Are Stellar Kinds Natural Kinds? A Challenging Newcomer in the Monism/Pluralism and Realism/Antirealism Debates
Author(s): Stéphanie Ruphy
Reviewed work(s):
Source: *Philosophy of Science*, Vol. 77, No. 5 (December 2010), pp. 1109-1120
Published by: The University of Chicago Press on behalf of the Philosophy of Science Association
Stable URL: http://www.jstor.org/stable/10.1086/656544
Accessed: 24/03/2012 05:34

Are Stellar Kinds Natural Kinds? A Challenging Newcomer in the Monism/ Pluralism and Realism/Antirealism Debates

Stéphanie Ruphy†‡

Stars are remarkably absent from reflections on natural kinds and classifications, with gold, tiger, jade, and water getting all the philosophical attention. It is a pity, for interesting philosophical lessons can be drawn from stellar taxonomy as regards two central debates about natural kinds, to wit, the monism/pluralism debate and the realism/antirealism debate. I show in particular that stellar kinds will not please the essentialist monist, nor will it please the pluralist embracing promiscuous realism à la Dupré. I conclude on a more general note by questioning the relationship between taxonomic scientific practice and philosophical doctrines of natural kinds.

1. Introduction. "Species are evidently not arbitrary like the grouping of the stars in constellations" (Darwin 1859/1962, 411): apparently, Darwin did not have a high opinion of stellar taxonomy, nor did the French mathematician and philosopher A.-A. Cournot, for whom constellations were a typical example of artificial groups of things (1851/1975, 199–208). But stellar taxonomy has come a long way since Darwin and Cournot's time. Yet, it is still remarkably absent from reflections on natural kinds and classifications, with gold, tiger, jade, and water getting all the philosophical attention. It is a pity, for, as we shall see, the practice and

†To contact the author, please write to: Département de philosophie, Université de Provence, 29, av. Robert Schuman, 13621 Aix-en-Provence Cedex 1, France; e-mail: stephanie.ruphy@wanadoo.fr.

‡I would like to thank two astrophysicists, Nicolas Epchtein and Michèle Gerbaldi, for lively discussions on the science of stellar taxonomy. Needless to say, they cannot be blamed for the residuum of error this article may contain. I am also indebted to Matthew H. Slater for helpful comments on an earlier draft of this article.

Philosophy of Science, 77 (December 2010) pp. 1109–1120. 0031-8248/2010/7705-0017$10.00

achievements of stellar taxonomy raise fruitful challenges to the current main philosophical standpoints on natural classifications. Moreover, stellar classifications are representative of what many taxonomic enterprises are about in science today, that is, coming up with kind-membership conditions that define epistemically fruitful groupings of entities whose diversity is revealed (or even created) by scientific investigation, rather than trying to discover the hidden essence of antecedently recognized kinds. Not surprisingly then, I will not have much to say about traditional issues of reference of ordinary language natural-kind names. However, my discussion of stellar kinds will be directly relevant to two other central, ongoing debates about natural kinds and classifications, to wit, the monism/pluralism debate and the realism/antirealism debate.

On the face of it, stellar taxonomy does not seem to be a very monist-friendly domain. Take one of the brightest stars of the Northern Hemisphere, Vega in the Lyra constellation, and ask astrophysicists what kind of star Vega is. Commonly known as an "A0 V" star, that is, a relatively hot, slightly bluish "main sequence dwarf," Vega is also classified by astrophysicists observing in the far infrared part of the electromagnetic spectrum as a "1n-18" star, that is, a star with no remarkable spectral feature in this domain of wavelength, and for those studying how the light emitted by a star varies, Vega is known as a "Delta scuti" type of star, that is, a kind of pulsating variable star.

My aim in this article is to investigate how this taxonomic pluralism should be interpreted and which metaphysical and epistemological lessons about natural kinds and classifications can be drawn from it. I start with a (shallow) plunge into the practice of grouping stars, which will allow us to grasp the sources of stellar taxonomic pluralism. Along the way, comparisons with two familiar cases—the classification of chemical elements and the classification of living organisms—will bring out the specificities of the stellar case. I then discuss whether the stellar world comes prepackaged with any objective divisions, putting on the carpet both traditional essentialist standpoints on natural kinds and nonessentialist, realist ones, such as Dupré's promiscuous realism (1993). I conclude on a more general note by questioning the relationship between taxonomic scientific practice and philosophical doctrines of natural kinds.

2. The Art and Quirks of Grouping Stars.

2.1. Stellar Structuralism. Stars are grouped together in a class when they exhibit features "similar enough" to those of a standard star picked up to define the class. But of course, not just any feature will do as a similarity parameter. For instance, in spite of the fact that this intrinsic property is known for a very large number of stars, stars are not classified by their proper motion, for the same reasons that animals are not sorted out by, say, their number of hairs or chemical substances by their color: what stellar taxonomists share with their confreres in other scientific domains is a search for "privileged" or taxonomically "significant" similarity parameters. My putting these epithets between quotation marks follows a widespread habit in philosophical discussions about natural kinds and classifications that conveys a crucial ambiguity of the use of the terms. In what sense can similarity parameters be said to be "privileged"? A metaphysical reading of the term may refer to some form of traditional essentialism. For less metaphysically inclined philosophers, the reading may be more epistemological: a set of similarity parameters is privileged to the extent that it defines epistemically fruitful groupings (i.e., those lending themselves to generalizations and predictions, playing a role in causal explanations, etc.). Actually, it is hardly overstated to claim that the main lines of disagreement between various standpoints on natural kinds and classifications (i.e., monism, pluralism, realism, antirealism, and some combinations of those four) boil down to divergent views of what privileged means. But until section 4, where I will ask whether stellar kinds are natural kinds and discuss these divergent views more extensively, I will remain neutral as regards the appropriate reading of the notion in the astrophysical context and stick to the description of kind-membership conditions in the scientific practice of sorting out stars.

So what are the similarity parameters that are taken as privileged by stellar taxonomists? Astrophysicists want to know how stars form, evolve, and disappear. Their theoretical understanding of the behavior of gaseous spheres tells them that parameters such as temperature, density, or mass loss are determinant parameters in stellar evolutionary processes, whereas proper motion or distance from the earth are not; hence, we have their choice of the former, and not the latter, as taxonomic parameters. In short, kind membership is conferred by structural properties central for explaining a large variety of stellar behaviors (and those properties translate into spectral features that are directly observable).

2.2. Wavelength Dependency. For a long time, classificatory schemes were based on properties observable in the visible part of the electromagnetic spectrum. But from the late 1970s, with the launch of satellites instituting detectors working in other domains of wavelength (in particular in the infrared and in the ultraviolet), astronomers began to design independent classificatory schemes based on spectral features observable in these newly accessible domains. Hence, there was a multiplication of wavelength-dependent taxonomic systems. It is important to note, though, that due to practical observational limits (and budgetary constraints), the development of independent classificatory schemes in various regions of the electromagnetic spectrum concerns only a very limited number of stars, compared to the number of stars classified by spectral features observable in the visible spectrum. In other words, there are large differences as regards the comprehensiveness of the various existing taxonomic systems, with systems based on visible features being by far the most comprehensive.[1] This predominance is easily explained. The earth's atmosphere happens to be transparent, and we human observers happen to see in this domain of wavelength. Not surprisingly then, the most comprehensive classification systems are relative to this domain. But one can easily imagine that alien astrophysicists endowed with a sharp view in, say, the infrared, would have come up with large-scale, comprehensive classifications based on infrared properties rather than visible ones. Hence, there is the contingency of the current taxonomic landscape.

2.3. Resolution Dependency. Most stellar structural parameters vary continuously from one star to another. Therefore, in the stellar bestiary, there does not exist any level of genuine discontinuity above the level of individual stars. In other words, by analogy with the notion of an "infimic species," defined by Ellis (2002, 57) as "a species that has no subspecies, [and that] is ultimately specific," an astrophysicist cannot expect to come up with "infimic stellar kinds" (more on the important consequences of that point in sec. 4 when I discuss essentialism and realism about kinds). Let us spell out why. Stellar kinds are defined by cutting up the observational continuity into boxes. We have seen that stars are grouped together in a class when they exhibit structural features "similar enough" to those of a standard star picked up to define the class and that those features vary continuously from one star to another. For a given set of similarity parameters, as to whether a star is similar enough to the standard, one depends on the resolution of the observations used by the classifiers. Hence, we have what I call the "resolution dependency" of stellar classifications.[2]

2.4. Vagueness. Another straightforward consequence of stellar structure being defined by continuous parameters (such as temperature and

1. See Jaschek and Jaschek (1990) for a detailed description of the most comprehensive two-dimensional classification system, the Morgan Keenan (MK) system, based on spectral features—spectral type and class of luminosity—observable in the visible spectrum and governed by the temperature and the density of the star, respectively.

2. For instance, the MK system requires spectra at a dispersion of 115 A°/mm (at Hγ). Spectra at higher dispersion have been obtained for stars of a certain spectral type (e.g., O stars) leading to the division of the corresponding "MK box" into finer boxes.

density) is the vagueness of the similarity relations between two stars. As a result, stellar kinds do not have sharp boundaries, and a star may be classified as intermediate between two kinds. As regards the vagueness of the similarity relations, stellar kinds resemble to a certain extent molecular kinds. Because of isomerism, to define molecular kinds, similarity of chemical element composition must be supplemented by similarity of molecular structure. But as Hendry (2006) reminds us, sameness of molecular structure is a vague relation since molecular structure is defined in terms of variables—to wit, internuclear distances and angles between bonds—that vary continuously. As a result, "interatomic geometry will . . . group molecules into vague-bounded, overlapping clusters of similar structures" (869).

2.5. Taxonomic Nomadism. Another important feature of stellar taxonomy is the fact that a star's classification is not a permanent matter: properties on which stellar classifications are based are transitory properties. A star does not have the same temperature, density, mass loss, and so on, throughout its life and, consequently, will not belong to the same category. I will call this specificity *taxonomic nomadism*. Note that the pace of stellar taxonomic nomadism is rather slow. The sun will spend altogether more than 8 billion years in its current category before moving on to another one.

Taxonomic nomadism may turn out to be an embarrassment for certain philosophical standpoints on natural kinds (more on that in sec. 4), but it is a feature much appreciated by astrophysicists. Here is why. Given the timescale of stellar evolution, astrophysicists cannot study evolutionary processes by monitoring the evolution of individual stars. To learn about the different evolutionary phases—in particular, how long a star will spend in each of these phases—they compare how many stars belong to each of the associated stellar kinds. From the statistical repartition of stars into kinds, they are then able to derive information on various physical states along an evolutionary path.

3. Stellar Pluralism. We now have at hand the main sources of pluralism in stellar classifications illustrated at the beginning of this article by the display of the several kinds to which a given star may belong. Two stars classified in the same category of spectral type in the visible spectrum may have different ultraviolet (UV) spectra. This simply reflects the fact that two stars may have similar structural properties governing their visible spectra (say, similar temperature), but they may differ significantly by structural properties governing their UV spectra (e.g., they may have different mass loss). Different investigation techniques focusing on different structural properties thus result in different crosscutting classifications. The use of one domain of wavelength rather than another reflects specific epistemic interests. Astrophysicists interested in, say, the physics of stellar winds need a UV-based classification, whereas those studying evolved stars surrounded by dust rely on infrared-based classifications. And the same goes for the choice of the level of resolution of the taxonomic units: astrophysicists interested in stellar magnetic fields need high-resolution spectral classifications, whereas those studying the chemical composition of stars in order to understand the overall chemical evolution of a galaxy are happy with standard resolution levels.

Stellar taxonomy should please pluralists on several grounds. Pluralists usually draw on the diversity of biological taxa to dismiss the monist quest for a unique correct way of classifying things (Dupré 1993; Kitcher 2001), whereas physics and chemistry are widely considered as monist friendly (see, e.g., Ellis [2002] on the monist side and Slater [2005] on the pluralist side). Stellar taxonomy challenges this traditional partition by extending the domain of relevance of the pluralist claim beyond its usual domain, biology, and by adding to the pluralist's money bag a significant bit of the traditional ally of the monist, namely, the physical sciences.

Moreover, in light of similarities with the familiar case of the classification of chemical elements, stellar taxonomy invites us to reconsider the support this case traditionally brings to a monist standpoint on scientific classification. The main similarity between the two taxonomies is that in both cases, kind membership is conferred by structural properties. But an important difference is that in the chemical case, a single microstructural property, to wit, nuclear charge, happens to be the overwhelming determinant of a large variety of chemical behaviors, whereas we have just seen that no such single behavioral determinant is to be found in the stellar case.[3]

This invites us to clearly distinguish between two claims: the claim that the appropriate kind-membership conditions are structural conditions and the claim that there exists a single kind-membership condition (or set of them) that is central to explaining a large variety of behaviors. Structuralism and monism happen to both hold for chemical elements (and, incidentally, neither holds for biological species), but the stellar case shows us that they do not always go hand in hand: structuralism does not favor taxonomic monism over taxonomic pluralism.[4] If chemistry is, on the face of it, hospitable to taxonomic monism, it is not because its kind-membership conditions are structural—if so, stellar taxonomy would also be

3. As noted by Hendry (2006, 868), atomic weight, e.g., is a negligible factor, except for hydrogen in which the isotope effect might be noticeable.

4. This association between structuralism and monism is often made, not only by monists such as Wilkerson (1993) but also by pluralists (see, e.g., Slater 2005).

monist friendly. Inversely, a case for taxonomic pluralism does not require showing that structural kind-membership conditions cannot be found (note that this is a strategy commonly used by proponents of species pluralism; see, e.g., Dupré 1981).

How then should one interpret the monist friendliness of the chemical element case? Stellar taxonomy draws our attention to a central part of the answer, by putting to the fore what is admittedly much less manifest in other domains of the physical sciences, to wit, the interest dependency of a taxonomic system. We have just seen that different crosscutting taxonomic systems respond to different epistemic interests about stars. Is this interest dependency specific to astrophysics and an exception in the physical sciences? On the face of it, the classification of chemical elements seems rather immune to interest dependency: nuclear charge does not have any serious competitor as a grouping criterion for chemical elements, which would respond to alternative epistemic interests. For all that, this consensus should not be interpreted as vindicating that the periodic table constitutes an interest-free classification of the chemical elements. It can be argued that it rather reflects the fact that, as Hendry aptly emphasizes when contrasting chemistry with biology, "the interests that govern its classifications are more unified" (2006, 865). By contrast, no such unifying character is to be found in the epistemic interests scientists have in living organisms, hence, the much discussed interest dependency and resulting pluralism of the groupings of living organisms and the related hot debate on the elusive proper concept of species. But to make a case for the interest dependency of classifications in the physical sciences, so far, pluralists (e.g., Kitcher 2001, chap. 4) have had to contend with imaginary "fantasies" in which classifiers would have come up with different taxonomic systems, had they started with alternative or less unified epistemic interests. The good news for such pluralists is that astrophysics provides them with an actual case in the physical sciences to support their contention that classifications are also interest dependent in this domain.

The main upshot of my analysis of the grouping of stars is twofold. First, by challenging the idea (still widespread even among pluralists) that at least one domain, the physical sciences, is hospitable to interest-free, monistic classifications, stellar taxonomy further undermines the monist thesis (already significantly weakened by arguments drawing on the diversity of biological taxa) that there exists only one correct way of classifying things that science aims at discovering. Second, it shows that one may have several crosscutting ways of grouping things, all based on the same type of kind-membership condition, to wit, structural. In other words, stellar pluralism is less promiscuous, as regards kind-membership conditions, than taxonomic pluralism is about living organisms and, therefore, less prone to monist objections. For instance, Wilkerson's (1993) attack against Dupré's promiscuous realism on the grounds that too many of the kinds accepted by Dupré do not lend themselves to "serious scientific investigations" is irrelevant to the stellar case. Being all based on structural properties, stellar classifications do sort out stars into kinds that lend themselves to causal explanations and predictions. By contrast with the classifications of living organisms, they do not include any "useful system of classification" (14) where any kind-membership condition goes, as long as it responds to peculiar practical or epistemic needs (as diverse as those of cooks, taxidermists, gardeners, or professional biologists). For all that, are stellar kinds natural kinds?

4. Are Stellar Kinds Natural Kinds? The issue takes us back to the central question I left unanswered earlier, about the correct reading of the notion of "privileged" similarity parameters. It is time now to spell out the proper reading of the notion in the astrophysical context.

As suggested by Slater (2005), taxonomic monism may be split into two claims: a claim about classification—there exists one unique way of classifying things—and a metaphysical claim about the objectivity and the uniqueness of the distinctions demarcating natural kinds. So far, only classificatory monism has been dismissed. Investigating which reading of the notion of "privileged" boundaries is valid in the stellar case will tell us whether, at least, metaphysical monism is tenable. Metaphysical monism states that there exists some natural order, that is, some objective, mind-independent divisions that cut nature at its real joints in a unique way. In other words, the world comes prepackaged with a unique set of objective divisions demarcating natural kinds. Note that metaphysical monism is stronger than realism. It does not only state that there exist real, mind-independent similarities and differences in nature; it also claims that there exists a uniquely privileged set of such similarities and differences, where "privileged" is conceived in an essentialist way. Sharing with Kripke (1972), Putnam (1975), Ellis (2002), and others a commitment to essentialism, here is how Wilkerson (1993, 5) sums up the thesis: "there are many similarities and differences between things, one set is privileged because they are the real essences," the traditional candidates for essential properties being structural properties (e.g., genetic structures for biological species, molecular structures for chemical substances).

So does the stellar world come prepackaged with a privileged set of objective divisions demarcating kinds defined by essential properties? Let us consider first whether essentialism is tenable about stellar kinds, before addressing the issue of realism. Essentialism traditionally requires this (see, e.g., De Sousa 1984; Wilkerson 1993; Ellis 1996): kind membership is conferred by possession of an essential property or properties, that is, by a property or properties necessary and sufficient for membership of the kind in question. Moreover, essential properties are what determine lawlike behaviors. Traditional essentialism also requires that a thing cannot belong to more than one natural kind (unless the kinds in question are hierarchically nested kinds) and that natural kinds have sharp boundaries. In the stellar case, structural properties (temperature, density, etc.) are also the obvious candidates to the status of essential properties, for they are the type of properties that determine stellar behaviors. But the kinds they demarcate cannot count as natural kinds for at least two straightforward reasons: stellar kinds do not have sharp boundaries, and a star may belong to more than one kind (not to mention taxonomic nomadism). Sticking to an essentialist conception of natural kinds would lead to the contention that there are far more stellar natural kinds than the stellar kinds currently demarcated by astrophysicists. Actually, in light of what has been said about the continuous character of taxonomic parameters and the lack of infimic kinds, the quest for essential properties inevitably leads us to "individualism" about natural kinds, that is, to count as many kinds of stars as there are stars. But individualism is a rather unappealing option, to say the least, for a central motivation for the search of natural kinds is that they are supposed to be the subject of scientific laws.[5] When you want to explain or predict the behavior of a thing, you identify the kind to which it belongs and apply the laws known to be governing the members of that kind. Saving an essentialist conception of stellar kind would thus come at the price of giving up on the economy of work that scientific generalizations governing the behavior of natural kinds are supposed to provide. The metaphysical monist may agree to pay this price, but such a radically monistic ontology seems not only a bit desperate but also utterly irrelevant to actual scientific practice.

On an essentialist, monistic reading of the term, our quest for privileged similarities and differences demarcating stellar kinds has thus proved fruitless. For want of such a unique set of privileged divisions, let us see now whether, at least, a realist standpoint on divisions demarcating stellar kinds is tenable. Are differences demarcating stellar kinds objective? Are they discovered rather than conventionally marked by the classifier? We have to be careful here about what a negative answer means. Denying as I do that there are objective distinctions between stellar kinds does not mean that taxonomic features are not real, mind-independent features of the world. I do take temperature and density as objective features of the

5. Note that a monist such as Wilkerson (1993, 16) bites the bullet and admits that individualism is indeed a possibility for biological species defined in an essentialist way by their genetic structure, but he immediately adds that it is very unlikely that we finished up with as many natural kinds as individuals. No such potential escape from individualism is available in astrophysics.

stellar world: no doubt, differences in terms of structural properties between individual stars are discovered, rather than conventionally marked. But given the continuous variation of taxonomic parameters from one star to another, and the resulting vagueness and lack of infimic kinds, differences demarcating stellar kinds are not discovered but conventionally marked. Realism about stellar kinds is untenable.

So not only does the stellar world not come prepackaged with a unique set of objective, privileged (in an essentialist sense) divisions, but also it does not come prepackaged with objective divisions, tout court. In that respect, metaphysical monists and realists end up on the same boat: their only option to accommodate stellar kinds is to retreat to the unsavory individualist standpoint on natural kinds.

So, are stellar kinds natural kinds? Well, in light of the previous discussion, the answer is a ringing no on any realist reading of the notion, be it monist (essentialist) or pluralist (promiscuous realism à la Dupré). In other words, if they are privileged similarities and differences in the stellar world (and we have seen that, indeed, not just any similarity parameters are taxonomically significant), it is not because they are objective, real ones but because they define kinds that fulfill a useful role in scientific investigations. The appropriate reading of the term "privileged" in the astrophysical context is therefore an epistemological, interest-depending one.

Given this correct reading of "privileged," the next step would be to specify exactly in what epistemological sense stellar taxonomic parameters can be said to be privileged, in order to examine whether they favor one of the current nonessentialist doctrines that ground the fruitful role natural kinds are taken to play in scientific inquiries in terms of explanatory power (LaPorte 2004) or categories allowing reliable predictions (Boyd 1999; Griffiths 2004). My hunch is that stellar kinds will not be easily recruited by any of these doctrines, but establishing this point would require another paper devoted to a thorough analysis of the epistemic virtues of stellar kinds in terms of explanation, inductive prediction, and so on. Meanwhile, one can at least raise the following question: if none of the current standpoints turned out to be hospitable to stellar kinds, would that be an embarrassment for those standpoints?

5. Concluding Interrogative Remarks. When navigating through the intricate variety of currently competing doctrines of natural kinds—from strong, essentialist ones (Wilkerson 1993; Ellis 1996, 2002) to more or less weaker, nonessentialist ones (Dupré 1993, 2002; Boyd 1999; Griffiths 2004; LaPorte 2004)—it is not always clear what their motivations and expectations are as regards existing scientific kinds. Is the relaxation of kind-membership conditions motivated by a desire to avoid ending up, in light of new scientific knowledge, with few candidates, or even no candidate at all, to the status of natural kind? Consider essentialism about biological species—for a long time the canonical examples of natural kinds. When traditional essentialism turned out to be untenable in light of post-Darwinian biological knowledge, was the development of more hospitable kind-membership conditions driven by a desire not to relieve biological species from their traditional status of natural kinds? If so, is tailoring a doctrine of natural kinds so that it includes one's favorite candidates (biological species being the most coveted ones) not a bit circular? For, what makes certain kinds paradigmatic examples of natural kinds to start with anyway? To come back to the stellar case, if none of the current standpoints on natural kinds can accommodate stellar kinds, what will be the appropriate attitude? Will it be tailoring a weaker doctrine that accommodates this newcomer or claiming "so much for stellar kinds, they are just not natural kinds"? The point I want to make is simply this: whatever the answers to those questions are, they will need to be justified by specifying what should be expected from a theory of natural kinds. In other words, as newcomers in the field, what stellar kinds make thus vivid is the need, when discussing doctrines of natural kinds, for being explicit on general metacommitments, to wit, commitments about what should be the constraints on those doctrines brought by the kinds defined and successfully used by practicing scientists. That is all the more reason for ending the philosophical disgrace of stellar kinds since Darwin's and Cournot's outdated verdicts and putting stars back on the agenda of discussions about natural kinds and classifications.

REFERENCES

Boyd, Richard. 1999. "Homeostasis, Species and Higher Taxa." In *Species: New Interdisciplinary Essays*, ed. Robert A. Wilson, 141–85. Cambridge, MA: MIT Press.

Cournot, Antoine-Augustin. 1851/1975. *Essai sur les fondements de nos connaissances et sur les caractères de la critique philosophique*. Paris: Vrin.

Darwin, Charles. 1859/1962. *On the Origin of Species*. New York: Collier.

De Sousa, Ronald. 1984. "The Natural Shiftiness of Natural Kinds." *Canadian Journal of Philosophy* 14 (4): 561–80.

Dupré, John. 1981. "Natural Kinds and Biological Taxa." *Philosophical Review* 1:66–90.

———. 1993. *The Disorder of Things*. Cambridge, MA: Harvard University Press.

———. 2002. "Is 'Natural Kind' a Natural Kind Term?" *Monist* 85:29–49.

Ellis, Brian. 1996. "Natural Kinds and Natural Kind Reasoning." In *Natural Kinds, Laws of Nature and Scientific Methodology*, ed. P. J. Riggs, 11–28. Dordrecht: Kluwer.

———. 2002. *The Philosophy of Nature: A Guide to the New Essentialism*. Chesham: Acumen.

Griffiths, Paul E. 2004. "Emotions as Natural and Normative Kinds." *Philosophy of Science* 71:901–11.

Hendry, Robin F. 2006. "Elements, Compounds, and Other Chemical Kinds." *Philosophy of Science* 73:864–75.

Jaschek, Carlos, and Mercedes Jaschek. 1990. *The Classification of Stars*. Cambridge: Cambridge University Press.

Kitcher, Philip. 2001. *Science, Truth, and Democracy*. Oxford: Oxford University Press.

Kripke, Saul. 1972. "Naming and Necessity." In *Semantics of Natural Language*, ed. D. Davidson and G. Harman. Dordrecht: Reidel.

LaPorte, Joseph. 2004. *Natural Kinds and Conceptual Change*. Cambridge: Cambridge University Press.

Putnam, Hilary. 1975. "The Meaning of 'Meaning.'" In *Philosophical Papers*, vol. 2, *Mind, Language, and Reality*, ed. Hilary Putnam, 215–71. Cambridge: Cambridge University Press.

Slater, Matthew H. 2005. "Monism on the One Hand, Pluralism on the Other." *Philosophy of Science* 72:22–42.

Wilkerson, T. E. 1993. "Species, Essences and the Names of Natural Kinds." *Philosophical Quarterly* 43:1–19.