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The Illogical Basis of Phylogenetic Nomenclature

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I. Abstract

The current advocacy for the so-called PhyloCode has a history rooted in twentieth-century arguments among biologists and philosophers regarding a putative distinction between classes and individuals. From this seemingly simple and innocuous discussion have come supposed distinctions between definitions and diagnosis, classification and systematization, and now Linnaean and "phylogenetic" nomenclature. Nevertheless, the metaphysical dichotomy of class

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versus individual, insofar as its standard applications to the issue of biological taxonomy are concerned, is an outdated remnant of early logical positivist thinking. Current views on natural kinds and their definitions under a scientific realist perspective provide grounds for rejecting the class versus individual dichotomy altogether insofar as biological entities are concerned. We review the role of natural kinds in scientific practice and the nature of definitions and scientific classifications. Although inherent instabilities of the PhyloCode are clearly sufficient to argue against the general application of this nominally phylogenetic system, our goal here is to address serious and fundamental flaws in its very foundation by exposing the unsubstantiated philosophical assumptions preceding and subtending it.

Resumen

Las propuestas actuales en favor del llamado Código de Nomenclatura Filogenética (PhyloCode) tienen una historia basada en argumentos desarrollados, durante el siglo veinte, por biólogos y filósofos sobre una distinción putativa entre clases e individuos. De esta simple y aparentemente inocua discusión han surgido supuestas distinciones entre definición y diagnosis, clasificación y sistematización, y ahora entre nomenclatura Lineana y "filogenética." Sin embargo, la dicotomía metafísica clase contra individuo, al menos en lo concerniente a su aplicación estándar al tema de taxonomía biológica, es un remanente obsoleto del pensamiento positivista lógico. Opiniones actuales sobre categorías naturales y sus definiciones bajo la perspectiva del realismo científico proveen bases para rechazar por completo dicha dicotomía, al menos en lo que concierne a las entidades biológicas. En este artículo se revisa el papel de las categorías naturales en la práctica científica, y la naturaleza de las definiciones y la clasificación científica. Aún cuando la inestabilidad inherente en el Código de Nomenclatura Filogenética es claramente suficiente para argumentar contra la aplicación general de este sistema nominal filogenético, el objetivo de este artículo es mostrar las serias y fundamentales deficiencias en sus propias bases al exponer las suposiciones filosóficas sin fundamento que le preceden y sustentan.

II. Introduction

The current advocacy for the so-called PhyloCode has a history rooted in twentieth-century arguments among biologists and philosophers regarding a putative distinction between classes and individuals. From this seemingly simple and innocuous discussion have come supposed distinctions between definition and diagnosis, classification and systematization, and now Linnaean and "phylogenetic" nomenclature. Although inherent instabilities of the PhyloCode (Dominguez & Wheeler, 1997; Nixon & Carpenter, 2000; Forey, 2002; Carpenter, 2003; Schuh, 2003) are clearly sufficient to argue against the general application of this nominally phylogenetic system, no rebuttal would be complete without addressing serious and fundamental flaws in the philosophy that is its very foundation.

Because the initial argument for individuality of species and taxa was given free reign in the systematics literature, it has become intertwined with a number of more or less related issues, making it virtually impossible to discuss in isolation. Each of these issues could be the subject of one or more in-depth analyses. This, however, would fail to give an overview of the breadth of the problem and a context for such detailed arguments. Our goal here is to, as briefly as possible, lay out our objection to the PhyloCode and, in particular, to unsubstantiated philosophical assumptions preceding and subtending it. We recognize the inadequacy of a terse argument against several decades and several scores of published articles, but we suggest that this is a first necessary step in articulating clearly the nature and range of the issues at hand.

In the first part of this article we lay out briefly what we identify as the general philosophical position behind the PhyloCode, which we take to be derived mostly from the now standard perspective developed inside the philosophy of biology to treat species and higher taxa as individuals. We identify this biological thesis as part of a general philosophical critique of Aristotelian essentialism within the empiricist tradition[1] developed mostly from a commitment to Lockean nominalism. We argue that, although the empiricist rejection of Aristotelian essentialism in biology is well taken, its alternative—i.e., the thesis that species are individuals—is unsatisfactory. We then present criticisms and objections that have been raised against the nominalist conception of essences and scientific kinds from a scientific realist perspective. The realist alternative in thinking about natural kinds and their definitions amounts to the adoption of a radically different approach to the understanding of scientific classifications in general, and we describe some of its consequences for biological taxonomy in particular. We hope to persuade the reader that the realist critique is severe enough to allow us to abandon the basic tenets of species individualism and, by so doing, expose the inadequacy of the PhyloCode.

III. The Philosophical Background of Phylogenetic Nomenclature: A Rejection of Aristotelian Essentialism in Biology

We can separate the conceptual issues that form the philosophical basis of the PhyloCode and its "phylogenetic definitions" into two distinct, but highly connected, theses. The first is that species and higher taxa are best viewed as conceptual individuals and not classes of similar organisms. The second is the view that we should construct taxonomies by ordering species into a system based on their natural relationships instead of arranging them into classes of increasing inclusiveness by virtue of their shared characters. Both of these theses are part of a reaction against traditional essentialism that has taken place within biology since the middle of the twentieth century.

Essentialism in biological taxonomy, also known as "typology," is commonly associated with anti-evolutionism. In a now classical work, Hull (1965) points out that taxonomy, prior to Darwin, was largely influenced by an "essentialist" theory of definition that could allegedly be traced back to the writings of Aristotle.[2] The essentialism that Hull refers to entails that species and higher taxa, or any other natural kinds, possess definitional essences that define them in terms of necessary and sufficient, intrinsic, unchanging, and ahistorical properties. Under this view taxa are to be conceptualized in very much the same way that classes or sets normally are in logic.[3] Noting that this view is largely incompatible with evolutionary theory, Hull welcomed the fact that contemporary taxonomists had already started to abandon it. Mayr's insistence that we abandon "typological thinking" in favor of "populational thinking" (1976) is one of the most familiar examples of the conceptual shift identified by Hull. However, it is worth noting that, as Panchen (1992) has rightly pointed out, what Mayr identifies as "typology" corresponds to Platonic idealism—the view, in taxonomy, that a perfect ideal type or form exists characteristic of a given taxon, e.g., a *Bauplan*—rather than to a strictly Aristotelian version of essentialism.

A. INDIVIDUALISM

As an alternative to the traditional conception of species and other taxa as kinds or classes, Ghiselin (1966b, 1969, 1974, 1987a, 1987b, 1988, 1989, 1997), and a large number of philosophers and biologists (e.g., Löther, 1972; Griffiths, 1974; Hull, 1974, 1976, 1977, 1978; Mayr, 1976; Mishler & Brandon, 1987; de Queiroz, 1988; Ridley, 1989; de Queiroz & Gauthier,

1990; Kluge, 1990; Frost & Kluge, 1994; Baum, 1998; Ereshefsky, 2001) have argued that such entities are better conceptualized as individuals.[4] As such, species and higher taxa do not possess definitional (nominal) essences; that is, we cannot define them, merely diagnose them. They are spatiotemporally localized, cohesive, and continuous entities. They do not have members; rather, they exhibit part–whole relations among their constituents. Their names are proper names, just as in the case of individual organisms. Despite earlier comments on the absurdity of such views (e.g., Patterson, 1982; Farris, 1985; Nelson, 1985; Ruse, 1987), the thesis has gained immense popularity and has been the subject of dozens of publications. In the present discussion we refer to this view and all its consequences as "individualism."

Ghiselin's original argument to support individualism is a mixture of a particular theory of definition, some basic logic, and an appeal to metaphysical "correctness." First, he sets out his theory of meaning and definition (1966a), complaining that systematists often fail "to distinguish between the definition of words and the identification of things" (1966b: 207). In his view "one does not define a thing, one describes it. Definitions apply only to words, not to the things to which the words correspond. . . . Usage being conventional, definitions are perfectly precise, exactly because they say nothing empirical" (1966a: 127). Moreover, "[d]efinitions are all *nominal* in the sense that we define names and not the things named" (1987b: 134, emphasis added). Then he turns to consider species, asserting that "it would be nonsense to say that one *defines* a species. Species are discovered, described and named" (1966a: 128, emphasis added) and concluding that "[b]iological species are, in the logical sense, individuals, and assertions to the contrary reflect mere verbal confusion" (1966b: 209).[5]

The theory of meaning and definition that Ghiselin is describing in the paragraphs quoted above is part of the standard philosophical conception in the empiricist tradition according to which scientific (and everyday) kinds are defined by purely nominal essences or by other conventional specifications of membership conditions. This view on definitions has been called "methodological nominalism" (Popper, 1957; see also de Queiroz, 1994). There is another perfectly good sense of nominalism that pertains to the existence or reality of such kinds—one according to which only individuals are real, whereas classes, kinds, or universals are abstractions. Ghiselin (1966b) also acknowledges this nominalist view and contends that, because species are individuals, we can see that nominalism is fully consistent with the real existence of such biological entities. Treating species as kinds or nominal classes will entail that they have no real existence—that they are purely conventional groups of organisms.[6]

This simple metaphysical consequence about the reality of species taxa, derived from the traditional nominalist conception of kinds, is probably the major reason why the view that species are individuals has been accepted among biologists almost unquestioned. In general, biologists hold a "realist" position regarding species taxa, having the intuition that their existence is largely independent of our theorizing (e.g., Bryant & Cantino, 2002). For example, Baum (1998: 651) recently remarked that "[w]ithout a claim of individuality, it is difficult, if not impossible, to claim that species have independent existence." We will return to the issue of "realism about" species and other scientific categories later.

What is important to note about Ghiselin's original individualism is that it was introduced primarily as a way to deal with his truism about the reality of species taxa and only secondarily as a conceptual resource to accommodate evolutionary considerations surrounding species. In fact, the eighteenth-century French naturalist Buffon, who maintained a nominalist view about the world, considered species to be individuals while holding a nonevolutionary view of them (Sloan, 1987). This suggests that considerations about species evolution may not be so crucial in the debates over the nature of species as kinds or individuals (Gayon, 1996). Interestingly enough, Buffon used nominalist arguments, similar to the ones posited by Ghiselin, to attack

his contemporary, Linnaeus, and his system of nomenclature, which was gaining popularity in the mid-1700s (Sloan, 1976; Papavero et al., 1994).

The compatibility of individualism with evolutionary theory was more fully and clearly articulated by Hull (1976, 1978) after Gishelin's first arguments about meaning and definition. Hull emphasized the historical nature of species under the Darwinian paradigm. Species have a unique beginning, are continuous in time, and have a unique end. Once a species ceases to exist, once it is extinct, no new organism can reevolve that will belong to that particular species. Individuals are supposed to have this specific characteristic of spatiotemporal restriction, all other properties being mere accidents and therefore of secondary importance for evolutionary theory. Furthermore, defining a species by the possession of necessary and sufficient characters will putatively fail because evolutionary change results in the modification or loss of the defining characters without the species losing its individuality. Therefore, the defining characters are not necessary and sufficient for the species' identity. In the absence of such defining characters, the names of species must by fixed by ostension—i.e., by "pointing at" the species —in the same way that proper names are fixed to individual organisms like Michael or David (Ghiselin, 1974, 1995; Hull, 1976, 1978).

Issues of reality and spatiotemporal localization are the main metaphysical concerns of individualism and the source of an emphasis on the dichotomy of classes versus individuals, forming the basis for all subsequent discussions to date. Hull made this point clear from the beginning, writing that "[t]he individual–class distinction used in this paper hinges on distinguishing spatiotemporal properties from all other properties" (1976: 187). With regard to the philosophical framework for this assertion, in a footnote to the same article, Hull writes as a disclaimer "I have presupposed a particular philosophical outlook throughout this paper, an outlook which is a lineal descendant of *logical empiricism*" (1976: footnote 9, emphasis added).

B. GRIFFITHS'S CLASSIFICATION VERSUS SYSTEMATIZATION

Around the same time that Ghiselin (1974) fully articulated his thesis about species and some philosophers started taking individualism seriously, G. C. D. Griffiths published an influential article entitled "On the foundations of biological systematics" (1974). In it he makes a conceptual distinction, which has become key in the development of ideas among some biologists, about the way taxonomy ought to be changed if the Darwinian revolution is to be undertaken in taxonomy (de Queiroz, 1988; Frost & Kluge, 1994; Kluge, 2003).[7]

In the introduction to his article Griffiths regrets the lack of interaction among systematic philosophers and systematic biologists: "Biologists in turn suffer from lack of understanding of how biological systematics relates to systematic philosophy as a whole. This leaves them particularly prone to be misled by naive theories which purport to rest on some philosophical authority. . . . I therefore offer this interpretation as one of the few workers with some training both in philosophy and biology"(Griffiths, 1974: 86). He then launches into describing his own theory of taxonomy.

According to Griffiths, there are two ways to construct taxonomies: classification and systematization. Classification is the ordering into classes. Particular things are grouped together because they share similar attributes. These groups are defined by necessary and sufficient properties and are abstract and universal classes. The periodic table of elements exemplifies this type of taxonomy. Particular atoms are grouped into classes by their common possession of certain number of protons in their nuclei. Hence atomic number is the intension of each of the classes termed "elements," the choice of atomic number as the defin-

ing property over many of the other properties exhibited by atoms being just a matter of useful chemical convention. A classification like this one is supposed to hold true in any given place at any given time, the specific origin of any particular atom being irrelevant to its place in the periodic table.

Systematization, on the other hand, consists of the ordering of particular things into systems. Systems are more inclusive wholes, based on the relationships that their parts exhibit one to another due to a natural process. Therefore, it is claimed, these relationships exist objectively. Systematization aims at representing the systematic order of the real world. Systematization produces natural taxonomies, whereas classification results in artificial taxonomic arrangements.

Griffiths's distinction between classification and systematization is just an implementation of the class versus individual dichotomy in a taxonomic context, also motivated by a rejection of "Aristotelian essentialism" in biology. Griffiths discusses Aristotelian essentialism at length and criticizes the use of Aristotle's theory of definitions when applied to species, concluding also that species and other taxa should be treated as individuals without essences (Griffiths, 1974: 103). Therefore, species should be arranged in systems to represent the real phylogenetic hierarchy, rather than arranged into classes by shared possession of similar attributes (essences). He also maintains that any arrangement of organisms into classes, any classification, will fail because the characters possessed by organisms do not form simple and unique hierarchical distributions. According to the classification/systematization distinction, the historical nature of species and monophyletic taxa precludes them from being intentionally definable by necessary and sufficient set characters or even by a combination or cluster of shared characters (see the discussion of homeostatic property cluster kinds in section V.B, below).

In support of his individualism, Griffiths cites the following passage from Woodger's "From biology to mathematics":

> In the Linnaean system of classification of animals and plants a species was a set or class, in fact it originally meant a smallest named class in the system. But a class or set is an *abstract* entity and thus has neither beginning nor end in time. We cannot, therefore, speak of the origin of species if we are conceiving species in the Linnaean manner. The doctrine of evolution is not something that can be grafted, so to speak, onto the Linnaean system of classification. The species of Darwin and the species of Linnaeus are not at all the same thing—the former are *concrete* entities with a beginning in time and the latter are *abstract* and timeless. (1952: 19, emphasis added).

Not surprisingly, Woodger was one of the few authors to work on the axiomatization of biology (Papavero, 1994; Smocovitis, 1996). The axiomatization of the sciences was the great project (so to speak) of the logical positivists to translate all the empirical sciences into pure logic and symbolic language. This was supposed to purge all the metaphysical considerations that were considered unnecessary for scientific progress, and work toward the unification of the sciences. Another prominent author in that area was J. R. Gregg, famous for his paradox concerning the redundancy of Linnaean categories (1954; for some interesting recent developments in the axiomatization of biology and especially phylogenetic systematics, see Abe & Papavero, 1992).

The classification/systematization distinction of Griffiths is the point of departure for the current PhyloCode crusade to "revolutionize" taxonomy. Indeed, it is maintained (de Queiroz, 1988) that the cause for the supposed delay of the Darwinian revolution in biological taxonomy is the failure on the part of taxonomists to grasp Griffiths's distinction (but see below).

C. PHYLOGENETIC DEFINITIONS: SEMANTIC SCHIZOPHRENIA

Philosophers of language commonly point to a basic distinction between intension and extension when talking about definitions. In the case of definitions of scientific (and everyday) kinds or classes, the definition is a formula that denotes the intention of the class; i.e., the characteristics or properties that are necessary and sufficient for inclusion. The intension, in turn, determines the extension of the class; i.e., the actual members that belong to the class defined by the intension. As in the previous example of the periodic table, the element gold is the class of atoms defined by having atomic number 79. This specific atomic number is the intention of "gold," its extension being all the atoms in the universe with an atomic number of 79. Some authors (e.g., Hull, 1965) trace this traditional notion of definition, in particular the requirement of necessary and sufficient properties, back to Aristotle, so, especially in discussions of individualism, such definitions are known as "Aristotelian definitions" (e.g., Ghiselin, 1969; de Queiroz & Gauthier, 1990). Individuals or particulars, on the other hand, having part–whole relations instead of member–class relations, cannot have intentions and hence their names are proper names. A name is attached to an individual by ostension; i.e., by "pointing at" the individual (Ghiselin, 1974, 1995; Hull, 1976, 1978; Frost & Kluge, 1994). In the case of reference by ostension, the extension is trivial—it corresponds to the actual individual being pointed at. Individualists argue that it is possible to refer ostensively to an individual (e.g., a monophyletic taxon) by listing some of the characteristics generally displayed by the majority of its parts. This form of descriptive definition based on characters is called "diagnosis" (Frost & Kluge, 1994; Kluge, 2003).

De Queiroz (1988) and de Queiroz and Gauthier (1990, 1992), following individualism, originally introduced their phylogenetic definitions of taxa with the intention that they would function as a reference by ostension. These definitions (node based, stem based and apomorphy based) are based solely on common descent, the idea being to "point at" a common ancestor and all of its descendants. They rejected any definitions based on characters, even in the form of a diagnosis, arguing that "organismal traits are fundamentally nonevolutionary. Such definitions were in use long before the widespread acceptance of an evolutionary world view, and furthermore, they make no reference to common descent or any other evolutionary phenomenon" (de Queiroz & Gauthier, 1992: 460–461; see also de Queiroz & Gauthier, 1990; de Queiroz, 1992). By its reliance on characters, the use of apomorphy-based definitions appears to be incompatible with de Queiroz and Gauthier's view, although it is claimed that such definitions are supposed to work by specifying an ancestor to "point at" rather than defining a class of organisms based on shared derived states.[8]

Nevertheless, phylogenetic definitions create major logical inconsistencies within the individualist paradigm in which they are supposed to function. By defining a taxon as consisting of all the descendants of a specified common ancestor, a phylogenetic definition appears to be treating the taxon as a class defined by the necessary and sufficient property of common origin, rather than as an individual. In this sense, phylogenetic definitions fix the reference by intension (de Queiroz, 1992), and not by ostension, since the "pointing" at ancestors proceeds by description. This would seem to make its mode of reference at odds with the individualism that the PhyloCode endorses in the first place (Ghiselin, 1995, 1997). This logical inconsistency led de Queiroz (1992, 1995) to claim that phylogenetic definitions, by treating common descent as a nominal essence, provide a way to reconcile the individualist view of the nature of taxa (as individuals) with the essentialist view of Aristotelian definitions, a claim rightly characterized as semantic trickery (Frost & Kluge, 1994: 265).

What all this reveals is a further confusion in the standard treatment of the notion of a class in the taxonomic literature. Most writers have assumed that a class defined by necessary and

sufficient conditions would have to be eternal or ahistorical, in the sense that it could have members from any time or place. Of course this is not so. If sp_1 and sp_2 denote species, then the necessary and sufficient condition "is a descendent of the most recent common ancestor of sp_1 and sp_2" defines a historically delimited class.

IV. A Natural Theory of Natural Kinds

In the preceding section we identified individualism and its associated notions of definitions as the foundation of the PhyloCode. We also pointed out that these philosophical views are situated in a larger context within the empiricist tradition in the philosophy of science that regards scientific kinds to be defined by purely nominal essences. In order to introduce some of the prominent realist critiques that have been raised against these empiricist conceptions of natural kinds and their definitions, we now provide a brief overview of the subject.

A. LOCKEAN NOMINALISM: REAL AND NOMINAL ESSENCES

The traditional empiricist account of definition by nominal essences, posited by the individualist argument and supporting the classification/systematization distinction, comes largely from Locke's discussion of essences and a resulting skepticism about knowledge of the unobservable. Locke distinguished between real and nominal essences. According to him, what governs the behavior of substances are their real essences corresponding to the actual, insensible (unobservable) microstructure present in nature. In contrast, nominal essences correspond to characterizations of the sensible (observable) properties displayed by substances. The former are characteristics of the independent and already made world; hence they are "natural." The latter are categories imposed by ourselves, a priori; therefore, they are "artificial" or "constructed" at best. Now, under the Aristotelian conception, the world is made out of a set of predefined substances with independent existence, and the task of man is to discover these substances. These predefined substances correspond, roughly, to the real essences of Locke, and that is why the view that our task is to discover the real essences in nature is sometimes called "Aristotelian essentialism," or simply "essentialism."

Now comes skepticism. In the *Essay*, Locke defends a nominalist conception of kinds on (roughly) the grounds that our senses are not acute enough ever to permit us to know anything about the unobservable essences of substances. He takes his nominalism to have distinctly skeptical consequences. He argues that when kinds of substances are defined by nominal essences it will be impossible to have a general science for the following reason: Kinds are defined by arbitrary, nominal essences that characterize the substances in terms of their observable properties, but the behavior of substances is governed by their unobservable, corpuscular, real essences. Because there is no reason to suppose that our nominal essences will correspond to categories that reflect uniformities in microstructure, there is no reason to believe that kinds defined by nominal essences provide a basis for obtaining general knowledge of substances (Locke 1975; Boyd, 1988, 1991, 2000). This amounts to the rejection of any form of real essentialism in favor of a nominalist position.

The traditional nominalist view of definitions endorsed by Ghiselin and other individualists, and passed on to the PhyloCode, is reflected in the Lockean position. Although nature makes things similar and different, the classification of them into kinds or classes is "the workmanship of men" (Locke 1975; see also Boyd, 1999). Sorting organisms into kinds or classes—i.e. classification—results in a taxonomy that, although practical for certain purposes, will be entirely conventional without any reason to suspect that the natural order of the organisms has been represented. Of course, to save the day "[i]t is possible to accept species as real and still

embrace a kind of nominalism, if one looks upon species as individuals" (Ghiselin, 1969: 53). In this way Ghiselin does not deny nominalism, he only argues that viewing species as kinds, defined by nominal essences and hence not real, is a mistake. By claiming that species are individuals, and not nominally defined kinds, he actually embraces nominalism about other taxa (Ghiselin, 1974).

Another way to look at the a priori, largely conventional character of the definition of kinds or classes, is in the context of the analytic/synthetic distinction. Philosophers of language traditionally maintain that statements come in two sorts: analytic and synthetic. Analytic statements are statements whose truth or falsity depends only on their logical structure and the conventional meanings of the words they contain. For example, the statement "Today is Monday or some other day of the week" is said to be true regardless of the actual day of the week on which it is stated; i.e., we do not have to check our calendar to assess the truth value of such a statement. Also, the statement "Today is not Monday or any other day of the week" is said to be false regardless of what our calendars show. Synthetic statements, on the other hand, are statements whose truth value is to be determined empirically, after the fact, by examination of the relevant cases where the statement is concerned. The statement "Today is Monday" requires us to look at the calendar to assess whether it is true or false. Tautologies are a type of analytic statements, and their empirical emptiness is what makes them so repudiated in scientific discourse.

Now, according to the traditional empiricist conception of meaning, which is largely a nominalist one, definitions are a type of analytic statement. When we assess the truth value of a definition like "bachelor" as "unmarried male legally eligible to marry," we realize that no empirical investigation is necessary. The definition is correct by convention—by linguistic stipulation. The nominalist view of definitions maintains that kind definitions are always analytic and always a priori true.

It can thus be seen why Ghiselin, in his empiricism, rejects "nominalistic species concepts" (a.k.a., species as classes or kinds) according to which species are analytically defined by the possession of common attributes (1974). If species were defined in this way, species delimitations would be a matter of a priori truth—without the possibility of revision in the light of newly acquired knowledge. If the above description of how classification works were true, we would have very strong reasons to reject treating species as classes and move toward individualism. Taxonomists obviously build classifications on characters, but individualism tells us that it is "philosophically" incorrect to think about those characters as part of definitions; i.e., setting the boundaries of species in terms of necessary and sufficient membership conditions. Ghiselin (1966b, 1974, 1995, 1997; see also Frost & Kluge, 1994; Kluge, 2003) contends that such species delimitations based on characters are better understood as diagnoses useful for identification but nevertheless revisable to accommodate new evidence. Individualists are right to think that a nominalist conception of species or other taxa as kinds or classes would preclude revisability of their definitions in the light of new evidence. This is another place where de Queiroz and Gauthier's phylogenetic definitions are illogical with respect to their own adopted philosophy: According to them, defining clades intentionally presupposes that their definitions are analytically true and hence not amenable to revision in the light of new knowledge. If we are to think of them as analytic definitions, then, when phylogenetic definitions point or refer to (whatever the proper term is) some hypothetical ancestor, no new knowledge of phylogeny can indicate any flaw in those definitions (Nixon & Carpenter, 2000). De Queiroz and Gauthier's phylogenetic definitions are irrefutable a priori statements. The very fact that the name is fixed a priori by a definition that will accommodate itself to any monophyletic group in a cladogram where the two or more specifiers occur makes the reference provided by phylo-

genetic definitions evolutionarily irrelevant; i.e, nonevolutionary. It is in this sense that phylogenetic definitions are stable, immune to scientific progress (Dominguez & Wheeler, 1997; see Appendix 1).

B. NATURAL DEFINITIONS: REALIST CRITIQUE OF LOCKEAN NOMINALISM

In contrast to the philosophical empiricist conception of kinds, where their definitions are determined a priori as a matter of convention, in the actual practice of science the definitions of scientific kinds, properties, and relations are normally taken as a posteriori and revisable in the light of new knowledge. Homology, for example (or at least certain versions of the term), changed from being viewed as topological similarity at the beginning of the nineteenth century to being regarded as involving similarity due to common ancestry by the end of that same century (Lankaster, 1870; see also Rieppel, 1988). Mayr (1942), Simpson (1944), and other evolutionary systematists advocated a broad conception of monophyly that allowed what we now call paraphyletic groups. Hennig (1950, 1965, 1966, 1968) restricted the term "monophyly" to refer only to groups including an ancestral species and all of its descendant species, as originally conceived by Haeckel (1866). There is also a plethora of examples about definitions of less theoretical terms. These revisions of term definitions are more than a matter of semantics; in the case of the term "monophyly," such restrictions result in more natural classifications with greater explanatory power (Farris et al., 1970; Farris, 1971, 1974, 1979a, 1979b, 1980, 1982, 1983, 1991; Platnick, 1977; Wiley, 1981). The reliability of this scientific practice poses a problem to the empiricist theory of kind definitions (Boyd, 1989).

The revisability of kind definitions has given support to a more naturalistic conception of language and has led philosophers, even within mainstream empiricism, to lean toward a scientific realist view of natural kinds and their definitions by essences (Boyd, 1989). The realist explanation for the reliability of such a practice as revising definitions comes from a naturalistic conception of natural kinds (Kripke, 1971, 1972; Putnam, 1973, 1975a, 1975b; Boyd, 1989, 1991, 1999, 2000). Realists agree with Locke that only when kinds are defined in terms of real essences are we able to succeed in our inferences regarding induction and explanation (Quine, 1969; Putnam, 1975b; Boyd, 1979, 1982, 1983, 1989). Prime examples of natural kinds of the sort envisioned by Locke, which are defined by real yet unobservable essences, are chemical kinds defined by molecular formulas. Although the recognition of water is as old as our existence (as a distinct species), the definition of water as "H_2O" was not achieved until atomic theories of matter were formulated. Scientific methods of classification are profoundly theory dependent, and kind definitions are thus revisable in the light of new knowledge (Boyd, 1991: 134). That "water = H_2O" is an a posteriori truth, determined by experience, and is highly theory dependent (Kripke, 1971, 1972; Putnam, 1973, 1975a, 1975b).

Recognition of such natural kinds is an indispensable part of science. The definition "water = H_2O" is said to be "natural" because it is able to explain successfully the chemical behavior of water and predict all its physical properties. That is why the theory of natural kinds is not a scientifically intractable, "metaphysical" theory about which "substances" exist in the world independent of scientific practices. It is a theory about how classificatory schemes come to contribute to the epistemic reliability of explanatory and inductive practices (Boyd, 1982, 1983, 1991, 1999, 2000). Natural kinds are scientific categories posited by our theories as epistemological devices; insofar as they have ontological status, it is as features of the ways in which causal structures in the world interact with our classificatory practices in such a way as to support reliable induction and explanation. The naturalness of natural kinds consists in their aptness for induction and explanation—definitions of natural kinds are reflections of the properties of their members that contribute to that aptness (Boyd, 1991, 1999, 2000). Questions

about the "reality" of kinds are thus best understood as questions about their contribution to successful induction and explanation (Boyd, 1999).

Questions of this sort may be metaphysical—many philosophers think that they were among the questions Aristotle was trying to address—but, whether they are metaphysical or not, they are surely the sort of questions that can be answered by empirical investigations.

This view gives support to what is normally called "traditional essentialism," with kinds defined by real as opposed to just nominal essences, so the empiricist skepticism shared by individualists cannot be justified. It becomes rather difficult to argue that species and other taxa are not kinds or classes just because of one's acceptance of the truism that they are more than mere abstractions. The philosophical theory of natural kinds provides us with a scientifically respectable way of distinguishing kinds that are mere abstractions from natural kinds that are "real" in the sense discussed above.

Nevertheless, at this point, even if we accept the naturalistic conception of natural kinds advanced by realists, we still face the problem that species and higher taxa, by virtue of their historical nature, appear not to be definable in terms of necessary and sufficient properties shared by their members. The kinds mentioned in previous examples (e.g., chemical elements and molecules) are still defined by essences that are intrinsic, unchanging, and ahistorical (Boyd, 2000). In other words, natural kinds are still viewed as classes—as that notion is understood in the philosophy of taxonomy. They are now viewed as real or natural classes instead of abstract or artificial ones, but classes nevertheless, supporting the distinction between classes and individuals drawn by individualists and the resultant distinction between classification and systematization. What is no longer possible is to argue for species individualism based solely on the premise that only in this way we can claim that species are real (e.g., Baum, 1998).

Interestingly enough, Griffiths comes very close to a naturalistic conception of classification, suggesting that "in the natural science we must treat our constructions as hypotheses about the structure of the world and devise empirical means of testing them" (Griffiths, 1974: 113). But again, his distinction is based on differentiating member–class from part–whole relations, where characters serve as essences in the former and as identifiers in the latter.

Accepting the idea that natural kinds possess real essences which define them in terms of necessary and sufficient membership conditions does not alone reconcile species with classes or kinds (Hull, 1981). What really compromises individualism and the resulting classification/systematization distinction is that there are many natural kinds (almost all!) posited by our theories, especially within the realm of biology, that do not satisfy such requirements of definition. What is left to ask, then, is "To what extent is the requirement of being defined in terms of necessary and sufficient membership conditions essential to the theory of natural kinds?" The answer is: Not essential at all! The explanation for such an answer is to be found in the concept of homeostatic property cluster kinds and in the notion of accommodation between conceptual and classificatory practices and causal structures.

V. Homeostatic Property Cluster Kinds and Accommodation

Individualists maintain that species cannot possibly be classes or kinds (natural or otherwise), partly because they are not definable by necessary and sufficient membership conditions, as the standard conception of scientific kinds holds they should be. As a solution to this problem they argue that taxa are better viewed as individuals. In support of their thesis they point out that species: are not defined in terms of the intrinsic properties of their members; are spatiotemporally restricted; do not fall under universal exceptionless laws; and are united by historical relationships rather than shared properties. Nevertheless, species have always been viewed as paradigm examples of natural kinds. They indeed have a central role in biological

theories. Species are basic units of taxonomic studies and phylogenetic analysis, they are involved in all sorts of ecological theories, they are key in evolutionary biology, and they are important to more applied areas of biology, like medicine or agriculture. This situation, rather than leading us to conclude that species are not natural kinds, urges us to reconsider the standard conception of such kinds. One feature of individuals is that they are usually not scientifically interesting (Hull, 1976, 1978; Frost & Kluge, 1994; Kluge, 2003). This is a conclusion perhaps not sufficiently appreciated by many of the people who subscribe to the view that species and higher taxa are individuals. Individualism misestimates the explanatory role of species concepts in biology (Boyd, 1999).

Here, we argue for a more promising alternative. We think that species are counterexamples to the claim that natural kinds must be defined by necessary and sufficient conditions. This requirement of the definition of natural kinds is too restrictive to account for the great many categories used successfully in guiding induction and explanation in science and everyday life. Such a restrictive conception of natural kinds may fit well many of the phenomena studied by physicists and some of the ones studied by chemists, but it clearly fails to fit the messy and complex situations normally encountered in biology. Boyd (1991: 142; see also 1999) diagnosed this requirement for the definitions of natural kinds as a holdover from traditional empiricist conceptions of linguistic precision. The same holds true of individualism and the classification/systematization distinction, two conceptions that, as we pointed out at the beginning of this article, have strong empiricist roots. If anything, this conception must be abandoned once it is agreed that kind definitions must function to aid induction and explanation in domains as complex as the biological sciences.

A. THE ACCOMMODATION THESIS

Boyd (1999, 2000) provides a conceptual framework for the required revision of the traditional conception of natural kinds. Recall the suggestion made earlier that questions about the "reality" of a kind should be understood as scientific (and metaphysical!) questions about the ways in which reference to that kind contributes to (or fails to contribute to) successful induction and explanation. We can make questions of this sort more precise by recognizing that what is required of classificatory practices within a scientific discipline in order that they contribute to reliable induction and explanation is that those practices help bring about an accommodation between classificatory practices—and the inductive and explanatory practices that depend on those classificatory practices—and the causal structures in the world that determine the relevant properties of the phenomena under study. We are able to succeed in induction and explanation only when, and to the extent that, our classificatory and inferential practices are accommodated to relevant causal structures.

In this view, natural kinds are not so much features of the world independent of scientific practice but features of the interaction between scientific practice and practice-independent causal structures.

The accommodation thesis helps us see why questions about the "reality" or definitions of natural kinds are metaphysical questions amenable to scientific investigation. It also helps us to see why natural kinds need not be defined by necessary and sufficient intrinsic and eternal properties, as the standard conception is thought to require.

B. HOMEOSTATIC PROPERTY CLUSTER KINDS

In the sciences that study complex systems, successful accommodation of inferential and explanatory practices to relevant causal structures often requires that we refer to families of

properties, such that: 1) they tend (imperfectly) to co-occur in nature; 2) their co-occurrence is explained by inductively and explanatorily important mechanisms that (imperfectly) establish a sort of "homeostasis" between them; and 3) the homeostatic unity they (imperfectly) display is a causally and explanatorily important factor in the complex systems we study.

The terms by which we refer to the things that participate in such homeostatic property clusters (HPCs)—the homeostatic property cluster terms—are defined by the associated property clusterings understood as ongoing phenomena in the world. Because the homeostasis is ordinarily imperfect, and because some things can participate in the cluster without exhibiting all of the clustered properties, the kinds defined by HPCs do not have necessary and sufficient membership conditions. Because the clustering in the world that defines such a kind can be an ongoing process, the properties in the cluster can sometimes vary over time, and the kind's boundaries can be historically delimited if the relevant clustering is historically delimited (contra Ereshefsky, 2001).

Nevertheless, HPC kinds are full-blown natural kinds. The naturalness (and the "reality") of a kind consists in its aptness for induction and explanation and—for disciplines that study complex systems—recognition of HPC kinds is essential for the accommodation of inferential practices to the causal structures upon which the reliability of induction and explanation depends.

Species in biology, mineral "species," many kinds of geological formations, explanatorily important kinds of economic or social systems, and higher monophyletic taxa are probably HPC kinds (Boyd, 1999, 2000). They are counterexamples to the empiricist idea that natural kinds must have eternal definitions in terms of intrinsic necessary and sufficient conditions and play a role in completely exact laws. Indeed, they are natural kinds precisely because they lack such definitions and instead have definitions that make possible the right sorts of accommodation between classificatory and inductive practices and relevant causal structures.

Thus none of the reasons grounded in empiricist conceptions for denying that species are natural kinds withstands the criticisms that recent realist work in the philosophy of science has directed at the empiricist conception of kinds.

It is worth remarking that the accommodation thesis allows us to distinguish two sorts of definitions that a natural-kind term (whether it is an HPC term or not) will possess. A programmatic definition of a natural kind is provided by specifying a certain inductive or explanatory role that the use of a natural kind term referring to it plays in satisfying the accommodation demands of a disciplinary matrix. Defining a monophyletic taxon by the explanatory role indicated by its unique phylogenetic position would be an example of offering a programmatic definition for it. There is another perfectly legitimate sense of definition according to which a definition of a natural kind is provided by an account of the properties shared by its members. This obtains when reference to the kind defined in this way plays the role required by its true programmatic definition. Call this sort of definition an "explanatory" definition (Boyd, 1999: 149). Defining the taxon in terms of the synapomorphies shared by its members is an example of offering an explanatory definition. The HPC conception is in the first instance an account of (some) explanatory definitions. It is worth noting that identifying a programmatic definition for a natural kind term seems to be a more nearly a priori matter than identifying its explanatory definition is, because part of what is involved is identifying the inductive or explanatory role that practitioners expect the term to play. Even so, programmatic definitions cannot be established a priori. A pre-Darwinian biologist might have defined the category "species" as the category into which we place the fundamental units of God's special creation in the biological domain. Such a biologist would have offered a false and revisable proposal about how the species category is programmatically defined. Any proposed programmatic definition re-

flects an a posteriori judgment about the actual inductive and explanatory successes of a disciplinary matrix (Boyd, 1999: 150).

C. THE MEANING OF "REALITY"

Recall that when we ask about the "reality" of a kind or of the members of a family of kinds, what we are addressing is the question of what contribution, if any, reference to the kind or kinds in questions makes to the ways in which the classificatory and inferential practices in which they are implicated contribute to the satisfaction of the accommodation demands of the relevant disciplinary matrix. Claims to the effect that some kind or kinds are not "real" are best understood as claims to the effect that reference to the kind or kinds in question fails to play an appropriate role in such accommodation. It is thus always preferable for such claims to be spelled out explicitly in terms of the relevant sort of contribution to accommodation, rather than by a misleading reference to issues regarding the "reality of" the kind(s) in question. Issues about "reality" or "realism about" are always issues about accommodation (Boyd, 1999: 159).

Once we see this, we can see another way in which focusing on the distinction between kinds or classes and individuals can be misleading. Just as there can be classes that are "unreal" because reference to them makes no contribution to accommodation (consider the class of all organisms that are either insects and mainly aquatic or flowering plants and mainly terrestrial), so too are there individuals that are unreal in the same way. Many of the African countries artificially created by European powers in the nineteenth and twentieth centuries are "unreal" in this way (contra Ghiselin, 1974).

Exploring the distinction between individuals and kinds is thus not a promising approach to discussing issues about "reality." At least in the scientific domain, the issue is accommodation.

VI. Conclusion

The PhyloCode is intended to rest on the philosophy of individualism—a dubious philosophy about the nature of species and higher taxa. Individualism purposed to "solve" the species problem by endorsing a problematic and outdated theory of meaning and definition. Arguments about species-as-individuals and their supposed compatibility with evolutionary theory are commonly deployed to persuade biologists to accept phylogenetic nomenclature (e.g., Brochu & Sumrall, 2001; Bryant & Cantino, 2002); however, their own methodological tools, "phylogenetic definitions," are logically incompatible with those views.

The Linnaean system, rather than having been an obstacle to biological progress within an evolutionary worldview, is a paradigmatic example of a natural language: a language that has been able to incorporate the immense acquisition of knowledge about the diversity of the organic world during more than 200 years and that is consistent with the phylogenetic explanations behind our classifications. Perhaps it may require revision or abandonment (Ereshefsky, 1999, 2001), but this cannot be established by simple philosophical arguments.

It is ironic to see that de Queiroz's claim that "taxonomists have been largely unaware of the philosophical positions implied by their views" (1994: 499) holds even more truly among the fervent followers of the PhyloCode than among taxonomists in general.

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VIII. Notes

1. The terms "empiricism" and "realism" or "scientific realism" (as well as their adjectival forms "empiricist" and "realist") used throughout this article refer to different schools of thought within the philosophy of science and not to the regular scientific usage pertaining to experience or the putative existence of the phenomena under investigation.

2. In this article we take no stand on issues regarding the correct interpretation of Aristotle's work or on subtle issues about the relative influence of Aristotelian and Platonist ideas on pre-Darwinian essentialism.

3. There is a divergence between the set-theoretic notion of class and the notion of class operative in the philosophical literature on taxonomy. In the set-theoretic conception a class is any collection, subject to the understanding that any two collections with the same members correspond to the same class. There is no requirement that the collection have any particular sort of definition, or any definition at all. In the set-theoretic conception, neither species nor chemical elements can be classes simply because they can acquire or lose members, as organisms are born and die and as samples are created and destroyed. In the present article we will follow standard usage in taxonomy and understand classes as collections defined by necessary and sufficient membership conditions.

4. The idea that species are individuals can be traced back at least to the writings of the eighteenth-century French naturalist Georges-Louis Leclerc de Buffon (see Papavero et al., 1995), but it is Ghiselin who should be credited for laying the groundwork for the contemporary debates on the subject.

5. Individualism has been greatly refined and expanded since the 1970s in a large number of publications. Nevertheless, for the present discussion it is sufficient to point out these basic premises and their connection to the theory of meaning and definition just described.

6. Because of this, Ghiselin refers to the view that species are classes defined by purely nominal essences and concludes that they are not real as the "nominalistic species concept" (1974).

7. We do not accept the premise that taxonomy was not changed by the Darwinian revolution, in part because Hennig's (1966) phylogenetic systematics was a direct realization of the explicit phylogenetic goals of Darwin and Haeckel.

8. For this reason de Queiroz and Gauthier's definition should be called an "autapomorphy-based" definition, in order to distinguish it from "synapomorphy-based" definitions used by cladists (e.g., Nixon & Carpenter, 2000).

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X. Appendix 1: Phylogenetic Definitions: A Hypothetical Example

Example: Consider the "sea snakes" (traditional subfamily Hydrophiinae, in the traditional family Elapidae with the cobras, kraits, mambas, and coral snakes). They were for a long time thought to form a monophyletic taxon. The best current research apparently shows that elapids moved from the land environment in Australia to the sea on several different occasions, so Hydrophiinae is anything but monophyletic.

Suppose that a herpetologist (Jane) constructed a taxonomy of sea snakes before this departure from monophyly was discovered. She intended to erect something like a "genus-level" taxon, although she knew that the notion of a genus-level taxon was methodologically suspect. Jane identified a bunch of species she was sure belonged in the taxon and, being a fan of ostensive definitions in the style of phylogenetic nomenclature sensu de Queiroz and Gauthier, picked two of them to ostensively indicate the species all of whose descendant species constituted the taxon she meant to study.

Jane's work was important in herpetology, and many dissertations were written about the natural history of snakes in her taxon and about their evolutionary history. Finally, after decades of research, it was discovered that one of the species—call it S—commonly thought to belong to the taxon was actually representative of an adaptive radiation from the terrestrial environment of Australia to the sea which was entirely different from that of all the others. Jane tried to publish an article in which she assigned it to a different taxon, but the editors noticed that Jane had years ago chosen S as one of the species she used in ostensively defining the taxon in question. The editors rejected her article on the grounds that its conclusion was analytically false and, instead, accepted a article showing that her taxon included many terrestrial Australian elapids.