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THE EFFECT OF ESSENTIALISM ON TAXONOMY— TWO THOUSAND YEARS OF STASIS (I) *

DAVID L. HULL

I *Introduction and Purpose*

A CONVENIENT year to designate as the beginning of the scientific revolution is 1543. In that year Nicholas Copernicus published *De Revolutionibus Orbium Coelestium* and Andreas Vesalius published *De Humani Corporis Fabrica.* In a little more than a hundred years classical physics reached its fruition in Newton's *Principia.* At first biology promised a similar development with the work of Leewenhoek, Schwammerdam, and Malpighi, but no theoretical achievements even vaguely comparable to those in physics were forthcoming. It wasn't until the nineteenth century with the work of Darwin and Lamarck on evolution, of Mendel on genetics, of Pasteur on micro-organisms, and of Schleiden and others on cell theory that biology came of age. In taxonomy the scientific revolution has been even slower in making itself felt. Although John Ray and Carolus Linnaeus made some advances in the methodology of taxonomy and in organising their taxa, they made no significant contributions to taxonomic theory as devised by Aristotle. As biology lagged behind physics in divesting itself of scholastic influence, taxonomy lagged far behind the other biological sciences. In fact, contrary to popular opinion, the process is still far from complete. And taxonomy only now is reaching a stage of maturity comparable to that of physics 300 years ago or to that of other biological sciences of fifty or a hundred years ago. Why is this?

Karl R. Popper's answer is that ' the development of thought since Aristotle could, I think, be summed up by saying 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 that the degree to which the various sciences have been able to make any progress depended on the degree to which they have been able to get

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rid of this essentialist method'.[1] In no other science is this statement as true as it is in taxonomy, for in no other science is definition as important as it is in taxonomy. Correspondingly, in no other science has there been as much empty verbiage about the meaning of a word as there has been in taxonomy about the meaning of 'species'. But Darwin supposedly put a stop to all that. He himself said in commenting on such endless disputes, 'When the views advanced by me in this volume . . . are generally admitted, we can dimly foresee that there will be a considerable revolution in natural history. Systematists will be able to pursue their labours as at present; but they will not be incessantly haunted by the shadowy doubt whether this or that form be a true species. This, I feel sure and I speak after experience, will be of no slight relief'.[2]

Darwin's views on the evolution of species *have* been generally admitted; there *has* been a considerable revolution in natural history (phylogenetic taxonomy), but a spectre of essentialism continues to haunt the taxonomist. Ernst Mayr says, for example, 'It is a curious paradox that so many taxonomists still adhere to a strictly static species concept, even though they admit freely the existence of evolution'.[3] And again, 'It is a curious paradox in the history of biology that the rediscovery of Mendelian laws resulted in an even more unrealistic species concept among the experimentalists than had existed previously'.[4] With the discovery of biology's two most important theories, one would think that something as basic as the unit of classification would have come into clearer perspective instead of becoming more blurred. In the first instance taxonomists admit that species evolve but find it impossible to define species names accordingly.[5] In the second they admit that there is a genetic continuity among the members of a species

[1] Karl R. Popper, *The Open Society and Its Enemies*, Princeton, 1950, p. 206

[2] Charles Darwin, *The Origin of Species*, New York, 1859, p. 447

[3] Ernst Mayr, *Systematics and the Origin of Species*, New York, 1942, p. 103

[4] Ernst Mayr, 'Species concepts and definition', *The Species Problem*, Washington, 1957, p. 5

[5] Throughout this paper 'species names' and 'taxa names' will be used. These phrases are not presently used in taxonomy, but some terminological device must be made to mark the logically crucial distinction between defining the names of categories such as species, genus, and phylum and defining the names of taxa classed at these category levels such as *Bos bos*, Homo and Protozoa. A second distinction is also important—the distinction between defining a word and defining (or delineating) a group. The name of a particular taxon is defined in terms of certain properties. The membership of that taxon is thus delineated.

but deny species any reality. Both have combined to contribute to the continuation of the species problem.

As A. J. Cain has pointed out,[1] the solution to Mayr's paradoxes can be found in a remnant of essentialism which has not been fully eliminated from taxonomy. It is responsible for taxonomists retaining what is loosely called a static species concept, which in turn is responsible for species being divested of reality. Of course, there are other reasons for taxonomists wanting to retain the trappings of Aristotelian definition, most probably the same reasons which led Aristotle to devise his system in the first place. Presented with the welter of diverse forms to be classified, a taxonomist can greatly simplify his task if he pretends that certain properties are 'essential' for definition. But he would have to do just that—pretend—since the names of taxa cannot be defined in terms of essential characters without falsification on a scale which should have been evident even to the most uncritical investigator with only a limited knowledge of the organisms being classified.

The conflict between reality and theory was largely ignored by early taxonomists both because they did not understand the logic of Aristotelian definition very clearly and because even scientists have a way of not noticing what conflicts with their philosophical presuppositions. At any rate, the thesis of this paper is not that Aristotelian definition was responsible for taxonomists being unable to define taxa names appropriately (although this is certainly true). The thesis of this

[1] A. J. Cain, 'Logic and memory in Linnaeus's system of taxonomy', *Proceedings of the Linnaean Society London*, 1958, **169**, 149. In this article Cain makes the point that Aristotelian definition of species names had given rise to difficulties in the species concept. He does not go on to extend his analysis to 'species' itself which is the purpose of this paper.

Also in this article Cain criticises the use of 'diagnostic' properties by present day phylogeneticists, which he identifies with the practice of weighting some properties more heavily than others because of their varying phylogenetic significance. Thus, it is charged that the variable weighting of properties according to their phylogenetic significance is a development from Aristotelian logic. Cain, op. cit., pp. 150, 161-162. R. R. Sokal and P. H. A. Sneath reiterate the charge in their recent book. R. R. Sokal and P. H. A. Sneath, *Principles of Numerical Taxonomy*, San Francisco, 1963, pp. 8, 16, 34. Unfortunately for this thesis the variable weighting of different characters according to their presumed phylogenetic importance is in direct opposition to the Aristotelian theory of essences. According to Aristotle either a character is essential or it is not. One character cannot be more essential than another. If the variable weighting of properties as now practised by the phylogeneticists is a development from Aristotle, it is an illogical development. Perhaps this is what Cain intended. This is not what Sokal and Sneath interpreted him to mean.

paper is that Aristotelian definition is responsible for taxonomists being unable to define 'species' adequately. The actual distribution of properties among organisms has finally forced taxonomists to abandon Aristotelian definitions of taxa names. There is no comparable conflict to force taxonomists to abandon their attempts to define 'species' in the Aristotelian manner. Nevertheless, it will be argued that Aristotelian definition is just as inappropriate for 'species' as it is for the names of taxa.[1]

2 *Essentialism*

Karl Popper characterises essentialism as follows:

> I use the name *methodological essentialism* to characterize the view, held by Plato and many of his followers, that it is the task of pure knowledge or 'science' to discover and to describe the true nature of things; i.e. their hidden reality or essence. It was Plato's peculiar belief that the essence of sensible things can be found in other and more real things—in their primogenitors or Forms. Many of the later methodological essentialists, for instance Aristotle, did not altogether follow him in determining this; but they all agreed with him in determining the task of pure knowledge as the discovery of the hidden nature or Form or essence of things. All these methodological essentialists also agreed with Plato in holding that these essences may be discovered and discerned with the help of intellectual intuition; that every essence has a name proper to it, the name after which the sensible things are called; and that it may be described in words. And a description of the essence of a thing they called a 'definition'.[2]

In taxonomy this philosophical position became known as typology. The three essentialistic tenets of typology are (1) the ontological assertion that Forms exist, (2) the methodological assertion that the task of taxonomy as a science is to discern the essences of species, and (3) the logical assertion concerning definition. These three separate tenets must be distinguished if we are to avoid making such statements as those that have been made accusing Darwin and Lamarck of being 'typologists'. They were typologists only in the sense that they retained part of the third element of essentialism—the logic of Aristotelian definition. 'According to essentialism (especially Aristotle's version of it) a definition is a restatement of the inherent essence or

[1] It is not being claimed here that the typical practising taxonomist is consciously aware of the logic of Aristotelian definition and has opted for it rather than for some other type of definition.

[2] Popper, 1950, p. 34

nature of a thing. At the same time, it states the meaning of a word—of the name that designates the essence '.[1] In Aristotle's view three things can be known about any entity—its essence, its definition, and its name. The name names the essence. The definition gives a complete and exhaustive description of the essence. Derivatively, the name is the name of the entity and the definition a description of it. ' Aristotle considers the term to be defined as a name of the essence of the thing, and the defining formula as the description of the essence. And he insists that the defining formula must give an exhaustive description of the essence or the essential properties of the thing in question '.[2]

Disregarding all the talk about essences, what Aristotle was advocating in modern terms is definition by properties connected conjunctively which are severally necessary and jointly sufficient.[3] For example, being a three-sided plane closed figure is necessary and sufficient for being a triangle. Such a mode of definition is eminently suited for defining eternal Forms. It is not very well suited for defining the names of evolving species or for ' species ' itself, and yet it is exactly this mode of definition which has been assumed to be the only mode of definition permissible until recently. Evolutionary theory necessarily challenged the ontological assertion that species as Forms existed. Quite obviously it also challenged the methodological assertion. If there were no Forms, then the task of taxonomy could not be to discern them. But evolutionary theory had a third consequence for taxonomy, and it was *this* consequence which Darwin and his followers *did not see*. Aristotelian definition had to be abandoned both for species names and for ' species '. Typologists could ignore the actual untidy distribution of properties among living organisms and the variety of methods of reproduction used to perpetuate species. Evolutionists could not.

3 *Aristotelian Definition and Evolution*

From the beginning taxonomists have sought two things—a definition of ' species ' which would result in real species and a unifying principle which would result in a natural classification. The fervour

[1] Karl R. Popper, *Conjectures and Refutations*, New York, 1962, 19

[2] Popper, 1950, p. 208

[3] The important distinction for this paper, however, is not between definite conjunctive and definite disjunctive definitions but between definite definitions of either kind and indefinitely long disjunctive definitions.

with which taxonomists searched for such a unifying principle is evident in the following quotation by Linnaeus. 'For a long time I have laboured to find it; I have discovered many things, but I have not been able to find it. I shall continue to search for it as long as I live'.[1] In evolutionary theory taxonomists at last had their unifying principle. A natural classification would be a classification which in some sense 'represented' phylogeny.[2] From its very inception the enthusiasm with which some taxonomists welcomed the phylogenetic programme was equalled only by the vehemence with which others rejected it. It is obvious why typologists opposed phylogenetic taxonomy, but phylogenetic taxonomy also met with resistance from taxonomists who accepted evolutionary theory but who denied it any relevance to taxonomy. This latter group has come to be known as the classificationists. Their modern counterparts are the numerical or neo-Adansonian taxonomists. The explanation for the early classificationist stand can be found again in the third element of essentialism.[3] Although all early phylogeneticists and most classificationists abandoned the first two assertions of essentialism, neither abandoned Aristotelian definition.

Because of evolution taxonomists felt confronted by a dilemma. If they accepted evolutionary theory as the unifying principle of a natural classification, they had to abandon any hope of ever having real species. If they wished to retain real species, they had to give up any hope of ever having a natural classification. The rationale behind this dilemma can be seen in the following quotations from Lamarck, Lyell, and Darwin. Lamarck said, for example, 'The part of the work of naturalists which concerns the determination of what one calls "species" becomes day by day more defective, that is to say, more entangled and more confused, because it is executed in the almost universally admitted supposition that the productions of nature constitute species constantly distinguished by invariable characters, and whose existence is as ancient as that of nature itself'.[4] Lamarck's conclusion was then that since species couldn't be defined by an invarying list of

[1] Tindell Hopwood, 'Animal classification from the Greeks to Linnaeus', *Lectures on the Development of Taxonomy*, London, 1950, p. 26

[2] David L. Hull, 'Consistency and Monophyly', *Systematic Zoology*, 1960, **13**, 1-11

[3] Adanson was unique in several respects, two of which are that he abandoned all the tenets of essentialism before evolutionary theory and that evolution had no relevance for taxonomy but for the very simple reason that it hadn't been discovered yet.

[4] J.-B. Lamarck, *Discours D'Ouverture*, Paris, 1097, p. 110

characters, they couldn't be real. Lyell replied, 'If species are not real, the obvious consequences are alarming: unlimited change becomes not only possible but even necessary. Species will no longer have well-defined limits, classification becomes a purely arbitrary exercise, and any species may easily be transformed into another'.[1] Even Darwin said that once his or an analogous view was accepted, 'systematists will have only to decide (not that this will be easy) whether any form be sufficiently constant and distinct from other forms to be capable of definition; and if definable, whether the difference be sufficiently important to deserve a specific name. . . . In short, we shall have to treat species in the same manner as those naturalists treat genera, who admit that genera are merely artificial combinations made for convenience. This may not be a cheering prospect; but we shall at least be free from the vain search for the undiscovered and undiscoverable essence of the term species'.[2]

When the logic of the preceding argument is set out in full, it goes something like this. The only basis for a natural classification is evolutionary theory, but according to evolutionary theory, species developed gradually, changing one into another. If species evolved so gradually, they cannot be delimited by means of a single property or set of properties. If species can't be so delineated, then species names can't be defined in the classic manner. If species names can't be defined in the classic manner, then they can't be defined at all. If they can't be defined at all, then species can't be real. If species aren't real, then 'species' has no reference and classification is completely arbitrary.

Elements of this same argument can be found in the writings of modern taxonomists. For example, A. J. Cain says the following things: 'But when good series are available, forms that seem to be good species at any one time may become indefinable since they are successive stages in a single evolutionary line and intrograde smoothly with each other[3] . . . with the passage of time, they change continuously and are gradually transformed into two modern species, without any sudden discontinuity which could be used as a specific boundary. . . . [4] The limits of both subspecies and species within a genus are equally arbitrary, since there is no reason to make a break in a continuous

[1] William Coleman, 'Lyell and the "reality" of species', *Isis*, 1962, **53**, 326

[2] Darwin, 1859, p. 447

[3] A. J. Cain, *Animal Species and Their Evolution*, London, 1954, p. 107

[4] Cain, 1954, p. 111

series at any one point rather than at another '.[1] Cain concludes that the problem is insoluble.[2] Ernst Mayr concurs, saying, ' Even though the number of cases that cause real difficulties is very small, the fact remains that an objective delimitation of species in a multidimensional system is an impossibility '.[3] And G. G. Simpson says, ' Certainly the lineage must be chopped into segments for the purposes of classification, and this must be done arbitrarily . . . , because there is no non-arbitrary way to subdivide a continuous line. . . . '[4]

Even though ' species ' has all the faults mentioned, A. J. Cain says that species as single phyletic lines are ' less artificial, subjective or arbitrary than any other rank '.[5] Mayr says, ' The species is an important unit in evolution, in ecology, in the behavioral sciences, and in applied biology.[6] . . . it has a very distinct biological significance. . . .'[7] And Simpson says, ' The point will be discussed later, but even here it is advisable just to mention that such arbitrary subdivision does not necessarily produce taxa that are either " unreal " or " unnatural ", as has sometimes been stated. A simple but, at this point, sufficiently explanatory analogy is provided by a piece of string that shades continuously from, say, blue at one end to green at the other. Cutting the string into two is an arbitrary act, but the resulting pieces are perfectly real sections of the string that existed as natural parts of the whole before they were severed '.[8]

Quite obviously taxonomists still believe there is a species problem and at the heart of it is the biologically uninteresting but the logically crucial notion of *definition*.

4 *Taxa Names as Cluster Concepts*

Mayr says that although there has been steady clarification of the issue, ' there is still much uncertainty and widespread divergence of opinion on many aspects of the species problem. It is rather surprising that not more agreement has been reached during the past two hundred years in which these questions have been tossed back and forth. This certainly cannot be due to lack of trying, for an immense amount of time and thought has been devoted to the subject during this period.

[1] Cain, 1954, p. 113
[2] Cain, 1954, p. 114
[3] Ernst Mayr, ' Difficulties and importance of the biological species ', *The Species Problem*, Washington, 1957, p. 376
[4] G. G. Simpson, *Principles of Animal Taxonomy*, New York, 1961, p. 165
[5] Cain, 1954, p. 183
[6] Mayr, 1957, p. 385
[7] Mayr, 1957, p. 384
[8] Simpson, 1961, pp. 60-61

One has the feeling that there is a hidden reason for so much disagreement'.[1] One of the reasons why more agreement has not been reached is that the classificationists and phylogeneticists disagree over the purposes of taxonomy. One wants the unit of classification to be the unit of identification. The other wants it to be the unit of evolution. But there is also a hidden reason for so much disagreement—the philosophical predisposition on the part of taxonomists of both schools for Aristotelian definition. An important clue that Aristotelian definition is at fault is the conclusion reached by Mayr and almost all other taxonomists who have attended to the species problem that 'perhaps the disagreement is due to the fact that there is more than one kind of species and that we need a different definition for each of these species'.[2]

The influence of Aristotelian definition on taxonomic thought can best be revealed by investigating the definition of a type of term for which taxonomists have already abandoned Aristotelian definition—the definition of taxa names. It is commonplace now to recognise what Adanson realised almost two hundred years ago that taxa names cannot be defined by sets of properties the members of which are severally necessary and jointly sufficient, for seldom is a property of any taxonomic value distributed both universally and exclusively among the members of a taxon. The properties which are used to define the names of taxa do not respect taxonomic boundaries. For example, depending on whether the hemichordates are included in the phylum Chordata or whether they are made a separate phylum, none of the properties used to define 'Chordata' are both necessary and sufficient. If the hemichordates are included in Chordata, then a few of the properties are possessed exclusively by the chordates; e.g. notochord, dorsal hollow nerve cord, metameric musculature, internal skeleton of cartilage or bone, and a closed circulatory system. But then none of the properties are possessed universally. Possession of internal gill slits comes the closest to being universally distributed; however, some hemichordates do not have anything that faintly resembles gill slits. If on the other hand the hemichordates are not included in Chordata, then several defining properties become universally possessed by the chordates; e.g. notochord, dorsal hollow nerve cord, and gill slits. But then several of the properties which were exclusively chordate cease to be possessed exclusively by them; e.g. dorsal hollow nerve cord. The only property that is both universally and exclusively possessed by the chordates is the notochord,

[1] Mayr, 1957, p. 10 [2] Mayr, 1957, p. 10

although some vertebrates and urochordates possess one only in the embryo or larva. Even if only contemporary forms are taken into consideration, Aristotelian definition simply won't do.

Traditionally a word is considered to be explicitly defined if and only if a set of properties can be given such that each property is severally necessary and the entire set of necessary properties is jointly sufficient. For example, a bachelor is a male adult human being who has never married and a sibling is one of at least two children of the same parents. If ' A ' is the word to be defined and a, b, c, and d are properties, then the logical structure of such a definition is ' $A^{DF} a.b.c.d$' Words can also be defined disjunctively without violating the spirit of Aristotelian definition. For example, a sibling is a brother or a sister and an uncle is the brother of one's father or the brother of one's mother or the husband of one of one's aunts. The logical structure of such a definition is ' $A^{DF} a \vee b \vee c \vee d$.' In such a disjunctive definition each property is severally sufficient and the possession of at least one of the properties is necessary.[1]

However, neither of these types of definition is appropriate for defining the names of taxa and, hence, for delineating taxa. Whether from the viewpoint of phylogenetic or numerical taxonomy, taxa names can be defined only *by sets of statistically covarying properties arranged in indefinitely long disjunctive definitions.* The logical structure of such a definition is ' $A^{DF} a.b.c.d \vee b.c.d.e \vee a.c.d.f$ and so on '. Usually no one particular property or set of properties is necessary and any one of numerous sets is sufficient. An example from ordinary discourse of a word which can be defined only in such a manner is ' lemon '. A description of a lemon would contain such properties as coming from a particular type of tree, having a sour taste, an ovoid shape and so on. None of these properties is necessary since a fruit could lack any one of them and still be a lemon. Several different but overlapping sets of properties are accordingly each sufficient.[2]

In defining taxa names as cluster concepts, taxonomists have (whether they realise it or not) adopted a new and rather controversial philosophical position. They have abandoned the simple dichotomy

[1] Each disjunct may also be a conjunction of two or more properties without altering the logic of a definite disjunctive definition as long as each conjunction has a certain set of members.

[2] Michael J. Scriven, ' The Logic of Criteria ', *The Journal of Philosophy*, 1959, **56**, p. 860

between analytic and synthetic connections in definition. The traditional view is that either a defining property is analytically connected to the word it defines or it is not. There is no middle ground. According to one version of the new position, ' Any property that is connected with another in such a way that it does not make sense to deny its application will be said to be analytically connected with it, as, e.g. brotherhood is connected with siblinghood. A property that does not meet this requirement, but which would have to occur in a thorough explanation of the meaning of the term nonetheless, will be said to be normically connected with it. Other connections will be called synthetic '.[1] With rare exception the properties that occur in the definitions of the names of taxa are normically connected. They are not analytically connected because an individual or a population could lack any one or few of the properties and still be a member of the taxon. Yet they are not merely synthetic because they are the *only* properties used in the definitions.

In terming certain properties ' normic ', laws are implied. In phylogenetic taxonomy these laws are those of evolutionary and gene theories. Which properties are normic and how important each is for definition is determined by these theories. Advocates of traditional Aristotelian definition and the simple, clear-cut analytic-synthetic distinction on which it is based usually counter attempts to define words as cluster concepts by one of two moves. They claim that such words are ' used in a fuzzy way by the casual users, but that (*a*) usually these users can be persuaded on reflection to accept certain necessary and sufficient conditions as analytic and to reject other connections as synthetic, or (*b*) the fuzzy concept should be replaced by a more precise one, which can be defined in a traditional way '.[2]

Neither of these alternatives is viable in the case of taxa names. Taxonomists certainly do not use the names of taxa casually and could not accept certain necessary and sufficient conditions as analytic even if they wanted to, as the chordate example showed. Nor can they replace the taxa names they now have with more precise ones and still fulfil the purposes of phylogenetic taxonomy. For example, all and only the vertebrates, the cephalochordates and the urochordates possess a notochord at some time in their ontological development. No other property covaries with this property. Even so a taxon ' Notochordata ' could be formed by making the possession of a notochord both necessary and sufficient. On the other hand, the vertebrates, cephalo-

[1] Scriven, 1959, p. 861 [2] Scriven, 1959, p. 859

chordates, urochordates, enteropneusts and some pterobranchs (both of the hemichordates), and an extinct echinoderm possess gill slits at some time in their ontological development. No other property covaries with it. If the possession of gill slits was made both necessary and sufficient, a taxon 'Branchiata' could be defined traditionally. But the preceding definitions are *just* the type of definition of taxa names which modern taxonomists have striven to avoid.[1] Whether a classification is to be merely useful (the position of numerical taxonomy) or both useful and phylogenetically significant (the phylogenetic position), taxa names can be defined only by sets of statistically covarying properties.

All the examples of cluster concepts given thus far have a second peculiarity. After several members of the disjunction have been given, the definition is terminated with a phrase like 'and so on'. In the case of most taxa names, the reason for not listing all of the disjuncts is not that the list is too long or too well known to bother writing down but that it *cannot be completed.* The property of cluster concepts which bothers traditionalists most is that often the entire disjunction cannot be stated. It is indefinitely long. Instead of being detrimental for the purposes of phylogenetic taxonomy, such indefiniteness is essential.

Morton Beckner says of defining the name of a taxon K that if we had an enumeration of the defining properties and if the number of properties sufficient for membership were determined once and for all, then 'we have provided ourselves with the means of defining K as a monotypic class. We can form all the distinct classes that are the Boolean product of k members of G (the set of defining properties), and then say that X is a member of K if and only if it is a member of the class which is the Boolean sum of these Boolean products. In short, K would be the disjunction of all conjunctions of k members of G. This function lays down a single condition which is both necessary and sufficient for membership in K'.[2] But in the case of phylogenetic taxonomy seldom can either of the two conditions which prefaced the quotation be realised until K and its neighbouring taxa[3] have ceased

[1] Cain, 1954, p. 18

[2] Morton Beckner, *The Biological Way of Thought*, New York, 1959, p. 24. Ludwig Wittgenstein was an early proponent of cluster concepts or 'family resemblances,' as he termed them. He also foresaw the possibility of Beckner's move and commented on it appropriately. Ludwig Wittgenstein, *Philosophical Investigation*, New York, 1945 sect. 67.

[3] The species are 'neighbouring' in the sense of being near each other in taxonomic space.

to evolve, for not until all the species which must be distinguished from each other have ceased to evolve can it be decided which and how many properties are sufficient to distinguish them *once and for all.* For example, very few properties are needed to distinguish modern man from any other known species. However, if a species of ape were to begin to develop along the same lines as man, acquiring comparable properties, the definition of *Homo sapiens* would have to be expanded to exclude this new form if *Homo sapiens* is to be kept minimally monophyletic. Even if a taxonomist wanted to, he could not supply these distinguishing properties in advance. Besides, until such an unlikely event occurs, there is no reason to complicate the definition. Taxonomists cannot be prepared in advance for all contingencies. All that they need do is to accommodate the contingencies that do arise as they arise.

In the case of entirely extinct species, it is at least in principle possible to define the names of these species once and for all *if* a complete fossil record is present for the species concerned and its neighbouring taxa. If the fossil record is not complete, the definition of the name of an extinct species must be changed as fossils of similar species are discovered. Thus, the definitions of taxa names as cluster concepts are peculiar in a second respect. Unlike traditional definitions, they cannot be forever insulated against empirical findings. As more evidence is accumulated, they will have to be altered to accommodate this evidence.

(*To be concluded*)