Conceptual Natural Realism and Aristotelian Essentialism: Plenary Session (Originally Written as Lecture Nine) Intensive Course STOQ 50547 II Semester April 26–30, 2004

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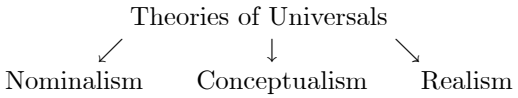
April 29, 2004, 13:00–16:30

1 Introduction

Formal ontology, we have said, is a discipline in which the formal methods of mathematical logic are combined with the intuitive, philosophical analyses and principles of ontology. What we do in formal ontology is bring together the clarity and precision of the methodology of logical analysis with the philosophical insights of ontological analysis. One of the fundamental issues in ontology is the problem of universals, which formally is represented by the problem of predication, which includes not only the problem of what, if anything, predicates stand for, but also how we are to account for the nexus of predication in language, thought, and reality.

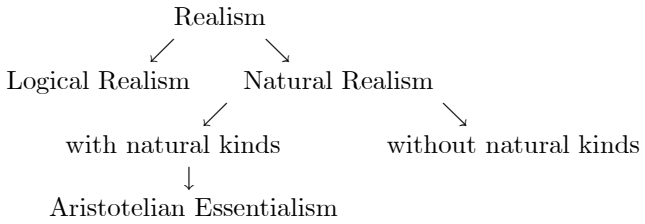
The three main theories of universals in the history of philosophy have been nominalism, realism, and conceptualism.



In **nominalism**, there are no universals that predicates stand for, and there is only predication in language.
In **conceptualism**, predication in thought is what underlies predication in language, and what predicates stand for are concepts as rule-following cognitive capacities underlying our use of predicate expressions.

In **realism**, what predicates stand for are real universals that are the basis for predication in reality, i.e., for the events and states of affairs that obtain in the world.

We distinguished **two types of realism** in previous lectures, namely Bertrand Russell's and Gottlob Frege's different versions of **logical realism** as modern forms of Platonism, and several variants of **natural realism**, one variant of which is logical atomism, and another variant of which we will discuss today is a modern form of Aristotle's theory of natural kinds, or what is usually called Aristotelian essentialism.



Now the relationship between conceptualism and realism is more complex than the simple kind of opposition that each has to nominalism. Conceptual intensional realism, for example, is similar to logical realism with respect to overall logical structure, and yet the two formal ontologies are different on such fundamental issues as the nature of universals and the nexus of predication.

The relationship between conceptualism and natural realism, on the other hand, is even more complex. They do not, for example, have the same overall logical structure, and they also differ on the nature of universals and the nexus of predication. And yet, conceptualism and natural realism have been intimately connected with one another throughout the history of philosophy—though not always in an unproblematic way. One reason for this connection is that without some form of natural realism associated with it, conceptualism becomes an ontology restricted to the conceptual realm, where, without an ontological ground in nature, it turns into a form of conceptual idealism, sometimes with, and sometimes without, a transcendental subjectivity, as has occurred in the history of British and German philosophy.

Conceptualism, we have noted, is based on a socio-biological theory of the human capacity for language, culture and thought, and therefore it must presuppose some form of natural realism as the causal ground of that capacity. On the other hand, natural realism must in turn presuppose some form of conceptualism by which to explain our capacity for language and thought, and in particular our capacity to form theories of the world and conjecture about natural properties and relations as part of the causal order. Conceptualism and natural realism, in other words, presuppose each other as part of a more general ontology, which, in one form or another, may be called conceptual natural realism.[1]

The connection between conceptualism and natural realism goes back at least as far as Aristotle whose doctrine of moderate realism, i.e., the doctrine

[1] Some of the differences between these forms depends on whether a constructive or holistic conceptualism is assumed, and whether the natural realism is part of an Aristotelian essentialism or not.

that universals "exist" only in things in nature, is well-known for its opposition to Platonism, i.e., the doctrine that universals exist as abstract entities independently of concrete objects. Peter Abelard, in his *Glosses on Porphyry*, also dealt with the connection between the conceptual and natural orders of being. In particular, Abelard gave an account that is very much like Aristotle's in being both conceptualist and realist. But in combining these positions, Abelard did not sharply distinguish the universals that underlie predication in thought from those that underlie predication in reality. In particular, a universal, according to Abelard, seems to exist in a double way, first as a common likeness in things, and then as a concept that exists in the human intellect through the mind's power to abstract from our perception of things by attending to the likeness in them. What Abelard describes is a form of *natural realism*, where a property exists only in the causal or natural order and as a common likeness in things; and yet if those things were to cease to exist, the property would somehow still exist in the human intellect as a concept.

Aristotle also seems to have described natural kinds and properties in this double way, i.e. as having a mode of being both in things and then, through an inductive abstraction (*epagoge*), in the mind as well. But then it is possible to interpret him otherwise, especially in his discussion in the *Posterior Analytics* of how concepts such as being a chimera or being a goat-stag can be formed otherwise than by abstraction. Such an alternative interpretation was in fact developed by Aquinas in his distinction between the active intellect (*intellectus agens*) and the receptive intellect (*intellectus possibilis*), which are not really two intellects but two kinds of powers or capacities of the intellect *simpliciter*.[2] In fact, Aquinas apparently developed the central idea of conceptual natural realism, namely, that the problem of the "double existence" of universals is not an ontological problem but a problem of explaining how the same predicate can stand for, or signify, a concept in the mind on the one hand, and a natural property in nature on the other, where the natural property corresponds to, or is represented by, the concept. The two are not really the same universal, in other words, and do not even have the same mode of being.[3]

Concepts cannot literally be the same as the natural properties and relations they purport to represent, in other words, and in fact some concepts—especially those for artifacts and social conventions—do not represent any natural properties or relations at all.

2 The Problem with Moderate Realism

One reason why the universals of natural realism were confused with predicable concepts is that both can be designated by predicates—or, more precisely, that a predicate that stands for a concept can also be taken to stand for a natural property or relation that corresponds to that concept. A predicate can be taken to stand for a natural property or relation, in other words, as well as for a

[2] Cf. Kenny 1969.
[3] See Basti

concept, but then the sense in which it stands for a property or a relation is secondary to the sense in which it stands for a concept. As Aquinas noted, the traditional problem about universals "existing in a double way" was really a matter of there being two ways in which a predicate can signify a universal, one way being primary in which the predicate stands for a concept, and the other being secondary in which the predicate stands for natural property or relation that corresponds to that concept.

Now the sense in which a predicate stands for a concept is primary because it is the concept that determines the functional role of the predicate and the conditions under which it can be correctly used in a speech act. It is only by assuming that the truth conditions determined by the concept have a causal ground based on a natural property or relation that we can then say that the predicate also stands for a natural property or relation. In other words, even though the natural property or relation in question may in fact be the causal basis for our forming the concept, and therefore is prior in the order of being, nevertheless, the concept is prior in the order of conception.

The distinction between concepts in the order of conception and natural properties and relations in the order of being does not mean that there should also be a distinction in the theory of logical forms of conceptual natural realism between predicates that stand for concepts and predicates that stand for a natural property or relation. The whole point of the double significance of a predicate is that the same predicate can stand for both a concept in the primary sense and a natural property or relation in the secondary sense. Thus, it is not that the same universal can "exist in a double way," as Abelard assumed, first in nature and then in the mind, but rather that the same predicate can stand in a double way for both a concept and a natural property or relation—though it stands first for a concept, and then also for a natural property or relation—but only in the sense of an hypothesis about nature, which might not always be explicit, but only implicit.

Now, just as a predicate constant can be taken to stand in double way both for a concept and a natural property or relation, so too a predicate variable can be taken in a double way to have both concepts and natural properties and relations as its values. The difference between the universals in the one order and the universals in the other is reflected not in a difference between two "types" of predicate constants and variables—where the one "type" stands for concepts and the other stands for natural properties and relations—but in the kind of reference that is made by means of predicate quantifiers, i.e., the quantifiers that can be affixed to predicate variables and that determine the conditions under which a predicate constant can be substituted for a predicate variable. In this way, the difference is reflected not in a difference of types of predicate variables to which predicate quantifiers can be affixed, but in a difference between the predicate quantifiers themselves, i.e., in the types of referential concepts the quantifiers stand for.

What we need to add to the second-order conceptualist theory of logical forms described in our fourth lecture, accordingly, are special quantifiers, $\forall^n$ and $\exists^n$, that can be applied to predicate variables, and that, when so applied,

can be used to refer to natural properties and relations. In this way Aristotle's moderate realism as a form of natural realism can be stated as follows:

$$(\forall^n F^j)(\exists^e x_1)...(\exists^e x_j)F(x_1,...,x_j), \qquad (\mathbf{MR})$$

where the quantifier $\exists^e$ is as described in the logic of actual (concrete) objects (in our second and fourth lectures). With the possibilist objectual quantifiers, we have the following as a consequence of this thesis:

$$(\forall^n F^j)(\forall x_1)...(\forall x_j)[F(x_1,...,x_j) \rightarrow E!(x_1) \wedge ... \wedge E!(x_j)],$$

where the monadic predicate $E!$ stands for the concept of concrete existence. This concept of existence, as we analyzed it earlier (in lecture 4, §5), is a logical construct, and hence there is no presumption that there is a natural property corresponding to it.

> What the thesis of moderate realism, (MR), says is that natural properties and relations "exist" only as components of facts, i.e., the states of affairs that obtain in the world. It is in that sense that we say that a natural property or relations "exists" only in things.

Unfortunately, this is much too restrictive a view of natural realism as a scientifically acceptable ontology. At the moment of the Big Bang, for example, when the universe was first formed, there was mostly raw energy and only very few elementary particles. There were no atoms or molecules of any kind, or at least certainly not of any complex kind, all of which came later in the physical evolution of the universe. Consequently, many of the natural properties and relations that we now know to characterize atoms and compounds as physical complexes were not at that time realized in any objects at all. But of course that does not mean that they did not then have a real mode of being within nature's causal matrix even at the beginning of the universe. Indeed, even today there may yet *be* some transuranic elements, and natural properties of such, that, as a matter of contingent fact, will never be realized in nature by any objects at all, but which, nevertheless, as a matter of a natural or causal possibility, could be realized by atoms that are generated, e.g., in a supernova, or in a very high energy accelerator. The being of such a natural property or relation does not consist of its being a property of some transuranic atom at the moment of the Big Bang, nor even, for that matter, of its being *in re* at some time or other in the history of the universe. Instead, its being consists of its being part of nature's causal matrix right from the beginning of time, and therefore of its possibly being realized in nature, i.e., of its *possibly being in re*.

> The being of a natural property or relation is its *possibly being in re*, i.e., of its being realizable in nature as a matter of a natural or causal possibility.

Now one important consequence of this view of natural properties and relations is that they are not intensional objects, nor are they *objects* of any kind at all. This is so because if natural properties and relations were objects, then, in order to *be* even when they are not in things, they would have to be *abstract objects.* How could they *be,* in other words, when they are not in things, unless their being is that of an abstract object in a Platonic realm of forms, in which case they would have a mode of being that transcended the natural world and nature's causal matrix. But natural properties and relations do not exist independently of the world and its causal matrix, even though they are not contained within the space-time causal manifold the way concrete objects are. Natural properties and relations cannot be objects, in other words, and therefore their mode of being as *possibly being in re* must have a different explanation. As universals that correspond to concepts as unsaturated cognitive capacities, the most plausible explanation is that they too have an unsaturated nature, albeit one that is only analogous to, and not the same as, the unsaturated predicative nature of concepts. As components of the nexus of predication in reality, which we can comprehend only by analogy with the nexus of predication in thought, natural properties and relations are *unsaturated* causally determinate structures that become saturated in the states of affairs that obtain in nature, and that otherwise "exist" only within nature's causal matrix.

Thus, even though natural properties and relations do not "exist in a double way," one in nature and the other in the intellect, nevertheless, they have a mode of being as unsaturated causal structures that is *analogous* to that of concepts as unsaturated cognitive capacities, and hence their unsaturatedness must be understood by analogy with the unsaturated nature of concepts. In terms of the theory of logical forms of a formal ontology, where predicates signify both kinds of universals, this means that both kinds of universals are values of predicate variables, albeit variables bound by different quantifiers, namely $\forall^n$ and $\exists^n$ in the case of natural properties and relations, and $\forall$ and $\exists$ in the case of predicable concepts.

Finally, we should note that just as predicable concepts do not exist independently of the general capacity humans have for language and thought, so too natural properties and relations do not exist independently of nature's causal matrix. That is why, just as the laws of compositionality for concept-formation, as characterized by the comprehension principle $\mathbf{(CP^*_\lambda)}$, can be said to characterize the logical structure of the intellect as the basis of the human capacity for language and thought, so too the laws of nature regarding the causal connections between natural properties and relations, especially as determined by natural kinds, can be said to characterize the causal structure of the world. Thus, just as concepts have their being within the matrix of thought and concept-formation, so too natural properties and relations have their being within the matrix of the laws of nature.

3 Natural Realism as Modal Moderate Realism

What is needed in the formal ontology of natural realism is a modal logic for a causal or natural necessity, or dually, for a causal or natural possibility. By a natural possibility we mean what is possible in nature, i.e., what is not precluded by the laws of nature. A natural necessity therefore is what must be so because of the laws of nature. This suggests that **S5** is the appropriate modal logic for natural necessity; or to express the matter in model-theoretic terms, that possible worlds that have same laws of nature are all accessible to one another with respect to this modality, and hence constitute an equivalence class. Different equivalence classes of possible worlds will then represent different causal matrices as determined by the laws of nature that are invariant across the worlds in those equivalence classes. As is well-known, necessity, when interpreted as invariance over each equivalence class of a set of equivalence classes of models ("possible worlds")—i.e., where each model in any one such equivalence class is accessible from every other model in that equivalence class—results in a completeness theorem for **S5** modal logic.[4]

By a causal possibility, on the other hand, we mean what can be brought about in nature through causal mechanisms of whatever natural sort, physical, biological, etc. A causal necessity then is what must be so because of its causal ground, i.e., what caused it to be so. This suggests that **S4** is the appropriate modal logic to adopt, because whereas causal relations are transitive they are not also symmetric, and, as is well-known, **S4** is the modal logic characterized by a transitive accessibility relation between possible worlds.

We will not attempt to decide here whether the appropriate modal logic for conceptual natural realism is **S4** or **S5**. Instead, we will leave that decision to the different variants of this ontology that might be developed. These variants might differ not only in respect of which modal logic is adopted, but also in whether the first-order logic of the variant is possibilist or actualist, and also whether it allows for only a constructive conceptualism or a more comprehensive holistic conceptualism. However, because **S4** is a proper part of **S5**, we will use **S4** here without assuming that **S5** is thereby precluded. In regard to notation, we will use $\Box^c$ for causal necessity and $\Diamond^c$ for causal possibility.

Now, instead of the ontological thesis of moderate realism **(MR)**, we have the following ontological thesis of *modal moderate realism* as a fundamental principle of natural realism:

$$(\forall^n F^j)\Diamond^c(\exists^e x_1)...(\exists^e x_j)F(x_1,...,x_j). \qquad \textbf{(MMR)}$$

Natural properties and relations "exist", in other words, not as components of actual facts, as was stipulated in the thesis of moderate realism, but as the nexuses of possible states of affairs.

> What the principle of modal moderate realism, (MMR), says is that natural properties and relations "exist" as

[4] See Cocchiarella 1986, chapter III, §7, for an axiomatization and completeness theorem of natural realism based on this interpretation.

> components of the nexuses of possible states of affairs, i.e., the states of affairs that can be caused to obtain in the world. It is in this sense that the being of a natural property or relation is its *possibly being in re*.

Now the fact that only concrete objects can have a natural property or relation is reflected in the following consequence of **(MMR)**:

$$(\forall^n F^j)\Box^c[F(x_1, ..., x_j) \rightarrow E!(x_1) \wedge ... \wedge E!(x_j)],$$

where, as already indicated, we use $E!$ to stand for the formal concept of (concrete) existence (in the causal space-time manifold). If the first-order logic is possibilist (in the causal sense of possibilism), then this consequence can be formulated as

$$(\forall^n F^j)(\forall x_1)...(\forall x_j)\Box^c[F(x_1, ..., x_j) \rightarrow E!(x_1) \wedge ... \wedge E!(x_j)].$$

The concept of (concrete) existence, we have said , is a logical construct, and in fact, as constructed within conceptual realism, it is an impredicative concept, because it is constructed, or formed, in terms of a totality to which it belongs. That is, as defined earlier, to exist is to fall under an existence-entailing concept, or, in symbols,

$$E!(x) \leftrightarrow (\exists^e F)F(x).$$

Now because natural properties can be realized only by things that actually exist in nature, it might be thought that we could give a more specific kind of analysis in natural realism, and, in particular, that we could define concrete existence as having a natural property, and therefore as being a constituent of a fact, i.e., a state of affairs that obtains in the world:

$$E!(x) =_{df} (\exists^n F)F(x). \qquad (\mathbf{E?})$$

Such an analysis will not suffice, however, because it is possible that some existing objects might not have a natural property, but only stand to other existing objects in a natural relation. The point is that standing in a natural relation to other existing objects does not constitute having a natural property. Relational properties do not in general generate monadic properties, in other words, and to claim otherwise is to confuse the conceptual order, where monadic concepts can be constructed from relational concepts, with the natural order, where properties and relations can be posited to existed only as hypotheses about nature. This is part of what we mean when we said that conceptualism and natural realism do not have the same overall logical structure.

There is no general comprehension principle that is valid in natural realism, accordingly, the way that the comprehension principle $(\mathbf{CP}^*_{\boldsymbol{\lambda}})$ is valid for conceptual realism. Natural properties and relations, in other words, are not formed, or constructed, out of other properties and relations by logical operations. But this does not mean that no natural property or relation can be specified in terms of a complex formula, i.e., a formula in which logical constants occur. What it

does mean is that such a specification cannot be validated on logical grounds alone, but must be taken as a contingent hypothesis about the world.

Now in order to even consider specifying natural properties and relations in terms of complex formulas, it is convenient to do so with some abbreviatory notation. In particular, we can adopt some useful abbreviatory notation that *simulates* nominalizing predicates as objectual terms. We adopt for this purpose the following notation, which simulates a kind of identity between natural properties or relations:

$$F^j \equiv_c G^j =_{df} \Box^c(\forall x_1)...(\forall x_j)[F(x_1,...,x_j) \leftrightarrow G(x_1,...,x_j)]$$

Unlike concepts, in other words, natural properties and relations are "identical" when, as matter of causal necessity, they are coextensive. As part of the causal structure of the world, natural properties and relations retain their "identity" as natural properties and relations across all causally accessible worlds.

> As part of nature's causal matrix, natural properties and relations are "identical" when, as a matter of causal necessity, they are co-extensive.

Now the assumption that there is a natural property or relation corresponding to a given predicable concept that is represented by a complex formula, and hence by a λ-abstract, can be formulated as follows:

$$(\exists^n F^j)\,([\lambda x_1...x_j\phi] \equiv_c F)\,.$$

Here, we note again, that, unlike the comprehension principle of conceptual realism, such an assumption is at best only a scientific hypothesis, and as such must in principle be subject to confirmation or falsification. In this regard, there is no comprehension principle valid in natural realism other than the trivial one stipulating that every natural property or (j-ary) relation is a value of the bound (j-ary) predicate variables, i.e.,

$$(\forall^n F^j)(\exists^n G^j)(F \equiv_c G).$$

4 Conceptual Natural Realism and Aristotelian Essentialism

Conceptual natural realism without natural kinds might be an adequate ontological framework for some philosophers of science; but to others, especially those who fall in the tradition of Aristotle and Aquinas, it is only part of a larger, more interesting ontology of Aristotelian essentialism. This is a framework that a part of cosmology as well as of ontology. It is part of cosmology in that it is based on natural kinds as causal structures, and it is part of ontology in that it determines two types of predication in reality, essential and accidental. Natural kinds—whether in the form of species or genera, and whether of natural kinds

of "things," such as plants and animals, or natural kinds of "stuff", such as the chemical substances gold, oxygen, iron, etc., or compound substances such as water, salt, bronze, etc.—are the bases of essential predication, whereas predicable concepts and natural properties and relations are the bases of accidental, or contingent, predication.

The basic assumption of this extension of natural realism is that in addition to the natural properties and relations that may correspond to some, but not all, of our predicable concepts, there are also natural kinds that may correspond to some, but not all, of our common-name concepts. By a natural kind we understand here a type of causal structure, or mechanism in nature, that is the basis of the powers or capacities to act, behave, function, etc., in certain determinate ways that objects belonging to that natural kind have. Natural kinds, in fact, are the causal structures, or mechanisms in nature, that underlie the causal modalities, and in particular they underlie the natural laws regarding the different natural kinds of things there are, or can be, in the world. In this ontology, natural kinds are an essential part of the internal hierarchical network of nature's causal matrix, and in fact they constitute the more stable nodes of that hierarchical network.

Now a natural kind is not a natural property or a "conjunction of natural properties," as David Armstrong and other philosophers have claimed.[5]

> Instead of being a "conjunction of natural properties," a natural kind is a type of unsaturated causal structure that is the causal ground of the events and states of affairs containing the natural properties that are said to "conjunctively define" that natural kind.

Indeed, if a natural kind were a conjunction of natural properties, then we would need an explanation of why some conjunctions result in a natural kind whereas others do not. Why, in other words, do not all "conjunctions of natural properties" result in a natural kind if some do?

If certain "conjunctions of natural properties" were to "produce," or "generate," a natural kind, whereas others do not, then that would suggest that there is more to a natural kind than just a "conjunction of natural properties." In fact, the ontological dependence is just the opposite of what the conjunction thesis maintains, because instead of a "conjunction of natural properties" being the causal ground of a natural kind, it is the natural kind that is the causal ground of the natural properties in the "conjunction". Moreover, there really are no "conjunctions of properties" in nature, but only causally related groups of events or states of affairs having those properties as predicable components, which, of course, we could in principle described in terms of a conjunction of sentences.

> In other words, as a causal structure, a natural kind has an ontological priority over the natural properties that are

[5] Cf. Armstrong 1978, chapter 15. In my first paper on natural kinds, Cocchiarella 1976, I did take natural kinds to be properties, but later corrected that view in Cocchiarella 1996.

> predicated of the objects of that kind, a priority that is part of what Aristotle means in describing natural kinds as secondary substances.[6]

Neither natural properties, nor so-called "conjunctions of natural properties," on the other hand, can be described as secondary substances.

Now as the causal ground of natural properties, a natural kind has a "substance-like" structure in that it is unsaturated in a way that is complementary to the unsaturated predicative structures of natural properties and relations. The nexus of predication in reality, in other words, is a kind of mutual saturation of a "substance-like" natural kind structure, as realized by an object (or primary substance) of that kind, with a natural property or relation as a predicative structure, the result in being an event or state of affairs that obtains in reality. Of course, the fact that natural kinds are unsaturated causal structures to begin with allows for there being natural kinds that in fact are not realized in nature at a given time, but that could be realized, or brought about, in appropriate environmental circumstances. The transuranic elements of atomic numbers 113 and 115, for example, have only recently been brought about and realized in nature, even though for just a few fractions of a second.[7]

> A natural kind, as an unsaturated "substance-like" causal structure, has its being in possibly being realized in things, and in that regard natural kinds can be realized in nature at different times in the evolution of the universe, or even possibly not at all.

It is because the being of a natural kind is its possibly being realized in nature, that Aristotle's problem of the fixity of species can be resolved in modal moderate realism.

The ontological difference between natural kinds and natural properties and relations is analogous to the conceptual difference between common-name concepts and predicable concepts and the way that referential concepts based on the former may be saturated by the latter in speech or mental acts. Thus, just as a referential concept that is based upon a common-name concept can be saturated by a predicable concept in a speech or mental act, so too a natural kind, as the causal structure of an object of that kind, can be saturated by the natural properties and relations of that object, the result being a complex of events or states of affairs having that object as a constituent.

Accordingly, just as a predicate expression can signify both a predicable concept and a natural property or relation, a common name can also signify or stand in a double way for both a concept and a natural kind as a causal structure. Similarly, name variables can also be given a double interpretation as well. Thus, just as the quantifiers $\forall^n$ and $\exists^n$ can be affixed to predicate variables and enable us to refer to natural properties and relations, so too we can introduce

[6] Cf. *Categories* 2^{a11}.

[7] Cf. *Science News*, February 7, 2004, vol. 165, no. 6, p. 84.

special quantifiers $\forall^k$ and $\exists^k$, which, when affixed to name variables, enable us to refer to natural kinds. For convenience, we will assume that objectual quantifiers range over all objects, single or plural, abstract or concrete, and actual or merely possible in nature. We also assume all the distinctions we have made in previous lectures, including those that are about classes as many and membership in a class as many. Thus, e.g., where A is a common name, then $x \in A$, i.e., x belongs to A-kind, if, and only if, x is an A, i.e.,

$$x \in A \leftrightarrow (\exists yA)(x = y).$$

Similarly, for complex common names, e.g., $A/F(y)$, we have

$$x \in [\hat{y}A/F(y)] \leftrightarrow (\exists yA/F(y))(x = y).$$

That is, x belongs to the A-kind that are F if, and only if, x is an A that is F.

Now because names can be transformed into objectual terms, we can state the fact that a natural kind A is not just contingently a natural kind, but that as a node in the network of nature's causal matrix it is necessarily so, i.e.,

$$(\forall^k A)\Box^c(\exists^k B)(A = B). \qquad \textbf{(K1)}$$

Of course, that a common name A is co-extensive with a natural kind B, i.e.,

$$(\exists^k B)(A = B),$$

does not mean that A is itself a natural kind. Thus, assuming that the common name Man stands for a natural kind, but that the common name 'featherless biped', i.e., $Biped/Featheless$, does not, then even though all and only men are featherless bipeds (or so we will assume), i.e., even though it is now true that

$$Man = [\hat{x}Biped/featherless(x)],$$

nevertheless it does not follow that being a featherless biped is a natural kind. That Man is a natural kind, incidentally, can be formulated as

$$(\exists^k B)\Box^c(Man = B).$$

So-called "real definitions" can be described in terms of this notation by means of a specification of the following form:

$$(\exists^k B)\Box^c(B = [\hat{x}A/\varphi x]),$$

where A is a natural kind genus, and B is specified as an species of A the members of which satisfy the condition φx. This would not be a "nominal definition," i.e., a matter of introducing a simple common name as an abbreviation of a more complex common name; instead, it would be an hypothesis about the world, namely that there is a natural kind corresponding to the complex common name $[\hat{x}A/\varphi x]$.

> A "real definition" is not a definition after all, in other words, but instead it is an hypothesis about the members of a natural kind, e.g., $[\hat{x}A/\varphi x]$, being a species of a genus A.

Now there are a number of interesting laws of natural kinds can be formulated in this formal ontology. For example, one such law is:

> An object belongs to a natural kind only if being of that kind is essential to it, i.e., only if it must belong to that kind whenever it exists as a real, concrete object.

With $E!$ as the predicate for concrete existence, this principle is formulated as follows:

$$(\forall^k A)(\forall x A)\Box^c\left[E!(x) \rightarrow x \in A\right]. \qquad \textbf{(K2)}$$

In other words, where A is a natural kind, i.e., $(\exists^k B)\Box^c(A = B)$, and x is an A, i.e., $x \in A$, then x is an A whenever x exists in any causally possible world, i.e., *x is essentially an A*, which can be symbolized as

$$\Box^c\left[E!(x) \rightarrow x \in A\right].$$

Essential predication is of course one of Aristotle's two types of predication. The other, accidental, or contingent, predication, is represented simply as $(\exists y A)(x = y)$ or $F(x)$. Thus, given that Socrates is a teacher, but only contingently so, then this "accidental" predication is represented as follows:

$$(\exists x Socrates)(\exists y Teacher)(x = y).$$

Similarly, the accidental, or contingent, predication that Socrates speaks Greek can be symbolized as follows

$$(\exists x Socrates)F(x),$$

where the predicate 'speaks Greek' is represented by the predicate constant F.

> Thus, as these examples illustrate, we have a natural and intuitive way to represent Aristotle's two types of predication in our formal ontology.

Another law of our logic is that the being of a natural kind, like that of natural properties, is its possibly being realized in nature.

$$(\forall^k A)\Diamond^c(\exists^e x)(x \in A). \qquad \textbf{(K3)}$$

The quantifier phrase '$(\exists^e x)$' ('there exists') in **(K3)** can be replaced by the more general phrase '$(\exists x)$' ('there is'), because we assume that only concrete existents belong to natural kinds. The following principle, in other words, is also an axiom of out logic of natural kinds.

$$(\forall^k A)(\forall x)[x \in A \rightarrow E!(x)] \qquad \textbf{(K4)}$$

If we adopt the following abbreviatory notation for the subordination, and proper subordination, of one kind to another,

$$\begin{aligned} A &\leq B =_{df} \Box^c(\forall x)[x \in A \rightarrow x \in B], \\ A &< B =_{df} (A \leq B) \wedge \neg(B \leq A), \end{aligned}$$

then *the partition principle for natural kinds* can be stated as follows:

$$(\forall^k A)(\forall^k B)[\Diamond^c(\exists x)(x \in A \wedge x \in B) \rightarrow A \leq B \vee B \leq A]. \qquad \textbf{(K5)}$$

In other words, if two natural kinds are not necessarily disjoint, then one must be subordinate to the other.

> This means that the family of natural kinds to which any object may belong forms a chain of subordination of one natural kind to another—where each natural kind in the chain is, as it were, a template structure that is causally more determinate and finer-grained than the natural kinds to which it is subordinate.

An important consequence of **(K2)** and **(K5)** is the thesis that an object can belong to two natural kinds only if, as a matter of causal necessity, it belongs to the one kind when and only when it belongs to the other:

$$(\forall^k A)(\forall^k B)(\forall x)[\Diamond^c(x \in A) \wedge \Diamond^c(x \in B) \rightarrow \Box^c(x \in A \leftrightarrow x \in B)].$$

Another version of the partition principle is a consequence of **(K5)**, namely that

natural kinds that are subordinate to the same immediate genus are either identical or necessarily disjoint:

$$\begin{aligned} (\forall^k A)(\forall^k B)(\forall^k C)(A < C \wedge B < C \wedge (\forall^k D)[A < D \rightarrow C \leq D] \wedge \\ (\forall^k D)[B < D \rightarrow C \leq D] \rightarrow \Box^c(A = B) \vee \neg\Diamond^c(\exists x)[x \in A \wedge x \in B]) \end{aligned}$$

Still yet another partition principle is the thesis that every genus is the sum of its species:

$$(\forall^k A)[(\exists^k B)(B < A) \rightarrow \Box^c(A = [\hat{x}/(\exists^k B)(x \in B \wedge B < A)])] \qquad \textbf{(K6)}$$

In terms of this view of natural kinds as template causal structures that can fit one within another, it is only natural to assume

> a summum genus principle to the effect that any chain of subordination between natural kinds must have a summum genus as an ultimate, superordinate template structure within which all of the natural kinds of that chain must fit. It is only in this way that the individuation of natural kinds of objects can even begin to take place in the universe as an ontological process.

Formally, *the summum genus principle* can be stated as follows:

$$(\forall^k A)(\forall x)[x \in A \rightarrow (\exists^k B)(x \in B \wedge (\forall^k C)[x \in C \rightarrow C \leq B])]. \qquad \textbf{(K7)}$$

Thus, any object that belongs to a natural kind belongs, according to this thesis, to a natural kind that is a summum genus—that is, a natural kind that has subordinate to it every natural kind to which that object belongs. Given the partition principle, **(K5)**, **(K7)** is equivalent to the following alternative way of stating the summum genus principle, namely, that
every natural kind is subordinate to a natural kind that is properly subordinate to no other natural kind:

$$(\forall^k A)(\exists^k B)[A \leq B \wedge \neg(\exists^k C)(B < C)].$$

The opposite of a summum genus as the ultimate, superordinate causal template structure of a natural kind of object is the infima species of that object. This is the finest grained template structure determining the causal nature of that object.

The infima species principle stipulates that if an object belongs to a natural kind, then it belongs to a natural kind that is subordinate to all of the natural kinds to which that object belongs:

$$(\forall^k A)(\forall x)(x \in A \rightarrow (\exists^k B)[x \in B \wedge (\forall C)(x \in C \rightarrow B \leq C)]). \qquad \textbf{(K8)}$$

A consequence of **(K8)** is the following alternative version of the infima species principle, namely, that every natural kind has subordinate to it a natural kind to which no other natural kind is subordinate:

$$(\forall^k A)(\exists^k B)[B \leq A \wedge \neg(\exists^k C)(C < B)].$$

5 General Versus Individual Essences

Aristotelian essentialism is an ontology of general essences, it should be noted, and not of individual essences, such as is described by Alvin Plantinga in *The Nature of Necessity*. Unlike a general essence that can be common to many objects, an individual essence is unique to just one thing. Also, individual essences are properties, whereas general essences are natural kinds, and natural kinds are not properties, nor, as we have said, are they "conjunctions of properties".

Thus, according to Plantinga, "to be an essence of Socrates, a property must be such that nothing else *could have* had it.[8] That is,

> "E is an essence of Socrates if and only if E is essential to Socrates and there is no possible world in which there is an object distinct from Socrates that has E."[9]

[8] Plantinga 1974, p. 70.
[9] Ibid.

Socrates, according to Plantinga, clearly has such an essence, namely "*Socrateity*, the property of being Socrates or being identical with Socrates is such a property."[10]

Now although there is the predicable concept of being identical with Socrates, nevertheless, there is no *natural property* in Aristotelian essentialism that corresponds to that concept. Nor is there a natural kind that corresponds to the name concept that 'Socrates' stands for. In other words, there is no such essence as *Socrateity*, which is not to say that Socrates does not have an essential nature as a human being—assuming, of course, that being a man, i.e., a human being, is a natural kind that Socrates shares with all other humans.

As a form of conceptual natural realism, Aristotelian essentialism is an ontology of general essences, not of individual essences. Of course, one might raise the question of whether it is possible that each natural kind of object, i.e., each object that belongs to a natural kind, might itself constitute a natural kind that was both subordinate to the infima species to which that object belongs and yet so unique to that object as to distinguish it from all other objects belonging to the same infima species. Could Socrates, for example, or perhaps his unique genetic structure, constitute such a natural kind, i.e., a natural kind that in effect amounted to an individual essence? Formally, this could be stated as follows:

$$(\exists^k A)\Box^c[E!(Socartes) \rightarrow Socrates = A] \wedge \Box^c(\forall x A)(x = Socrates).$$

That is, there is a natural kind A such Socrates, and only Socrates, belongs to A in any world in which he exists, and if anything is A in a possible world, then it is Socrates, in which case, by **(K4)**, it is world in which Socrates exists. Could this be what Aristotle means in *Metaphysics Z6* (1032a4–6) when he says that each primary substance is identical with its essence?

The notion of a natural kind that is also an individual essence seems dubious in the case of natural kinds of objects in the microphysical world, such as electrons, assuming, of course that there is a natural kind corresponding to the common name *Electron*. How could a single electron have an individual essence that distinguished it from every other electron not only in this world but in every other possible world in which that electron exists? If that were so, would it not be like each point on a continuous line having its own individual essence, i.e., an essence that distinguished it from every other point on the line? Doesn't the same doubt apply to all objects in the microphysical world? And might one not doubt that it applies to each grain of sand in the Sahara desert as well?

Could it be that only certain natural kinds of physical objects have an individual essence, e.g., complex physical objects such as plants and animals? But then would a clone of Socrates, were such an individual actually brought about, have the same individual essence as Socrates? What scientific considerations would settle this question? That is, how could one determine by scientific investigations that Socrates had, or was, an individual essence?

[10] Ibid., pp71–71.

These are matters we cannot settle here. In any case, the general framework of natural kinds as general essences is a already a sufficiently strong and useful formal ontology even without individual essences.

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