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Aristotle's Pluralistic Realism

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1. Introduction

Realism about natural kinds goes back at least as far as Plato's *Phaedrus*, which famously employs the metaphor of a butcher to describe the method of collection and division (265D–E).[1] Collection (*sunagôgê*) consists in "seeing together the many scattered things and drawing them into a single form," while division (*diaresis*) involves cutting up each thing "along its natural joints" (*kat' arthra ê$_i$ pephuken*). In doing so, Socrates tells the young Phaedrus, one must be careful not to break any part into pieces "like a bad butcher might do." It is hard not to read Socrates's metaphor as expressing a commitment to the reality of natural kinds. The natural world contains "parts" (cf. *Statesman* 262AB) that are individuated on the basis of real, mind-independent boundaries (the "joints"). Being a bad butcher consists in dividing across those boundaries. In contrast to this, the nominalist claims that nature contains no natural joints; there is simply a continuity of similarities that blend into one another.[2] Therefore, any divisions *we* make are ultimately arbitrary and self-serving. For the nominalist, even our best scientific classifications will be anthropocentric insofar as they reflect properties that we as humans find interesting. Plato was aware of these anthropocentric concerns. At *Statesman* 236D, the Eleatic Stranger criticizes Young Socrates's division of animals into humans and nonhumans by saying that if cranes could speak they would balk at this and insist that the world comes divided into cranes and noncranes. Presumably the theory of Forms is supposed to avoid this problem by grounding division in objective reality. Although biologists no longer take seriously the theory of Forms, they are not very impressed by nominalism either, at least when it comes to the existence of species.[3] Species such as *Pandion haliaetus* and *Vampyroteuthis infernalis* are real groups individuated on the basis of objective biological properties that do not depend on our recognizing them as such.[4]

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While there are various competing theories of natural kinds on the market, the following characterization captures the main idea behind natural kinds.[5] First, natural kinds are groups of things sharing certain objective properties in common, in virtue of which they form a single kind. What makes a kind *natural* as opposed to *conventional* is a difficult issue. One way of drawing the distinction is to say that the former share objective similarities in common while the latter depend mainly on human interests. For this reason gold constitutes a natural kind while all the objects in my garage do not. Second, natural kinds have essences. Typically an essence is understood to be a membership-determining property that is both necessary and sufficient for belonging to a kind. On some more robust theories (such as Aristotle's), the essence also plays a causal role in determining other properties of the kind. For example, having the atomic number 79 not only makes something a member of the kind gold but is also causally responsible for the possession of other characteristic properties, including a certain colour and malleability. Elliot Sober (1980, 354) puts the point this way: "The key idea, I think, is that the membership condition must be explanatory. The essentialist hypothesizes that there exists some characteristic unique to and shared by all members of *Homo sapiens* which explains why they are the way they are. A species essence will be a causal mechanism which works on each member of the species, making it the kind of thing that it is."

Not all theories of natural kinds agree on how to characterize the essentialism involved. One might take kinds to be defined by essential properties without thinking of those properties as being causally responsible for other properties associated with the kind. Nor do all essentialist theories accept the idea that kinds are defined by properties that are both necessary and sufficient for membership. So-called cluster kind theories, for example, take certain properties to be *diagnostic* but deny that they are "essential" in the sense that nothing can lack them and still be a member of the kind. On this account, natural kinds are defined by a cluster of stable features, none of which are necessary and only a subset of which are sufficient for membership in the kind.[6]

While all realists about natural kinds accept Plato's metaphor about cutting nature at the joints, they differ in terms of how they understand the metaphor.[7] Monistic realism is the view that there is only one true set of

(nonoverlapping) kinds for any given scientific domain and that discovering those kinds will yield a single, unified system of natural classifications. By contrast, pluralistic realism sees a given domain as a multidimensional space that can be divided along multiple axes.[8] This multidimensional complexity is not something that can be captured by a single, universal classification. Instead, there are many equally legitimate ways of dividing the objects in that domain into natural kinds, which may cross-classify one another in indefinitely complex ways. For example, the living world might be divided along its 'trophic joints' into one set of kinds (coprophagous, necrophagous, phytophagous, saprophytic, etc.), or along its 'parasitic joints' into another set of kinds (endoparasites, ectoparasites, parasitoids, etc.), or along its 'phyletic joints' into phylogenetic kinds (monophyletic, paraphyletic, polyphyletic).[9] Assuming that each of these divisions picks out a set of real kinds, the pluralist will argue that no one set of kinds should be privileged over another.

In this paper I argue that Aristotle is a *pluralist* when it came to the study of biological diversity: he denies that there is only one true set of biological kinds and that a natural classification will divide those kinds into a single set of exhaustive and nonoverlapping categories.[10] Instead, there are many equally legitimate ways of classifying living things, though no single way of classifying them is privileged over the other. Despite this pluralistic approach to classification, Aristotle remains committed to *realism* and thus shares an affinity with traditional scientific realists who hold that there are objective kinds in nature (such as chemical kinds) delineated by real, mind-independent boundaries.[11] Thus, like Plato, Aristotle thinks the natural world comes divided up into kinds that are somehow "out there" waiting to be discovered and that our best scientific classifications will be those that successfully map out these natural divisions. This interpretation places Aristotle squarely in the camp of *pluralistic realism*.[12]

This reading is similar to that of Pellegrin (1982). On Pellegrin's reading, Aristotle treats classification as a pragmatic exercise in which the division of animals into kinds is "developed for the occasion, adapting their extension and rigor to the needs of the exposition in progress" (115). My reading differs from this in that I take Aristotle also to be a realist

about biological kinds rather than being merely pragmatic about them. That is, despite his pluralistic approach to classification, Aristotle still believed there is a certain naturalness to the various biological groupings (hence the realism). For at the core of each cross-cutting kind lies a real essence that corresponds to an *aitia* or cause. And according to *APo.* II 2, we are justified in claiming that some kind exists once we have discovered that there is a cause that is responsible for the fact that a certain cluster of attributes regularly co-vary. So Aristotle's practice of classification in the biological works is not subjective but identifies real kinds, despite the fact that which kinds are identified is governed largely by the explanatory goals of the classifier. For "explanation" in Aristotle is limited to phenomena that exhibit a determinate causal structure.

My defense of this reading is concentrated in sections §2 and §3. Section §2 establishes the pluralist aspect of this interpretation by showing how Aristotle's biology employs several overlapping divisions without privileging one set of divisions over another. Section §3 attempts to establish the realism by looking at Aristotle's concept of "nature" and the method he recommends for determining the existence of a natural kind. According to this account a genuine kind is a group of individuals sharing a "common nature," which I take to be a nexus of correlations underwritten by a set of causally basic features (the kind's real essence). In the final section (§4) I defend the claim that Aristotle's biology should remain of interest to philosophers and biologists alike insofar as it combines pluralism and realism with a rank-free approach to classification, which some philosophers see as the way forward in systematics. In this context Grene (1974, 74) is surely right that the besieged biologists and their philosophical defenders can learn something valuable by reflecting on the one great philosopher who was also a great biologist.

2. Aristotle's Pluralism

History of Animals I 6 identifies seven major biological kinds, which Aristotle calls the *megista genê* or "Great Kinds:" birds, fish, cetaceans, cephalopods, crustaceans, hard-shelled animals, and insects. Yet, this list excludes many groups that Aristotle finds scientifically interesting enough to investigate. For example, snakes are treated as a unified group sharing a single common nature and containing specific forms that differ only by

degree (e.g. *History of Animals* [*HA*] I 6, 490b24; II 14; III 1, 511a14–15). As we shall see, these are marks of a natural kind. Other significant groupings that Aristotle discusses in his biological writings include: live-bearers and egg-layers; lung-possessors and gill-possessors; claw-possessors (e.g. *Parts of Animals* [*PA*] IV 8, 684a34); horn-bearing animals that lack incisors in both jaws, what we call "ruminants" (e.g. *HA* III 1, 511a28–34; cf. *Posterior Analytics* [*APo.*] II 14, 98a13–19); bipeds, quadrupeds, and footless animals; walkers, crawlers, leapers, and fliers (e.g. *Progression of Animals* [*IA*] III; *Generation of Animals* [*GA*] I 1, 715a27–8); political (*politika*) animals, which include humans, bees, ants, and cranes (*HA* I 1, 488a9); and my personal favourite, marine animals that make use of crafty mechanisms (*technika*), which is a rather eclectic group that includes the angler fish, various sea snakes, torpedo fish, fox sharks, cuttlefish, and many more (*HA* VIII 37).[13]

According to the traditional view Aristotle assumes as uncontroversial that there is a single correct way to classify animals into kinds, which could be formulated in a single taxonomy (M. Tweedale, personal communication). Yet, a complete survey of all the ways that Aristotle divides up the living world reveals a tendency to classify things from a "multiplicity of viewpoints" (to borrow Pellegrin's phrase), a practice which often leads to multiple cross-classifications and overlapping kinds. And yet, none of these ways of dividing up the biological landscape appears to represent a privileged classification. Rather, each set of divisions proves to be useful for a different causal investigation.

There are two main pieces of evidence that support this pluralistic reading. The first are the several occurrences of cross-division, where a division of animals into one set of kinds can be shown to cut across a division into another set of kinds. And yet neither way of classifying animals is said to be privileged over the other in any absolute sense. The following example makes the point explicit.

Division 1. In *GA* II 1 Aristotle carves up the biological landscape according to differences in mode of reproduction, which yields four extensive kinds: live-bearers, egg-layers, larva-producers, and animals that are spontaneously generated (732a26–733a1; cf. *HA* I 5, III 1). This classification identifies the primary reproductive kinds that are the focus of inquiry in the *GA*. From this perspective lizards and turtles are grouped together with fish, birds, and snakes as *egg-layers*, while cetaceans are

grouped with humans, elephants, and bats as *live-bearers*. Some of the insects are then marked off as *larva-producers*, while others are said to be *spontaneously generated*.

Division 2a. When Aristotle turns from reproduction to locomotion in the *IA* (cf. *HA* I 1, 5), the very same animals are regrouped into a different set of kinds. Here two main differentiae are used to classify animals. In some places, Aristotle groups animals according to their type of locomotion (*IA* III). The primary division here is into those that change place with their whole body at the same time (e.g. jumpers) and those that do so part-by-part (e.g. walkers).[14] From this perspective lizards and turtles are classified together with humans, elephants, and crabs as *walkers*, cetaceans go with fish, water snakes, and crustaceans as *swimmers*, while birds, bats, and insects make up the class of *flyers*.

Division 2b. In other places, Aristotle groups animals according to the parts used for locomotion. From this perspective birds and humans are classified together as *bipeds*, elephants, lions, lizards, and crocodiles as *quadrupeds*, insects as *polypods*, while cetaceans, fish, and snakes are classed as *footless* animals.

Division 3. Finally, in *On Respiration* Aristotle divides animals according to their different ways of cooling themselves, giving us three major refrigerative kinds: lung-possessors, gill-possessors, and membrane-possessors.[15] From this perspective, cetaceans get reclassified with lizards, humans, and birds as *lung-possessors*, separating them off from fish, cephalopods, and all the other marine animals that cool themselves by means of *gills*, leaving the insects as the only animals that cool themselves by means of a *vibrating membrane*.

It is easy to see that these different ways of classifying animals partition the biological world into kinds that cross-cut one another. For example, Division 1 cuts across Division 3: some egg-layers are lung-possessors (e.g. birds, lizards, turtles, all the snakes except the viper), while others are gill-possessors (e.g. the bony fish); likewise, some live-bearers possess lungs (e.g. humans, cetaceans, horses, vipers), while others possess gills (e.g. certain sharks and rays). Division 3 also cuts across Divisions 2b: some lung-possessors are two-footed (humans and birds), some four-footed (e.g. horses, oxen), some footless (e.g. whales and dolphins), and at least one four-footed animal is a gill-possessor (e.g. the

water newt: *On Resp.* 476a5).[16] Aristotle himself draws our attention to the fact that Division 1 overlaps with Division 2a:

> In fact there is a good deal of overlapping among the kinds. For not all two-footed animals are live-bearing (for birds are egg-laying) nor are they all egg-laying (for humans are live-bearing), and not all four-footed animals are egg-laying (for horses and oxen and a great deal of others are live-bearing) nor are they all live-bearing (for lizards and crocodiles and many others are egg-laying). Nor does the difference even lie in having-feet or not-having-feet; for some footless animals are live-bearing (e.g. vipers and the cartilaginous fish), while others are egg-laying (e.g. the kind consisting of fish and the remainder of the snakes). And of the footed animals many are egg-laying, many live-bearing (e.g. the four-footed animals already mentioned). There are two-footed animals which are internally live-bearing (e.g. humans) and footless ones as well (e.g. the whale and dolphin). So we find no means of making a division here. (*GA* II 1, 732b15–27)

Finally, these different ways of classifying animals cut right across the so-called Great Kinds of *HA* I 6. For example, Division 1 breaks up the fish: bony fish are egg-layers, cartilaginous fish (with the exception of the fishing frog) are live-bearers,[17] while eels are spontaneously generated (*GA* III 11). The division into larva-producers and spontaneously generated animals also breaks up the insects, while Aristotle's locomotive kinds break up the cephalopods (some cephalopods are footed walkers, while others are footless swimmers: *PA* IV 9, 685a14–15).

The other piece of evidence that suggests Aristotle was a pluralist about classification comes from those animals that he describes as being "*epamphoterês*." Such animals are susceptible to multiple ways of classifying them. Some of their features are best explained by classifying them as one kind of animal, while others are explained by classifying them under another (mutually exclusive) kind. The most spectacular example is the Libyan ostrich. Incredibly, Aristotle claims that the Libyan ostrich is both a bird *and* a live-bearing quadruped, which explains why this strange animal possesses some of the features characteristic of the one kind and some characteristic of the other kind:

> In the same way, too, the Libyan ostrich [is ambiguous between two kinds]. On the one hand it has the character of birds, on the other hand that of the live-bearing quadrupeds. For as a non-quadruped it has feathers but as a non-bird it does not take to the air in flight and its feathers are not useful for flying but are hair-like. Furthermore, as a quadruped it has upper eyelashes and is

> bald around the head and above the neck, so that it has hairier eyelashes. Yet as a bird the lower body is feathered, and while as a bird it is two-footed, as a quadruped it is hoofed. For it has, not toes, but hoofs. This is because its size is not that of a bird but of a quadruped; for generally speaking, it is necessary for birds to be as small as possible with respect to their size, since it is not easy for a body of great mass to get off the ground. (*PA* IV 14, 697b13–28)

This example nicely illustrates how classification is tied to explanation.[18] In order to explain why the ostrich's lower body is covered in feathers and why it is two-footed we need to classify it as a bird and then ask why those features belong to all birds *qua* bird. For the cause of those features are to be found at the level of *that* wider kind. But if we want to explain why the ostrich is bald around the head and above the neck, has eyelashes, and sports hoofs instead of split toes, we need to reclassify it as a quadruped and look for the cause the level of *that* kind. The crucial point here is that, for Aristotle, there is no single privileged way of classifying the ostrich, either as a bird or as a quadruped, but rather how we classify it depends on what features we are trying to explain. If we want to know why it has some traits, we need to treat it as a bird; if we want to know why it has other traits, we need to treat it as a quadruped. A commitment to the idea that there is one and only one way to classify each animal would inevitably leave some of its traits unexplained.

My other example follows the same pattern. In *HA* II 8 Aristotle tells us that apes, monkeys, and baboons can be classified both as bipeds and as quadrupeds, since they share in the essential properties of both kinds (502a16–24). This has explanatory significance. In *PA* IV 10 we are given a causal explanation for why bipeds have haunches but lack a tail, while quadrupeds have a tail but lack haunches. We are then told that being intermediate between these two kinds explains why the ape lacks both features: "The ape, because it is intermediate between the two (*epamphoterês*) with respect to its form, and because it is neither and both, has neither a tail nor haunches: *as a biped* it lacks a tail, and *as a quadruped* it lacks haunches" (689b32–4). Again, how we classify the ape depends on what features we want to explain. If we want to know why it lacks a tail, we need to treat it as a biped; if we want to know why it lacks haunches, we need to treat it as a quadruped. There is no privileged way of classifying the ape from an unqualified perspective.

There is a worry here about substances having multiple essences and thus being subject to multiple definitions, a position that Aristotle undoubtedly rejects. The worry can be reduced by noting that its force derives from the thinking of an essence (the object of definition) as a single property. In that case in order to be a bird *and* a quadruped the ostrich would have to have two essences. But Aristotle thinks biological kinds are characterized by essences composed of multiple attributes (*PA* I 3), some of which may be part of the essences of other kinds. His essentialism only requires that the entire complex of attributes that makes up a kind's essence picks out that kind uniquely (*APo.* II 13, 96a24–b1). The *single* essence of the Libyan ostrich will thus be defined by a *single complex* of multiple attributes, some of which are characteristic of birds and others characteristic of quadrupeds.[19]

For Aristotle, then, there is no single way of classifying animals from some absolute, context-free perspective. Instead, how we classify animals depends on the problem at hand: what wider kinds we subsume an animal under depends on which of its features we are trying to explain. This is hard to square with the idea that Aristotle was committed to a form of monism when it came to classification. For Aristotle, there is no one way of carving nature at the joints that will fit all animals into a single set of mutually exclusive, exhaustive, and nonoverlapping kinds. Instead nature contains many cross-cutting joints, and which joints we choose to cut along depends in large part on the explanatory aims of the biologist. The embryologist divides the animal kingdom according to the various modes of reproduction, while the student of biomechanics divides by the different ways of moving in space. And yet a division of animals into swimmers, walkers, flyers, and crawlers will be of no use to the biologist studying animal refrigeration. The set of problems that define her inquiry require dividing the world into lung-possessors, gill-possessors, and membrane-possessors.

There is one passage that appears to commit Aristotle to monism. In *PA* I 2 Aristotle criticizes Platonic division for splitting apart certain kinds that he claims ought to be kept together:

> Further, one should avoid tearing each kind apart, e.g. putting some of the birds in one division and some in the other, as the written [sc. Platonic] divisions have done; there, some of the birds end up divided off with the water-dwellers, some in another kind. . . . If, then, nothing alike in kind

> should be torn apart, division into two is worthless. For people who divide in this way necessarily separate and tear apart; some of the many-footed things are among the land-dwellers, while some are among the water-dwellers. (642b10–19, Lennox trans.)

It is tempting to read this passage as treating certain kinds as privileged so that any divisions that split them up must somehow be unnatural. However, as we have just seen, this way of reading the text faces the problem that Aristotle himself is willing to split up kinds when the occasion calls for it.

One way to avoid this tension is to distinguish between one set of "true kinds" (e.g. the Great Kinds) and downgrade all cross-cutting groups to mere pragmatic groupings formed for expedience.[20] While this might work for a group like the "*technika*" (*HA* VIII 37), which is a motley crew of animals from different Great Kinds, it will not work for groups like egg-layers and lung-possessors, which (as we shall see) bear all the hallmarks of Aristotelian natural kinds. The alternative is to take the claim that "one should avoid tearing each kind apart" and "nothing alike in kind should be torn apart" as being relative to the division under consideration. Thus, for example, when dividing by mode of reproduction we should avoid tearing apart those groups that share a common reproductive nature (e.g. live-bearers, egg-layers, etc.). However, when dividing by mode of locomotion those same animals should be kept apart as belonging to different kinds (e.g. flyers and swimmers), since their locomotive features are the same only by analogy.

A further worry arises from the fact that Aristotle's so-called Great Kinds (birds, fish, etc.) appear to play a special role in the organization of his various biological treatises. For most of the time Aristotle's discussions proceed according to the Great Kinds.[21] The role of the Great Kinds in Aristotle's biology is a very complicated issue, and I do not have the space to offer anything more than a cursory response. The key question is whether or not Aristotle *privileges* these kinds as having inviolable boundaries such that any divisions that cut across those boundaries must fail to pick out "true" kinds. The answer seems to be 'No'. For example, while Aristotle often treats the fish together as a single kind, he thinks that it sometimes makes better sense to classify the cartilaginous fish with things that are not fish for the purpose of explaining some of their features—for example, when trying to understand certain parts of their reproductive

anatomy that make no sense when compared with other fish (e.g. *GA* 716b26–33, 718a35–b2, 718b34–719a2, 732a26–b7). Although I have only pointed to a few such examples, they are evidence of a tendency on Aristotle's part to split up the Great Kinds when the occasion calls for it. It is this tendency towards splitting that is important for my reading. For it shows that Aristotle did not treat the Great Kinds as *ontologically* privileged so that "don't tear apart the Great Kinds" is not an overriding concern of his systematics. However important the Great Kinds might be as *organizational* concepts, they do not enjoy a privileged status as *ontological* groupings.

3. Aristotle's Realism

So far I have argued that Aristotle was a pluralist when it came to biological classification. According to this view, there are a number of equally legitimate ways of dividing living things into kinds, and these kinds often overlap with one another. Within this pluralistic framework, no one set of kinds is privileged in any absolute sense; rather, which set of kinds is selected for a given inquiry depends on the explanatory goals of the inquirer. Despite this fact, Aristotle remained committed to realism. For Aristotle, the kinds from which the inquirer selects are *natural* kinds delineated by objective, mind-independent boundaries. Defending that thesis will be the focus of this section.

A common objection to the idea of pluralistic realism is that the pluralism involved is far too liberal. Without any clear criteria for deciding which classifications are legitimate and which are not, pluralistic realism allows anything to count as a genuine kind and thus loses its connection with reality:

> The metaphysical angst that many realists experience with pluralism concerns the extent to which one can make sense of the idea that there are incompatible but equally 'natural' (i.e., real) ways in which a science can taxonomize the entities in its domain. There is at least the suspicion that . . . pluralism is driven more by the 'purpose of the classification' than by the 'peculiarities of the organisms in question'. . . . (Wilson 1999, 203; cf. Wilkins 2003, 623–24)

The worry here is that pluralistic realism simply collapses into a form of conventionalism, with classification depending entirely on the interests of

the classifier.[22] Aristotle's version of pluralistic realism avoids this problem, since the possession of shared similarities is necessary but not sufficient to constitute a genuine kind. For Aristotle, natural kinds are limited to those groups whose shared similarities are underwritten by common causes. In this way Aristotle's approach differs from other versions of pluralistic realism that treat all (or most) classifications as equally legitimate.[23]

This reading is supported by two considerations. First, according to *PA* I 4, genuine kinds (*genê*) are groups that (1) share "a single common nature" and (2) contain "forms that are not too distant" (644b1–6). The second condition has to do with a distinction between higher-level kinds (such as birds and snakes), which are divisible into forms, and so-called *infima species* (such as humans), which are not. The idea is that, while different forms of wider kind all share a common nature, that common nature will differ in each form by what Aristotle calls "the more and less." So, for example, while all birds have beaks, each form of bird (e.g. sparrow, curlew, osprey) has a beak whose particular structure differs by degree along its various dimensions (e.g. longer/shorter, curved/straight, etc.).[24]

What exactly it means to share a "single common nature" is more difficult. However, the rough outlines of an answer can be sketched by considering Aristotle's different uses of the term "nature" (see *Physics* II 1, *Metaphysics* V 4). Although "nature" is said in many ways, there are two uses that are particularly relevant here. First, Aristotle often associates the nature of a thing with the basic form that results from its normal development (*Metaphysics* V 4, 1015a11–12). In this sense having wings, a beak, and two backwards-bending legs will be part of the common nature of a bird (*HA* II 12), while being footless, blooded, and covered in horny plates is part of the common nature of snakes (*HA* I 6, 490b23–4). However, "nature" is also said to be "a certain principle and cause" of a thing's characteristic attributes insofar as it is the "inner source" of the changes that produce them (*Physics* II 1, 192b21–3, 193a30–1, 199b31). This is the key to Aristotle's account of natural kinds. What makes a group of similar individuals a genuine kind is the fact that their shared attributes all result from the same intrinsic causes, which Aristotle identifies with the kind's real essence.

With this in mind let me turn to Aristotle's account of egg-layers in *GA* III in order to demonstrate how, despite overlapping with other important biological kinds (including the Great Kinds), this group constitutes a natural kind in the technical sense. In *GA* III Aristotle identifies a network of interrelated egg-laying features that are correlated with one another in systematic ways. At the core of this network lies a common set of causes (including shared developmental capacities, reproductive goals, and a particular material constitution), which together give rise to all those features that mark off the egg-layers from other reproductive kinds. More fine-grained differences within these common causes in turn explain the specific "more-and-less" differences that mark off one form of egg-layer from another (as predicted by *PA* I 4). For example, all egg-layers are said to be colder and more solid in their nature than their live-bearing counterparts, which explains why they all lay eggs rather than bear live young (*GA* II 1, 732b29 ff.). However, where an egg-layer is located within this particular range of the hot-cold/fluid-solid continuum causally determines the kind of egg it lays (*GA* 751b8–752a10):

1. Those egg-layers whose material nature is hottest and most fluid (e.g. snakes, lizards, and land-dwelling birds) produce 'double-coloured' eggs that are completely separated into white and yolk.
2. Those whose nature is coldest and least fluid (e.g. bony fish, cephalopods) produce 'single-coloured' eggs that are not at all separated into white and yolk.
3. Those whose nature lies between these two extremes (e.g. water-dwelling birds) produce eggs that are only partially separated into white and yolk.

These more-and-less differences in the internal structure of the egg are then further correlated with other reproductive differences, including where the embryo develops inside the egg (*GA* 751b4–7, 754b20–7), the shape of the egg (*GA* 752a11–21), and whether or not it can be fertilized multiple times (*GA* 757b7–14). In this way, differences in the material nature of an egg-layer (where it lies on the hot-cold/fluid-solid continuum) cause differences in the internal structure of its eggs, which are in turn causally linked to other specific egg-laying features.

In this example, the material nature of the animal is causally basic. But there are other causes involved in explaining other differences between egg-layers, including formal, final, and efficient causes. For example, all members of the kind produce embryos that develop inside an egg (for the same reason), which generates the need for protection—a final cause. Now in the hotter egg-layers (e.g. birds and snakes) this goal is satisfied by producing a hard shell around the egg. But since shells are hardened by heat, egg-layers that are too cold (e.g. bony fish) can only produce a soft-shelled egg. And since these animals are also naturally prolific, they must lay their eggs before they finish growing, since the female cannot carry a large clutch of full-sized eggs inside herself. But this makes their eggs vulnerable to predation. In order to compensate for this, their eggs get injected with a special yeast-like substance that causes them to expand rapidly after being laid. This causal mechanism provides the necessary protection for the preservation of the kind, which in other egg-layers is achieved by a hard shell.[25]

This example nicely illustrates how developmental, material, and teleological causes all conspire to produce a network of other egg-laying attributes included in the common nature of the kind. Aristotle's emphasis on common causes behind the shared attributes of egg-layers, and on the correlation between those attributes and other egg-laying features, is exactly what we should expect if he is thinking of the egg-layers as a natural kind with the right causal structure for being an object of scientific inquiry.

The claim that Aristotle limits natural kinds to those groups whose shared similarities are underwritten by common causes is further evidenced by the way he thinks a science goes about determining whether or not its basic kinds exist. In *APo.* II Aristotle divides scientific inquiry about kinds into three stages:[26]

Stage 1. We do not yet know if the kind K exists; all we have is a preliminary grasp of a set of properties that are correlated with one another in regular ways.

Stage 2. We know that K exists (it is a real kind), but we do not yet know what it is to be a K (we lack knowledge of its essence).

Stage 3. We know both that K exists and what K is (we grasp its essence).

The key to this approach is Aristotle's insistence that the answer to "Why is it?" which states a cause, and the answer to "What is it?" which states an essence, are identical (*APo.* II 2, 90a15–19). In this way we come to know the essence of a kind at Stage 3 by discovering the cause of those shared similarities grasped in Stage 1. More importantly for our purposes, we know that the kind *exists* (Stage 2) once we know *that there is* a cause of those similarities, even if we do not yet know what that cause is (*APo.* II 2, 89b37–90a1).

We can illustrate this method using a simplified example. Imagine the kind cuttlefish (*Sepioidea*) was unknown to science. Stage 1 of our inquiry is an empirical investigation aimed at building up a profile of features by establishing correlations among the properties of certain individuals. Lennox (2004, 92) calls these "predicate profiles," or "*loci* of co-extensive predication," which are built up by "establishing links between universal or general differentiae." For example, through careful observations we come to discover a set of general correlations between having eight arms and two tentacles, a single fin around the full length of the body, an internal gas chamber for regulating buoyancy, chromatophores for rapid colour change, and a jet propulsion system. In this way we build up, through induction, a profile of features that are regularly found together in the same individuals. However, at this preliminary stage of our inquiry we do not yet know whether those shared similarities are evidence of a natural kind or whether these correlations are just a coincidence. This is the task of stage 2. According to *APo.* II 2, the inquiry into whether or not we have hit upon a natural kind involves asking whether or not there is an underlying cause (or "middle term" as *APo.* II 2 puts it) that explains the correlations in our preliminary (Stage 1) account.[27] Once we discover that there is a cause—although we do not yet know what that cause is—we are justified in believing that we've got a natural kind. At this point we go on to investigate (in Stage 3) what that cause is. That causally basic feature(s) will correspond to the essence in our complete scientific definition of this newly discovered kind.[28]

For Aristotle, then, what makes a group of individuals a genuine kind is its possession of a determinate causal structure, which we come to discover by this empirical method. It follows that, while scientific classification is driven mainly by the explanatory aims of the scientist, there

are constraints on which groups she can select for her inquiry. And these constraints derive from the world rather than from her own proclivities as a classifier. For whether or not some group constitutes a natural kind depends on whether or not their shared attributes actually do result from common causes. And this depends on certain facts about the world that are independent of our interests. In this way, although the "joints" the biologist chooses to cut along will depend largely on her explanatory aims as a biologist, those joints are prior to her interests. She does not decide where the joints are.

It should be clear by now that Aristotle sees the reality of a kind as being strongly connected with its explanatory power, which in turn derives from the causal structure of the world. Real kinds are just those theoretically important groups that have the sort of causal structure that allows them to enter into scientific explanations. Since not all correlations of properties are due to common causes (e.g. *GA* IV 4, 771b1–13), not all entities that share properties in common will constitute genuine kinds. Coincidental correlations that are not underwritten by common causes will not constitute real kinds and so cannot enter into any scientific explanations (*Metaphysics* VI 2, XI 8, *APo.* I 2).

The type of explanations that are relevant here are what we might call *classificatory* explanations.[29] Here we attempt to explain why some feature *F* belongs to some subject *S* by classifying *S* as a member of some wider kind *K* to which *F* belongs "universally and primitively" (*APo.* I 5), i.e., *F* is a basic feature of *K*. The corresponding *causal* explanation then attempts to demonstrate why *F* belongs to *K* by identifying some aspect of *K*'s nature that is causally linked to *F*.[30] In syllogistic terms, the middle term of a classificatory explanation identifies the wider kind to which the subject in question belongs, while the middle term of the corresponding causal explanation identifies the underlying cause that explains why the feature in question belongs to that wider kind. For example, we explain why deer lack incisors by first classifying them as a form of horn-bearing animal: deer lack incisors *because* they are horn-bearers (the classificatory explanation).[31] Assuming this feature is a primitive attribute of that wider kind, our inquiry then shifts to the level of horn-bearers and asks what it is about horn-bearing animals as such that explains why they lack of incisors. On Aristotle's account, all horn-bearing animals lack incisors

because of certain developmental constraints related to the production of the horns (the causal explanation).[32] This further investigation reveals the ultimate cause for why deer lack this feature.

For Aristotle, then, classification plays an important role in science because it helps identify the right level at which causal investigations should take place; it helps locate the widest kind to which a given feature belongs "universally and primitively" (*APo.* I 4–5, II 14).[33] By consulting the appropriate classification tree, we can see that lacking incisors is a basic feature of horn-bearers. Thus, in order to discover why deer ultimately lack incisors, we must shift our focus to that wider kind and ask what it is about that kind that explains why its members universally lack that property. Clearly the success of this explanatory strategy depends on picking out real kinds with an appropriate causal structure.

Aristotelian natural kinds can also be seen to differ from one another in terms of their explanatory power, depending on the number of features that are explained by being a member of that kind. For example, bird has a high degree of explanatory power; it functions as the middle term in a wide range of classificatory explanations. Thus classifying something as a bird helps explain a whole series of facts about it, including its possession of a beak, two backward-bending legs with four separately articulated toes, a crest and a long haunch bone. This makes the kind bird, we might say, highly inductively projectible.[34] The kinds lung-possessor and egg-layer also have a relatively high degree of explanatory power to them for the same reason. Horn-bearer, on the other hand, is less explanatory. Being a horn-bearer helps explain why an animal lacks a complete set of teeth (*PA* 663b25–644a8; *APo.* 98a13–19), which in turn explains why it produces hard marrow (*PA* 651b30), and why it has a four-chambered stomach (*PA* 674a32–4). But it explains very little else about it. Yet each of these still constitutes a natural kind, for their members all share a set of features in common that result from the same underlying causes (the essence). It is in virtue of this fact that such kinds have the explanatory power they do.[35]

4. Realism, Pluralism, and Systematics

To close this paper I want to draw attention to a further aspect of Aristotle's approach to classification that finds a close parallel with recent trends in contemporary philosophy of biology, namely, its lack of

taxonomic ranks. The aim is to show that Aristotle's biology is not as outmoded as it is often taken to be. On the contrary, it should remain of interest to philosophers and biologists alike insofar as it combines pluralism and realism with a rank-free approach to classification, which many philosophers of biology see as the way forward in systematics.

The contemporary theory of pluralistic realism was first introduced in response to a version of the so-called species problem. Philosophers of biology generally distinguish between the species *category*, which is a rank in the Linnaean hierarchy, and species *taxa*, which are the particular groups of organisms that biologists rank under that category (e.g. *Homo sapiens*, *Alca torda*). In philosophical terms, the distinction is between a general *type* of thing and its concrete *tokens*. One version of the species problem concerns the proper definition of the species category. What is it that makes a group of organisms a species rather than, say, a genus or a phylum? A "species concept" is an attempt to provide an answer to this question by identifying the essential feature(s) that makes all species taxa instances of the species category.

The problem arises because working biologists employ a number of competing species concepts. Some identify species in terms of interbreeding criteria, some on the basis of a shared ecological niche, others based on common ancestry (just to name the three most popular concepts).[36] This is problematic for two reasons. First, in many cases different species concepts partition organisms into different and often cross-cutting species taxa.[37] Second, not all species concepts actually manage to capture all the groups that biologists recognize as "species."[38] There are two general responses to this problem. Monists argue that only one species concept should be adopted by all biologists and that further philosophical (and empirical) work will eventually reveal the right one.[39] By contrast, pluralists embrace the fact that nature contains many different and irreducible types of species and argue that these cannot be captured by a single, universal species concept. Instead, biologists should recognize a plurality of equally legitimate species concepts, each one of which is useful for investigating a different set of biological relationships.[40]

Biologists and philosophers of biology have traditionally drawn an ontological distinction between species, on the one hand, and higher ranks (genera, families, etc.), on the other. While they agree that the higher

ranks do not correspond to any real divisions in nature, the species category is taken to have ontological significance. In other words, "species" picks out a real kind of thing. This has been embraced by both monists and pluralists alike. However, some have urged that a commitment to *pluralistic realism* should actually lead us to doubt the very existence of the species category itself; it entails antirealism about species. Ereshefsky (1998) advocates this position and offers what he calls the "heterogeneity argument" to support it:

> In sum, a realistic interpretation of species pluralism—one that accepts the existence of different types of species taxa—implies that there is no unified ontological category called 'species'. It implies that the species category does not exist. This I take to be the strong argument from species pluralism to the non-existence of the species category. (113)

The heterogeneity argument relies on the principle that some category *K* exists (it is a "unified ontological category") if only if all the members of *K* share a common property that unifies them as *K*s and distinguishes them from all non-*K*s. Species pluralism holds that there are a number of different kinds of species (interbreeding species, ecological species, phylogenetic species, etc.) but denies that there is any common feature that makes them all instances of a species. Each kind of species is defined by a different essential property. Therefore, the argument goes, the species category fails to pick out a unified ontological category: "[T]here is no single unitary species category, but a heterogeneous collection of base taxa referred to by the term 'species'" (Ereshefsky 1999, 290).[41]

It is important to be clear on what Ereshefsky is suggesting here. He is not an antirealist about those entities biologists *call* species: "The heterogeneous nature of the species category gives us reason to doubt the existence of that category, yet it does not give us reason to doubt the reality of the taxa we call 'species'."[42] Our recognition of a distinction between, say, *Cardinalis cardinalis* and *Cardinalis sinuatus* is not an arbitrary boundary imposed on a perfectly continuous world as a result of our own subjective interests. These two groups really do constitute distinct biological entities. Ereshefsky simply rejects the idea that the distinction we make between "species," "genera," and the other Linnaean ranks corresponds to any ontological distinctions within those taxa themselves. In other words, there is no natural reason for ranking these as species rather than genera or varieties; for those ranks are all artificial. As

such, Ereshefsky recommends getting rid of the Linnaean ranks entirely. For Ereshefsky, the way forward is to recognize that there are different types of lineages of greater or lesser inclusiveness, without insisting on their position in some fixed taxonomic hierarchy.

This rank-free approach to classification is precisely the approach adopted by Aristotle. One of the main lessons from the work by Balme (1962, 1987) and Pellegrin (1982) is that Aristotle's twin concepts of *genos* and *eidos*—traditionally translated as "genus" and "species"—do not designate fixed ranks in any taxonomical hierarchy. In particular, they do not function like "genus" and "species" in the modern Linnaean sense. Instead they are relative concepts that can be used to identify groups at any level of inclusiveness in a given division tree.[43] This is why I have insisted on following the more recent conventions of translating *genos* and *eidos* as "kind" and "form (of a kind)." A *genos* designates any group at any level of classification that possesses a single common nature and is divisible into forms whose differences are a matter of degree. An *eidos* is simply one of those divided forms. Thus dogs might be an *eidos* relative to some wider kind (e.g. four-footed live-bearers) and a *genos* relative to some more specific forms (e.g. buhunds, sheppards, spaniels, etc.).

Some have taken this as evidence that Aristotle is simply inconsistent in how he ranks animals. But for Pellegrin and Balme this is incontrovertible evidence that Aristotle was not interested in taxonomic rankings at all. The kind of plasticity afforded to the concepts of *genos* and *eidos* in Aristotle's biological works simply does not sit well with the idea that they were ever meant to pick out fixed ranks in a single taxonomic hierarchy or that they even remotely resemble the modern Linnaean ranks of "genus" and "species." Aristotle's method of classification is free of such ranking concerns.

The upshot of looking at things in this way is that the species (category) problem simply disappears. Aristotle has no species problem precisely because he has no concept of a "species" in our sense. His approach to classification does not involve an attempt to pigeonhole animals into the fixed ranks of some predetermined taxonomic hierarchy. The way he divides animals has no use for such ranks. Thus Aristotle's biology is an interesting case study for Mishler's hypothesis that the current muddle over species concepts is the result of our doomed attempts to shoehorn the diversity of the living world into "an outdated and

misguided classification system, the ranked Linnaean hierarchy," and that the way out of this confusion is simply to remove the ranks.[44] In this sense, it is the dead hand of Linnaeus, not Aristotle, that is impeding real progress in systematics.

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NOTES

1. The topic of natural kinds has both a metaphysical (or ontological) and a semantic dimension. The former deals with the nature of natural kinds, while the latter has to do with the meaning and reference of natural kind terms (Bird and Tobin 2010). In this paper I am interested purely in metaphysical side of the debate.

2. Nominalism in biology goes back at least as far as Lamarck (e.g. 1809, Ch. 3).

3. Biologists have traditionally drawn an ontological distinction between species, on the one hand, and higher taxa (genera, families, etc.), on the other. The latter do not correspond to any real divisions in nature. I return to this in section §4.

4. There is an ongoing debate in the philosophy of biology over whether particular species taxa (e.g. *Homo sapiens*) are natural kinds or individuals. See Ghiselin (1974), Hull (1978), Kitcher (1984a), Dupré (1993, Ch. 2), Coleman and Wiley (2001), Mayden (2002), Brogaard (2004). However, even those who claim that particular species *taxa* are individuals still tend to treat the species *category* as a natural kind with essential properties. (For this distinction see below.)

5. See Wilkerson (1993), Daly (1996), Bird and Tobin (2010, npage).

6. Boyd's theory of "Homeostatic Property Cluster" (HPC) kinds is an example of this approach to essentialism. Boyd takes natural kinds to be groups of objects sharing a cluster of stable properties in common whose co-occurrence is the result of shared underlying homeostatic causal mechanisms, which he identifies with the kind's *real essence* (Boyd 1999). This account of natural kinds has become increasingly popular among contemporary philosophers, especially as an account of biological kinds. As we shall see, it also accords well with view attributed to Aristotle in this paper (see Section §3).

7. There is of course more to realism than the following distinction between monism and pluralism, but this is all that concerns me here.

8. Ereshefksy (1992), Dupré (1993, 1981, 1999), Kitcher (1984a, 1984b), Boyd (1999), Wilkins (2003), Brigandt (2003).

9. Cf. Hennig (1979, 5–6); Ali Khalidi (1993, 105–6).

10. The question of whether or not Aristotle had a deep interest in biological classification as such remains controversial. See Balme (1969, 1987); Pellegrin (1982); Gotthelf (1988); Bayer (1988); Lennox (1990, 2001, Ch. 1, 2005); Charles (2000, Ch. 12). In what follows I shall use "classification" to mean the systematic arrangement of organisms into a hierarchy of kinds on the basis of shared similarities and differences. Understood in this way, Aristotle can surely be said to "classify" animals (e.g. *GA* II 1, 732b15–27). Of

course, classification is never pursued by Aristotle as an end in itself. Instead it is used to achieve other goals, such as constructing definitions (*APo.* II 13, *PA* I 2–3) or generating scientific problems (*APo.* II 14), both of which are related to the primary goal of explanation (see below). Moreover, as Balme (1969) and Pellegrin (1986) have shown, Aristotle never set out to produce an exhaustive "taxonomic" system (as Linnaeus would later attempt to do) designed to locate animals in a nested hierarchy of *fixed* and *exhaustive* ranks (e.g. family, genus, species). In this sense Aristotle can be said to have adopted a *rank-free* approach to classification (see §4 below).

11. On traditional scientific realism, see Wilson (1996, 1999). The literature on natural kinds tends to use "real" and "natural" interchangeably, and I shall follow that lead. By calling Aristotle a realist about biological kinds I do not mean to ascribe to him any position on the ontological status of universals.

12. Although the idea of "pluralistic realism" is discussed mainly in the context of a debate about species concepts to which Aristotle was not party (see section §4), the position itself is part of the broader philosophical discourse on natural kinds (e.g. Ali Khalidi [1993, 106]; Slater [2005]). Indeed, as we shall see in section §4, it is possible to be a pluralist realist without accepting our notion of species.

13. It is a separate question as to whether or not all of these count as "natural kinds" in the sense discussed in Section §2. Undoubtedly some do not.

14. See also *HA* I 1, 487b14–32; *GA* I 1, 715a28; III 1, 749a15.

15. Aristotle thinks these are all mechanisms for cooling an animal.

16. For both of these cross-divisions see *On Resp.* 10.

17. In most contexts Aristotle classifies the cartilaginous fish as a form of live-bearing animal (e.g. *GA* II 1, 732a32, 733b6; cf. *On Respiration* 10, 475b10), although he sometimes treats them as egg-layers (e.g. *GA* I 9, 718b28–719a1; *GA* III 1, 749a18–22) and sometimes as intermediate between the two (e.g. *GA* I 9, 719a11–12). This would be an example of the second kind of case discussed below, where a given animal is susceptible to being classified in multiple (mutually exclusive) ways.

18. For more on this see below.

19. I am grateful to Charlotte Witt and Mariska Leunissen for raising this point.

20. This seems to be what Balme (1987, 85) has in mind by distinguishing true kinds from "mere differentiae classes." Balme does not expand on this distinction, nor do I find any basis for marking such a distinction in Aristotle's use of *genos*.

21. I am grateful to Jim Lennox for pushing me on this.

22. See Ereshefsky (2007, npage). For an extended defense of pluralistic realism against this objection see Ereshefsky (2001, 154–93).

23. Dupre's "promiscuous" realism, for example, treats both common sense and scientific classifications as equally legitimate. This includes the kinds recognized by botanists *and* florists, zoologists *and* culinary experts. Aristotle's realism is not this promiscuous. He is more sympathetic to Wilkerson who ties natural kinds to "causation and explanation" (Wilkerson 1993, 13–14).

24. For a thorough account of this idea see Lennox (2001, Ch. 7).

25. For this account see *GA* III 4, 755a11–b1.

26. See Charles (2000, Ch. 1), Lennox (2004).

27. Compare *GA* IV 4, 771b1–13 for a case where we fail to find a cause.

28. Aristotle's account can be usefully compared with Brigandt (2002) and the characterization of the three stages of scientific inquiry attributed to Bhaskar in Goodwin and Webster (1996, 10–11). Aristotle does not say how we come to know that a certain corre-

lation of features is underwritten by a common cause, though he may be relying on empirical regularities. The fact that B is regularly correlated with A is taken as evidence either that one is the cause of the other or that they are both due to common cause C; for regular correlations could not be due to chance (*Physics* II, 196b10–16; cf. *PA* III 2, 663b27–9; *GA* IV 4, 770b10–14; IV 8, 777a20). If this is right, then Stages 1 and 2 may collapse into a single step. But notice that, while this regularity tells us *that* some cause must exist, it does not tell us *what* that cause is. That requires a further stage of inquiry.

29. The following is based on Lennox (2001, Chp. 1), who calls these "A-type" explanations. "Classificatory" explanation comes from Bayer (1998).

30. These are Lennox's "B-type" explanations.

31. See *APo.* II 14, 98a13–19, as well as *PA* IV 8, 684a33 ("They [sc. lobsters] have claws *because* they are in the kind that possesses claws.").

32. For this explanation see *PA* III 2, 663b28–664a2.

33. Gotthelf (1988).

34. The notion of inductive projectability comes from Goodman (1973), though I am using it in the sense used by Boyd (1999, 147) and Griffiths (1999, 215).

35. Compare Wilkerson (1993, 13–14).

36. For a recent survey of the myriad of different species concepts see de Queiroz (2007).

37. See Mishler and Donoghue (1982, 494–95) for examples.

38. Franklin-Hall (2007) discusses problems concerning the applicability of the biological and phylogenetic species concepts to bacteria.

39. For two recent defenses see Lee (2006) and de Queiroz (2007). See Ereshefsky (2007, §3.2) for further references.

40. For references see note 8.

41. For a response to Ereshefsky's heterogeneity argument see Brigandt (2003). Ereshefsky (1999, 286–90) adds a second argument that claims there are no biologically adequate criteria for distinguishing species from higher taxa, and so again "species" fails to meet the requirements for being a real category.

42. Ereshefsky (1998, 114).

43. For a precise statement of this view see Pellegrin (1982, 68–69) and Balme (1987, 87).

44. Mishler (1999, 311). Mishler is not suggesting we eliminate *hierarchies* from biological classification. The nesting of groups within groups is an essential feature of the tree of life. It is our tendency to assign these levels fixed ranks that he thinks is the source of our current species problem.

REFERENCES

Ali Khalidi, Muhammad 1993. "Carving Nature at the Joints," *Philosophy of Science,* 60: 100–13.

Balme, David 1962. "GENOS and EIDOS in Aristotle's Biology," *The Classical Quarterly*, New Series, 12(1): 81–98.

———. 1987. "The use of differentiae in Aristotle's biology" in Gotthelf and Lennox, eds., 69–89.

Barnes, Jonathan 1975a. Aristotle *Posterior Analytics*. Translation with commentary. Oxford: Clarendon Press.
———. 1969. "Aristotle's Theory of Demonstration" *Phronesis* 14(2), 123–52.
Bayer, Greg 1998. "Classification and Explanation in Aristotle's Theory of Definition," *Journal of the History of Philosophy*, 36(4): 487–505.
Bird, Alexander, and Emma Tobin 2010. "Natural Kinds," *The Stanford Encyclopedia of Philosophy* (Summer 2010 Edition), E. Zalta, ed., URL=http://plato.stanford.edu/archives/sum2010/entries/natural-kinds/.
Boyd, Richard 1999. "Homeostasis, Species, and Higher Taxa" in Wilson, ed., 141–85.
Brogaard, Berit 2004. "Species as Individuals," *Biology and Philosophy*, 19(2): 223–42.
Brigandt, Ingo 2003. "Species Pluralism Does Not Imply Species Eliminativism," *Philosophy of Science,* 70: 1305–16.
Charles, David 2000. *Aristotle on Meaning and Essence*, Oxford: Oxford University Press.
Coleman, Keith A. and E.O. Wiley 2001. "On Species Individualism: A New Defense of the Species-as-Individuals Hypothesis," *Philosophy of Science,* 68(4): 498–517.
Daly, Chris 1996. "Defending Promiscuous Realism About Natural Kinds," *The Philosophical Quarterly*, 46(185): 496–500.
de Queiroz, Kevin 2007. "Species concepts and species delimitation," *Systematic Biology*, 56: 879–66.
Devitt, Michael 2008. "Resurrecting Biological Essentialism," *Philosophy of Science,* 75: 344–82.
Devereux, Dan and Pierre Pellegrin. eds. 1990. *Biologie, Logique et Métaphysique chez Aristote*, Paris: Éditions du CNRS.
Dupré, John 1999. "On the Impossibility of a Monistic Account of Species," in *Species: New Interdisciplinary Essays,* R. Wilson, ed., 3–22.
———. 1993. *The Disorder of Things: Metaphysical Foundations of the Disunity of Science*, Cambridge, MA: Harvard University Press.
———. 1981. "Natural Kinds and Biological Taxa," *The Philosophical Review*, 90(1): 66–90.
Ereshefsky, Marc 2007. "Species," in *The Stanford Encyclopedia of Philosophy* (Summer 2007 Edition), E. Zalta, ed., URL = http://plato.stanford.edu/archives/sum2007/entries/species/.
———. 1999. "Species and the Linnaean Hierarchy," in *Species: New Interdisciplinary Essays,* R. Wilson, ed., 285–305.
———. 1998. "Species Pluralism and Anti-Realism," *Philosophy of Science,* 65: 103–20.
———. 1992. "Eliminative Pluralism," *Philosophy of Science,* 59: 671–90.
Franklin-Hall, Laura 2007. "Bacteria, Sex, and Systematics," *Philosophy of Science,* 74: 69–95.
Ghiselin, Michael 1974. "A Radical Solution to the Species Problem," *Systematic Biology,* 23(4): 536–44.
Goodman, Nelson 1973. *Fact, Fiction, and Forecast*, New York: Bobbs-Merrill.
Goodwin, Brian and Gerry Webster 1996. *Form and Transformation: Generative and Relational Principles in Biology*, New York: Cambridge University Press.
Gotthelf, Allan 1988. "*Historiae I: plantarum* et *animalium*" in *Theophrastean Studies: On Natural Science, Physics and Metaphysics, Ethics, Religion, and Rhetoric*, William W. Fortenbaugh and Robert W. Sharples. eds., Oxford: Transaction Books, 100–35.

Gotthelf, Allan and James Lennox, eds.1987. *Philosophical Issues in Aristotle's Biology*, Cambridge: Cambridge University Press.
Grene, Marjorie 1974. *The Understanding of Nature: Essays in the Philosophy of Biology*, Boston: D. Reidel Publishing Company.
Griffiths, Paul E. 1999. "Squaring the Circle: Natural Kinds with Historical Essences," in *Species: New Interdisciplinary Essays,* R. Wilson, ed., 209–28.
Hennig, W. 1979. *Phylogenetic Systematics*, Urbana: University of Illinois Press.
Hull, David 1978. "A Matter of Individuality," *Philosophy of Science,* 45: 335–60.
Kitcher, Philip 1984a. "Species," *Philosophy of Science*, 51: 308–33.
———. 1984b. "Against the Monism of the Moment: a reply to Elliot Sober," *Philosophy of Science,* 51: 616–30.
Lamarck, Jean-Baptiste 1809. *Philosophie zoologique*. Paris.
Lee, M.S.Y. 2003. "Species Concepts and Species Reality: Salvaging a Linnaean Rank," *Journal of Evolutionary Biology*, 16: 179–88.
Lennox, James 2004. "Getting a Science Going: Aristotle on Entry Level Kinds," in *Homo Sapiens und Homo Faber,* G. Wolters, ed., Berlin: Walter De Gruyter, 87–100.
———. 2001. *Aristotle's Philosophy of Biology*. Cambridge: Cambridge University Press.
———. 1990. "Notes on David Charles on *HA*" in *Biologie, Logique et Métaphysique chez Aristote*, Devereux and Pellegrin, eds., 169–84.
Mayden, Richard 2002. "On Biological Species, Species Concepts and Individuation in the Natural World," *Fish and Fisheries*, 3: 171–96.
Mishler, B. 1999. "Getting Rid of Species?" in *Species: New Interdisciplinary Essays,* R. Wilson, ed., 307–15.
Mishler B. and M. Donoghue 1982. "Species Concepts: a Case for Pluralism," *Systematic Biology* 31(4): 491–503.
Pellegrin, Pierre 1982. *Aristotle's Classification of Animals*, Translated by Anthony Preus, Berkeley: University of California 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," *The Philosophical Quarterly*, 43: 1–19.
Wilkins, John S. 2003. "How To Be a Chaste Species Pluralist-Realist: The Origins of Species Modes and the Synapomorphic Species Concept," *Biology and Philosophy*, 18: 621–38.
Wilson, Robert, ed. 1999. *Species: New Interdisciplinary Essays*. Cambridge: MIT Press.
———. 1999. "Realism, Essence, and Kind: Resuscitating Species Essentialism?" in *Species: New Interdisciplinary Essays,* R. Wilson, ed., 187–207.
———. 1996. "Discussion: Promiscuous Realism," *British Journal for the Philosophy of Science,* 47, 303–16.