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REPLACEMENT OF AN ESSENTIALISTIC PERSPECTIVE ON TAXONOMIC DEFINITIONS AS EXEMPLIFIED BY THE DEFINITION OF "MAMMALIA"

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Abstract.—Current controversies about the definitions of taxon names reflect different underlying philosophical perspectives concerning the nature of definitions. The antithetical perspectives, called methodological essentialism and methodological nominalism (Popper, 1966, *The open society and its enemies*, Princeton Univ. Press, Princeton, NJ), are exemplified by alternative views in a controversy surrounding the definition of the name "Mammalia." Traditional perspectives on the definition of "Mammalia" are essentialistic in that the definition takes the form of a description stated in terms of the traits of individual organisms, thus implying that taxa are abstract categories, i.e., that taxa have essences. In addition, the extension of the defined term (the set of species or organisms to which the name applies) is logically prior to its intension or defining formula (the property or properties that a species or organism must have to be designated by the name). Consequently, the name is treated as if it had a designation proper to it, which conforms with the essentialistic view that the name is an abbreviated description of the essence. An alternative perspective is manifested in the redefinition of "Mammalia" as the name of the monotreme and therian crown clade. This perspective contrasts with the traditional one in that the definition is stated in terms of common ancestry relationships rather than organismal traits, thus implying that taxa are concrete composite wholes rather than abstract categories. In addition, the defining formula is logically prior to the extension of the defined term, and thus the name is treated only as a convenient label or shorthand symbol for the defining formula that has no proper designation. The replacement of an essentialistic perspective on the definitions of "Mammalia" and other taxon names by a more nominalistic one is associated with the development of a phylogenetic perspective on biological nomenclature and represents an important step in the development of a more broadly scientific approach to that subject. [Definition; essentialism; nominalism; Mammalia; nomenclature; philosophy; taxonomy; Karl R. Popper.]

It has been said that "in no other science is definition as important as it is in taxonomy" (Hull, 1965:315). Recently, the importance of definitions in taxonomy has been highlighted by the realization that explicitly phylogenetic methods for defining the names of taxa are central to the development of a phylogenetic system of biological nomenclature (de Queiroz and Gauthier, 1990, 1992, 1994). But many of the taxon names in current use, particularly the oldest and most familiar, were coined long before the advent of phylogenetic definitions. Indeed, many were coined before widespread acceptance of the concept of phylogeny itself. Consequently, it should not be surprising that definitions formulated in the context of the phylogenetic system are coming into conflict with older definitions of the same names.

An example of this conflict concerns the name "Mammalia," which has been defined phylogenetically as the crown clade stemming from the most recent common ancestor of monotremes and therians (Gauthier et al., 1988a, 1988b, 1988c, 1989; Rowe, 1988; de Queiroz and Gauthier, 1992). This definition has been contested by systematists adopting a view that has become traditional among paleontologists, according to which "Mammalia" designates a taxon including not only the monotreme and therian crown clade but also several of its extinct outgroups (Miao, 1991; Lucas, 1992; for further discussion see Rowe and Gauthier, 1992; Bryant, 1994). On one level, the disagreement is nothing more than a difference in preferences concerning the association of a taxon name with one clade or another. Here, I argue that it also reflects

deeper underlying philosophical differences concerning the nature and significance of definitions, differences that bear on the intellectual vigor of systematic biology as a scientific discipline.

ESSENTIALISTIC AND NOMINALISTIC INTERPRETATIONS OF DEFINITIONS

The philosopher Karl Popper, most widely known among systematists for his writings on the scientific method (e.g., Popper, 1959, 1962; see Bock, 1973; Wiley, 1975; Platnick and Gaffney, 1977, 1978a, 1978b), called attention to a distinction between what he called *methodological essentialists* and *methodological nominalists* based on differences in their perspectives on definitions (Popper, 1964, 1966). Popper illustrated the difference between the essentialistic and nominalistic perspectives using the sentence "A puppy is a young dog" as an example of a *definition or definition-sentence* (Popper, 1966[2]:10). In Popper's terminology, "The subject of such a definition-sentence, the term 'puppy', is called the *term to be defined* (or *defined term*); the words 'young dog' are called the *defining formula*" (Popper, 1966[2]:10, emphasis in original).

Popper (see also Griffiths, 1974) traced the roots of the essentialistic interpretation of definitions to the philosophies of Plato and Aristotle, who considered "the term to be defined as a name of the essence of a thing, and the defining formula as the description of that essence" (Popper, 1966[2]:10) and taught

that by thus describing the essence to which the term points . . . we determine or explain the *meaning* of the term also. Accordingly, the definition may at one time answer two very closely related questions. The one is "What is it?", for example, "What is a puppy?"; it asks what the essence is which is denoted by the defined term. The other is "What does it mean?", for example, "What does 'puppy' mean?"; it asks for the meaning of a term (namely of the term that denotes the essence). (Popper, 1966[2]:13, emphasis in original)

Popper emphasized "that both *questions are raised by the term that stands, in the definition, on the left side and answered by the defining formula which stands on the right side*" (Popper, 1966[2]:13-14, emphasis in original).

Thus, "the essentialist interpretation reads a definition 'normally', that is to say, from the *left to the right*" (Popper, 1966[2]:14, emphasis in original). In other words, the essentialistic interpretation starts with the term to be defined and then asks for its meaning (i.e., defining formula). As Popper (1966[2]:14) put it, essentialistic definitions "serve to substitute a long formula for a short one." Furthermore, for an essentialist, the particular term chosen is not arbitrary, because "every essence has a name proper to it" (Popper, 1966[1]:31).

Popper contrasted the essentialist interpretation of definitions with the interpretation that he proposed characterizes modern science, which he called the nominalist interpretation. According to Popper,

a definition, as it is normally used in modern science, must be read from back to front, or from the right to the left; for it starts with the defining formula, and asks for a short label to it. Thus the scientific view of the definition "A puppy is a young dog" would be that it is an answer to the question "What shall we call a young dog?" rather than an answer to the question "What is a puppy?" (Popper, 1966[2]:14, emphasis in original)

In other words, nominalistic definitions serve to substitute short terms for longer expressions. Rather than starting with the defined term and then attempting to determine its meaning, a nominalist starts instead with the description of a concept or entity that initially must be stated using many words and equates it, by means of a definition, with a single word or short phrase. Of course most people, when first studying a science, "*learn the definition [of each new scientific term] 'from the left to the right', substituting, as if it were an essentialist definition, a very long story for a very short one*" (Popper, 1966[2]:15, emphasis in original). But this has nothing to do with the original formulation of the definition, which took place only after the need for a concise way of referring to an existing concept or entity had arisen. Finally, for a nominalist, the particular term chosen is more or less arbitrary, because nominalists "*regard words merely as useful instruments of description*" (Popper, 1964:29, emphasis in original). Consequently, they

introduce new terms freely, and they redefine old ones when convenient (Popper, 1964).

This philosophical distinction between essentialistic and nominalistic interpretations of definitions has considerable significance for practicing systematists, because it is closely related to scientific progress in their discipline. Indeed, Popper (1966[2]: 9) held the view that

every discipline, as long as it used the Aristotelian method of definition, has remained arrested in a state of empty verbiage and barren scholasticism, and . . . the degree to which the various sciences have been able to make any progress [has] depended on the degree to which they have been able to get rid of this essentialist method.

This characterization applies well to biological nomenclature, where the essentialistic perspective is associated with a seemingly endless and strictly verbal debate about the meaning of the name "Mammalia" (see Rowe and Gauthier, 1992). It also appears that systematic biology has already moved away from the essentialistic perspective in other aspects of its terminology. For example, systematists have for the most part abandoned their search for whatever it is that is common to all those entities previously designated by the term "species." Instead, they have redefined this term to designate one class or another of entities that they later came to consider significant (de Queiroz and Donoghue, 1988).

CLARIFICATIONS ABOUT PHILOSOPHICAL POSITIONS

Before analyzing the nomenclatural controversy, it is important to clarify several things about essentialism and nominalism. First, in characterizing a perspective on the definitions of taxon names as essentialistic, I do not mean to imply that systematists adopting this perspective advocate the idea that eternal, immutable essences existing outside of space and time are the underlying bases of taxa. Similarly, in characterizing a definitional perspective as nominalistic, I do not mean to imply that its advocates embrace the idea that taxa are human constructs that have no objective

existence (see Mayr, 1968, 1982). My characterizations of alternative positions on the definition of taxon names as essentialistic or nominalistic follow Popper's (1964, 1966) distinction between methodological essentialism and nominalism, which refers to different perspectives on the interpretation of definitions without any necessary connotations about the metaphysical issue concerning the existence of universals.

Second, in characterizing a position as either essentialistic or nominalistic, I do not mean to imply that its proponents have fully embraced, even in a strictly methodological sense, the positions so termed by Popper. My point is that arguments on one side of the controversy over the definition of "Mammalia" have been raised from a perspective that retains holdovers from an essentialistic way of thinking and that the proposal that these arguments have been raised against shows evidence of a shift toward a more nominalistic approach. Nevertheless, taxonomists have been largely unaware of the philosophical positions implied by their views, which often are amalgamations of ideas that are individually compatible with different philosophical positions. Thus, advocates of definitions that I characterize as essentialistic sometimes adopt ideas that are congruent with a nominalistic perspective, whereas advocates of definitions that I characterize as nominalistic sometimes retain ideas that reflect an essentialistic outlook. This inconsistency is in keeping with the historical nature of science, an appreciation of which leads one to expect that any scientific discipline at a given time in its history will be a mosaic of "vague and incoherent anticipations of future ideologies side by side with highly sophisticated theoretical systems and ancient and petrified forms of thought" (Feyerabend, 1978:146).

Third, despite associating my own writings on taxonomic definitions (de Queiroz, 1988; de Queiroz and Gauthier, 1990, 1992, 1994) with the nominalistic position, I do not mean to imply that I oppose the proposition—sometimes labeled as essentialistic (e.g., Hull, 1965, 1976; Kitts, 1983, 1984; Ghiselin, 1984a, 1985)—that the defining

formulas of taxon names can be stated in terms of logically necessary properties, in other words, that the names of taxa have *intensions*. I have argued elsewhere (de Queiroz, 1992, 1994) that phylogenetic definitions of taxon names not only are compatible with this proposition but they also provide the basis for resolving a seemingly fundamental disagreement between its advocates (e.g., Kitts and Kitts, 1979; Kitts, 1983, 1984; Bernier, 1984) and their critics (e.g., Ghiselin, 1974, 1981, 1984a, 1994; Hull, 1976, 1978). Moreover, to the extent that intensions are the same as defining formulas, the present analysis rests on the applicability of this concept to the names of biological taxa.

Fourth, the term "essentialistic" has several meanings. Often it is applied rather loosely as a means of denigrating an opponent's position. My use of the term is not so intended. I have adopted Popper's terminology because his distinction between (methodological) essentialism and nominalism forms the foundation of my argument.

Finally, despite my advocacy of the crown clade definition of "Mammalia," I regard this definition (in keeping with the nominalistic perspective) as a useful but strictly verbal convention. Many of the nominalistic characteristics of the crown clade definition of "Mammalia" apply to a general perspective on definitions that is manifested not only in this particular definition but (to varying degrees) in phylogenetic definitions generally. Furthermore, elements of this general perspective may be present even when the use of phylogenetic definitions is only partial and implicit, as in much of the post-Darwinian and particularly the post-Hennigian literature. For example, an alternative definition of "Mammalia" uses this name to designate the clade going all the way back to the split of the lineage leading to the monotreme and therian crown clade from the nearest lineage leading to other extant organisms (e.g., Ax, 1987), and this definition also shows evidence of having been formulated within the context of a more nominalistic perspective. I will focus on the crown clade definition of "Mammalia"

because it has generated the most discussion and hence the largest number of examples for my analysis. In any case, my primary goal is not to defend any particular definition of "Mammalia" but rather to clarify some general philosophical issues about definitions that are relevant to the names of biological taxa. I hope that this discussion will provide a deeper understanding not only of the current debate over the meaning of the name "Mammalia" but also of similar debates that are developing, or are likely to develop, over the definitions of other taxon names.

TRADITIONAL VERSUS CROWN CLADE DEFINITIONS OF MAMMALIA

Taking the above caveats into consideration, opposing views in the controversy concerning the definition of "Mammalia" serve as almost classic examples of essentialistic and nominalistic perspectives on definitions. The traditional perspective on defining "Mammalia" exemplifies the essentialistic position, which is manifested in three closely related issues. The traditional approach states its definitions in a way that closely resembles the description of a Platonic or Aristotelian essence. It reads the definition from "left to right," starting with the name and then asking for its meaning, and in so doing, it treats the name as if it has a designation proper to it. In contrast, the alternative perspective manifested in the crown clade definition of "Mammalia" exemplifies Popper's nominalistic interpretation of definitions. This approach states its definitions in a way that is difficult to interpret as the description of a Platonic or Aristotelian essence. It reads the definition from "right to left," starting with the defining formula and then asking for a short label to substitute for it, and in so doing, it treats the name itself as an arbitrary label that is important only insofar as it serves as a useful means of communication.

Organismal Traits versus Phylogenetic Relationships

One way in which traditional and crown clade perspectives on the definition of "Mammalia" align with essentialism and

nominalism concerns the terms in which the definitions are stated. This contrast is related to deeper philosophical differences between the alternative philosophies, i.e., not only to the methodological distinction described above. In an essentialistic definition, the defining formula takes the form of a description of the *essence* designated by the defined term (Hull, 1965; Popper, 1966). For Plato, such essences, sometimes also called forms or ideas, existed outside of space and time and independently of their particular manifestations, which were viewed as imperfect representations of the essences that exist in the material world. And even for Aristotle, essences were not viewed as belonging to individuals as such but to individuals as members of certain kinds (abstractions, universals) (Randall, 1960). Therefore, definitions apply only to abstract kinds and not to individuals (Griffiths, 1974). Nevertheless, kinds or essences are discovered by induction from the particular instances (individuals) in which they are manifested (Randall, 1960). Consequently, an essentialistic definition takes the form of a description of the individual members of the kind whose name is being defined.

Although most contemporary biologists no longer hold the view that eternal, immutable essences are the underlying bases of taxa, or even that all members of a taxon have certain invariant characters by which they can be distinguished, they have nonetheless continued to formulate taxonomic definitions as lists of organismal traits or characters, i.e., as descriptions of individual organisms (de Queiroz and Gauthier, 1990; de Queiroz, 1992). For example, traditional definitions of the name "Mammalia" have been summarized by Rowe (1988) and include such organismal traits as hair, mammary glands, endothermy, a dentary-squamosal articulation, three auditory ossicles, a coiled cochlea, diphyodont tooth replacement, postcanine teeth with divided roots, and a petrosal promontorium. Treating lists of organismal traits, i.e., descriptions of individual organisms, as the defining formulas of taxon names implies that taxa are abstract categories (kinds), the members of which belong to

those categories for the reason that they share certain (defining, essential) characters. This view is very much in keeping with—and probably has been inherited directly from—the metaphysics of essentialism, in which individual organisms are viewed as the concrete manifestations of an abstract, ideal organism (essence). Some recent taxonomists have stated explicitly that they view taxa as abstract concepts or ideas (e.g., Muir, 1968; Løvtrup, 1986, 1987a, 1987b), and others use terms with obvious essentialistic connotations, for example, Gow's (1985:558) reference to the "essential characteristics of the Class Mammalia" (see also Gregory, 1910:28).

One of the ways in which the crown clade definition of "Mammalia" differs most strikingly from traditional definitions concerns the terms in which it is stated. As a phylogenetic definition, the crown clade definition of "Mammalia" is not stated in terms of organismal characters but in terms of common ancestry relationships and the evolutionary entities deriving their existence from that phenomenon (de Queiroz and Gauthier, 1990, 1992; de Queiroz, 1992). Thus, the defining formula of the crown clade definition of "Mammalia," that is, "the clade stemming from the most recent common ancestor of monotremes and therians," does not even make reference to an organismal character. Moreover, such a definition discourages an essentialistic interpretation because it takes a form that is difficult to interpret as the description of an abstract, ideal organism. Instead, it describes a concrete composite whole known as a clade. Thus, mammalian organisms are not viewed as members of an abstract category to which they belong because they share certain traits but rather as component parts of a larger whole into which they are united by common evolutionary descent (e.g., Woodger, 1952; Hennig, 1966, 1975; Ghiselin, 1969, 1980, 1981, 1984b, 1994; Griffiths, 1974; Hull, 1978; Patterson, 1978; de Queiroz, 1988, 1994; de Queiroz and Donoghue, 1988, 1990).

The persistence of an essentialistic way of stating definitions in traditional practice seems to explain certain confusions of taxonomists concerning the application of def-

initions. Definitions, statements specifying the meanings of words, apply to taxon names, not to the taxa designated by those names (Ghiselin, 1966, 1969). Nevertheless, taxonomists have often treated definitions as if they applied to taxa themselves (Muir, 1968, is an unambiguous example). For instance, taxonomists commonly make statements similar to the following one, in which it is unclear whether Lucas (1992: 371) meant to define a taxon itself as opposed to its name: "I define Mammalia as the monophyletic taxon whose members share biologically significant evolutionary novelty(ies)." Although equivocation of this kind is often harmless, sometimes it leads to confusion. For example, Miao (1991) implied that he perceived a contradiction between Ax's (1987) statement that a clade, which is ontologically an individual, cannot be defined and Rowe's (1988) proposal to define "Mammalia." Miao thus confused the clade itself with the name used to designate it. The situation is aggravated when definitions, i.e., statements specifying the meanings of taxon names, are confused with diagnoses, i.e., statements specifying the means by which particular organisms are recognized as parts of the taxa designated by those names (de Queiroz and Gauthier, 1990; de Queiroz, 1992). Thus, according to Miao (1991:586), "Rowe's definition of mammals does not offer a practical solution to our problems. To answer the question 'What are mammals?' we still must identify diagnostic features." Only by confusing definitions with diagnoses is Miao able to criticize a definition for not doing the job of a diagnosis.

Confusions of this kind are not surprising under an essentialistic interpretation of definitions. An essentialistic definition answers at the same time two closely related questions. One concerns the nature of the kind (essence) designated by the defined term; the other concerns the meaning of the term itself. Furthermore, an essentialistic definition takes the form of a description of the essence whose name is being defined (Hull, 1965; Popper, 1966), i.e., a list of the essential characters shared by the members of the kind. Thus, in tra-

ditional taxonomic practice, both definitions of taxon names and descriptions/diagnoses of taxa take the form of lists of organismal traits, and it is easy to see why they are often confused (Ghiselin, 1966).

Such confusions are discouraged by the phylogenetic perspective on taxonomic definitions, which clearly separates statements specifying the meanings of taxon names from statements describing the organismal parts of the clades designated by those names (de Queiroz and Gauthier, 1990). Because the meanings of taxon names are stated in terms of phylogenetic relationships rather than organismal traits, there is little possibility of confusing the definitions of taxon names with diagnoses of taxa or descriptions of their component organisms. In this light, it is probably not coincidental that the distinction between definitions and descriptions/diagnoses has been emphasized by the same people who advocate a phylogenetic approach to taxonomic definitions (Ghiselin, 1966, 1984a; Rowe, 1987; de Queiroz and Gauthier, 1990, 1992; de Queiroz, 1992). Nevertheless, even these authors have sometimes equivocated on the application of definitions (for examples, see de Queiroz, 1988; Rowe, 1988; Ghiselin, 1994).

The preceding discussion is not meant to imply a strict association between essentialism and definitions based on organismal characters on the one hand and between nominalism and definitions based on phylogenetic relationships on the other. Organismal characters are central to one of the three major classes of phylogenetic definitions identified by de Queiroz and Gauthier (1990, 1992). Thus, the defining formula in an apomorphy-based phylogenetic definition specifies a clade stemming from the ancestor in which a particular character arose. Furthermore, stating taxonomic definitions in terms of phylogenetic relationships does not itself require defining "Mammalia" or any other name as the name of a crown clade. Moreover, it is possible to interpret phylogenetic definitions in a methodologically essentialistic manner, and it is also possible to interpret traditional character-based def-

initions in a methodologically nominalistic manner. Therefore, although the terms in which traditional and crown clade definitions are stated suggest respective associations with essentialism and nominalism, the critical distinction concerns the part of the definition sentence that is granted primacy.

*Primacy of Defined Term versus
Defining Formula*

In some ways, alternative definitions of "Mammalia" serve as better examples for illustrating the difference between essentialistic and nominalistic approaches to definitions than does the example used by Popper (1966) himself. For one thing, the defined term "puppy" is only slightly shorter than the defining formula "young dog," whereas "Mammalia" is considerably shorter than either "the group of organisms possessing hair, mammary glands, a four-chambered heart, etc." or "the clade stemming from the most recent common ancestor of monotremes and therians." But more importantly, different approaches to the definition of "Mammalia" are concrete examples of different perspectives concerning the relationship between the defined term and the defining formula, or more specifically the relationship between the *extension* of the defined term, the entity or set of entities to which the name applies, and its *intension*, the property or properties that an entity must have to be designated by the name.

As noted above, nominalistic and essentialistic approaches to definitions differ in granting primacy to one versus the other of the two components of the definition sentence. Traditional perspectives on taxonomic definitions are essentialistic in granting primacy to the defined term. The definition of "Mammalia," for example, was originally formulated with strong ties to the essentialistic perspective on definitions. Linnaeus (1758) coined the name "Mammalia" in the 10th edition of his *Systema Naturae* (Gill, 1902). According to Gregory (1910:27-28), Linnaeus "was in the habit of first 'sensing' a natural group and then finding the characters to define it af-

terward." One could hardly ask for a more explicit statement attesting to the logical priority of the extension of the defined term relative to the defining formula.

This relationship between defined term and defining formula is also evident in subsequent modifications of the definition that were necessary for its application to fossils. Linnaeus (1758) apparently coined the name "Mammalia" for a group of living organisms. For one thing, fossils considered mammals yet lying outside of the monotreme and therian crown clade were unknown at the time (see Simpson, 1928), and furthermore, Linnaeus's definition consisted almost exclusively of characters with poor fossilization potential, including a four-chambered heart, endothermy, rhythmic breathing, flesh-covered jaws, male intromittent organ, female viviparity and lactation, etc. (see Gregory, 1910). Because such characters are difficult to assess in fossils, paleontologists have effectively replaced Linnaeus's defining formula with defining formulas based on skeletal characters, most notably a dentary-squamosal jaw articulation, three auditory ossicles, a petrosal promontorium, and divided roots on the postcanine teeth (e.g., Simpson, 1959; Young, 1962; Hopson and Crompton, 1969; Kermack and Kermack, 1984; Crompton and Sun, 1985; Gow, 1985; Hopson, 1991; Lucas, 1992). But this shift to characters with high fossilization potential was made possible by the presence of these characters in organisms that were already recognized as mammals on the basis of previous definitions. Thus, reformulation of the definition in terms of skeletal characters rested on prior establishment of the set of mammalian organisms, i.e., the extension of the defined term.

A methodologically essentialist perspective on the definition of "Mammalia" is also seen in definitional changes associated with increases in knowledge about phylogeny. For example, prior to the late 1950s, mammals were perceived as being sharply separated from "reptiles" by four anatomically and functionally related characters, including a jaw articulation formed by the dentary and squamosal rather than the

quadrate and articular bones (Simpson, 1959; Romer, 1969, 1970). But the subsequent discovery of fossils with characters of both mammals and "reptiles," i.e., with both pairs of bones contributing to the jaw articulation, compromised this previously sharp distinction. Consequently, the definition of "Mammalia" was called into question (e.g., Crompton, 1958; Kermack and Mussett, 1958; Simpson, 1959, 1971; Romer, 1969, 1970; Barghusen and Hopson, 1970).

Faced with problematical fossils, paleontologists accepted, rejected, or reserved judgement on the characters previously considered defining, but an implicit essentialistic perspective is evident in all cases. Those who retained the dentary-squamosal articulation as a defining character did so in spite of the partial contribution of quadrate and articular bones in the fossils they studied. They did so because those fossils seemed to have affinities "with undoubted mammals . . . rather than with any mammal-like reptile" and therefore were "included in the Mammalia" (Kermack and Mussett, 1958:211; see also Simpson, 1959, 1960). In contrast, those who rejected the same character as defining did so because the fossils they studied possessed "numerous other reptilian features" or were "far from attaining mammalian conditions" in other characters and hence were classified as reptiles (Crompton, 1958:205; Romer, 1969:882, 1970). Considering the possibility of using alternative characters, Simpson (1959:408) rejected several as potentially defining despite their presence "in animals generally considered to be primitive mammals" on the basis of their occurrence "in some animals now universally classed as reptiles." Finally, even those who chose not to give a revised definition stated that in theory such a definition could be derived from the characters shared by those organisms generally considered mammals (Barghusen and Hopson, 1970; Simpson, 1971). Thus, despite the different conclusions reached by these authors, in all cases those conclusions were based on prior acceptance of the mammalian or non-

mammalian status of particular fossils. In other words, the extension of the defined term was accepted prior to establishing the precise defining formula.

Perhaps because certain fossils compromised the distinctiveness of the mammalian jaw articulation, some recent definitions of "Mammalia" have emphasized different characters. But here again, the definitions rest on prior establishment of the mammalian status of particular fossils. These cases also demonstrate that a methodologically essentialistic perspective can be adopted even when definitions are stated in terms of phylogenetic relationships. For example, Lucas (1992:370) advocated what might be considered an apomorphy-based phylogenetic definition of "Mammalia" when he defined "Mammalia" as "the monophyletic taxon whose members . . . [are] united by the presence of a petrosal promontorium." However, his choice of that character depended on his prior identification of "morganucodontids [which possess a petrosal promontorium] as the most primitive mammals" (Lucas, 1992:370).

Granting logical priority to the extensions of taxon names seems to reflect deeper essentialist underpinnings of traditional taxonomic definitions. In the philosophies of Plato and Aristotle, *intuitive knowledge* or *intellectual intuition* was involved in grasping the essence or essential nature of a thing (Randall, 1960; Popper, 1966). To the extent that traditional definitions of the name "Mammalia" are dependent on prior knowledge concerning which organisms are mammals, they require some kind of intuitive grasping of what it is to be a mammal, such as Linnaeus's "sensing" of natural groups prior to finding their defining characters. Although contemporary systematists use more explicit methods for discovering monophyletic groups, their methods for determining which of several such groups is to be designated by a particular name are less clear. Often such decisions are said to be based on assessments of "biological significance" (e.g., Lucas, 1992), but this assessment involves subject-

tive value judgements about the relative importance of characters (Bryant, 1994), if not intuition.

In terms of the relationship between the two parts of the definition sentence, the proposal to define "Mammalia" as designating the monotreme and therian crown clade gives clear evidence of a move from essentialism toward nominalism. That is, reasons given for using the name "Mammalia" to designate a particular crown clade indicate that primacy is granted to the defining formula rather than the defined term. The crown clade definition of "Mammalia" is one case of a general proposal to define various widely known taxon names as the names of crown clades (de Queiroz and Gauthier, 1992; see also Gauthier et al., 1988a, 1988b, 1988c, 1989). The reasons behind this proposal can be summarized as follows. Most comparative biologists study aspects of biology that are rarely (if ever) preserved in fossils. Therefore, they make generalizations that can only be applied with reasonable certainty to the members of clades stemming from the most recent common ancestors of certain extant organisms (e.g., "mammals nurse their young"). Consequently, it is useful to name those clades. Further, many widely known names are most commonly used as if they designate such clades (e.g., "mammals nurse their young"). Consequently, it is most convenient to define those names so that the designations are made explicit.

The validity of this argument is not critical; what is significant is that it is based on granting primacy to the defining formula. This is evident from the very fact that the crown clade definition of "Mammalia" departs from traditional ideas concerning which organisms are mammals (i.e., the extension of the defined term). Rather than trying to remain faithful to such traditional ideas, advocates of the crown clade definition of "Mammalia" started with a clade that they considered important to name, and then chose a name by which to designate it. In other words, they started with the defining formula and then sought a short label for it. Thus, the

crown clade definition of "Mammalia" represents, by its very nature, a more nominalistic perspective on definitions.

Arguments offered against the crown clade definition and in favor of traditional definitions highlight the difference between the two perspectives in terms of the relationship between the defined term and the defining formula. Lucas (1992), for example, implied that associating the name "Mammalia" with the origin of a biologically significant character is more useful than associating that name with a particular crown clade. However, he presented no argument supporting his implied claim that the petrosal promontorium has profound biological significance for the organisms that have it, particularly relative to hair, endothermy, and mammary glands (see Lucas, 1990, 1992; Lucas and Hunt, 1990). Instead, the significance of the petrosal promontorium seems to be that it is present in morganucodontids—fossils that Lucas presupposes to be mammals.

Lucas's argument against the crown clade definition of "Mammalia" rests implicitly on potential fossilization rather than on biological significance (see also Young, 1962; Kermack and Kermack, 1984). Miao's (1991) argument is explicit. He objected to the crown clade definition on the grounds that among the diagnostic characters listed by Rowe (1988) there is not a single dental character. According to Miao (1991:589), this renders the crown clade definition of limited applicability to "the major portion of the early mammalian fossil record [which] is represented by isolated teeth." However, to conclude that the dental characters in question are mammalian characters, Miao must have already decided that the fossils possessing them are mammals. Otherwise, at least in the case of fossils that are outgroups to the crown clade, the characters could be interpreted as characters not of Mammalia but of a taxon stemming from a more remote ancestor. Thus, Miao's argument, like that of Lucas, is based on establishing the mammalian status of certain fossils prior to determining the precise defining formula.

As an advocate of the traditional perspective, Miao (1991) interpreted poor fossilization potential of the diagnostic characters as a deficiency of the crown clade definition. Because the crown clade definition of "Mammalia" grants primacy to naming the monotreme and therian crown clade, it suggests a very different interpretation concerning the nature of the problem. Viewed from the perspective of the crown clade definition, the problem is not that this definition is deficient because of its limited applicability to fossils; instead, it is the fossils that are deficient in that it is often difficult to determine whether they are parts of the crown clade. This conclusion is highlighted by the fragmentary nature of many fossils, such as those consisting only of isolated teeth. For similar reasons, de Queiroz and Gauthier (1990) argued that adopting a phylogenetic perspective on taxonomic definitions will ultimately reorient questions away from the uncertain monophyletic status of taxa and focus instead on the uncertainty of hypotheses concerning their diagnostic characters and included organisms or species.

Significance Attached to Particular Names

The difference between methodological essentialists and methodological nominalists concerning their perspectives on the relationship between defined term and defining formula leads them to attach very different significance to the designations of particular names. Because essentialists grant primacy to the defined term, they necessarily attach much significance to the designations of particular names. According to Popper (1966[1]:31), methodological essentialists consider it the task of science "to discover and to describe the true nature of things, i.e. their hidden reality or essence." They believe "that every essence . . . may be described in words. And a description of the essence of a thing they [call] a 'definition.'" But a name is itself a word, which can thus be used to describe an essence, and names often serve as abbreviated descriptions/definitions (the name "Mammalia" is an excellent example). Consequently, it is not surprising that

methodological essentialists believe "that every essence has a name proper to it" (Popper, 1966[1]:31). Thus, for an essentialist, the name used to designate a particular taxon is not arbitrary—one name is not just as good as any other.

Methodological nominalists reverse the relationship between defined term and defining formula, and this leads them to attach much less significance to the designations of particular names. In contrast with essentialism, "methodological nominalism sees the aim of science in the description of the things and events of our experience . . . words it considers rather as subsidiary tools for this task, and not as names of essences" (Popper, 1966[1]:32). Consequently, names are viewed not as the proper designations of essences but simply as useful instruments for description (Popper, 1964). Thus, for a nominalist, names do not have designations proper to them, and consequently any name can be used to designate a particular taxon.

Different perspectives on the definition of "Mammalia" align themselves with either essentialism or nominalism in terms of the significance they attach to the designations of particular names. This fact is manifested in three interrelated differences between the perspectives, the first of which concerns the acceptability of names with potentially misleading connotations. Because essentialists use names as abbreviated descriptions of essences and thus treat names as if they had designations proper to them, essentialists tend to oppose names with potentially misleading connotations. This attitude can be seen in traditional perspectives on taxonomic definitions. Early in the history of biological nomenclature, existing names that suggested properties not actually possessed by some or all members of the taxa designated by those names were often replaced with names that more accurately described the members of the taxa in question. Some early nomenclatural codes (e.g., Strickland, 1837; Strickland et al., 1843) contained explicit rules against descriptively inaccurate names. Although current versions of the nomenclatural codes do not require that taxon names be descriptively accurate (Jef-

frey, 1989), the attitude nonetheless persists.

For example, Miao (1991) criticized Ax's (1987) definition of "Mammalia," which uses this name to designate the clade stemming from the initial divergence of the mammalian stem lineage and thus includes numerous taxa that share only very remote common ancestors with extant mammals. Miao's (1991:587) criticism was based in part on the grounds that early representatives of the clade in question probably "did not possess mammae and had not yet evolved lactation." Similarly, one might object to the crown clade definition of "Mammalia" on the grounds that some of the immediate outgroups of the crown clade, which are not considered mammals under the crown clade definition, may well have possessed mammae and lactation.

In contrast with the traditional view, the view associated with the crown clade definition of "Mammalia" is nominalistic in its perspective on names with potentially misleading connotations. The possibility that certain outgroups to the crown clade are not considered mammals yet may have possessed mammary glands is not considered problematical. Indeed, the crown clade definition of "Mammalia" seems to have been proposed in spite of its less than perfect correspondence with the group of organisms possessing mammae. This is not to say that taxonomists adopting a nominalistic perspective treat the designation of taxon names as completely arbitrary; however, they grant more importance to such things as usage, usefulness, and nomenclatural conventions (e.g., priority) than to descriptive accuracy.

A related manifestation of the different significance that methodological essentialists and methodological nominalists attach to particular names concerns their interpretations of the questions answered by their definitions. Because methodological essentialists think the goal of science is to describe the essences of things and concomitantly to define the names of those essences, they "are inclined to formulate scientific questions in such terms as 'what is matter?' or 'what is force?'" (Popper,

1964:29). In keeping with this essentialistic perspective, taxonomists have traditionally viewed their definitions of "Mammalia" as answers to the question "What are mammals?" Thus, this very question (or the variant "What is a mammal?") has been stated explicitly by at least six different authors in connection with traditional definitions of "Mammalia" (Olson, 1959; Simpson, 1959; Reed, 1960; Aulie, 1975; Thenius, 1979; Miao, 1991).

Because nominalists attach less significance to the designations of particular names, they view their definitions as answering very different questions. For nominalists, "Questions like 'What is life?' or 'What is gravity?' do not play any rôle in science" (Popper, 1966[2]:14, emphasis in original). Because nominalists believe that the aim of science is to describe the things and events of our experience, and because they use words only as shorthand symbols to help them accomplish this task, the question answered by a nominalistic definition is not "What is the thing designated by the defined term?" but rather "What shall we call the thing described by the defining formula?" In keeping with this nominalistic perspective, advocates of the crown clade definition of "Mammalia" do not view their definition as an answer to the question "What are mammals?" or even "What is the meaning of the name 'Mammalia'?" Instead, the crown clade definition is meant to answer the question "What shall we call the clade stemming from the most recent common ancestor of monotremes and therians?" This interpretation of the definition is evident in the importance attached to the fact that monotremes and therians share a common ancestor not shared with other extant organisms (e.g., Rowe, 1988; Rowe and Gauthier, 1992) and consequently that the clade stemming from this particular ancestor is significant to many comparative biologists (de Queiroz and Gauthier, 1992). The decision to use the name "Mammalia" to designate this clade is logically secondary to recognizing the existence of the clade and the usefulness of naming it.

Finally, the difference in the significance that essentialists and nominalists attach to

particular names is manifested in a difference in their emphases on defining versus naming. Because methodological essentialists grant much significance to the designation of particular names, their representatives among taxonomists emphasize the meanings of names rather than the naming of clades. This emphasis is seen in traditional perspectives on the definition of "Mammalia." For example, in his argument against the crown clade definition of "Mammalia," Lucas (1992) devoted all his effort to justifying the association of this name with the clade stemming from the ancestor in which a particular character arose. But he did not even consider what name should be given to the crown clade or whether it should be named at all. Moreover, he criticized Rowe for creating new names to designate clades stemming from more remote ancestors. Lucas's emphasis reveals a greater concern for establishing the meaning of the name "Mammalia" than for naming significant clades.

Although advocates of the crown clade definition have also devoted considerable attention to the definition of "Mammalia" and other widely known names, they have done so from the nominalistic perspective of naming clades rather than determining the meanings of names. De Queiroz and Gauthier (1992), for example, discussed the importance of naming not only crown clades but also the more inclusive clades consisting of a crown clade and its extinct outgroups. Naming the clades is what is most important; the proposal to designate particular crown clades with widely known names is only a recommendation intended to standardize the use of those names (de Queiroz and Gauthier, 1992; Bryant, 1994). From a similar perspective, Rowe (1988) not only redefined the name "Mammalia," he also coined the names "Mammaliomorpha," "Mammaliaformes," and "Theriformes" for other clades in a nested series. All of these names are useful in that they permit reference to the various clades with single words rather than lengthy descriptions. Both the redefinition of "Mammalia" and the naming of additional clades are very much in keeping with the nominal-

istic perspective on definitions, in which words are redefined when the need arises and new terms are introduced freely (Popper, 1964).

CONCLUSION

Biological taxonomy is widely held to be one of the oldest scientific disciplines, its origins often being traced to Aristotle. Despite the considerable advances that taxonomy has undergone since Aristotle's time, the influence of the Greek philosopher is still felt in a widespread perspective on the nature of taxonomic definitions—a perspective considered by Popper (1966) to be extremely detrimental to scientific progress. Taxonomists themselves have been largely unaware of their implicit adoption of the Aristotelian (methodologically essentialistic) perspective on definitions. They have also been largely unaware that they have recently begun to move toward an alternative philosophical perspective on definitions. This new perspective has arisen within the context of an idea that, although now widely accepted for more than 100 years, is still relatively new in the long history of biological taxonomy—namely, the principle of evolutionary descent. As an explicitly phylogenetic approach to biological taxonomy has been emerging, systematic biologists have been discovering that there are many more things to name than they had considered under traditional views. This discovery is compelling them to coin new names, to redefine old ones, and—whether they realize it or not—to adopt a very different perspective on the nature and significance of taxonomic definitions. If I have interpreted this new perspective correctly, the changes associated with it should be welcomed. They represent a move away from the constraining influence of essentialism toward an outlook that has been closely associated with progress in other scientific disciplines.

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