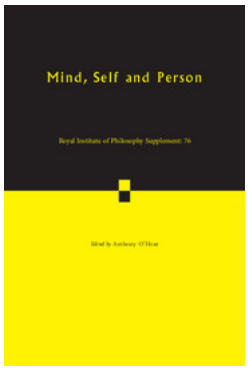

Natural Kinds: Rosy Dawn, Scholastic Twilight

Ian Hacking

Royal Institute of Philosophy Supplement / Volume 61 / October 2007, pp 203 - 239
DOI: 10.1017/S1358246107000203, Published online: 01 November 2007

Natural Kinds: Rosy Dawn, Scholastic Twilight

IAN HACKING

The rosy dawn of my title refers to that optimistic time when the logical concept of a natural kind originated in Victorian England. The scholastic twilight refers to the present state of affairs. I devote more space to dawn than twilight, because one basic problem was there from the start, and by now those origins have been forgotten. Philosophers have learned many things about classification from the tradition of natural kinds. But now it is in disarray and is unlikely to be put back together again. My argument is less founded on objections to the numerous theories now in circulation, than on the sheer proliferation of incompatible views. There no longer exists what Bertrand Russell called 'the doctrine of natural kinds'—one doctrine. Instead we have a slew of distinct analyses directed at unrelated projects.

First thesis:

Some classifications are more natural than others, but *there is no such thing as a natural kind*.

That, in the smallest number of words, is exactly what I mean. Rigour demands more words. In the language of classes, there is no well-defined or definable class whose members are all and only natural kinds. Likewise there is no fuzzy, vague, or only loosely specified class that is useful for any established philosophical or scientific purpose, and which is worth calling the class of natural kinds.

Nelson Goodman was right. If the word 'kind' is to be used as a free-standing noun with a grammar analogous to 'set'—a practice introduced by William Whewell in 1840—there are only relevant kinds.

> I say 'relevant' rather than 'natural' for two reasons: first, 'natural' is an inapt term to cover not only biological species but such artificial kinds as musical works, psychological experiments, and types of machinery; and second, 'natural' suggests some

> absolute categorical or psychological priority, while the kinds in question are rather habitual or traditional or devised for a new purpose.[1]

Goodman wanted philosophers to realize that many questions posed in the context of natural kinds—induction for example—arise equally for other kinds of things, such as machinery or musical works. In consequence he may have overstated the case, and be taken to imply that there is no point in distinguishing some kinds, in a variety of contexts, as natural.

Obviously, what makes a class relevant to a person or a community may be facts about nature in the wild, on the farm, in the stars, in the lab, in the human psyche, or in the nucleus of an atom. Goodman asserts only that we cannot proceed in a general way, beyond the fact that some kinds are relevant for this or that purpose. Some kinds are relevant because of their role in systematic biology. Among the questions that arise: are our classifications natural in the sense that they represent morphology and function, or in the sense that they capture evolutionary history? Some kinds are relevant because of their role in experimental and theoretical physics. Philosophers tend to single out as natural those that are profound, or fundamental, or, in Quine's word, cosmic. Polymer science, cognitive psychology, and silviculture all have their kinds which are relevant to the varied interests of current research and application. Meteorologists, seamen and peasants distinguish cirrus from altostratus from cumulonimbus, kinds of clouds found in nature and even today very useful for predicting the weather. Natural kinds of clouds, we might say, as opposed to those found in a cloud chamber for studying cosmic rays—and yet the cloud chamber was developed for studying—clouds.

Certain artificial crystals are superconducting at (relatively) high temperatures. No one understands why. In one sense these crystals are not a natural kind: they are made in the laboratory. In another sense they are a natural kind, precisely because of this fascinating and probably useful property of being superconducting. They are subject to very intense scientific research right now (a criterion sometimes used to distinguish natural kinds). A more pedestrian example in the same vein is Kevlar®: a kind of material substance so artificial that DuPont holds the patent. It is relevant to policemen and canoeists because if is light and very sturdy,

[1] N. Goodman, *Ways of Worldmaking* (Indianapolis: Hackett, 1978), 10.

resisting both bullets and jagged rocks in the white water. It is also relevant to materials science where its properties are still under investigation using tools such as the atomic force microscope for examining the unique structure of its surface.

Goodman's expression, 'habitual or traditional or devised for a purpose' does not do justice to the variety of kinds of relevance to students of nature, but his instinct was right. There is no such thing as the class of natural kinds. This first thesis may be the other side of the coin on which John Dupré inscribes his pluralism, which he formerly called promiscuity.[2] He urges that even in the case of the life sciences there are some and maybe numerous cross-cutting classifications that yield classes worth calling natural kinds. Morphological kinds and evolutionary kinds, to take two examples just mentioned. My argument is that there are so many radically incompatible theories of natural kinds now in circulation that the concept itself has self-destructed. The reverse side of the coin, Dupré's, may be less disconcerting than my obverse. If so, I urge the reader to accept Dupré, and then turn the coin over, and acknowledge that the concept of a natural kind, which began in a promising way and has taught us many things, is now obsolete.

Humpty Dumpty

Stipulative definitions are always open for those who wish to wax rhetorical. Humpty Dumpty can call any class he fancies the class of natural kinds. I, for instance, am at present very keen on bosons and fermions. I am wont to say, not entirely falsely, that everything is either a boson or a fermion, or a species of one or the other. I can express my high regard with an even greater flourish, saying that there are exactly two natural kinds in the universe, *boson* and *fermion*, and, derivatively, their species. Now *that* is a well-defined class! (Yes, physicists do speak of species. Fermions tend to be light, such as electrons, but in this context, an experimenter who speaks of species is likely referring to atoms or ions of an isotope.

[2] J. Dupré, *The Disorder of Things: Metaphysical Foundations of the Disunity of Science* (Cambridge, Mass.: Harvard University Press, 1993). 'In Defence of Classification' *Studies in the History and Philosophy of the Biological and Biomedical Sciences* **32** (2001), 203–219; reprinted in *Humans and Other Animals* (Oxford: Clarendon, 2002), 81–99. 'Is "Natural Kind" a Natural Kind?', *The Monist* **85** (2002), 29–49, reprinted in *ibid.*, 103–123.

Every element except Beryllium has isotopes that are bosons. Every element has isotopes that are fermions. So the unexpected talk of species suits: Rubidium 47 is a species of boson.) I have, however, added nothing to our understanding of *anything*, by calling this class of fundamental kinds of entities the class of natural kinds.

Notice that I have not used a wholly arbitrary class as my example. There are good reasons to say that bosons, fermions and their species are curiously fundamental to the universe as (for the moment) we know it.

Philosophical research programmes connected with natural kinds have brought many logical truths to light. They have fallen on hard times. They have split into sects, to the extent that paradigm natural kinds for one set are not natural kinds at all for another. The doctrine of natural kinds is in such disarray that it does tend to humptyism. Advocates will refer to the class of classifications they most admire, as the class of natural kinds. The class is often of great interest. Yet the chief reason for calling it the class of natural kinds is that that sounds good. It confers a rhetorical pedigree on the class. When natural kinds become redefined as some special-interest class, one is tempted to invoke Imre Lakatos's phrase, and speak of a degenerating research programme.

Second thesis:

Many philosophical research programmes have evolved around an idea about natural kinds, but *the seeds of their failure (or degeneration) were built in from the start*.

There are standard examples of natural kinds. Familiar ones from the 1970s include: tigers, lemons, water, gold, multiple sclerosis, atoms, heat and the colour yellow. Each of these classifications, with the possible exception of multiple sclerosis (which might turn out to be several quite distinct diseases), will have a useful role for the foreseeable future. But there is neither a well-defined class, nor any useful vague class, that collects together these heterogeneous examples in the ways that philosophers have hoped for.

Look no further than the paradigms just cited, and wonder, how could there be a class that fruitfully collects together such a wonderful array of interesting kinds of ...—kinds of what, anyway? *Tiger* names a kind of animal, *lemon* a kind of fruit, and also, in a related sense, a kind of tree. *Gold* names an element, and in another sense a metal, a substance that comes in lumps, dust and flakes.

Beyond the animals, vegetables, and minerals, the standard examples do not seem to be kinds of anything. Of what is heat a kind? The sheer heterogeneity of the paradigms for natural kinds invites scepticism. The question should be: why would philosophers ever have imagined that there is one definite, human-independent, class of natural kinds? There have been good reasons, as we shall see, but it is not a concept to be taken for granted.

A handy tag

My first thesis does not imply that the expression 'natural kind' is useless. It may even be crossing from technical philosophy to more common usage. In May 2001 I read in a *New Yorker* book review that: 'Unlike, for instance, a high school, a decade is not what philosophers call a "natural kind": life does not carve itself up spontaneously into ten-year segments.'[3] No philosopher of science has ever called *high school* a natural kind, but it is perfectly clear what the author, Louis Menand, meant. He was reviewing two books about the Seventies. Our fixation on decades or centuries is conventional. It can be a cheerful or ironical way to identify our generation, our friends, and our times. Or other generations, other times. 'The seventies' is nevertheless an artefact of our decennial dating system. The high school, on the other hand, is a cardinal institution in American life, and for many it marks the time when one grows up, a very natural kind, which has become one of the seven ages of middle-class American men and women.

For another example, in a more philosophical vein, we can go back to Richard Rorty.[4] In an ironic critique of Bernard Williams's position that science and morality are fundamentally different in character, he challenged the thought that natural science is a natural kind. He meant that there is a sort of continuum between moral and scientific reasoning. Both Menand and Rorty made good use of the phrase 'natural kind'. Neither implied that there is a distinct class of natural kinds, only that in this or that context, some kinds are more—or less—deeply rooted than others.

[3] L. Menand [book review], *The New Yorker,* 28th May 2001, 128.

[4] R. Rorty, 'Is Natural Science a Natural kind?', in E. McMullen (ed.), *Construction and Constraint: The Shaping of Scientific Rationality* (Notre Dame, Ind.: Notre Dame University Press, 1988), 49–74. Reprinted in Rorty, *Objectivity, Relativism, and Truth* (Cambridge: Cambridge University Press 1991), 46–62.

Finally, in a spirit of what sounds like post-modern reflexivity, John Dupré asks, 'Is "natural kind" a natural kind?'[5] Merely modern persons like me will answer no-or-meaningless, because we tend to practice, even if we do not affirm, the theory of types. For the nonce, let us follow Quine's famous paper and regard natural kinds as sets: 'Kinds can be seen as sets, determined by their members. It is just that not all sets are kinds.'[6] If so, Dupré's question violates any informal theory of types: 'natural kind' cannot apply to itself. That is not to say his discussion fails to cohere. One of his minor conclusions comes to this: if an essentialist wishes to extend his essentialism to second-order talk of natural kinds, then he will answer: 'Yes, the class of natural kinds is a natural kind.' Pluralists will answer: 'No, but nevertheless there are a number of ways in which our interests in natural phenomena lead us to single out some systems of classification as peculiarly natural.'

Perhaps these usages point the way for a modest future role for the expression 'natural kind'. It will no longer be used as an absolute classification that divides sets and their ilk into those that are natural kinds and those that are not. It will no longer have anything special to do with 'Nature', that wondrous world independent of the human mind. It will be used for those classifications that in context strike us as natural, as opposed to those that strike us as conventional. A future *OED* could use my quotation from *The New Yorker* for one of its examples.

William James: seven-league boots

I have nothing against classification. I love the richness of the different kinds of things there are in the world and of the innumerable ways in which they can be grouped together. Fools and poets may see this best, as chanted in Nietzsche's wild paean, *Only a fool! Only a poet*! in praise of, among other things, the fierceness

[5] 'Is "Natural Kind" a Natural Kind?', *op. cit.* note 2.

[6] W.V.O. Quine, 'Natural Kinds', *Ontological Relativity and Other Essays* (New York: Columbia University Press, 1969), 114–138, on 118. Note that after the first few pages, Quine drops the adjective 'natural' and writes of kind and kinds. One could propose this as the truly pragmatist way of speaking, a return to William James, as discussed in the next section.

of variety.[7] It can be read as an apocalyptic version of the gentle wisdom of Hopkins's equally philosophical *Pied Beauty*. Protestant children still sing, 'All things bright and beautiful, / All creatures great and small', another hymn to variety that is not be despised. But best of all, for we more prosaic thinkers, is the good old Yankee common sense of William James:

> Kinds, and sameness of kind—what colossally useful *denkmittel* for finding our way among the many! The manyness might conceivably have been absolute. Experiences might have all been singulars, no one of them occurring twice. In such a world logic would have had no application; for kind and sameness of kind are logic's only instruments. Once we know that whatever is of a kind is also of that kind's kind, we can travel through the universe as if with seven-league boots.[8]

James spoke of kinds, not natural kinds. It is the idea of a well-defined class of natural kinds that has self-destructed, not kinds and sameness of kind.

Dawn

Natural History: species become absolute

The doctrine of natural kinds grew out of the problem of natural groups. That had two origins, travel, and an intellectual innovation. Exploration brought to European shores ever so many new kinds of plants, animals and rocks. To quote James from another context, 'a blooming, buzzing confusion'. The sheer proliferation of fauna and flora and minerals created a demand for classificatory systems.

[7] *Nur Narr! Nur Dichter!* in F. Nietzsche, *Dithyrambs of Dionysus*, bilingual edition, translated by R. J. Hollingdale from *Dionysos-Dithyramben* (1891), (London: Anvil Press, 1981, 22–27). Hollingdale translates *bunt* as gaudily or gaudy, as in *ein Tier, ein listiges, raubendes, schleichendes, / das lügen mu*β*, / das wissentlich lügen mu*β*, / nach Beute lüstern, / bunt verlarvt*—'lusting for prey, gaudily masked'. Or *Nur buntes redend*—Talking only gaudy nonsense. I do not wish to argue with such a masterly translator, but would add that *bunt* above all is associated with varied bright colours, our bunting on festive sailboats. Joseph's cloak of many colours is *bunt*. It is the *bright variety* that I take from Nietzsche's *bunt* more than the gaudiness.

[8] W. James, Pragmatism: A New Name for Some Old Ways of Thinking (New York: Longmans Green 1907), 179.

More radical historians of systems of thought propose that a felt need to represent the order of things happened to precede the sudden influx. Be that as it may, the intellectual innovation is what matters to us.

In all scholastic classification, going back to Aristotle and beyond, genera and species were relative terms. Porphyry's *Introduction* to Aristotle's *Categories* explained for generations upon generations of schoolchildren that *animal* was a species of *living thing*, but a genus of *rational animal*. *Eidos* and *genos* have a far wider application in Aristotle than logic, but I accept Pierre Pellegrin's definitive analysis according to which Aristotle's biology did not aim at a hierarchy of ranks, or a taxonomy.[9] It was only in the time of Linnaeus that species and genera were made part of an absolute hierarchy. Species fell below genera, and no species could be a genus of something else. The hierarchical structure became irreversible, and with it, higher ranks: families, orders, and classes.

That is when a series of problems arose. Imagine the naturalist sorting specimens into groups, to be called species. There arises a first, descriptive, question: does this sorting represent the way the individuals resemble each other, or does an alternative represent nature better?

Resemblance requires a further term, resemblance in what respect? Many great debates reduce to that. Morphology and function of organs were major candidates for the basic ways in which living things should be classified. Linnaeus's brilliant decision is with us still: we start classifying using resemblance in sexual organs as the key.

The natural historian arranges the groups called species into higher groups, called genera. After that, a whole hierarchy is created, genera grouped into families, families into classes, classes into orders and so on. There arises a second, more ontological, question: are such structures mere conveniences, mnemonics so that naturalists can remember what goes where in the ever expanding tables of representation of an ever expanding collection

[9] P. Pellegrin, *Aristotle's Classification of Animals: Biology and the Conceptual Classification of the Aristotelian Corpus*, translated from the French of 1982 by A. Preuss (Berkeley and Los Angeles: University of California Press, 1986). A subtle exposition of the earlier view, that Aristotle was groping for a taxonomy, is found in G. E. R. Lloyd, 'The Development of Aristotle's Theory of the Classification of Animals', *Phronesis* **6** (1961), 59–80.

of specimens? Or is there a right arrangement, which shows how nature truly is? Are genera real? Buffon wrote in 1749, that nature

> knows none of these pretended families, and contains in fact nothing but individuals.[10]

Linnaeus, in 1751:

> Revelation, observation and thought confirm that all genera and species are natural. All genera are natural, and have been such since the beginning of time.[11]

Readers today note the assumed (and wrong) eternal fixedness of species, but in mid-eighteenth century, the debate was whether the arrangement of individuals into species and genera and families told the truth about nature. Michel Adanson, in 1763:

> I do not know how any botanist can maintain such a thesis: it is certain that until now no one has been able to prove it, or to give a definition of a natural genus, but only of an artificial one.[12]

There you have it. Which groups are natural, which artificial? When naturalists spoke of artificial classes, they did not have in mind the wholly arbitrary classes often mentioned by modern philosophers, to contrast with natural kinds. 'Natural kinds are standardly distinguished from arbitrary groups of objects, such as what you had for breakfast.'[13] Classes were artificial rather than natural, when they had been invented by botanists, but did not accurately represent the order of living things.

Even a smattering of history informs us that ever so many questions were in play. Linnaeus ruthlessly decided that what matters is sex, and used methods of reproduction as the basic tool both for sorting specimens into species, and for sorting species into genera. Adanson said the choice of sex was artificial, and proposed 65 different characters in terms of which plants could resemble each other. The more the characters, by which individuals closely

[10] G.-L. L. Buffon, Histoire naturelle générale et particulière, avec la description du cabinet du roi, Vol. IV, Histoire générale des animaux (Paris: Imprimerie Royale, 1753), 355b.

[11] C. Linnaeus, *Philosophia Botanica* (Stockholm: G. Kiesewetter, 1751), 100.

[12] M. Adanson, *Histoire naturelle du Sénégal* (Paris: C.-J.-B. Bauche, 1763), xv.

[13] C. Daly, 'Natural Kinds', *Routledge Encyclopedia of Philosophy* CD-ROM (London: Routledge, Version 1.0.)

resembled each other, the more natural was the grouping. Hence he is regarded as the precursor of numerical taxonomy.

I have just distinguished two questions, which I called descriptive and ontological. Once the idea of a taxonomic hierarchy is established, we have ranks—species, genera, families, orders. Suppose that in the botanical or zoological garden, and in the tables that correspond to it, we find an interesting group of groups. That poses a third question, what is its rank? Is it a genus or a family? According to the doyen of the history of systematics, Peter Stevens, these three questions were seldom distinguished.[14] Collectively one asked: *what is a natural group?*

The polemics continued, with no definitive resolution, until 1859, when Darwin asked:

> Naturalists try to arrange the species, genera, and families in each class, on what is called the Natural System. But what is meant by that system?

We all know his answer:

> All true classification is genealogical; that community of descent is the hidden bond which naturalists have been unconsciously seeking. [...] The *arrangement* of the groups within each class, in due subordination and relation to the other groups, must be strictly genealogical in order to be natural.[15]

This answer leaves wide open what the true genealogical order is. There are just as many polemics about correct and incorrect phylogenetic trees today as there were about natural classification two centuries ago, maybe more. But aside from new and vexing issues about lateral gene transfer among the earlier organisms, such as bacteria, we are agreed on what makes a group natural. In 1859 the species ceased to be objects that represent nature in terms of resemblance, and became historical objects. We might have to replace the post-Darwinian structure of a tree of life by the model of an estuary, but the objects will still be historical.[16]

[14] P. Stevens, *The Development of Biological Systematics: Antoine-Laurent de Jussieu, Nature, and the Natural System* (New York: Columbia University Press, 1994), 10–13.

[15] C. Darwin, *The Origin of Species* (London: John Murray 1859), 413, 420.

[16] For a popular account of post-tree architecture, see W. F. Doolittle, 'Uprooting the Tree of Life', *Scientific American*, February 2000, 90–95. For the estuary model, and other reasons for not sticking with trees, see

Miscellaneous hierarchies

One more word about species before we move to natural kinds. The hierarchical model was not restricted to plants and animals. Using exactly those words, species and genus, and to some extent the higher taxa, it applied across the board in descriptive sciences. All tried to emulate life. Rocks were for long classified in the same way as plants. The vast halls of mineralogical specimens in the École des Mines in Paris were modelled on the Jardin des Plantes a mile away. There was a resolute desire to organize things into a hierarchy, with each successive room containing a group of subgroups. It did not work. Specimens are now arranged using two non-meshing principles, namely the chemical substances they contain, and their crystalloid shape. The degenerating project of hierarchical classification continued well into the nineteenth century. William Whewell was the man who reintroduced the word 'kind' into logic. His first job? Professor of mineralogy at Cambridge University. In those days it was still plausible to imagine that plants and rocks could be sorted according to the same principles.

The garden of species was planted deep.[17] Take diseases. Medical nosology was patterned on plants. Great nosologists such as Boissier de Sauvages in France and Robert James in England followed Linnaeus—with whom Sauvages corresponded extensively. The Linnaean model continued longest in the classification of mental illness, through Kraepelin to the latest *Diagnostic and Statistical Manual of Mental Disorders*, although as with any other degenerating programme, the *Manual* resorts to more and more epicycles.

Neither last nor least, as the chemists formed the idea of what we call the chemical elements, they tried to sort these into a taxonomy. For example, in 1815 Ampère made a valiant attempt at a 'natural classification of the simple bodies', *les corps simples* being the then

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Dupré, *Humans and Other Animals*, (*op. cit*. note 2), p. 86. For the origins of tree diagrams in Western logic and science, see Ian Hacking, 'Trees of Logic, Trees of Porphyry', in *Advancements of Learning: Essays in Honour of Paolo Rossi*, J. Heilbron (ed) (Florence: Olschki, 2007), 157–206.

[17] This insightful phrase comes from Michel Foucault, in the title of Chapter I, Part II of *Folie et Déraison: Histoire de la folie à l'age classique,* Paris: Plon, 1961. Finally translated as *History of Madness* (London: Routledge, 2006).

current name for the elements.[18] The result looks just like Linnaeus. Repeated attempts to build tables did in the end succeed. Mendeleev made the radical break with botany. The periodic table is the permanent refutation of the idea that natural kinds have to be organized into a tree-like hierarchy. There are obvious genera and species within the table, for example the halogens form a genus of which chlorine and iodine are species. But the structure is not a simply hierarchic set of nested sets. The tragedy of the final contributions of Thomas Kuhn is that he thought that a theory of tree-like kinds, arranged as genus and species, would explain incommensurability and much else.[19] Unfortunately kinds are not tree-like unless nature makes them so. It has been repeatedly argued that natural kinds must, as a matter of logic, be arranged in a tree-like hierarchy.[20] Not so. Bosons, isotopes, and elements are commonly regarded as natural kinds. But since rubidium-47 is a species both of boson and of rubidium, but rubidium is not a species of boson or vice versa, you cannot put these on a branching tree. The fundamental point is that, as Darwin saw, genealogy does the trick for kinds of living things (or does so until lateral gene transfer kicks in). But little in nature is genealogical except life itself.

Darwin and Mendeleev between them demolished the conceptual structure to which the doctrine of natural kinds emerged as a plausible response.

William Whewell 1840

The question of natural groups was everybody's problem in 1840: botanists, zoologists, mineralogists, and students of disease, of language, of human societies, of races and of the chemical elements. Up stepped a formidable duo to translate the whole thing into philosophy, namely William Whewell and John Stuart Mill.

[18] A.-M. Ampère, 'D'une classification naturelle pour les corps simples', *Annales de Chimie et Physique* (n.s.) **1** (1815), 295–309, 373–395, **2** (1816), 105–116.

[19] T. S. Kuhn, 'Afterwords', in P. Horwich (ed.), *World Changes: Thomas Kuhn and the Nature of Science*, (Cambridge, Mass.: MIT, 1993), 311–341. Reprinted in T. S. Kuhn, *The Road since Structure,* J. Conant and J. Haugeland (eds.) (Chicago: University of Chicago Press, 2000), 224–252.

[20] For example, by R. Thomason, 'Species, Determinates and Natural Kinds', *Nous* **3** (1969), 95–101.

Formidable partly because they agreed about almost nothing except kinds. Between them they set the engine of natural kinds in motion. Whewell provoked, but is innocent of, the notion that there is a privileged, well-defined, class of kinds, independent of human interests, that should uniquely be called the natural kinds. That is Mill's contribution, but he probably took his building blocks from Whewell.

The word 'kind' had long disappeared from logic, and had little use in any context as a free-standing noun.[21] Whewell revived it. He was the great word-minter of English science, giving us even the name of the occupation, 'scientist'. Quite a number of his hundreds of more specialised nouns 'took', and are in use today. Whewell thought he could cut across the polemics about natural groups by insisting on logical clarity. Behind all the furore, quite aside from the specific science, we had to ask for the fundamentals of classification. The word he chose for this purpose was 'kind'. With the hindsight of our modern convictions he looks wonderfully prescient. What are kinds? '[...] such classes as are indicated by common names.'[22]

Items are grouped under common names when they are like each other: 'The idea of likeness is perpetually operating to distribute [our sensations] into kinds, at least as far as the use of language requires'. But unlike so many philosophers before and after him, resemblance was not the end of the matter but a question to pose. 'Upon what principle, under what conditions, is the idea of likeness thus operative? What are the limits of the classes thus formed? Where does that similarity end, which induces and entitles us to call a thing a *tree*?'

Whewell did not proceed to say that *tree* must be defined by some set of necessary and sufficient conditions, or that there was a set of properties (other than, trivially, being a tree) that nicely determines which things are trees. Explicit definitions are not usually possible.

[21] C. S. Peirce cites Wilson's *Rule of Reason* (1551) and Blundeville's *Arte of Logicke* (1599) for stand alone 'kind' in logic. 'Kind', *Baldwin's Dictionary of Philosophy and Psychology*, (New York: Macmillan, 1903), Vol. I, 600. He might have mentioned Locke, who takes 'kind' to be English for genus, and 'sort' to be English for species; *Essay*, III.i.6.

[22] W. Whewell, *The Philosophy of the Inductive Sciences, Founded upon Their History* (London: Parker, 1847), I, 469. All quoted sentences are found in the first edition of 1840, but I cite the second because it is widely available while the 1840 edition is rare. Book VIII, ch. I, §5, is headed *Kinds*, 469. The third and fourth quotations below are from pages 475 and 471 respectively.

His next section is headed, '*Not made by definitions*'. I commend his discussion to you, but here I shall leave you only with his aphorism: '[...] any one can make true assertions about dogs, but who can define a dog?'

Kinds are classes for which we have names. What determines the application of common names? '[...] the Condition which regulates the use of language is that it shall be capable of being used;– that is, that general assertions shall be possible.' Or again, 'The principle, that *the condition of the use of terms is the possibility of general, intelligible, consistent assertions*, is true in the most complete and extensive sense.'

I summarize Whewell thus: A kind is a class denoted by a common name about which there is the possibility of general, intelligible and consistent, and probably true assertions. By 'general' he need not mean only universal assertions, but also assertions that hold, as Aristotle put it, 'for the most part'. Philosophers will find offensive Whewell's explanation of kinds as denoted by common names. Surely there are many kinds for which we have no names in English or other languages! Yet almost exactly Whewell's definition has become the current definition of 'category' in cognitive science and developmental psychology. In a much reprinted and now classic article we read that a category is picked out by 'lexical entry' (viz. a common name) and that a 'A category is a partitioning or class to which some assertion or set of assertions might apply'.[23]

Whewell was able to stand outside sectarian disputes between the Natural Method and the Artificial System of Classification—labels much in use at the time. What makes a good classification? It should deliver us with kinds, and kinds are classes about which we can frame a number of general, intelligible assertions. That gives a positive (positivist) but wholly realist answer to the underlying issue of natural groups. He goes on to produce specific answers to the descriptive, ontological, and hierarchical question about natural groups, anticipating, among other things, Eleanor Rosch's theory of prototypes.[24]

[23] D. L. Medin, 'Concepts and Conceptual Structure', *American Psychologist* **44 (**1989): 1469–1481, on 1469.

[24] E. Rosch, 'Natural Categories', *Cognitive Psychology* **4** (1973), 328–350. See, Whewell, 494, heading for § 10: 'Natural Groups given by Type, not by Definition'.

Natural Kinds: Rosy Dawn, Scholastic Twilight

John Stuart Mill 1843

People had been talking about natural groups for a century before Whewell, and he continued to do so. The word 'kind' was his innovation, but he never spoke of natural kinds. We know from the *Autobiography* that as early as 1832 Mill wrote a draft manuscript that

> became the basis of that part of the subsequent Treatise [*A System of Logic*]; except that it did not contain the Theory of Kinds, which was a later addition, suggested by otherwise inextricable difficulties which met me in my first attempt to work out the subject of some of the concluding chapters of the Third Book.[25]

Book III of the *System of Logic*[26] is about induction, but Mill did not propose the Theory of Kinds to 'solve' the problem of induction. He began to insert the material on kinds in 1838, two years before Whewell publicly turned free-standing 'kind' into a technical term of logic. Mill had begun to 'recognize Kinds as realities in nature'.[27] But mere 'kind' would not do. It had to be *real* kinds. In case anyone might miss the point, he went through the last draft of the book writing in a capital 'K': real Kinds. This is the beginning of the cavalcade of superlatives. We start with *real*, pass to *natural*, and on to *genuine, aristocratic, strong*, *elite*, *pure*, all of which occur in the literature. It is as if you just can't insist enough that you want nothing but the very best: the highest quality kinds on offer in the universe. As if our problems in defining the class of important kinds stems from hitherto shoddy workmanship.

Mill's Theory of Kinds is embedded in his account of names and classes, but we do not need that to get his immediate thought. Not all useful classes are equal, for, 'we find a very remarkable diversity

[25] J. S. Mill, *Autobiography* (London: Longman, 1873), 191.

[26] J. S. Mill, *A System of Logic, Ratiocinative and Inductive. Being a Connected View of the Principles of Evidence and the Methods of Scientific Investigation* (London: Longman, 1st edition 1843). All 8 editions are collated and printed in Vols. VII and VIII of J. Robson (ed.), *Collected Works of John Stuart Mill* (Toronto: University of Toronto Press, 28 vols. 1965–83). References will be given as '*Logic*', followed by Mill's book, chapter and section number, followed by the page number in the Robson edition. Pagination of Vol. VIII continues that of Vol. VII.

[27] 1838 is the date furnished by Robson, 'Textual Introduction', *Logic*, lxv. It is not altogether clear that Mill used the actual word 'kind' before Whewell published.

in this respect between some classes and others.' A class of one type is picked out by a general name, but its members share at most a few other properties that are not implied by that general name. Call them finite kinds. White cells, white roses, and white paper, what have they in common but that they are white? Not much: 'white things, for example, are not distinguished by any common properties except whiteness; or if they are, it is only by such as are in some way dependent on, or connected with, whiteness.'[28]

Now consider the classes, *animal*, *plant*, *horse*, *phosphorus*, and *sulphur*. Phosphorus differs in innumerable ways from non-phosphorus: 'a hundred generations have not exhausted the common properties of animals or of plants, of sulphur or phosphorus; nor do we suppose them to be exhaustible, but proceed to new observations and experiments, in the full confidence of discovering new properties which were by no means implied in those we previously knew.' Such a class is a *real Kind*. Finite kinds and real Kinds, 'are parted off from one another by an unfathomable chasm, instead of a mere ordinary ditch with a visible bottom'.[29]

Why was Mill so excited by this distinction that he made one class into capital K real Kinds? One reason was that he came to believe, after a lot of scepticism, that the scholastic notion of species and genera makes sense. He did not mean the Linnaean concepts then current in natural history, or what was coming to be called biology, but rather the logical conceptions of the schoolmen. He thought he could naturalize them. The era of Whewell and Mill—as befits the closing years of the industrial revolution in Britain, and what Thomas Kuhn called the second scientific revolution—was an era of naturalization in British philosophy, be it empiricist (Mill) or neo-Kantian (Whewell). Rather than logic determining the species and genera, science would settle which classes are real Kinds. Book I, Chapter vii, §4 of the *System of Logic* is headed: *Kinds have a real existence in nature*. This is the clarion call for naturalism, to which the tradition has been faithful ever since. Science determines which kinds are real or natural, not metaphysics or logic.

There was a second reason for Mill's enthusiasm that I shall mention but not explain. Mill thought that he had naturalized scholastic species and genera. But he remained a notorious nominalist, and believed that his view put a final end to essence. He

[28] *Logic*. These two quotations and the next are from I. vii. §4, 122.
[29] *Logic*, 123, with a clause inserted in the 4th edition, revised, of 1856.

thought that the 'immortal Third Book' of Locke's *Essay* had almost killed off essence but not quite. 'A fundamental error is seldom expelled from philosophy by a single victory. It retreats slowly, defends every inch of the ground, and retains a footing in some remote fastness after it has been driven from the open country.'[30] Ever since Kripke's bombshell, many readers have associated the doctrine of natural kinds with some notion of essence. Hence it is often forgotten that it was born as a ruthlessly anti-essential philosophy, and remained so through generations of resolute nominalists such as Venn, Russell, Broad, and Quine.

There was a third reason. Real Kinds, as Mill wrote in the passage quoted from the *Autobiography*, were a lifeline to get him out of a hole in Book III, *Of Induction*. Black crows posed a problem for Mill that is specific to his philosophy, and so his discussion seems strange to us today. The problem about crows has nothing to do with Hempel's paradox of the ravens, even if the example may have been suggested to Hempel by Mill.[31]

Mill's analysis of inductive inference relied on his four methods, which in turn relied on causality. Non-causal propositions of coexistence present a problem. Uniformity in nature is commonly the result of causation. Causes precede effects. But some uniformities are simultaneous. How then can they be due to causation? In some cases they are the joint effects of a common cause—the simultaneous high tides on opposite sides of the earth. When uniformities of coexistence are derived from common causes, their degree of certainty or probability is that of empirical laws.[32]

The trouble is that we have good grounds for believing many universal propositions of coexistence, when we are entirely ignorant of a common cause. Hence we cannot use the four methods to investigate or ground our belief, or to explain why propositions of uniformity are (when not true by definition) merely probable. Mill needs to show that uniformities of coexistence, not known to derive from common causes, likewise have the status of

[30] *Logic*, I. vi. §3, 114; I have used the version in the first three editions rather than the slightly rewritten one of 1856 and thereafter. The reference to Locke is from 115.

[31] Hempel was working on confirmation on his arrival in the United States in 1941, publishing his first essay in *Mind* in 1945, followed by an essay specifically on the paradoxes in 1946. It may be relevant that the German translation of the *Logic* translated 'crow' by *Rabe*, rather than *Krähe*.

[32] 'When uniformities of coexistence are derivative, their evidence is that of empirical laws.' *Logic* III. xxii., heading of §6.

empirical laws. They do not have some superior, logical, or essential certainty. Above all, they do not reflect essential properties! This was of paramount importance for Mill.

> The notion that truths external to the mind may be known by intuition or consciousness, independently of observation and experience, is, I am persuaded, in these times, the great intellectual support of false doctrines and bad institutions. [...] There never was such an instrument devised for consecrating all deep-seated prejudices.[33]

He was here expressing his contempt for the Tory attitude, which would preserve the status quo on the grounds of an intuited sense of what is right and 'natural'. He trashed the arguments from mathematics, and in particular the a priorism of Whewell, early in his *Logic*. But now it could come in the back door, by way of uniformities of coexistence not known to be grounded on common causes.

A real Kind is precisely a class of items in which many independent properties coexist. If they coexist thanks to a common cause, no problem. But suppose there is no common cause? In my opinion the rest of the argument is weak. It does not excite us as it did Mill, but remember, for him the point was ideological as well as logical. Here is how it goes. There is never a difficulty in realizing that a uniformity of coexistence is merely contingent and might be false. Suppose that after all not all crows are black—not thanks to a few sports, albino crows, but to the discovery of crows with red shoulders and yellow tail feathers who inhabit remotest Yorkshire. That is only to suppose that, 'a peculiar Kind, not hitherto discovered, should exist in nature'—which 'is a supposition so often realized, that it cannot be considered at all improbable'.[34] Mill takes pleasure in reminding his readers of the strange kinds of animals and birds being reported from Australia, on an almost weekly basis, by every passing ship.

This part of the *Logic* is a rearguard action against essentialism, and the idea that essential coexistence might have an especially high degree of certainty, perhaps even some sort of necessity. That is one of the forgotten origins of the theory of real Kinds, and hence of the doctrine of natural kinds.

[33] *Autobiography*, 225–6.
[34] *Logic*, III. xxii. §7, 585–6.

John Venn 1866, 1889

John Venn, known to many for his diagrams, and to a few because of his understanding of frequencies, was probably the man who, in 1866, turned 'real Kinds' into 'natural kinds'. He was an early advocate of a frequency interpretation of probability, and it was there that he first invoked natural kinds. 'There are classes of objects, each class containing a multitude of individuals more or less resembling one another [...]. The uniformity that we may trace in the [statistical] results is owing, much more than is often suspected, to this arrangement of things into natural kinds, each kind containing a large number of individuals.'[35] Only in the next edition of the book, 1876, did he extend the thought from statistical regularity to 'such regularity as we trace in nature'.

Otherwise he made no use of the notion of a natural kind, and in due course he pretty well demolished it. He often took Mill's *Logic* as his guide, but his own logic textbook of 1889 savaged Mill, both on uniformities of coexistence and on the whole idea of a natural kind. He rightly separated what Whewell and Mill had thrown together as kinds, namely 'natural substances' like gold, and 'natural species or classes such as we find in Zoology or Botany'. In the former case, substances, there are indeed coexistent properties. Although (in 1889) we do not know much about the underlying structure that produces the properties of gold, its colour, degree of smoothness and toughness, ductility and malleability, they are, Venn is sure, 'results of the way in which the molecules are packed together'.

> From the practical point of view, such an analysis as [Mill's, in terms of coexistence] is needless. We are quite ready to admit [...] every natural substance contains a group of coexistent attributes. The practical difficulty does not consist in objectifying them [...] it shows itself rather when we attempt to say what belongs to one of these attributes and what belongs to another, in other words to draw the boundaries between them.[36]

[35] J. Venn, *The Logic of Chance: An Essay on the Foundations and Province of the Theory of Probability, with Especial Reference to its Application to Moral and Social Science* (London: Macmillan, 1866), 244. Note that the Second edition, much revised, of 1876, and the Third edition, revised, of 1888 contain the same discussion of natural kinds, but the arrangement of matter in the successive editions is very different.

[36] J. Venn, *The Principles of Empirical or Inductive Logic* (London: Macmillan, 1889), 82.

This is pretty damning. Mill's theory demands a sense of the way in which the properties of a real Kind are independent of each other. They are not to be in 'some way dependent on, or connected with' the others. The practical difficulty is how to explain this. C. S. Peirce made this point more sharply:

> Mill says that if the common properties of a class thus follow [as a consequence under a law of nature] from a small number of primary characters which, as the phrase is, *account for* all the rest,' it is not a real kind. [Mill] does not remark, that the man of science is bent upon ultimately thus accounting for each and every property that he studies.'[37]

In short, Peirce judged that the methodological assumption of scientific research is that there are no Millian real Kinds.

Venn turned from substances to plants and animals. He may have been the first author to insist that it is absurd to produce one category, 'natural kind', which spans such diverse items as substances and species. What connects the properties of substances is different from what connects the properties of any kind of living thing. Speaking of 'the colour, the smell, the taste of the peach: the speed, the size, the note of the swallow', he writes that:

> Mill, as we all know, writing in præ-Darwinian days, greatly overrated the distinctness and the ultimate or primitive character of these various attributes. He introduced the technical term of 'natural kinds' to express such classes as these, and those considered above [the substances], putting them on much the same footing in respect of natural distinctness and permanence [...].[38]

He noted scathingly (in the last ellipsis) that this implicit 'doctrine of the fixity of species' was the one point on which Whewell agreed with Mill—if Whewell agrees with you, the empiricist Venn implies, you know you must be wrong. If we took Mill (and Whewell) seriously, 'all the aggregate of successive living beings which constituted one of these natural kinds might be put upon

[37] Peirce, *op. cit.* note 21. Pierce presumably knew Venn on natural kinds for he referred often enough to his *Empirical Logic*. He does not seem to have reviewed that book, as he did the 1866 *Logic of Chance*: 'Here is a book which should be read by every thinking man.' *The North American Review* **105** (July 1867), 317–321, on 317. *Collected Papers of Charles Sanders Peirce*, vol. VIII, 3.

[38] Venn, *Empirical Logic*, 83.

much the same footing as the various specimens of the same mineral which exist upon earth'. *Which is absurd*. Later in the book, he rarely used the term 'natural kind' and when he did, he put it in quotation marks—what we now call 'scare-quotes' or 'shudder quotes'—to indicate disapproval.

Heterogeneity

Mill imagined that there is one class that covers two entirely different types of things, what Venn called 'natural substances' such as gold, phosphorus or sulphur, and 'natural species of classes such as we find in Zoology or Botany'. Mill 'writing in præ-Darwinian days', had an excuse. The excuse had vanished in Venn's day. But even Mill ought to have suspected that something was wrong. Mass nouns *are* different from count nouns, even to those who lack the terminology. Mill had another excuse: he wrote not only in pre-Darwinian but also in pre-set-theoretic days. He could use a notion of class in which *phosphorus* and *horse* are not sharply distinguished in point of logic. Those who follow Quine and think of kinds as sets can say that the kind *horse* has members, individual horses, but what are the members of *phosphorus*?

What set is phosphorus? Some people waffle, as if it did not matter much whether it was lumps of phosphorus, or phosphorus atoms. Or ions? Atoms and ions have the advantage that we can count them—and do, when they are trapped, where we may have six ions in a trap or about 10,000 atoms of the same isotope in a trapped cloud. But if we think of phosphorous as a substance, then it cannot be counted.

Quine, never waffling, valiantly tried to 'regiment' mass nouns in a way worthy of a great scholastic logician. In my opinion, once one goes into detail, the resulting regimented discourse makes little sense of what chemists say, or of what condensed matter physicists say. And as for polymer science! But let us stick with phosphorus. It has at least ten allotropic forms, and probably more as yet unknown. The known ones sort into three groups, white, red, and black. The α-white form has a cubic crystal form, while β-white has a hexagonal structure. Is each of these allotropes a natural kind? When Mill came to think about this, he concluded that 'the allotropic forms of what is chemically the same substance are so many different Kinds; and such, in the sense in which the word

Kind is used in this treatise, they really are.'[39] Each allotrope has a lot of properties that arise from its specific structure, for example, exposure to sunlight or heat changes white phosphorus to red, which neither phosphoresces nor ignites spontaneously in air.

If you hold that 'phosphorus' names atoms, then it looks like a count noun. But you cannot do this with 'α-white phosphorous', which refers to the substance characterized by its cubic crystal form. You cannot say it refers to the cubes, because each side of a cube has four atoms shared with the next cube.

A crude maxim is that many items used as examples of natural kinds are not sets and do not have members. Not substances, not diseases, and certainly not heat. Hence although kinds of living things may be regarded as sets, the candidates for being a natural kind are not, in general, sets. Indeed: there is *nothing* that they are in general.

A. A. Cournot 1851

The tradition of natural kinds exists only in the English language, and indeed before Quine it was wholly insular.[40] But the problem of natural versus artificial groups was European. A French contemporary of Mill's, A. A. Cournot (1801–1877), did turn his attention to the problem of natural groups. Logician, economist, probabalist and educator, he had the same instincts as Whewell and Mill, that philosophical logic and clear thinking might bypass the endless debates in natural history.

The tradition of natural kinds was not only insular but also empiricist. Cournot's book of epistemology was called *An Essay on*

[39] Mill, *Logic*, footnote to III. xxii. §6 added to the 6th edition of 1865, 585.

[40] There is no obvious way to translate 'natural kind' into French. *Genre naturel* and *espèce naturelle* were both used in the 1858 translation of Mill's *Logic*, once on the same page, but both make incomprehensible Mill's contrast between kinds on the one hand, and *species* and *genus* on the other. The translation of Quine used *espèce naturelle*. The translators of Putnam and Kripke followed suit. Cournot wrote about *genres naturels*, but he did not mean natural kinds. He meant natural as opposed to artificial genera; he believed that the species in use in the biology of his day were natural, and that the question of artificiality arose chiefly for higher ranks, starting with genera. Thus Cournot was addressing what I called the ontological, rather than the descriptive, problem about taxonomy.

the Foundations of our Knowledge and on the Characteristics of Philosophical Critique.[41] The first half of the title recalls the great books of the British Empiricists; the second half reminds us of Kant. That's Cournot for you. Neither rationalist nor empiricist, neither realist nor idealist, he had a thoroughly naturalistic view of knowledge as part of the human relationship with the world. In retrospect it seems curious that the English contributors said so little about causes in connection with natural kinds. Cournot's explanation of a natural group relies on the existence of underlying hidden causes that lead items to be grouped together—Putnam's hidden structures, if you will.

Author of a major philosophical work about probability, Cournot's master in matters of causation was neither Hume nor Kant but Laplace. Laplace did not address the metaphysics of causation, but the practical question of whether a phenomenon could be attributed to a cause or was simply a matter of chance. Cournot used the Greek constellations such as Cassiopeia as examples of artificial groups. They are convenient for navigators but the stars are grouped together by people, not nature. Cournot had translated William Herschel's *Treatise of Astronomy*. Herschel discovered the nebulae, what we now call galaxies. They furnished Cournot's contrasting example of a natural group. He used Laplace to argue that there must be some underlying cause that puts together the great clumps of stars identified as nebulae. 'Generic types and the classifications of naturalists give rise to remarks that are perfectly analogous [to the case of the nebulae]. A genus is natural, when the species of the genus have so many resemblances among each other, and by comparison differ so much from species that belong to neighbouring genera.'[42]

If different species fall under one (natural) genus, it must be highly improbable that a purely random assignment of individuals to the species, and of the species to the genus, should yield such a small distance between the species assigned to different genera. Referring to Laplace's theory of the probability of causes, he

[41] A. A. Cournot, *Essai sur les fondements de nos connaissances et sur les caractères de la critique philosophique* (Paris: Hachette, 1851).

[42] *Ibid*. 201. Darwin used exactly the same example to contrast with species explained in genealogical terms, *Origin* 397. Writing too soon after the *Origin* had been published, Cournot averred that we never would answer the question of the origin of species, but that we could tell on Laplacian grounds which groups of living things were natural groups. *Traité de l'enchaînement des idées fondamentales dans les sciences et dans l'histoire*, (Paris: Hachette, 1861).

concluded that the grouping 'cannot with any probability be attributed to the fortuitous play of causes that makes the types of organization of one species vary irregularly from that of another. There must be a bond of solidarity between the causes that constitute the species of a genus.'[43]

Cournot wrote as an astronomer and probability theorist rather than a naturalist. French taxonomists paid little attention to his characterisation of *genres naturels*, which was, in any event, to be upstaged by Darwin, admittedly rather more slowly in France than elsewhere. The English tradition of natural kinds ignored him altogether. The Laplacian probability of causes never entered the tradition, but it was Cournot, rather than the nineteenth-century empiricists, who saw that the idea of causality and of natural kinds had to be intricately intertwined.

1900–1970

The British doctrine of natural kinds was motivated by problems of natural history and the debates about natural groups that were still thriving in 1840. Those debates became obsolete. What with Venn and Peirce, the doctrine should never have entered the twentieth century. But other purposes were found for it. C. D. Broad tried to use natural kinds to analyse inductive inference. His exceptionally fine essay was the first to make clear that: 'The notions of permanent substances, genuine natural kinds, and universal causation are parts of a highly complex and closely interwoven whole and any one of them breaks down hopelessly without the rest.'[44] Broad was not able to fix any of the three to his satisfaction, and he confessed that he published the paper because he could not bear to think about this network of notions any more. Some readers will judge that this is a brilliant *reductio ad absurdum* of the idea, that you can elucidate this triangle of notions in an empiricist way.

The two great empiricist philosopher-logicians of the twentieth century, Quine and Russell, agreed completely about the idea of a

[43] Cournot, *Essai*, p. 202, 204. His words were *lien de solidarité*, a concept that he does not explain very clearly. But it is not idle to associate it with Putnam's concept of a hidden structure underlying a natural kind.

[44] C. D. Broad, 'On the Relation between Induction and Probability', Reprinted from *Mind* **27** (1918), 389–404; **29** (1920), 11–45, in *Induction, Probability, and Causation: Selected Papers by C. D. Broad* (Dordrecht: Reidel, 1968), 1–52, on 44.

natural kind. They thought of it as a sort of epistemological crutch for getting started in the world. 'The existence of natural kinds', wrote Russell, 'underlies most pre-scientific generalizations, such as "dogs bark" or "wood floats".' He gave a standard Millian explanation of the idea of natural kind and its uses. But in the end he had to 'conclude that the doctrine of natural kinds, though useful in establishing such pre-scientific inductions as "dogs bark" and "cats mew", is only an approximate and transitional assumption on the road to more fundamental laws of a different.'[45]

Quine, with his gift for giving the gist in the smallest number of words, gave us my favourite five-word characterization of natural kinds: 'functionally relevant groupings in nature'. Nevertheless he concluded his famous essay by repeating Russell's thought. 'In general we can take it as a very special mark of the maturity of a branch of science that it no longer needs an irreducible notion of similarity and kind.' Indeed the disappearance of this notion is, 'a paradigm of the evolution of unreason into science'.[46]

High Noon: Kripke and Putnam

My topic is dawn and twilight, not the heady days of the 1970s when Saul Kripke and Hilary Putnam did so much to give sense and use to the idea of a natural kind. Analytic philosophy is directed more at semantics than at nature. Hence causal theories of reference for natural-kind *terms* are often called simply the Kripke-Putnam theory. This is correct; indeed Putnam acknowledged a debt. 'Kripke's work has come to me second hand; even so, I owe him a large debt for suggesting the idea of causal chains as the mechanism of reference'.[47] It is seldom noticed that Kripke's and Putnam's theories of natural *kinds* are very different. Kripke single-handedly brought talk of essence back to life. This was an amazing feat. One would have thought that it was dead as a doornail in English-language analytic philosophy once Locke had savaged it with such relentless irony in that 'immortal Third Book'. To

[45] B. Russell, *Human Knowledge: Its Scope and Limits* (London: George Allen and Unwin, 1948), 335, 461–2.

[46] Quine, 'Natural Kinds', *op. cit.* note 6, 126, 138.

[47] H. Putnam, 'Explanation and Reference', in *Mind, Language and Reality: Philosophical Papers*, Vol. 2 (Cambridge: Cambridge University Press 1975), 198.

paraphrase Mill quoted above, Kripke brought it back from 'some remote fastness' and restored it to pride of place in 'open country'.

Putnam had almost no part in the restoration of essence. At the beginning he was quite willing to present his ideas as parallel to Kripke's, and to use the myth of baptism as giving a reference to natural kind words. Yes, he did *mention* essences—in scare quotes. When he put forward his fundamental idea that natural kinds have 'the same general *hidden structure*', he added, between parentheses, '(the same "essence", so to speak)'.[48]

Kripke and Putnam both formulated semantic theories of natural-kind terms. As a rule of thumb we may say that Kripke's theory of natural kinds was logico-metaphysical, with essence at its core, while Putnam's was empirico-logical, with hidden structure at its core. It was some time before Putnam came to realize that Kripke meant every word he said, and hence his statement became more and more clearly differentiated from Kripke's approach. I point this out in some detail elsewhere.[49]

TWILIGHT

Proliferation

The work of both men produced a rich sub-discipline of philosophy. There have been endless debates and numerous criticisms.[50] Yet despite the initial enthusiasm, by 2006 we are left with a great many almost unrelated research ideas about natural kinds. I shall not detail here how we got from high noon to here. I shall briefly summarize a situation that will be well-known to many readers. The present situation is scholastic, in several senses. The

[48] H. Putnam, 'The Meaning of "Meaning" ', in *ibid*., 215–271, on 235.

[49] I. Hacking, 'Why Putnam's Theory of Natural Kinds is not the same as Kripke's', to appear in *Principia: Revista Internacional de Epistemologica* (Florianopolis, Brazil). 'Hidden Structure and Natural Kinds', to appear in the Library of Living Philosophers ('Schillp') volume dedicated to Putnam.

[50] One of the most vigorous recent critiques is J. Laporte, *Natural Kinds and Conceptual Change* (Cambridge University Press, 2004). It contains thorough references to thirty years of debate. A decade earlier T. E. Wilkerson, offering a modest essentialism, provided ample references in *Natural Kinds* (Aldershot: Avebury, 1995), with an update, 'Recent work: Natural kinds' *Philosophical Books* **39** (1998): 225–233.

great schoolmen were deeply caught up in questions about general terms and classification. In this sense, the connotation of 'scholastic' is positive. Second, they argued exquisitely about the finest points. The present debates about natural kinds are reminiscent of those noble hours of the late middle ages. But there is a third connotation that I fully intend. 'Scholastic' suggests an inbred set of degenerating problems that have increasingly little to do with issues that arise in a larger context.

This is not to say that real problems do not abound. I say only that discussing them in terms of natural kinds does no good at all. It is an optional add-on. Not an empty add-on, because the term 'natural kind' now carries a lot of baggage with it, and a lot of mutually incommensurable theories that I am about to list. So speaking of natural kinds turns real difficulties into unnecessary confusions. Whewell made 'kind' a free-standing logical term intending to solve or evade problems about natural groups. The species remain a much-debated question in systematics, as do the higher taxa. But to discuss them in terms of natural kinds today is to spill ink. Take any discussion that helps advance our understanding of nature or any science. Delete every mention of natural kinds. I conjecture that as a result the work will be simplified, clarified, and be a greater contribution to understanding or knowledge. Try it.

Definitional confusion

Usually encyclopaedia articles summarize fairly standard recent knowledge. One may disagree with an entry because one is a rival expert or because one mistrusts the ideology implicit in the article, but in general we accept encyclopaedias as authoritative. I do not wish to be invidious, but it is convenient to use the article 'Natural Kinds' in the *Routledge Encyclopedia of Philosophy* to illustrate the confused state of the philosophy of natural kinds. An obvious response is that the article is defective, and that happens. Agreed. I offer no more than an illustration before turning to the details of proliferation.

> Objects belonging to a natural kind form a group of objects which have some theoretically important property, or properties, in common. Standard examples of natural kinds include biological species such as rabbits, oaks and whales, chemical

elements and compounds such as oxygen, carbon and aluminium, and stuffs such as salt, wool and heat.

I personally favour a mundane, rather than cosmic (Quine's word again) notion of natural kinds, and in that mood am content with these examples. But what is said about them is troubling. None of the kinds called biological species are in fact biological species.[51] They are respectively a genus, an order and a family. *Oak* is the genus *Quercus* (and some oaks are of the genus *Linocarpus*). *Whale* in biology denotes most of the order *Cetacea*. And *Rabbit* may be any of the long-eared burrowing animals of the family *Leporidae*. As noted below, there was a brief moment in molecular biology when one expected to find exactly what members of a given biological species have in common. Considered opinion now has it that there is nothing that all and only members of a given species have in common.

As for substances rather than kinds of living things, what determines that salt is filed as a stuff rather than a chemical compound? Heat is a *stuff*? What wool does the author have in mind? The dense, soft, often curly hair forming the coat of sheep and certain other mammals, such as the goat and alpaca, consisting of cylindrical fibres of keratin covered by minute overlapping scales and much valued as a textile fabric? Or what most of us think of, a textile fibre made from raw wool, or perhaps a material or garment made of this textile?

The New Essentialism

Keith Donnellan wryly observed that a weird thing about the discussions of Kripke and Putnam was that they almost always took examples from common English, and not the innumerable technical names actually introduced into the sciences, in order to refer to newly discovered or understood kinds of things.[52] Water, lemons, heat, gold. Brian Ellis's Scientific Essentialism fully rectifies that. It emphasizes three types of natural kinds. *Substantival natural kinds* include elements, fundamental particles, inert gases, sodium

[51] The same point was made long ago in J. Dupré, 'Wilkerson on Natural Kinds', *Philosophy* **64** (1989), 248–251. Wilkerson modified his account in the light of the criticism.

[52] K. S. Donnellan. 'Kripke and Putnam on Natural Kind Terms', in C. Ginet and S. Shoemaker (eds.), *Knowledge and Mind: Philosophical Essays*, (New York: Oxford University Press, 1983), 84–104.

salts, sodium chloride molecules, and electrons. *Dynamic natural kinds* include causal interactions, energy transfer processes, ionizations, diffractions, $H_2 + Cl_2 \Rightarrow 2HCl$, and photon emission at $\lambda = 5461$Å from an atom of mercury. *Natural property kinds* include dispositional properties, categorical properties, and spatial and temporal relations; mass, charge; unit mass, charge of $2e$, unit field strength, and spherical shape.[53] Species are *not* natural kinds, in this philosophy.

I fully respect, although I do not share, the anti-Humeian metaphysic that motivates Ellis's essentialism. But why should we say that *these* are the natural kinds? These various kinds of entities are all named in my undergraduate textbooks published in the 1950s. Very well, assert that these kinds have essences, if that helps you understand their agency. But should one not be worried that no science textbook of 1956 or 2006 ever mentions the essence of photon emission or anything else?

These kinds of item have stood up well, these fifty years, but why, I repeat, call them the natural kinds? That rhetorical add-on may give lustre to a new theory by hooking it up with an old tradition, but it adds not one jot of content. As stated in the first thesis at the start of this paper, stipulative definition, humpty-dumpty style, is always possible, and Ellis can define 'natural kind' as he will, but what good does it do?

Note that the causal theory of reference derived from Kripke and Putnam plays no role at all in the New Essentialism. Of course 'argon' continues to denote argon, but that goes without the theory. Kripke's motivation for introducing essences has entirely disappeared from the New Essentialism; we are left with bare essences. Those who want natural kinds to underwrite inductive inference must also be sorely disappointed, for we make inductive generalizations (*pace* Popper) about poplars, possums and potatoes, which are said not to be natural kinds, as readily as we do for potassium.

Michael Ghiselin's evolutionary biology

For some forty years Michael Ghiselin has been urging that the species (Mill's *horse*, say, *Equus caballus,* genus *Equus*) are

[53] B. Ellis, *Scientific Essentialism* (Cambridge: Cambridge University Press, 2001), 56.

individuals.[54] The individual horse, Black Beauty, is a *part*, and not a member, of this individual. On the other hand the ranks—species, genus, and the rest—are natural kinds.

The first assertion is Ghiselin's way of saying that the unit of natural selection and hence of evolution is the species, an individual that evolves. Moreover, there are no exceptionless laws of nature about horses. His second assertion means that there are biological laws of the form 'every species is so and so'. These are truly important propositions.

Ghiselin's logic of the species is mereological, while his logic of the taxa is set-theoretic. Some of us, starting perhaps with an old paper by Philip Kitcher,[55] suspect that such theses can be stated using a more conventional logical approach. Perhaps not. Either way, the biological substance of Ghiselin's proposals will be left intact. What they do not need is the rhetorical add-on about natural kinds.

Ghiselin fumes at John Dupré's doctrine of promiscuous natural kinds, which urges that several incommensurable modes of classification may be used for classifying living things. Ghiselin is not dogmatic; he does not say that the taxonomy he favours is right in all respects. But if it is not right, then another one *is* right. And whatever it is, it will be *the* fulfilment of Darwin's insight. It does not help, in my opinion, to conduct this polemic using the rhetorical label 'natural kind'.

Developmental Cognitive Science

An unexpected marriage of Chomskyian cognitive science and Piagetian psychology holds that many of the abilities, which children acquire early in their lives, are enabled by innate mental modules. One of these is a natural-kind module. It enables children at an early age to begin to classify, to generalize over classes, and to pick up common names for the classes. There is the additional thesis that children act as if the classes, for which they are innately primed, have essences. It is not asserted that metaphysical essences exist, but that children, and later on, adults, act as if they did.

[54] M. Ghiselin, 'On Psychologism in the Logic of Taxonomic Controversies', *Systematic Zoology* **15** (1966), 207–215. *Metaphysics and the Origin of Species* (Syracuse, N.Y.: State University of New York, 1997).

[55] P. Kitcher, 'Species', *Philosophy of Science* **51** (1984): 308–333.

Frank Keil is a leading worker in this field.[56] In a brilliant synthesis of cognitive science, Aristotelian scholarship, history of systematic biology and cross-cultural anthropology, Scott Atran has done most to advance the idea of a living-thing module for natural kinds.[57]

Atran thinks that Aristotle's accounts of living things pretty well reflects what he calls folk-biological concepts, which are universal in the human race. But he also studies, in rich historical detail, what he calls 'the scientific breakaway', in which natural history and then systematic biology replaced all those concepts by a nested hierarchy of taxa. It is hardly an exaggeration to say that none of the 'natural kinds' in folk biology coincides, except in rough outline, with any species or genus of systematics. Atran rightly concludes that the idea of natural kinds, pertaining to every kind of thing, is on the way out:

> The conception of 'natural kind', which supposedly spans all sorts of lawful natural phenomena, may turn out not to be a psychologically real predicate of ordinary thinking (i.e. a 'natural kind' of cognitive science). It may simply be an epistemic notion peculiar to a growth stage in Western science and philosophy of science.[58]

My only disagreement is that the conception of a natural kind never had a role in Western science—it was peculiar only to a growth stage in English-language philosophy of science.

Biological species

When Kripke first published, current scientific folklore held that in the next few years molecular biology would discover in the DNA of a species the necessary and sufficient conditions for being of that species. Hence one blithely talked of the essence of tigers and lemons. We would move from the phenotype to the genotype and on to the essence. Within twenty years the folklore had been

[56] F. C. Keil, *Semantic and Conceptual Development: An Ontological Development* (Cambridge, Mass.: Harvard University Press 1979). *Concepts, Kinds and Cognitive Development* (Cambridge, Mass.: MIT, 1989).

[57] S. Atran, *Cognitive Foundations of Natural History: Towards an Anthropology of Science* (Cambridge: Cambridge University Press, 1990).

[58] S. Atran, 'Folk Biology and the Anthropology of Science: Cognitive Universals and Cultural Particulars,' *Behavioral and Brain Sciences* **21** (1998), 547–569, with discussion and replies until 609, on 569, note 16.

superseded. There are no necessary and sufficient conditions for being a tiger or a lemon. No essence. Terence Wilkerson presented a far more modest essentialism than Brian Ellis, but holds that the biological species as we know them are not natural kinds.[59] It remains to be said that projects are afoot to identify genetic 'barcodes' for recognizing species, but these will be contingent markers, not essences that explain why the Toco Toucan has an enormous bill. They will be more like DNA fingerprints, which may identify Elizabeth II but do not define her.

Species die hard as the basic paradigm for natural kinds. Rachel Cooper ran through many of the competing accounts of natural kinds, not mentioning the New Essentialism.[60] Without herself taking any position on the definition of natural kinds, she regarded Wilkerson as an outlier, and concluded that most theories about natural kinds still count biological species as natural kinds. John Dupré, for example: 'there is no reason why the account of species currently offered [in classificatory systematics] should preclude their being modestly natural kinds'.[61] Memories die hard. Biological species have long served as paradigms of natural kinds—they are (one feels) natural kinds if anything is. Witness the definition in the *Routledge Encyclopedia of Philosophy*, with its oaks, rabbits and whales all called species.

Richard Boyd's Homeostatic Property Cluster Kinds

One of the most innovative approaches to species after Putnam is due to Richard Boyd.[62] The idea of homeostasis was introduced in the 1920s to describe human metabolism. It was taken over by

[59] Wilkerson, *op. cit*. note 50.

[60] R. Cooper, 'Why Hacking is Wrong about Human Kinds', *British Journal for the Philosophy of Science* **55** (2004), 73–85. Her point was to show that I was wrong about what I used to call human kinds. I do not protest her argument, but go further back. There is, if possible, even less of a class of human kinds than there is of natural kinds. See Ian Hacking, 'Kinds of People: Moving Targets', forthcoming in *Proceedings of the British Academy*.

[61] Dupré, *Humans and Other Animals*, *op. cit*. note 2, 97.

[62] R. Boyd, 'What realism implies and what it does not', *Dialectica* **43** (1989): 5–29; 'Anti-foundationalism and the enthusiasm for natural kinds', *Philosophical Studies* **61** (1991): 127–148; 'Homeostasis, species and higher taxa', in R. Wilson, *Species: New Interdisciplinary Essays* (Cambridge, Mass.: MIT, 1999), 141–186.

cybernetics together with the idea of positive and negative feedback. A system is homeostatic if it has an equilibrium state, and whenever it strays too far from that state, there are causes in the way of feedback that tend to restore equilibrium. Boyd adapts this concept for species and higher taxa, combining it in an unusual way with the Darwinian model of selective pressure..

In his analysis, kinds, and in particular species, are groups that persist in a fairly long haul. The properties that characterize a species form a cluster. No distinctive property may be common to all members of the species, but the cluster is good for survival. The species is in equilibrium in the sense that descendants that diverge too far from the cluster of properties die out or form a new group. Species thus endure thanks to a network of causes that produce stability of a homeostatic sort. That is, when members of successive generations of a species deviate too far from an earlier prototype, they either survive, and the phenotype of the species gradually changes, or else they die, leaving the surviving majority to keep the species prototype intact.

Boyd would like to extend his idea in many directions, including epistemological concepts. Knowledge, in his opinion, is a homeostatic property kind. It is thus a natural kind of epistemological state, in a way in which (if I understand him) belief is not. Note how the notion of homeostatic property cluster kinds may extend to kinds never before included in the pantheon of natural kinds, while it is not useful for old-time natural kinds such as phosphorus. Like many other kinds of stuff filed as natural kinds, phosphorus is highly unstable, the very opposite of homeostatic, which is why it is almost never found free in nature. It is made in factories, and preserved, in one or more of its allotropic forms, by artifice.

Induction

There are calls for natural kinds motivated by a wish to understand the philosophical problem of induction. I shall make four observations.

(a) As C. D. Broad, quoted above, may have been the first to say in detail, substance, kinds, and causation 'are parts of a highly complex and closely interwoven whole'. It is remarkable how few are the authors who have seriously examined these as parts of a whole. David Wiggins has doggedly treated the first two under the rubric of substance and sameness. Ruth Millikan

has proposed 'a common structure for individuals, stuffs and real kinds'.[63] There is a depth in the problems addressed by Wiggins and Millikan that seems lacking in most philosophising about induction without discussing substance.

(b) 'In induction', as Quine observed, 'nothing succeeds like success'. Hence the kinds—I follow Quine and drop the 'natural'—are the predicates that we come to use, and will regularly revise. Calling them natural kinds adds nothing. To call them kinds and speak of sameness of kinds is to speak with William James' pragmatism.

(c) Howard Sankey urges that: 'Inductive inference in science is rationally justified because of the existence of real, natural kinds of things, which are characterized as such by the essential properties which all members of a kind must possess in common.'[64] Are inductive generalizations about rabbits, oaks and whales not rationally justified, since biology now teaches that they lack such essential properties? As a matter of fact, induction works best with artefacts, because that is exactly what artefacts are, things that fairly reliably do what we want them too. That makes rather a hash of the popular distinction between 'natural' and 'artefactual' kinds, if one imagines that a chief task of natural kinds is to underwrite induction.

(d) To use a name for any kind is, among other things, to be willing to make generalizations and form expectations about items of that kind. That is a primary lesson to be drawn from Goodman's new riddle of induction.[65] The very words 'kind' and 'generalize' have the same roots—a story well narrated by the *OED*.

[63] D. Wiggins, *Sameness and Substance* (Cambridge, Mass.: Harvard University Press), 1980. *Sameness and Substance Renewed* (Cambridge: Cambridge University Press, 2001). R. B. Milikan, 'A Common Structure for Concepts of Individuals, Stuffs, and Real Kinds: More Mama, More Milk, and More Mouse', *Behavioral and Brain Sciences* **21** (1998), 55–65, with discussion and replies until p. 100. *On Clear and Confused Ideas: An Essay about Substance Concepts* (Cambridge: Cambridge University Press, 2000).

[64] H. Sankey, 'Induction and Natural Kinds', *Principia: Revista Internacional de Epistemologia* **1** (1997), 239–254.

[65] Indeed it is essentially the first sentence of my paper 'Entrenchment', in D. Stalker, (ed.), *GRUE! The New Riddle of Induction* (Chicago: Open Court), 193–223.

Laws of nature

Natural kinds are invoked to explicate the idea of a law of nature, or vice versa. One message of *Fact, Fiction, and Forecast* was that the connection was quite strong, so that they stood or fell together. Goodman judged that they fell. For quite other reasons, laws of nature are under a lot of pressure right now. In physics there is Nancy Cartwright's doctrine that they are all false, and only approximations are true.[66] There is Bas van Fraassen's thesis that 'no philosophical account of laws of nature does or can succeed.'[67] Symmetry is where the action is, he argues, rather than law. This opinion is at present asserted, if not so fervently, by many other philosophers of science. Turning to evolutionary biology, Ghiselin held that laws of biology apply to taxa, such as *species,* rather than to items that fall under the concept 'species'. This has certainly been contested.[68] The concept of a natural kind contributes nothing to those debates about fundamental issues, and they had better be settled before one imagines that the concept of a law of nature can be routinely invoked to explain the idea of a natural kind.

Philosophical purists no longer favour the concept of generalizations that are true for the most part. Yet these are good for predicting, and are very often the very propositions that earlier generations counted as laws of nature. I myself am no purist. Whewell was, in my opinion, on the right track when he said that a kind is a class denoted by a common name about which there is the possibility of general, intelligible and consistent, and probably true assertions. Thus there are plenty of law-like generalizations about both substances and species. Exposure to sunlight or heat changes white phosphorus to red, which neither phosphoresces nor ignites spontaneously in air. The Hyacinth Macaw (*Anodorhynchus hyacinthinus*) eats only the white fruit inside two kinds of very small palm nuts (*Suagrus commosa* and *Attalea funifera*); first animals such as peccaries, capybara or cattle must eat the green husk in order that the strong bill of the macaw can crack the nut underneath.

[66] N. Cartwright, *How the Laws of Physics Lie* (Oxford: Clarendon, 1983).

[67] B. van Fraassen, *Laws and Symmetry* (Oxford: Clarendon, 1989), vii.

[68] For example, by Dupré, *Humans and Other Animals*, *op. cit*. note 2, 108; not even the Hardy-Weinberg law will do the trick.

Many philosophers prefer to insert Latin tags here, *mutatis mutandis* or *prima facie*, or they speak of *ceteris paribus laws*. We do not bother to do so in plain English. The tags reveal that the philosophers want a definite class of such laws. Latin is the polite printed form of hand-waving. In fact there is no more a specific class of such laws than there is a specific class of natural kinds.

My two examples deliberately refer to facts and kinds of things about which few people are well informed. They present what for many readers will be new classifications and new knowledge. I like to use the label 'mundane' for the several kinds of minerals, animals and vegetables mentioned. Mundane kinds as opposed to cosmic ones.

In a first glance at natural kinds many years ago, I used the dictionary for a random sample of natural kinds, and by chance found a surprising number of mundane kinds whose names began with 'stone-'.[69] Few were minerals; instead I listed various kinds of plant, fish, fruit, bird, insect, algae and the stone-lily, which is an invertebrate marine animal. My favourite mundane kind is mud. Mud is a functionally relevant grouping in nature. It is familiar to parents scrubbing children's clothing, to football players, and to ditch-diggers in damp climes. Not scientific? I used to work around oil rigs in the Prairies. We always had a mud-engineer on the site, a man not ashamed to have that title, *mud engineer*, on his business card. (For current rates of offshore pay, from Aberdeen to Yemen, consult the Internet.)

What arrogance will insist that the ploughman is not in touch with nature's kinds, mud and dung?

Conclusion

Although one may judge that some classifications are more natural than others, there is neither a precise nor a vague class of classifications that may usefully be called the class of natural kinds. A stipulative definition, that picks out some precise or fuzzy class and defines it as the class of natural kinds, serves no purpose, given

[69] Ian Hacking, 'A Tradition of Natural Kinds', *Philosophical Studies* **61** (1991), 109–126. My long-postponed book, *The Tradition of Natural Kinds* (forthcoming with Cambridge University Press), tells more about the dawn, treats the high noon of Kripke and Putnam in respectful detail, and moves on to the present twilight.

that there are so many competing visions of what the natural kinds are. In short, despite the honourable tradition of kinds and natural kinds that reaches back to 1840, *there is no such thing as a natural kind*.