4 From a zooming-in model to a co-creation model

Towards a more dynamic account of classification and kinds

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1. Introduction

In this chapter I contrast two models of how kinds are made – what I call a "zooming-in" model and a "co-creation" model – and argue in favor of the latter model. The zooming-in model is widespread among realists about natural kinds (although it is usually only endorsed implicitly). It manifests itself in the assumption that kinds that are successfully used in scientific practice are successful because they represent aspects of the state of affairs in the world as it exists independently of us. Anti-realism or instrumentalism about kinds, in contrast, is often connected to versions of constructivism, which encompass a view of kinds as being made by us for practical purposes, without necessarily representing aspects of mind-independent reality. My aim in the present chapter is to bridge the opposition between straightforward realism and straightforward constructivism about kinds. I will argue that constructivist aspects typically enter into classificatory practices, without, however, implying that classification is *entirely* a matter of kinds being constructed and thus disqualifying realism. Rather, both the contributions from nature and from us to the making of classifications and kinds should equally be taken into account when it comes to understanding how classification works.

I proceed as follows. In Section 2, I examine and criticize realism about kinds in its currently most popular form and show that it – at least implicitly, but sometimes explicitly, too – suggests a zooming-in model of classification that involves metaphysical assumptions about what the world really is like. In such a model, classification is conceived as essentially consisting in attempts to map kinds onto certain aspects of the world as it exists independently of us. Section 3 illustrates an alternative model of classification and kinds, the co-creation model, on which classification is conceived of as a matter of kinds being co-determined by aspects of the state of affairs in nature as well as by background assumptions and decisions by investigators within particular contexts of investigation. Accordingly, I want to suggest, neither of these two sorts of factors should be privileged in philosophical accounts of classification and kinds. I consider two examples of *kind-making* in the social and the biological sciences to show how a co-creation model fits these better than a zooming-in model. The examples pertain to Hacking's well-known

work on what he called "human kinds", and to the classification of genes into kinds. Section 4 concludes.

2. Realism about kinds and the zooming-in model of classification

A background assumption of the argument in this chapter is that kinds are *made* by us, rather than simply *found* in nature. Classification is more a matter of kind-making than of discovery. In the literature on natural kinds this is not a straightforwardly warranted assumption, although it should not be as controversial as it might seem at first sight, even to traditionally minded realists about natural kinds. Traditional realist views of natural kinds often encompass the claim that natural kinds exist independently of human cognition and classificatory practices, thus suggesting that classification is a matter of discovering such mind-independent kinds. Realists about kinds accordingly often speak of the world's having a mind-independent natural-kind structure, or of kinds existing mind-independently in nature.[1]

But two things should be noted about such views. First, it is not clear how we should conceive of the world's "having" a kind structure, or of kinds as "existing" in nature. Second, even realists about natural kinds typically understand kinds as made by us. Bird and Tobin, for example, formulate realism about natural kinds as follows: "To say that a kind is *natural* is to say that it *corresponds* to a grouping or ordering that does not depend on humans."[2] Thus, there are at least two ways in which realism about natural kinds can be conceived: in a strong sense as a view that locates natural kinds in the world as it exists independently of human perception, or as a weaker view that locates natural kinds within the domain of human practices while presupposing that these kinds connect with certain mind-independent aspects of the natural order.[3] In both of these versions of kind realism classification is a human endeavor: *we* construct groupings in accordance with the natural order of things. The philosophical problem consists in determining the aspects of the natural order to which natural kinds are thought to correspond, or, on the stronger view, that are thought to *constitute* nature kinds.

Even hard-nosed realists about natural kinds, then, do not need to conceive of natural kinds as ontologically basic, that is, as themselves being elements of the furniture of the world as it exists independently of us. Rather, they can – and indeed often do – think of natural kinds as groupings made by us that represent certain features of the world. While often these features are thought to be natural boundaries between groups of entities – as is expressed in the popular slogan that picking out natural kinds has to do with "carving nature at *its* joints"[4] – other sorts of features may be picked out as the representational targets of man-made natural kinds.

At present the most prominent example of a realist approach that does not take natural kinds as basic elements of the furniture of the world is Boyd's Homeostatic Property Cluster Theory (henceforth HPC-Theory).[5] Among philosophers studying the special sciences, HPC-Theory currently is the most popular account of kinds.[6] Boyd starts from the basic claims that "[i]t is a truism that the philosophical

theory of natural kinds is about how classificatory schemes come to contribute to the epistemic reliability of inductive and explanatory practices," and "the theory of natural kinds just is (nothing but) the theory of how accommodation is (sometimes) achieved between our linguistic, classificatory and inferential practices and the causal structure of the world."[7] Boyd thus simply *defines* natural kinds as those kinds that appear in reliable inductive and explanatory practices (and presumably in other epistemic practices too), and proposes that the task of any philosophical theory of natural kinds is to explain the epistemic success of kinds and classifications in terms of the aspects of the natural order that kinds pick out.[8] In this way of defining the problem Boyd follows earlier suggestions by authors such as Goodman, for whom the main problem of kinds and classifications was not a metaphysical question about the structure of the world, but rather what makes certain groupings suitable as inferential bases. As this is more about the conditions for success in human epistemic practices than the ultimate kind-structure of the world, Goodman suggested to speak of "relevant kinds" instead of "natural kinds" and pointed out we should examine a much broader spectrum of kinds than just those kinds that are traditionally recognized as natural kinds or those kinds featuring in scientific contexts.[9] But while Goodman explains successful kind use as a consequence of the *mutual* fine-tuning of kinds and practices of use, in Boyd's view epistemic success of kinds is due to their *one-sided* accommodation to the causal structure of the world (whatever exactly this structure consists in).

An important aspect of HPC-Theory is that the mind-independency of natural kinds to some extent is given up: natural kinds are fundamentally mind-dependent by being defined as those kinds that feature in successful epistemic practices. Still, they retain a mind-independent aspect as they are thought to pick out certain features of the world that underwrite such epistemic practices. A central notion in HPC-Theory is the notion of accommodation, which for Boyd constitutes the connecting element between practices of kind *use* and kind *construction*.[10] For Boyd natural kinds by definition are kinds of entities that are successfully used in inferential and explanatory practices, that is, kinds over which generalized statements can be made that in turn can be used as grounds for explanations. The notion of accommodation refers to a "tuning" of kinds to factors in nature that explain the usefulness of kinds in inferential and explanatory practices: the usefulness of a particular kind as a basis of inferences and explanations is explained by its having been constructed in such a way that it traces factors in nature that play important roles in the phenomena that are to be explained and about which generalizations are to be formulated. In HPC-Theory the factors being traced are causally sustained property co-occurrences.

Accommodation thus constitutes a key aspect of practices of grouping and classification: when grouping entities into kinds it obviously is a good idea to try to fit the kinds that one creates to relevant aspects of the world, such that epistemically useful kinds are obtained. One can of course hope to get epistemically lucky and obtain a successful generalization or prediction by accident, but one surely cannot rely on epistemic luck all the time. Such considerations fuel thinking of classification and kind-making in terms of mapping the classifications and kinds we construct onto

aspects of an assumed mind-independent natural order. In the case of HPC-Theory these aspects are aspects of the *causal* structure of the world, but one might of course also single out other aspects of the world as relevant in this context.

The above is both a prima facie plausible view and one that is deeply entrenched in the history of science. Consider, for example, the following remark by Swiss biologist and first director of the Museum of Comparative Zoology at Harvard University, Louis Agassiz:

> [A] system may be natural, that is, may agree in every respect with the facts of nature, [i.e., be] the expression of a fact existing in nature – no matter how – which the human mind may *trace and reproduce* in a systematic form of its own invention.[11]

The view expressed here is a form of realism about biological kinds. For Agassiz, who was critical of Darwin's ideas and advocated a creationist view of biological diversity, the idea made sense that there are facts of nature that the human mind may trace and represent in the form of classifications. Agassiz assumed a created natural order consisting of natural groups of organisms that our best classifications should aim to track. Even though this assumption of a created natural order is no longer widely held, the ensuing view of practices of classification as consisting in the accommodation to, tracing of, or zooming-in onto certain aspects of the objective structure of the world remains prominent to the present day, as, for example, the popularity of HPC-Theory in the philosophies of the various special sciences shows.

On realist accounts like Boyd's, natural kinds have both an object-sided and a subject-sided element – in the making of kinds a contribution from nature as well as a contribution from us can be distinguished. This view has deep roots in empiricist thinking about kinds and classification. In his *Essay Concerning Human Understanding*, for instance, John Locke already pointed out that while *we* fix the boundaries of kinds, it is *nature* that makes things similar in such ways that there are natural groupings of entities.[12] Locke distinguished between two sides that were relevant to the classification of entities. On the one hand, nature produces entities with real essences that determine the kinds to which they belong. On the other hand, we are the beings that classify entities according to the similarities between things we find in the world. But as Locke held that we cannot get to know nature's side of things, as we are unable to perceive the real essences of natural entities with our limited sensory organs, in the end our classificatory practices are decisive in determining how entities are grouped into kinds.[13] In Locke's terminology, both a "workmanship of nature" and a "workmanship of the understanding" (or "workmanship of men") can be distinguished when examining kinds and classification.[14] While the workmanship of nature, largely inaccessible as it is to us, really determined the kind membership of entities, the grouping of things into kinds principally was the workmanship of men.

The motif seen in Locke's writings on the topic, as well as in the work of later authors to the present day, is that of classificatory practices consisting in attempts

to zoom-in onto relevant aspects of the structure of nature. For Locke, the workmanship of men consisted in trying to zoom-in onto the real essences of things that constituted the – inaccessible – target of our classifications. For present-day traditional kind realists, these targets are the natural kinds in the world, or at least the real joints of nature, onto which the kinds we construct are supposed to map. And for kind realists of a less traditional persuasion, such as HPC-theorists, these aspects can be such things as the causal structure of the world. In Boyd's writings this motif is explicitly present in his "accommodation thesis" – the claim that the theory of natural kinds is about the accommodation of inductive and explanatory practices to the causal structure of the world – but in other contemporary realist accounts of natural kinds, too, this motif at least implicitly plays a guiding role. Accordingly, the presumption is that the philosophically interesting questions pertain to whatever it is in or about the world that we are trying to zoom-in onto, putting aspects of the process of classifying second in line. Even though classifications and kinds are made by us, the thought goes, the proper topic of philosophical concern are the real targets of classification – nature's "joints," causal structure, or whatever – such that the principal aim of any account of natural kinds should be an explication of the nature of these targets.

3. From zooming-in to co-creation

Realism about kinds thus naturally suggests a zooming-in model of classification, involving basic metaphysical assumptions about mind-independent kinds, real essences, nature's "joints," causal structures, or something else in nature that exists mind-independently and constitutes the fixed target of zooming-in efforts. But in virtue of what are such assumptions warranted? The problem is that mind-independent kinds, "joints," structures, and so on aren't straightforwardly given to us in experience such that they actually *could* serve as the fixed targets onto which we could try to zoom-in. Rather, their existence must be postulated, such that not only our classificatory practices but also their targets ultimately come to be of our making. A more appropriate model of classification and kind-making, I suggest, begins by attaching equal explanatory weight to our contribution and nature's. In principle, such a model is compatible with a certain degree of realism about the aspects of nature that kinds latch onto, although it will be a less full-blown realism than traditional kind realists could accept. On such a view classification would be understood as a matter of what I call the *co-creation* of kinds by nature and us.

The co-creation model not only takes the contribution from both sides equally seriously as elements of the philosophical account of kinds and classification, but in addition conceives of them as mutually affecting each other. Recall that in the zooming-in model nature's contribution to classification consists in the mind-independent aspects of nature that we try to zoom-in onto. While in a zooming-in model these aspects of nature influence classificatory practices, as the targets that classificatory practices aim for, there is no influence in the opposite direction. That is, practices of classification and kind-making do not affect

whatever there is on nature's side that classifications represent. This is different in the co-creation model. It can be developed by looking more closely at some actual practices of grouping entities into kinds and constructing classificatory systems (both in scientific and everyday contexts), and thus to some extent shifting attention from the *products* of classificatory practices to the production *processes*. Let me illustrate the co-creation model in more detail with two examples.

3.1. The co-creation of human kinds

Perhaps the clearest example of what I mean by the co-construction of kinds can be found in Ian Hacking's work on what he called "human kinds." In a number of publications Hacking pointed to feedback effects, so-called looping effects, that may occur in the human sciences (sciences that study human behavioral traits, mental disorders, physiological conditions, social groups, etc.) between classificatory practices and the people who are being classified.[15] In such sciences, people are classified into kinds of people on the basis of particular behaviors, mental conditions, temperaments or inclinations, etc.[16] Examples of such kinds include "refugee," "genius," "anorectic," "fugue sufferer," "alcoholic," "hyperactive child," and so on. In the human sciences these feature as "kinds about which we would like to have systematic, general, and accurate knowledge."[17] But people may become aware of how they are classified and consequently may become motivated to change their behaviors such that the classification becomes inadequate, Hacking argued. The underlying reason is that kinds may have particular social connotations: some kinds of behaviors or people might, for instance, be valued very negatively by society, and consequently enter into the political or public discussion, such that a person who is perceived as belonging to a particular kind may have reasons to change the way he or she is perceived.

Consider the kind "prostitute."[18] Social scientists classify people exhibiting a certain sort of behavior into a particular social kind, such as the kind "prostitute," and can then try to find out important characteristics of members of this kind – in this case, for example, prostitutes' motivations to organize their trade in particular ways and their interactions with other social kinds of people. The results of this research will not only be of interest to other scientists, though, but will often be picked up by politicians, aid agencies, the general public, and, not least, by prostitutes themselves. Politicians and aid agencies may use the results as a basis for interventions aimed at controlling prostitution in particular areas of a city or at improving prostitutes' social circumstances and lives. Prostitutes themselves may come to learn about certain negative characteristics that are attributed to them and undertake actions accordingly. In this way research into the characteristics of a particular kind of people may lead to changes in these characteristics (which may be caused by the members of the kind as well as by their environment) in such ways that the achieved scientific knowledge about the kind – knowledge of the type "Prostitutes typically behave in such-and-such a way" – may cease to hold, rendering the kind's scientific value questionable.

Hacking explained this effect as follows:

> People of these kinds can become aware that they are classified as such. They can make tacit or even explicit choices, adapt or adopt ways of living so as to fit or get away from the very classification that may be applied to them. These very choices, adaptations or adoptions have consequences for the very group, for the kind of people that is invoked. [. . .] What was known about people of a kind may become false because people of that kind have changed in virtue of what they believe about themselves.[19]

The basic idea is that in contrast to the entities belonging to traditionally recognized natural kinds, people do not simply belong to a single kind of person for their entire time of existence, but may fall into particular kinds depending on particular behavioral characteristics, attitudes, and so on. As people to some extent can change their behaviors and attitudes, they are able to respond to how they are classified in ways that affect these classifications. Classificatory practices in the human sciences thus often consist in interactions between the produced classifications and kinds on the one hand and the "subject matter" (i.e., people) being classified on the other hand.

A major finding of Hacking's work on human kinds is that the classification of people may change the phenomena that these classifications were supposed to capture – a phenomenon that (according to Hacking, at least) does not occur in the natural sciences. On Hacking's account classificatory practices in the human sciences consist less in the tracking of a stable natural order than in a reiterative matching of kinds and classifications onto phenomena that themselves change in response to this matching. Such matching involves decisions by investigators on how to respond to people's reactions to the way they are classified: if people change their behaviors in response to how they are classified, should the kinds be kept as they were or be amended to better cover these changed behaviors; and if they should be changed, in what way? In this sense classificatory practices in the human sciences indeed seem different from those in the natural sciences: whereas in natural science classifications often can be understood as attempts at an ever better zooming-in onto stable kinds, in the human sciences kinds often are "moving targets" that continuously have to be negotiated anew.[20] While perhaps here, too, the metaphor of zooming-in onto aspects of the natural order may be applied, it should be clear that in the case of human kinds such zooming-in is onto targets that move *due to* our attempts at zooming-in onto them. I would suggest, therefore, that the zooming-in metaphor is inept and such cases are better conceived as cases of the *co-creation* of kinds – that is, kind-making by nature and us in collaboration – than by a one-sided zooming-in onto fixed aspects of nature.

For Hacking, the occurrence of such feedback effects marked a fundamental difference between two sorts of kinds that both may appear in scientific classifications. On the one hand there are natural kinds, or as Hacking later preferred to call them, indifferent kinds, for which no feedback effects occur. On the other hand there are interactive kinds, for which feedback effects do occur. Using the

two models highlighted in the present chapter, these two sorts of kinds may even be thought of as occurring in two different sorts of classificatory practices: on the one hand practices of zooming-in onto stable aspects of the natural world, and on the other hand practices of co-creating in which classifications and the entities being classified mutually affect one another. Classificatory practices of the former sort mainly occur in the natural sciences, while classifications of the latter sort are prominent in the human sciences.

Here I am not concerned with the question of whether Hacking is right in positing a dichotomy between two distinct sorts of kinds, or in thinking of these sorts as standing at the focus of two different domains of science.[21] For my purposes the importance of Hacking's views does not consist in the detailed accounts Hacking provided of the history of individual human kinds or in the general claims about kinds he derived from them, but rather in highlighting the fact that there is more to classificatory practices than is usually assumed in realist approaches to classification and kinds. While these approaches did consider classificatory practices to some extent, they tended to think of them as a one-sided zooming-in onto certain aspects of the world. Hacking's work in contrast highlighted an important aspect of the dynamics of (at least some) classificatory practices that the zooming-in model fails to cover and, I believe, can serve to inspire the development of a more adequate view of how classification and kind-making works.

3.2. The co-creation of gene kinds

An example from the biological sciences can serve to deepen the lesson from Hacking's work. According to Hacking, a central element of looping effects is that (in contrast to inanimate natural entities or nonhuman animals) the people who are being classified can become *aware* of how they are classified, and can act in response.[22] The occurrence of looping effects thus seems constrained to the domain of kinds in which sufficiently conscious beings are the "entities" being classified.

Hacking, however, pointed out that in many cases it is not the people being classified themselves who respond to particular ways of classification, but people in their surroundings, such that the feedback effects do not occur directly between the classifications and the people being classified, but indirectly in the context of a "larger matrix of institutions and practices surrounding the classification."[23] In the case of hyperactive children, for example, it is not the children themselves who respond to being classified as hyperactive, but rather actions of parents, schools, doctors, and so on who may change the children's behavior.[24] Such "larger matrices" of institutions and practices surrounding classifications, however, aren't exclusive to the human sciences. In the natural sciences, too, classifications are embedded in what may be thought of as matrices consisting of various investigative contexts, epistemic aims, institutions, and other elements. Thomas Kuhn introduced the notion of "disciplinary matrix" as referring to "the common possession of the practitioners of a particular discipline" of particular theoretical beliefs, values, methods, and so on.[25] For Kuhn, a disciplinary matrix consisted of elements that were shared between the members of a particular discipline and

commitment to which constituted a prerequisite for successfully carrying out investigations in the discipline in periods of "normal science." Hacking, however, seems to understand the notion of a matrix in a somewhat less strict sense (diverging from Kuhn's sense) as encompassing a variety of aims, beliefs, practices, institutions, and so on that are not necessarily shared or adhered to by *all* members of a discipline. In this sense a matrix simply is the investigative context in which kinds and classifications are constructed and employed, without it necessarily being the matrix shared by the members of a discipline.[26]

Such a view of kinds and classifications being embedded in contexts of use opens up the possibility of more concisely taking the workmanship of men into account when examining kinds and classifications in the natural sciences. The example I want to examine in what follows concerns the classification of genes into kinds.

Gene tokens, that is, segments of an organism's genome that are identified as genes, are both individuated *as genes* (members of the gene kind) and allocated to various kinds of genes on the basis of functions. Entirely non-functional stretches of a genome are not thought of as genes – genes are, as it were, "things you can do with your genome" or "ways in which cells utilize available template resources to create the biomolecules that are needed in a specific place at a specific time."[27] However, not all functions that can be realized by parts of an organism's genome count as individuating genes. Functioning as a template for the production of a particular amino acid molecule such as Phenylalanine or Isoleucine, or functioning as a start or stop signal, for example, does not individuate genes – that is, codons are functional parts of genes and appear as functional elements in genetics and genomics, but codons themselves aren't genes. Typically, the function that is used to individuate genes is playing the part of a template for the production of certain macromolecular products (polypeptide chains or RNA molecules).[28]When individuating genes molecular biologists reason backwards from particular functional macromolecules and identify as genes those continuous or discontinuous parts of the genome of a particular species that feature in the production of these macromolecules in the particular cellular context under study.[29] Genes thus are individuated as what may be thought of as the images on the genome of particular macromolecules for the production of which they function as templates.

Individuating genes by reasoning backwards isn't a straightforward matter, though, as, for example, the mismatch between the sizes of the human proteome and genome shows.[30] Because of various processes that can occur as parts of DNA transcription and translation, such as alternative splicing, frameshifting, or RNA editing, there usually is no unique mapping of macromolecular products onto particular stretches of DNA: a particular segment of an organism's genome may be involved in the production of multiple expression products and a particular expression product may involve several separate stretches of DNA.[31] In addition, the same stretch of DNA can count as a gene in some contexts and not count as a gene in other contexts. For example, a non-functional homolog in the genome of a particular species of a functional sequence in the genome of another species does not count as a gene because of its non-functionality, notwithstanding the structural

similarities between the homologous sequences. Such non-functional homologs, called pseudogenes, are "defunct genomic loci with sequence similarity to functional genes but lacking coding potential."[32]

Moreover, genes are not individuated and classified on the basis of functions alone. Other factors, such as DNA structure, copying lineage, and genome locus, play important roles in gene individuation and classification, too. Bare structure (i.e., the sequence of bases in a stretch of DNA) often serves to recognize genes in practice, but does not serve as a primary basis for individuating and classifying a particular stretch of DNA as a gene of a particular kind.[33] Elsewhere I have argued that gene kinds are often defined by means of a function that is played by members of the same copying lineage in cellular processes of the same taxon.[34] That is, when individuating gene tokens and allocating them to kinds, biologists often use as a basis the particular function that tokens of the same kind are thought to play within the cellular context of organisms of a particular taxon (reasoning backwards from macromolecular expression products, as explicated earlier), mapping this function onto tokens that stand in the same copying lineage and occupy the same locus in that taxon's genome.

Within this set of criteria picking out a function constitutes the basis for identifying segments of an organism's genome as genes in the first place: a prerequisite for being a gene is serving as a template for the production of a particular kind of macromolecule. Locating this function within the cellular context of a particular taxon (i.e., allocating it to a particular locus in the genome of a particular taxon) in turn serves to anchor the function within the particular material system under investigation. The investigative context in relation to which a particular gene is individuated and classified is the investigation of genome expression in *this* particular species (or genus, family, etc.): investigative contexts can be, for example, the expression of the gene *diaphanous* in organisms of the species *Drosophila melanogaster* under particular conditions, or the expression of the gene *DFNA1* in organisms of the species *Homo sapiens* under particular conditions. Although *diaphanous* in *D. melanogaster* and *DFNA1* in humans are homologous genes and thus could be thought of as being the same overarching gene kind (indeed *DFNA1* is sometimes called the human *diaphanous* gene), in most investigative contexts it makes sense to consider these to be different kinds of genes, as they occupy different loci in distinct genomes.[35] One is the kind "*Drosophila diaphanous* gene," the other the kind "human *diaphanous* gene." Investigators are interested in how a stretch of DNA at a particular locus in the genome of a particular taxon is expressed under certain conditions – that the stretches of DNA that occupy two loci in the genomes of different taxa are related by descent constitutes important background knowledge, but does not entail that the two kinds should be conflated into a single, undifferentiated kind of gene (*diaphanous*) that happens to be widespread throughout a large part of the living world. Keeping these gene kinds apart allows investigators to distinguish between similar phenomena and similar causal factors in different material systems.

To give another example, tokens of the *lacY* gene occurring in organisms of the two bacterial species *Escherichia coli* and *Klebsiella pneumoniae* are not

usually considered to be tokens of exactly the same, undifferentiated gene kind, but rather tokens of two orthologous kinds (i.e., distinct subkinds of the kind *lacY* that are related by descent). In their history the two lineages accumulated different mutations that make the sequences of *lacY* in *E. coli* and *lacY* in *K. pneumoniae* slightly different.[36] Both gene kinds are denoted by the same name, "*lacY*," but biologists distinguish them by specifying which bacterial species is under consideration. (This is not always done explicitly, though. While in research articles authors usually simply use "*lacY*," the context specified in the article clarifies which taxon was under investigation.) A token of *lacY* in an *E. coli* bacterium and a token of *lacY* in a *K. pneumoniae* bacterium thus are not tokens of the same basic kind of gene, but of distinct, homologous kinds that may be seen as subkinds of one overarching kind.

Allocating functions to tokens in the same copying lineage, lastly, allows investigators to trace connections between functions and structurally similar tokens at different loci in the same genome or in different genomes. For example, in cases of gene duplication (paralogy) the genome of a particular species contains multiple copies of the same copying lineage. These copies occupy distinct loci in the same genome and may perform different functions, or one copy may not be functional at all. Thus, besides the function played by a particular stretch of DNA both its actual locus in the genome and its lineage of descent are relevant for determining the kind of gene to which it belongs. Combining these three factors allows investigators to distinguish kinds of genes against the complex background of shared ancestry, same locus in the genome, structural similarity and functional similarity. Depending on the context of investigation, emphasis may be placed on one of these factors, and investigators have considerable freedom to shift between groupings.

Still, gene kinds do have *some* basis in nature. While the various ways in which gene tokens are allocated to kinds depend on investigative contexts and thus are fundamentally mind-dependent, there still are *some* natural boundaries within the confines of which gene kinds are delimited. The upshot is that the natural boundaries of gene kinds, whatever exactly they may consist in, do not *completely* determine the kinds, such that one cannot say that when classifying genes into kinds biologists are simply trying to zoom-in onto these boundaries. As the natural basis of gene classification does not suffice to give us gene kinds, in addition to taking aspects of an assumed natural order into account investigators have to *impose* divisions that make sense only within their particular context of investigation. Background assumptions and decisions by investigators with respect to such questions as which functions should be counted as individuating genes, at which level of the Linnaean hierarchy a gene kind is to be located (is it species-specific, genus-specific, etc.?), and so on play an important role in the creation of gene kinds. However, once divisions are imposed, they in turn affect investigative practices by enabling (or disabling) the making of generalizations about kinds, the individuation of aberrant instances of a kind, the posing of novel research questions and kinds, and so on. I would suggest that here, too, the zooming-in model of classification is inappropriate and classificatory practices should be understood as encompassing the co-creation of kinds by nature and us.[37]

4. Conclusion

Philosophical research on the topics of classification and kinds typically focuses on the question what exactly classifications try to zoom-in onto – mind-independent kinds, objectively existing property clusters, natural divisions, or something else. Against this model of classification I have argued that often there is more to processes of kind-making than merely zooming-in onto aspects of an assumed fixed natural order. The two examples of classification in the human sciences and gene classification served to show that classificatory practices are less one-sided than the zooming-in model assumes. At least for some cases of classification the zooming-in model should be replaced by a more flexible co-creation model, in which both nature and we – as those who do the classifying – fundamentally contribute to the creation of kinds. This co-creation model takes the Lockean intuition seriously that important factors in the making of kinds are found in two domains, the domain of nature and the domain of human investigative practices. To this intuition it adds the element of a mutual influence between the two domains.

The co-creation model highlights that a crucial part of classificatory practices consists in local decisions of investigators in particular contexts of research regarding how the targets of classification are to be set up. Examples include decisions on which similarities are to be counted as relevant in a particular context of investigation, how to decompose systems under study into their constituent parts, how to analyze phenomena in mechanistic terms, how to individuate the entities that perform a particular function in the phenomena under examination, and so on. Such decisions are guided by the theoretical frameworks within which investigators work as well as by practical considerations. Conversely, the products of classificatory practices can affect the theoretical frameworks that are in place as well as future practical considerations. Taking scientific practice seriously should involve taking these aspects of classificatory practices into account when investigating the nature of kinds and classification.

Notes

1 See, for example: Psillos, S. (1999) *Scientific Realism: How Science Tracks Truth*. New York: Routledge, p. xix; Ellis, B. (2002) *The Philosophy of Nature: A Guide to the New Essentialism*. Montreal and Kingston: McGill-Queen's University Press, p. 26; Ellis, B. (2008) 'Essentialism and Natural Kinds', In: Psillos, S. and Curd, M. (eds.) *The Routledge Companion to Philosophy of Science*. London and New York: Routledge, pp. 139–148, p. 139; Franklin-Hall, L.R. (2015) 'Natural Kinds as Categorical Bottlenecks', Philosophical Studies, 172, pp. 925–948, p. 2.

2 Emphasis added. Bird, A. and Tobin, E. (2012) 'Natural Kinds', In: Zalta, E. (ed.) *The Stanford Encyclopedia of Philosophy* (Winter 2012 edition), at: http://plato.stanford.edu/archives/win2012/entries/natural-kinds/, introductory paragraph.

3 See also: Bird, A. (2009) 'Essences and Natural Kinds', In: Le Poidevin, R., Simons, P., McGonigal, A. and Cameron, R.P. (eds.) *The Routledge Companion to Metaphysics*. London & New York: Routledge, pp. 497–506, p. 503.

4 Note that the point of the slogan, which is a loose paraphrase from remarks in Plato's *Phaedrus* and *Statesman*, is that nature has objective joints or divisions that we are supposed to follow when dividing her up into her constituent entities.

5 Boyd, R. N. (1991) 'Realism, Anti-foundationalism and the Enthusiasm for Natural Kinds', *Philosophical Studies*, 61, 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. 141–185; 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.

6 Although HPC-Theory is popular among philosophers of science, I think it is a deeply problematic account of natural kinds. For criticisms, see: Reydon, T.A.C. (2009b) 'How to Fix Kind Membership: A Problem for HPC Theory and a Solution', *Philosophy of Science*, 76, pp. 724–736; 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.

7 Boyd, R.N., 'Homeostasis, Species, and Higher Taxa', p. 146; Boyd, R.N., 'Kinds as the "Workmanship of Men": Realism, Constructivism, and Natural Kinds', pp. 55–56, 66.

8 While I agree that natural kinds are those kinds that feature in reliable epistemic practices, most importantly those of inference and explanation, I don't think this is a truism.

9 Goodman, N. (1975) 'Words, Works, Worlds', *Erkenntnis*, 9, pp. 57–73, p. 63; Goodman, N. (1978) *Ways of Worldmaking*. Hassocks: The Harvester Press, p. 10. In a similar vein, Brigandt recently suggested to speak of 'investigative kinds' – see: Brigandt, I. (2003) 'Species Pluralism Does Not Imply Species Eliminativism', *Philosophy of Science*, 70, pp. 1305–1316.

10 Boyd speaks of an "accommodation thesis"; e.g., Boyd, R.N., 'Kinds as the "Workmanship of Men": Realism, Constructivism, and Natural Kinds', pp. 55ff.; Boyd, R.N., 'Homeostasis, Species, and Higher Taxa', pp. 146ff.; Boyd, R.N., 'Realism, Anti-foundationalism and the Enthusiasm for Natural Kinds', p. 139.

11 Agassiz, L. (1859/2004) *Essay on Classification*. (Ed. E. Lurie) Mineola, NY: Dover Publications, pp. 8–9, footnote 7. Emphasis added.

12 Locke, J. (1690/1975) An Essay Concerning Human Understanding (Ed. P.H. Nidditch). Oxford: Clarendon Press, Book III, Chapter III, §13. In his papers on HPC-Theory, Boyd explicitly refers to Locke.

13 Locke, J. *Essay*, Book II, Chapter XXIII, §12; Book III, Chapter VI, §9.

14 Locke speaks of the "workmanship of the understanding", the "workmanship of the mind", and the "workmanship of men", contrasting these terms with the "workmanship of nature". See for example: Locke, J. *Essay*, Book III, Chapter III, §§12–14; Chapter V, §6 & §8; Chapter VI, §26 & §37.

15 For example: Hacking, I. (1992b) 'World Making by Kind Making: Child-Abuse for Example,' In: Douglas, M. and Hull, D. (eds.) *How Classification Works: Nelson Goodman among the Social Sciences*. Edinburgh: Edinburgh University Press, pp. 180–238; Hacking, I. (1995) 'The Looping Effects of Human Kinds', In: Sperber, D., Premack, D. and Premack, A.J. (eds.) *Causal Cognition: A Multidisciplinary Debate*. Oxford: Clarendon Press, pp. 351–383; Hacking, I. (1999) *The Social Construction of What?* Cambridge, MA: Harvard University Press; Hacking, I. (2007a) 'Kinds of People: Moving Targets', *Proceedings of the British Academy*, 151, pp. 285–318.

16 Hacking, I., 'World-Making by Kind-Making: Child Abuse for Example', p. 183; Hacking, I., 'The Looping Effects of Human Kinds', pp. 351–352.

17 Hacking, I., 'The Looping Effects of Human Kinds', p. 352. Hacking continues on the same page by saying that in the case of human kinds we are dealing with "classifications that could be used to formulate general truths about people; generalizations sufficiently strong that they seem like laws about people, their actions, or their sentiments." Human kinds thus are intended to perform the same epistemic role as natural kinds.

18 Hacking, I., 'Kinds of People: Moving Targets', p. 292.

19 Hacking, I., *The Social Construction of What?* p. 34.

20 Hacking, I., 'Kinds of People: Moving Targets'.
21 For criticisms of Hacking's views on this difference between the natural and the human sciences, see for example: Cooper, R. (2004) 'Why Hacking Is Wrong About Human Kinds', *British Journal for the Philosophy of Science*, 55, pp. 73–85; Khalidi, M. A. (2010) 'Interactive Kinds', *British Journal for the Philosophy of Science*, 61, pp. 335–360; Khalidi, M. A. (2013) *Natural Categories and Human Kinds: Classification in the Natural and Social Sciences*. Cambridge: Cambridge University Press, pp. 147ff.
22 See, e.g., Hacking, I., *The Social Construction of What?* pp. 31–32, 103–109.
23 Hacking, I., *The Social Construction of What?* p. 103.
24 Hacking, I., *The Social Construction of What?* pp. 102–103.
25 Kuhn, T. (1970) *The Structure of Scientific Revolutions*. (2nd edition) Chicago: University of Chicago Press, p. 182; see also: Bird, A. (2013) 'Thomas Kuhn', In: Zalta, E. N. (ed.) *The Stanford Encyclopedia of Philosophy* (Fall 2013 edition) at: http://plato.stanford.edu/archives/fall2013/entries/thomas-kuhn/, sec. 2–3.
26 This seems to be what Hacking had in mind when talking about the "larger matrix" surrounding a classification. Boyd, too, uses the notion of disciplinary matrices in such a broader sense to refer to the various contexts in which classifications and kinds are used in the sciences, as "the situations of inferential practice with respect to which accommodation is accomplished" (Boyd, R. N., 'Homeostasis, Species, and Higher Taxa', p. 148). While for Boyd a disciplinary matrix sets the context in which accommodation takes place between classification and inference on the one hand and the causal structure of the world on the other hand, there is no reason why such a matrix should be adhered to by an entire disciplinary community (other than that one might define a discipline by a unique disciplinary matrix). Kinds and classifications for Boyd are relative to disciplinary matrices: a kind that is successfully used in one such matrix may well be useless in another matrix. See: Boyd, R. N., 'Homeostasis, Species, and Higher Taxa', pp. 148ff; Boyd, R. N., 'Kinds as the "Workmanship of Men": Realism, Constructivism, and Natural Kinds', pp. 57ff.
27 Griffiths, P. E. and Stotz, K. (2006) 'Genes in the Postgenomic Era', *Theoretical Medicine and Bioethics*, 27, pp. 499–521; Griffiths, P. E. and Stotz, K. (2013) *Genetics and Philosophy: An Introduction*. Cambridge: Cambridge University Press, p. 75.
28 See, e.g., Portin, P. (1993) 'The Concept of the Gene: Short History and Present Status', *Quarterly Review of Biology*, 68, pp. 173–223. For an overview, see Griffiths. P. E. and Stotz, K. *Genetics and Philosophy: An Introduction*, chp. 4.
29 Gerstein, M. B., et al. (2007) 'What Is a Gene, Post-ENCODE? History and Updated Definition', *Genome Research*, 17, pp. 669–681; Griffiths, P. E. and Stotz, K. (2007) 'Gene', In: Hull, D. L. and Ruse, M. (eds.) *The Cambridge Companion to the Philosophy of Biology*. Cambridge: Cambridge University Press, pp. 85–102, p. 100; Griffiths, P. E. and Stotz, K., *Genetics and Philosophy: An Introduction*, p. 75.
30 Harrison, P. M., et al. (2002) 'A Question of Size: The eukaryotic proteome and the problems in defining it', *Nucleic Acids Research*, 30, pp. 1083–1090.
31 See: Waters, C. K. (1994) 'Genes Made Molecular', *Philosophy of Science*, 61, pp. 163–185; Wieben, E. D. (2003) 'Primer on Medical Genomics, Part VII: The Evolving Concept of the Gene', *Mayo Clinic Proceedings*, 78, pp. 580–587; Gerstein, M. B., et al., 'What Is a Gene, Post-ENCODE? History and Updated Definition'; Griffiths, P. E. and Stotz, K., 'Genes in the Postgenomic Era'; Griffiths, P. E. and Stotz, K., 'Gene'; Griffiths, P. E. and Stotz, K., *Genetics and Philosophy: An Introduction*, pp. 71–75, 84–97; Reydon, T. A. C. (2009a) 'Gene Names as Proper Names of Individuals: An Assessment', *British Journal for the Philosophy of Science*, 60, pp. 409–432.
32 Pei, B., et al. (2012) 'The GENCODE Pseudogene Resource', *Genome Biology*, 13, R51, p. 1. It is increasingly becoming clear that pseudogenes may have some functionality, though, albeit usually not the kind of functionality that would classify a pseudogene as a member of the gene category. See: Gerstein, M. B., et al., 'What Is a Gene, Post-ENCODE? History and Updated Definition'; Pei, B., et al., 'The GENCODE Pseudogene Resource'.
33 Base sequence thus is a *diagnostic* criterion, not a criterion that defines a gene kind.
34 Reydon, T. A. C., 'Gene Names as Proper Names of Individuals: An Assessment'.
35 Reydon, T. A. C., 'Gene Names as Proper Names of Individuals: An Assessment', pp. 421–422.
36 Brooker, R. T. (2005) *Genetics: Analysis and Principles*. (2nd edition) Boston, MA: McGraw-Hill, p. 594. This example is also discussed in Reydon, T. A. C., 'Gene Names as Proper Names of Individuals: An Assessment', p. 422.
37 The role of decisions made by investigators also becomes clear from examinations of practices of kind construction in bio-ontologies. E.g.: Leonelli, S. (2012) 'Classificatory Theory in Data-Intensive Science: The Case of Open Biomedical Ontologies', *International Studies in the Philosophy of Science*, 26, pp. 47–65; Leonelli, S. (2013) 'Classificatory Theory in Biology', *Biological Theory*, 7, pp. 338–345. However, as bio-ontologies are intended as storage-and-retrieval systems rather than as systems encompassing natural kinds, it seems that the case of bio-ontologies is different from the examples discussed in the main text. Therefore, I do not want to explore the case of bio-ontologies in more detail here.

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To my loving parents, G. Suzanne and Thomas C. Kendig