notion of natural kinds as mind-independent in 'Theorizing with a Purpose: The Many Kinds of Sex'. Relying on examples of how sex is categorized, she suggests the opposite. The naturalness of natural kinds is not based on their being separate from our minds and independent of our experiences, but their naturalness is anchored in our experience and the social facts of our purposeful activities. *How* we differentiate the sexes – male, female, intersex – and what are the criteria for membership within these categories can be answered many ways, but *that* we can draw a distinction between these is not what is most interesting. Haslanger seeks to answer the hard question – what is a *good* way of drawing the distinction? The answer to this ultimately rests on the purposes that we have for intending to make the categorical distinction. She suggests that the categorization of male, female, or intersex is made within a social context that shapes (and reshapes, sometimes surgically) these sites of kinding.

Pöyhönen's 'Memory as a Cognitive Kind: Brains, Remembering Dyads, and Exograms' also discusses questions of realism and the nature of natural kinds. His agnostic or nonrealist approach attempts to uncover underlying assumptions about natural kinds and the various conceptualizations used by tracking the roles they play in memory research. He dismisses the assumption, long held in traditional discussions of natural kinds, that natural kinds require some sort of metaphysical commitment. Pöyhönen evaluates traditional, essentialist, and alternatives to these. While critical of Boyd's (2010) pluralist realism apparent in his HPC Theory, Pöyhönen builds his defence of an approach to natural kinds applicable to cognitive kinds by decoupling Boyd's assumed connection between metaphysical commitments of the reality of kinds with their inductive reliability.

In ‘Genuine Kinds and Scientific Reality’, Spencer rejects the current trend in philosophy that assumes natural kinds, to be natural kinds, must be inductively powerful or mind-independent. Using examples of the Native American private allele in population genetics among others, he shows (contra Wilkerson 1988, Psillos 2002, and Andreasen 1998) how empirically informed natural kinds are not only not necessarily realist and mind-independent, but also (contra Boyd 1999 and Slater 2013) they needn’t be explanatory useful or even epistemologically reliable in order to be counted as natural kinds. Spencer seeks to secure a satisfactory theory of genuine natural kinds – one that can predict which kinds are those which are natural and which are non-natural by relying on sustained empirical success.

The final section, Part IV Shaping Scientific Disciplines, addresses how practice approaches to natural kinds affect, configure, and in some cases reconfigure scientific disciplines. Michael Wheeler, Josipa Petrunic, and Rasmus Winther investigate and reconceive the disciplines of cognitive science, nineteenth-century symbolic algebra, neuroscience, and cartography in virtue of kinding practices in these areas of study. Each examines sites of kinding and agents of kinding through diverse empirical activities and within different disciplinary communities.

Wheeler’s ‘A Tale of Two Dilemmas: Cognitive Kinds and the Extended Mind’, solves a dilemma that seems inherent in what Rupert (2009) has called ‘the natural kinds argument for the extended mind’: that the inclusion of extended cognitive kinds into the discipline of cognitive science would allow it to explain more than one that excluded them. Part of the problem is that if we individuate cognitive kinds, they must be explained by appealing to explanatory factors within current human cognitive psychology, but doing so seems to negate the explanatory power of the extended parts as cognitive. To avoid this, we could try another option – individuate cognitive kinds without appeal to human cognitive psychology – but then those extended elements fail to have cognitive status. Wheeler rejects both horns of what he calls *Rupert’s Dilemma* by appealing to current epistemic practices within cognitive science that show that there already exist cognitive kinds with extension within the discipline that could serve as benchmarks to justify extended cognitive kinds.

In ‘Mathematical Kinds? A Case Study in Nineteenth-Century Symbolical Algebra’, Petrunic suggests that in order to test the claim in philosophy of mathematics that mathematics is composed of kind-like things, we need to look at the actual mathematical practice of mathematicians. Petrunic uncovers justification for mathematical kinds in historical practice and in mathematicians acting *as if* mathematical kinds exist. Her close examination of the use of symbolic algebraic numbers in the work of the nineteenth-century mathematician George Peacock (1842, 1845), shows that he behaved as if symbolical algebraic numbers were natural kinds. Petrunic argues that behaving, acting, practicing, and treating kinds as natural kinds fixes their kindhood, not in any Platonic type of abstraction, but in mathematical knowledge *in use*.

Winther’s ‘Mapping Kinds in GIS and Cartography’ introduces the widely multidisciplinary study of Geographic Information Science (GIS) and provides a brief

history of it, outlining the epistemological and technological structure of a subset of the questions it addresses. He characterizes some of the key practices of GIS, including data collection, management, map generalization, data modelling, and spatial analysis. Winther then provides an outline for a new area of philosophy based on mapping kinds. Mapping kinds are not like kinds typically referred to in traditional metaphysics. They are at once discovered and made. He argues with substantial evidence of current kinding practices that their use in cartography calls into question the assumed dichotomies of theory/practice, natural/constructed, and other binary views. Winther suggests a close investigation of GIS and cartography and an elaboration of a philosophy of mapping kinds may not only reconfigure our understanding of mapping, but it may also restructure our thinking about the nature of kinds in general.

This volume of new essays is arguably innovative if not unique among the panoply of volumes on natural kinds. The essays within it are both philosophically rigorous and scientifically informed. It is this, rather than its novelty that justify its addition to the already vast literature on natural kinds. As such, the volume is intended to be a preliminary and exploratory examination of evidence-based approaches to kinding and classifying activities in a broad set of specific disciplinary contexts. It is intended to be read by both scientists and philosophers alike. Due to the interdisciplinary nature of the papers included, it is equally accessible to scientifically curious metaphysicians and epistemologists, philosophers of science, and philosophically interested scientists, engineers, and mathematicians. It will be an invaluable resource for anyone pursuing research on natural kinds, classification, scientific practice, and of course the intersections of these in history and philosophy of science, technology, engineering, and mathematics, and within science and technology studies.

Notes

- 1 I explain what I mean by ‘activities of kinding’ and kinding practices in the course of this introduction, especially in the sections, ‘Natural Kinding Practices and Discipline-Making’. See also chapter 7 in this volume, ‘Homologizing as Kinding’.
- 2 The four parts of the volume – I. Explaining Practices, II. Kinding and Classification, III. The Nature of Natural Kinds, and IV. Shaping Scientific Disciplines – track these questions. Chapters within each section respond to these from different scientific disciplines.
- 3 See Wittgenstein, L. (1973) *Philosophical Investigations*. (3rd edition). Translated by G.E.M. Anscombe. New York and London: Pearson, for his discussion on ‘family resemblance’ where he suggests that meanings and concepts work not because they demarcate necessary and sufficient conditions for kind membership but instead provide patterns of family resemblance. Natural kinds conceived of in this way mean that entities belonging to a kind do not need to share a common feature held by all members of that (and only that) kind. Members may share some features but there is no necessary relationship, trait, or feature that possession of which would amount to automatic inclusion within the kind (or lack of, exclusion from it).
- 4 See Putnam, H. (1975) ‘The Meaning of “Meaning”’. In: *Mind, Language, and Reality: Philosophical Papers, Vol. 2*. Cambridge: Cambridge University Press, pp. 215–271; Kripke, S.A. (1972) *Naming and Necessity*. Cambridge, MA: Harvard University

- Press; Wilkerson, T. E. (1988). 'Natural Kinds', *Philosophy*, 63:243, pp. 29–42; Andreasen, R. O. (1998) 'A New Perspective on the Race Debate', *British Journal for the Philosophy of Science* 49(2): 199–225; Andreasen, R. O. (2000) 'Race: Biological Reality or Social Construct?', 67 *PSA(Proceedings)*, pp. S653–S666; Psillos, S. (1999) *Scientific Realism: How Science Tracks Truth*. New York: Routledge. Bird, A. and Tobin, E., 'Natural Kinds', In: Zalta, E. N. (ed.) *The Stanford Encyclopedia of Philosophy* (Spring 2015 edition).
- 5 Andreasen, R., 'A New Perspective on the Race Debate', p. 209.
 - 6 Bird, A., and Tobin, E. 'Natural Kinds'.
 - 7 Some contributors disagree on this point.
 - 8 See in particular, Boyd, R. N. (1991) 'Realism, Anti-foundationalism and the Enthusiasm for Natural Kinds', *Philosophical Studies*, 61:1, pp. 127–148. Boyd, R. N. (1999) 'Homeostasis, Species, and Higher Taxa' In: Wilson, R. A. (ed.) *Species: New Interdisciplinary Essays*. Cambridge, MA: MIT Press, pp. 141–186. Boyd, R. N. (2000) 'Kinds as the 'Workmanship of Men': Realism, Constructivism, and Natural Kinds', In: Nida-Rümelin, J. (ed.) *Rationalität, Realismus, Revision: Vorträge des 3. Internationalen Kongresses der Gesellschaft für Analytische Philosophie*. Berlin: De Gruyter, pp. 52–89; and Boyd, R. N. (2010) 'Realism, Natural Kinds and Philosophical Methods', In: Beebe, H. and Sabbarton-Leary, N. (eds.), *The Semantics and Metaphysics of Natural Kinds*. New York: Routledge. 212–234.
 - 9 Boyd, R. N., 'Homeostasis, Species, and Higher Taxa'.
 - 10 Boyd, R. N., 'Homeostasis, Species, and Higher Taxa'.
 - 11 For more extended discussion of the problems with the HPC Theory see Ereshefsky, M. and Reydon, T.A.C. (2015) 'Scientific Kinds: A Critique of HPC Theory and a Proposal for an Alternative Account', *Philosophical Studies*, 172, pp. 969–986.
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- 30 The processes of kinding are of course not unique to the biological science.
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