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Three Basic Ontological Relations Concerning the Physical Realm*

ABSTRACT

The purpose of this paper is to establish a classification of the main ontological categories based on the predication, subsumption, and inherence relation. The classification is inspired by Aristotle's fourfold division of things into objects (primary substances), object kinds (secondary substances), attributes, and attribute kinds. It is argued that first, properties and relations are respectively meanings of monadic and polyadic predicate expressions, and second, (determinate) attributes are recurrent abstract particulars so that they are neither monadic nor polyadic. It follows that attributes constitute a category quite different from that of properties and relations. On the other hand, both object kinds and attribute kinds are considered to be non-semantic universals in contradistinction to properties and relations that are semantic.

1. Introduction

In this paper we shall inquire into the nature of the three basic ontological relations, viz., predication, subsumption, and inherence, and attempt to show the role they play in the classification of the basic categories of universals and particulars as well as of abstract and concrete entities. We restrict our attention to physical reality. Although our primary concern is nature, we are compelled to include mathematical objects which are also required for the scientific description of nature.

Our ontological view is inspired by Aristotle's fourfold division of things[1] based on the relations being-said-of and being-in, which correspond respectively to subsumption and inherence. The four types of things in the division correspond to the categories of objects, object kinds, attributes, and attribute kinds whose relationships to each other are systematically investigated in this paper. Besides these four categories of things, which we take to exist independently of language and mind, we consider also predi-

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[1] See Aristotle, *Categories* 2, $1^a20 – 1^b9$.

cates construed as the meanings of predicate expressions. Predicates are not things but rather semantic entities. Monadic predicates are properties, and polyadic ones are relations-in-intension.[2] Thus we distinguish properties and relations-in-intension from kinds and attributes, these being often conflated.

Consider, for example, the following two sentences expressing subject-predicate (categorical) propositions:

(1) Socrates[3] is pink,

(2) Socrates is a man.

In contradistinction to the contemporary interpretations of first-order languages (such as W. V. O. Quine's) according to which only the subject term refers to an extralinguistic entity, in traditional logic (especially in Aristotle's) both the subject and the predicate terms of a categorical proposition stand for extralinguistic entities. In second-order and in general higher-order languages, the interpretation of the predicate term agrees with that of traditional logic. In this paper we shall follow the latter standpoint.

Taking into consideration that the predicate term refers to an entity, viz., a property, (1) and (2) can be rewritten respectively as

(1.1) Socrates has the property of being pink,

(2.1) Socrates has the property of being a man.

We shall use "being-*F*" or "*F*-ness" ("being-an-*F*" or "*F*-hood"[4]) as short for a phrase of the form "the property of being *F*" ("the property of being an *F*"). Then (1.1) and (2.1) can be reformulated respectively as

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[2] Besides relations-in-intension, we consider also relations-in-extension which are sets of *n*-tuples, and hence abstract objects.

[3] Since our concern is the physical realm, the name "Socrates" throughout the paper denotes a body rather than a person having a soul.

[4] Whereas "*F*" (e.g., "pink" or "man") is a concrete general term, "*F*-ness" or "*F*-hood" ("pinkness or "manhood") is an abstract singular term. See W. V. O. Quine, *Word and Object* (Cambridge, Mass.: MIT Press and New York: John Wiley, 1960), pp. 118 – 129. In our conception, as will be stated below, such singular terms are names of merely semantic entities, not of genuinely existing things.

(1.2) Being-pink is predicable of Socrates,[5]

(2.2) Being-a-man is predicable of Socrates.

Notice that the latter two are equivalent respectively to

(1.3) Socrates instantiates[6] being-pink,

(2.3) Socrates instantiates being-a-man.

Clearly (1.2) and (2.2) express a relation between the subject and predicate, viz., the so-called *predication* relation. Analogously (1.3) and (2.3) express an instantiation (exemplification) relation which is the converse of the predication relation.

On the other hand, the predicate term "man" in (2) is correlated with the species or kind Man, i.e., Mankind. Then (2) can rather be construed as meaning

(2.4) Socrates belongs to the kind (species) Man.

Similarly the sentence

(3) A man is a living being

can be construed as

(3.1) The kind Man is a species of the genus Living-being.

We say that according to (2.4) the kind Man subsumes (is said-of) Socrates (who himself is obviously not a kind), and according to (3.1) the kind Living-being subsumes (is said-of) the kind Man. In general, we say that a kind K *subsumes* an entity x in case x is of the kind K or else x is a subkind[7] of K. We call the relation between the kind K and the entity x the *sub-*

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[5] Aristotle himself frequently uses "*A* is predicated of *B*" (or "*A* belongs to *B*") in the sense of "*B* is *A*".

[6] Often "exemplifies" is used instead of "instantiated." See, for example, G. Bergmann, *Logic and Reality* (Madison: The University of Wisconsin Press, 1964).

[7] We use "subkind" exclusively in the sense of proper subkind.

sumption relation, and the converse relation between *x* and *K* the *bearing relation.*

Let us now turn to the interpretation of (1). In analogy to the interpretation of (2) as (2.4), (1) might be interpreted as

(1.4) Socrates is a pink-colored thing,

or equivalently as

(1.5) Socrates belongs to the kind Pink-thing

where "thing" refers to spatio-temporal concrete things, since only such entities could be colored. Such an interpretation, however, is inadmissible. Indeed, we do not say that Socrates has the property of being pink for the reason that he is a pink thing, but rather the other way around. The class of pink things consists of utterly disparate things so that it is devoid of closed knit structure. Therefore, it is implausible to correlate an alleged kind of pink things with the property of being pink. Hence, the analysis of (1) should not depend on the existence of such a kind.

In our new analysis of (1) we correlate with the predicate being-pink the quality Pink construed as something which is a genuine non-semantic thing, in contradistinction to being-pink which is the meaning of a predicate expression. (1) asserts that Socrates is pink for the reason that he has the quality Pink. But Socrates has the quality Pink in virtue of his having a determinate shade of pink color, call it *Vink*.[8] The shade of color Vink is said to be a *determinate* under the *determinable* Pink.[9] Both Vink and

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[8] We borrow the attribute name "Vink" from G. E. L. Owen, "Inherence", *Phronesis* **10** (1965), p. 98. Notice that "Vink" is a notational abbreviation of the singular description "the shade of pink that is Socrates' color", assuming that Socrates has uniformly a single shade of color.

[9] See W. E. Johnson, *Logic: Part 1*, Ch. XI and Ch. XIV, § 8 (New York: Dover Publications, 1964 (1921, 1924)). Notice that the members of a color class *qua* shades of color are absolutely determinate in the sense that they themselves cannot be construed as determinables. Indeed the determinable/determinate distinction is used also in relative sense so that, for example, Red, Orange, Yellow, Green and Violet are relatively determinate under the determinable Color, although each of them is determinable with respect to their constitutive shades of color. The distinction in question is used here exclusively in the absolute sense so that a determinable is construed always as a kind of absolutely determinate attributes. Such a determinable is an attribute kind. We use the term "attribute" as short for "absolutely determinate attribute".

Pink are correlated to the predicate being-pink. Notice that the distinction between determinates and determinable holds, among others, also for quantities. For example, 2 meter is a determinate under the determinable Length.

Given that a thing possesses a given determinate, we say that the determinate *inheres* in this thing. A thing in which a determinate inheres is an *object*, whereas the inhering determinate an *attribute*. The relation between an attribute and an object in which it inheres is called the *inherence relation*. For example, given that Vink inheres in Socrates (i.e., Socrates' body), Socrates is an object and Vink is an attribute inhering in this object. We call the inverse of inherence the *bearing* relation. Thus, Socrates bears Vink. It is important to remark that the nature of both determinates, i.e., attributes in our sense, and determinables is a matter of dispute. We defend the view that attributes are abstract particulars whereas determinables are kinds whose instances are determinates. In other words, we introduce determinables as *attribute kinds*. For example, the attribute Vink is an abstract particular which is an instance of the attribute kind Pink, and Pink is a kind consisting of determinate shades of color one of which is Vink. Notice that Pink *qua* attribute kind must be distinguished both from the alleged kind Pink-thing and from the property (monadic predicate) being-pink. Furthermore, the attribute kind Pink must also be distinguished from the second-order property being-pink defined as follows: a physical thing has the second-order property of being pink just in case this thing has one of the first-order properties possessing the property of being a shade of pink color. (Being-vink is one of such first-order properties.)

The notion of subsumption is equivalent to Aristotle's notion of being said-of. On the other hand, the notion of inherence is closely related to Aristotle's notion of being present-in in the following way:

> A thing *x* is present-in a thing *y* just in case *x* is an object and either *y* is an attribute which inheres in *x*, or else *y* is an attribute kind and there is an attribute *z* of kind *y* such that *z* inheres in *x*.[10]

In the light of the above considerations we finally interpret the sentence (1) as

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[10] Cf. M. V. Wedin, *Aristotle's Theory of Substance* (Oxford: Oxford University Press, 2000), p. 73.

(1.6) An attribute of the kind Pink inheres in Socrates,

or equivalently

(1.7) Socrates bears an attribute of the kind Pink.

2. The Predication Relation
2.1 Universals and Particulars

Aristotle defines a "universal [as] that which is by its nature predicated of a number of things, and [a] particular as that which is not . . ."[11] Universals are also defined as entities which have or can have instances (or examples), and these instances are generally called particulars. But the very notion of instance is ambiguous. Indeed, an instance can be defined as an *x* such that there is an entity *F* satisfying one or more of the following conditions:

(i) *F* is predicated of *x*,
(ii) *F* subsumes *x*,
(iii) *F* inheres in *x*.

In (i) *F* is a predicate (viz., the meaning of the predicate expression "*F*"), in (ii) a kind, and in (iii) an attribute.

In (i) it is quite usual to call *x* an instance of the predicate *F*, but in (ii) also it is a widespread usage to call *x* an instance of the kind *F*, provided *x* itself is not capable of subsuming any entity. On the other hand, in (iii) we think that it is inappropriate to call *x* an instance of the attribute *F* for the following two reasons:

The first reason is that attributes are not universals but particulars (in the sense defined below), as will be argued. It might be suggested then that the term "instance" be exclusively reserved for entities to which universals are applied. Therefore, the objects in which an attribute inheres should not be considered as instances of this attribute.

The second reason is that the categories (in Aristotle's sense) of *x* and *F* in (iii) are radically different. Indeed *x* (say, Socrates) belongs to the category of Substance, whereas *F* (say, Pink) belongs to an attribute category (the category Quality in the example of the attribute kind Pink). Let us call any predication of the form *a* is *F* *homogeneous* in case *a* and *F* are

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[11] Aristotle, *De Interpretatione* 7, 17^a38 - 17^b1.

of the same category, and *heterogeneous* otherwise. Now it is advisable to call *a* an instance of *F* only if the corresponding predication is homogeneous. Since (iii) is always heterogeneous, the objects in which an attribute inheres should not be considered as instances of this attribute. We say instead that these objects are the *bearers* of the attribute.

We thus distinguish between two types of instances, viz., predicate instances and kind instances. Call predicate instances *things*,[12] and kind instances *particulars.* We call, then, the entities whose instances are things, viz., predicates, *semantic universals*, and those whose instances are particulars, viz., kinds, *ontic universals*. Semantic universals are called "semantic" for the reason that their nature and existence depend to a large extent to our conceptual-linguistic framework, whereas ontic universals are supposed to be extralinguistic full-fledged entities.

Notice that the members of a class (unless it constitutes the extension of a kind) are not instances. Therefore, mere classes are particulars rather than universals.

2.2 Predicates

Predication is a relation between the meaning of any linguistic expression in predicate position and a thing. The relation obtains in case the predicate expression truly applies to the thing. This thing is denoted by the subject term of the sentence expressing the predication. By the meaning of a linguistic expression we mean the semantic entity called by Stoic logicians the *lekton*, and by Bochenski the *objective meaning* of that expression.[13] (We adopt the latter term hereafter.) We shall call the objective meaning of an expression in predicate position, a *predicate*, and that of an expression in subject position, a *subject.* Consequently, the linguistic expressions

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[12] In this paper we consider exclusively first-order predicates, i.e., predicates of things. We disregard wholly higher-order predicates, i.e., predicates of predicates. Notice that predicates in our sense (as meaning of predicate expressions) are often called concepts or general ideas.

[13] See B. Mates, *Stoic Logic* (Berkeley: University of California Press, 1953), Ch. 2, and I. M. Bochenski, "The Problem of Universals" in I. M. Bochenski, A. Church, and N. Goodman (eds.), *The Problem of Universals* (Notre Dame: University of Notre Dame Press, 1956) pp. 36, 42 – 44. G. Frege's *sense* seems to be a counterpart of the antique notion of *lekton.* See A. Church, "Propositions and Sentences" in *The Problem of Universals*, p. 5. The term "*lekton*" can be translated as "that which is meant" (Mates, *op. cit.*, p.11) or "what is said" (Bochenski, *op. cit.*, p. 36).

denoting these entities will be called predicate expressions (terms) and subject expressions (terms) respectively. As usual, we shall also call the objective meaning of a declarative sentence a *proposition*.[14]

In particular, we shall call the objective meaning of a subject-predicate sentence a *subject-predicate proposition*. Such a proposition is a structure consisting of the objective meaning of the subject expression—called the subject of the proposition—and the objective meaning of the predicate expression—called the predicate of the proposition. For example, the subject of the proposition that-Socrates-is-pink consists in the thought (objective idea) of Socrates, and the predicate in the property of being pink.

We see that the subject of this proposition is neither the person Socrates (which is the object corresponding to the subject) nor the particular thinking about Socrates by the user of the sentence expressing the proposition. It can rather be identified with the mediaeval notion of haecceity or R. Carnap's individual concept. As already mentioned, if *F* is a one-place predicate expression, then being-*F* (as short for the property of being *F*) is the corresponding one-place predicate. The truth of a subject-predicate proposition is tantamount to the subsistence of the predication relation between the predicate and the entity denoted by the subject or, conversely, the subsistence of the instantiation relation between the entity in question and the predicate. Notice that what properly denotes (or names) an entity is not really a subject expression, but the objective meaning of that expression, i.e., a subject. Indeed, a subject expression denotes an entity only by virtue of its meaning. On the other hand, a *subject-predicate statement*, i.e., the act of asserting a subject-predicate proposition, establishes a semantic relation between the predicate and the subject of the proposition independently of its truth value. This relation holds just in case the predicate applies (truly or falsely) to the subject as asserted by the statement. Therefore, such a semantic relation can be called an *application* relation.

The identity criterion for objective meanings can be stated as follows. Different linguistic expressions have the same objective meaning if and only if they are synonymous, where linguistic expressions can be construed either as tokens or as types. (The notion of an expression-type is syntactic in the sense that expression-tokens, say, inscriptions, are of the same type in case they have similar shapes.) The notion of synonymy (as emphasized especially by Quine) is inexact or vague. We share, however, D. M. Arm-

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[14] See Church, *op. cit.*, 1956, p. 5.

strong's view that synonymy in its ordinary use is perfectly coherent and even indispensable for both practical and theoretical reasons.[15]

The identity criterion for objective meanings can be used for the clarification of the ontological status of predicates. The relation of synonymy underlying the identity criterion for objective meanings is obviously an equivalence relation. Therefore, the synonymy relation induces a partition of predicate expressions (including those belonging to different languages) into equivalence classes.[16] Each equivalence class consists of synonymous predicate expressions, whereas predicate expressions belonging to different equivalence classes are never synonymous. The members of each equivalence class are of a particular type, which may be called a *synonymy type.* Hence, the synonymy relation partitions the predicate expressions into classes of different synonymy types. Two predicate expressions are synonymous if and only if they are of the same synonymy type. Therefore, the identity criterion for objective meanings can be reformulated as follows. Different predicate expressions have the same meaning if and only if they are of the same synonymy type. In general, any equivalence class consists of elements of the same type, and the common type of the elements of the equivalence class can be called an *equivalence type*. The equivalence type corresponding to a given equivalence class can be reified as an abstract entity constituting the intension of the equivalence class. The equivalence class is then the extension determined by the equivalence type.

Hence, one can identify the objective meaning of any significant linguistic expression with its (reified) synonymy type on the basis of the following argument. Given that "E" is any linguistic expression type (in the syntactic or morphological sense), 'E' is the synonymy type of "E",[17] M("E") is the objective meaning of "E", and Syn("E_1", "E_2") is short for "E_1" and "E_2" are synonymous,

1. M("E_1") = M("E_2") iff Syn("E_1", "E_2") (Premiss: identity criterion for objective meanings)

[15] See D. M. Armstrong, *Universals and Scientific Realism*, *Vol. I* (Cambridge: Cambridge University Press, 1978), p. 8.
[16] As is well known, a partition of any class of entities is an exhaustive division of the members of this class into mutually disjoint subclasses.
[17] We adopt this peculiar use of the double and single quotation-marks from Armstrong, *op. cit.*, p. 7, as suggested by F. Jackson.

2. Syn(“E_1”, “E_2”) iff ‘E_1’ and ‘E_2’ belong to the same equivalence class (with respect to the synonymy relation).
3. Syn(“E_1”, “E_2”) iff ‘E_1’ = ‘E_2’ (from 2)
4. M(“E_1”) = M(“E_2”) iff ‘E_1’ = ‘E_2’ (from 1 and 3)
5. M(“E_1”) = ‘E_1’ (plausibly from 4, by Ockham’s razor)

By identifying objective meanings (especially subjects, predicates, and propositions) with synonymy types, they turn into immanent entities which are language-dependent regarding their features. But in so far as synonymy types are reified as abstract entities they exist independently of languages and their users. This is tantamount to saying that different linguistic frameworks may give rise to significantly different kinds of subjects, predicates, and propositions. But all these entities exist (or subsist) eternally, hence survive the removal of their underlying linguistic (or more generally cultural) frameworks. For example, a phenomenalistic framework gives rise to predicates concerning perceptual qualities, whereas a physicalistic one to predicates concerning physical quantities.

Predicates apply to any (finite) number of things. A predicate applying to nothing is a proposition by itself. Hence propositions can be considered as 0-place predicates. A predicate applying to one thing, i.e., a one-place predicate, is called a *property*, and finally a predicate applying to two or more things are called *relations-in-intension*.[18] Thus we construe propositions, properties, and relations-in-intension as semantic universals. We distinguish between properties and relations-in-intension on the hand, and attributes on the other, since the former ones are semantic universals whereas the latter ones will be shown to be abstract particulars. Each property or relation-in-intension has an extension consisting of the thing or *n*-tuple of things to which they apply. Such extensions are sets which are considered as abstract particulars, called relations-in-extension. (The extension of a property is one-place, and that of relation-in-intension many-place.)

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[18] We construe the predication relation as well as the subsumption and the inherence relation as relations-in-intension so that they themselves are predicates. It follows that the predication relation is a second-order predicate between a predicate and a thing. This is the unique usage of higher-order predication throughout the paper.

3. The Subsumption Relation

Let us analyze the notions of *subsumption*, *kind*, and *particular* in more detail. Denoting the subsumption relation by the symbol *S*, *x S y* is read as "*x* is subsumed by *y*" or equivalently "*y* subsumes *x*". We assume that the subsumption relation *S* is (i) irreflexive, (ii) transitive, and that (iii) every *S*-descending chain is finite. An *S-descending chain* is a sequence of things such that each non-terminal term of the sequence subsumes the next one. A finite *S*-descending chain is one which has a terminal term, i.e., one which does not subsume any thing.

We can now introduce the following definitions: Anything which subsumes something is a *kind*, and a thing which does not subsume anything is a *particular*. It follows from assumption (iii) that every kind subsumes some particular. Furthermore, we assume that (iv) every particular is subsumed by a kind. If a kind subsumes another kind, the latter is a *subkind* or *species* of the former called also a *genus*. A particular subsumed by a kind is an *instance* of that kind. This notion of instance is justified by the following considerations. Call a kind of particulars *first-order*, a kind of first-order kinds *second-order*, and so on. Second-order, and in general higher-order, kinds, in contradistinction to first-order ones, are kinds of kinds.[19] We call, then, the kind of the instances of a kind *K* (which may be of any order) the *reduct* of the original kind *K*. Clearly the reduct is always first-order, i.e., it is always a kind of particulars. For example, the reduct of a kind of kinds of numbers, say, the kinds of negative integers, positive rational numbers, and purely imaginary numbers, is the first-order kind of all these numbers. (Notice that we consider numbers to be particulars, viz., abstract objects.) In this paper, for the sake of simplicity, and relying on the possibility of using as substitutes for higher-order kinds their reducts, we shall consider only first-order kinds.

We further define the *extension of a kind* as the set of all of its instances. For example, the extension of the kind Man is the set of all men (existing in the past, present, and future). Since every kind has an instance, it follows that the extension of a kind is never empty. Hence kinds are universals in the sense that they have instances (examples).

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[19] Notice that the kinds defined above are all ontic universals. But there are also kinds, kinds of kinds, . . . of predicates. For example, the kind consisting of nominal, adjectival, and verbal predicates is a kind of predicates. Such kinds are completely disregarded in this paper.

Having investigated the formal properties of the notions of subsumption, kind, and particular, let us now try to elucidate the ontological nature of these notions. Now a kind can be represented in several different ways, viz., as a class of actual entities or of possible entities, a predicate, and an inhering attribute. We think that none of these alternatives is fully satisfactory. Instead we propose to represent a kind by a structure such that the extension of the kind is the domain or one of the domains of the structure. In the latter case, the extension is called the *principal domain* of the kind. We shall use from now on "domain", when unqualified, in the sense of principal domain.

The subkinds of a given kind are represented by substructures of the kind. From now on we shall identify, by abuse of language, kinds with their respective structures which represent them.[20] The idea of representing kinds by structures is suggested by the fact that mathematical kinds (such as kinds of numbers) are indeed represented by structures. Furthermore, H. Putnam's conception of the meaning of natural kinds[21] is an additional justification of such a representation. We consider kinds represented by structures to be genuine non-semantic things denoted by kind-names, which are usually common nouns such as "Man", "Electron", etc.

Kinds can be divided into object kinds and attribute kinds. The structure of object kinds involves attribute kinds but not vice versa. The instances of an attribute kind are unified by means of an ordering (grading) relation. For example, physical magnitudes[22] such as lengths, waves, temperatures as well as determinate qualitative physical attributes, such as shades of color or tones of sounds are related to each other by an ordering relation. We see that an attribute kind can be represented by a structure

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[20] Note, however, that the identification is only at the linguistic level. Ontologically they are different entities, since kinds are (ontic) universals whereas structures are ultimately sets (classes) and thus are particulars. Indeed it is clearly inappropriate to call the members of a class its instances or examples.

[21] See H. Putnam, "The Meaning of 'Meaning'", in his *Philosophical Papers, Vol. II* (Cambridge: Cambridge University Press, 1975), pp. 215 – 271.

[22] Although it is still widespread in contemporary philosophy of science to reduce magnitudes to real numbers assigned to physical objects, we follow some philosophers, such as D. M. Armstrong and C. Swoyer, who construe magnitudes as quantitative attributes, i.e., attributes to which numbers are assigned. See D. M. Armstrong, *The World of States of Affairs* (Cambridge: Cambridge University Press, 1997), pp. 63 – 65 and C. Swoyer, "The Metaphysics of Measurement", in J. Forge (ed.), *Measurement*, *Realism and Objectivity* (Dordrecht: Reidel, 1987), pp. 235 – 290.

with a unique domain consisting of attributes and an ordering relation on this domain. Turning to object kinds, we may distinguish between kinds of abstract and of concrete objects. Abstract object kinds (such as Natural Number, Real Number, etc.) are represented by pure sets. On the other hand, kinds of physical objects (such as River, Cat, Man, etc.) are represented by a structure with a principal domain consisting of a time sequence of actual or possible objects of the given kind, and with several domains of essential and accidental attributes and attribute kinds bearing certain properties and standing into lawlike relations.

To every kind name "K" corresponds the predicate being-a-*K*, e.g., being-a-man and being-an-electron. Kind names are usually common noun expressions. This is always the case for object kinds. But the name of an attribute kind, say "Pink", is at first sight an adjectival expression. "Pink", however, may be taken in the nominalized sense as short for the common noun expression "pink-color" or "shade of pink color". (This is indicated by capitalizing the word "pink".)

For any kind name "K", *K* is the *correlate* of the predicate being-a-*K*. Since we construe the kind *K* as a thing, the correlation of such a thing to a predicate being-a-*K* can be called *reification*. Reification is possible only in case the class of instances of the predicate being-a-*K* is the extension of a genuine kind having a well-determined structure for securing the kind's independent existence from its extension. For example, the predicate being-a-man is correlated with the kind Man since the class of men has a well-determined structure, whereas the predicate being-a-pink-thing is not correlated with any kind. Hence there is reification in the first case but not in the second.[23]

Let us now defend our view that kinds (of any type) are not mere classes (which are particulars) but rather universals. Indeed the assumption that they are mere classes leads to insurmountable difficulties. Now if a kind were a class, it would be identical to its extension. For example, one would say that the kind Man is nothing but the class of all actual men. The extension of a kind is identical with the extension of the corresponding kind name. But the extension of the name of a kind of physical objects is not the same in all possible worlds in which the name has a denotation. For example, we can conceive a possible world in which there exist par-

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[23] Often any class of objects having a common property is considered to be the extension of a kind. But here we require much more, namely that the class be endowed with a well-determined structure.

ticular men who do not exist in the actual world, or one in which a specimen of gold, say, a golden mountain, which is missing in the actual world. But, as shown rather convincingly by S. Kripke and H. Putnam, kind names are *rigid*, i.e., they denote one and the same kind in all possible worlds in which that kind exists. Since the assumption was that a kind is to be identified with the extension in the actual world of its name, it follows that a kind, at least one of physical objects, does not consist of the class of the things it subsumes.

A second argument in favor of the view that kinds are universals is that the typical universals considered throughout the history of philosophy are kinds such as Man, Horse, Animal, i.e., secondary substances in Aristotle's sense. So it seems unavoidable to take kinds as universals.

4. The Inherence Relation

4.1 Abstract and Concrete Entities

Some entities (such as ordinary objects) occupy a unique region of space-time. The occupied region is the *location* of the entity. We call entities possessing a (unique) location *located entities*, and those devoid of location *unlocated entities*. We define then, *concrete entities* as located, and *abstract entities* as unlocated.

An ordinary physical object has an indefinite number of attributes borne only approximately. But when the object is subject to investigation within a particular branch of science, only a given number of its attributes, viz., those relevant to the investigation, are taken into consideration while the rest are *abstracted.* Also the relevant attributes are supposed to inhere *exactly* in the object (from a theoretical point of view). For this purpose the ordinary object under investigation is *idealized.*[24] As an example, consider a small-sized object studied in Classical Particle Mechanics. In that case the object is idealized as a point-particle with a finite mass. But such a thing cannot be a real object. Note that this point-particle bears, besides mass, only mechanical properties such as position, velocity, energy, etc., whereas non-mechanical properties such as electromagnetic ones (say, electric charge) are abstracted. The entity resulting from abstraction and idealization (in the above-mentioned sense) is called a *physical system*.

[24] For the notions of abstraction and idealization, see F. Suppe, *The Semantic Conception of Theories and Scientific Realism* (Urbana and Chicago: University of Illinois Press, 1989), pp. 93 – 94.

Physical systems are neither fully concrete nor fully abstract. Since spatio-temporal attributes are borne by these systems they are located, and thus are not fully abstract. On the other hand, being constituted by abstraction and idealization they are surely not fully concrete. For these reasons we propose to call them *semiconcrete-semiabstract*.

On the other hand, all universals (semantic and ontic) are obviously abstract entities, whereas it is a widespread opinion that all particulars are concrete entities, i.e., that they are located. However, we defend the view that there are, besides concrete particulars, abstract ones, namely, inhering particulars (attributes) as well as non-inhering ones (mathematical objects such as numbers and pure sets).

4.2 Attributes and Attribute Kinds

Attributes have been classified by Aristotle into nine different categories, viz., quantity, quality, relative, place, time, position, state, action, affection.[25] The attributes in these categories are also called accidents. The categories in question concern not only the attributes but also their kinds. In fact, both are called by the same name *symbebekos*. Aristotle, however, strictly distinguishes between the ontological status of attributes and that of attribute kinds. Indeed, as mentioned above, attributes are entities which are present-in, but not said-of, a subject. On the other hand, attribute kinds are those entities which are both present-in and said-of a subject.[26] For example, according to Aristotle, given that Socrates is pink, the attribute kind Pink is present-in Socrates and is also said-of the attribute Vink. But in our sense of inherence, it is Vink, and not Pink itself, which inheres in Socrates.

Let us now inquire into the nature of attributes and attribute kinds. We shall first show that attributes are neither predicates nor reducible to predicates, and exist independently of them *qua* non-semantic entities. Attributes in this sense are rejected by nominalists who deny abstract entities.

Attributes and their kinds are usually derived from their correlated predicates by means of an operation of reification. Indeed, we construe attributes as well as their kinds to be full-fledged thing-like entities, whereas predicates are merely semantic entities depending partly on our linguistic and conceptual framework. We propose the following three criteria of rei-

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[25] *Categories* 1^b27 - 28.
[26] *Categories* 1^a30 - 32.

fication of a predicate into an attribute, i.e., of the correlation of an attribute to the given predicate:

(i) A predicate can be correlated with an attribute only if at least one of its expressions is an adjectival phrase which contains a name of a potential attribute.

(ii) A predicate satisfying criterion (i) can be correlated with an attribute only if using this potential attribute secures much more scientific and/or practical expediency than abstaining from reifying the predicate by way of paraphrasing each sentence containing (not within a predicate) a name of this attribute into one containing only predicate expressions.

(iii) The entity correlated with a predicate satisfying criterion (i) and (ii) is an attribute if this entity is an instance of a kind, i.e., an attribute kind.[27]

Applications of criterion (i): As examples satisfying criterion (i), consider the monadic predicates (properties) being-vink and being-2-m-long and the dyadic predicate being-2-m-distant-from. A predicate expression of being-vink can be nominalized into a name of a potential attribute, viz., "Vink". The predicate expressions of both being-2-m-long and being-2-m-

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[27] The criteria (i) – (iii) secure a sparse ontology of attributes and attribute kinds in Armstrong's sense. However, Armstrong takes attributes as universals rather than abstract particulars. Furthermore, in case a predicate being-*F* corresponds to a universal, he calls the universal by the very expression "being-*F*". Criterion (ii) is in full agreement with Carnap's use of expediency of the linguistic frameworks concerning a particular category of entities, and Swoyer's view that there is no demonstrative argument for the existence of an entity such as property (or attribute for that matter). See R. Carnap, "Empiricism, Semantics, and Ontology", in *Meaning and Necessity, 2nd ed., enlarged* (Chicago: The University of Chicago Press, 1956), p. 214, and Swoyer, *op. cit.*, p. 236, and n. 3, p. 286.

There are also criteria of reification of predicates into kinds more or less analogous to the criteria (i) – (iii). But we do not deal with them in this paper. We only mention that a predicate such as a being-a-pink-thing (in contradistinction to predicates such as being-a-man, and being-an-electron) should not be reified into a natural kind of physical objects, for the reason that such a kind would not have a well-determined structure, and its use in a discourse would not enhance the explanatory power of that discourse.

distant-from contain as their part the name of a potential attribute, viz., "2 m". Hence all the three predicates satisfy criterion (i).

Applications of criterion (ii): As examples satisfying criteria (i) and (ii), consider the predicates being-vink, being-vor, and being-vlue (where "Vor" and "Vlue" are respectively names of potential attributes, viz., a shade of orange and a shade of blue. Then, as shown convincingly by A. Pap and F. Jackson, a sentence like

(6) Vink is a color

cannot be paraphrased into "any thing that is vink is colored", and a sentence like

(7) Vink resembles Vor more than Vlue

cannot be paraphrased into "any thing that is vink resembles a thing that is vor more than it resembles to a thing that is vlue."[28] It follows that in order to explain the meaning of the sentences (6) and (7) we must admit that the names "Vink", "Vor", and "Vlue" refer to (potential) attributes that are irreducible to any predicate. Also, to give another example, the predicate being-2-m-long satisfies criterion (ii) (as well as (i)). Indeed, a sentence such as "the length of rod *a* is equal to 2 m" is often reduced in nominalistic measurement theory into "the length-in-meter of rod *a* is equal to 2" which does not contain a name of a potential attribute. However, such a reduction drastically reduces the expediency and explanatory power of the use of the original sentence.

Application of criterion (iii): To illustrate criterion (iii), consider again the predicates being-vink and being-2-m-long. The potential attributes Vink and 2 m belong respectively to (potential) attribute kinds Color and

[28] See A. Pap, "Nominalism, Empiricism and Universals - I", *Philososophical Quarterly* **9** (1959), esp. pp. 334 – 335, and F. Jackson, "Statements about Universals", *Mind* **86** (1977), pp. 427 – 429. Notice that Pap and Jackson used genuine color terms such as "red", "orange", "blue", but presumably in the sense of certain shades of color rather than color kinds. Armstrong (1978, *op. cit.*, p. 58) acknowledges that concerning some positive arguments for realism, he bases himself "almost entirely" upon these articles of Pap and Jackson.

Length. Color has the structure of a three-dimensional color space,[29] and Length that of the ray of positive real numbers.[30]

It follows that Vink (as well as any shade of color) and 2 m (as well as any determinate length) satisfy the three criteria of reification, and thus are really attributes so that Color and Length are genuine attribute kinds.

Let us now defend the view that attributes are both particulars and abstract. Indeed both qualifications are controversial. Some philosophers, for example, Armstrong, take all attributes to be universal, whereas other ones, such as G. F. Stout, D. C. Williams, C. B. Martin, K. Campbell, take them to be located and thus non-abstract in our sense. We shall first argue that attributes are particulars. We have seen that they are neither predicates nor reducible to them so that they are things. *Qua* things, attributes must be either kinds, i.e., ontic universals or they are, indeed, particulars. Furthermore, attributes are not kinds. Indeed, since we have distinguished attributes and attribute kinds, attributes cannot subsume any entity. (Otherwise they would be kinds.) Hence attributes are particulars (by virtue of our definition of "particular").

Secondly, we shall argue that attributes are also abstract so that they are in fact abstract particulars[31] in the sense of being unlocated. Let us start by calling an attribute which inheres, or at least can inhere, in more than one object a *recurrent attribute*. On the other hand, we call an attribute which inheres, as a matter of fact, in exactly one object, and furthermore cannot, as a matter of logic, inhere in more than one object, a *nonrecurrent attribute*. Our problem is to find out whether attributes are recurrent or not. We shall argue first that they are recurrent, and second, by virtue of being recurrent, that they are unlocated, from which it will follow that they are abstract.

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[29] See R. Carnap, "A Basic System of Inductive Logic, Part 2", in R. Jeffrey (ed.), *Studies in Probability and Inductive Logic* (Berkeley: University of California Press, 1980), p. 7 ff. Carnap construes in general all attributes as elements of the so-called "attribute-spaces" each endowed with a well-determined structure.

[30] See H. Whitney, "The Mathematics of Physical Quantities, Part II", *The American Mathematical Monthly*, **75** (1968), Ch. I.

[31] It is important to remark that attributes are not the sole abstract particulars. Indeed mathematical objects, such as numbers and pure sets as well as sets or classes of non-mathematical entities are also abstract particulars. The difference between these two types of abstract particulars is that the former ones (i.e., the attributes which are not objects) inhere, whereas the latter ones (which are objects) do not.

Now, by definition, attributes are entities which can inhere in an object. There is a widespread view, imputed as far back as to Aristotle's *Categories*, that an attribute (accident) is a nonrecurrent entity inhering in a unique object.[32] A nonrecurrent attribute has been called in recent analytic ontology a *trope*. We shall call the view that all attributes are tropes the *trope view*. There are two versions of the trope view: substance-attribute theory[33] and bundle theory.[34] It is the latter which is adopted by the majority of trope theorists. According to the former any attribute *qua* trope inheres in an object whereas to the latter an object is itself a bundle of tropes. Inherence is a primitive (irreducible) relation in the first version whereas in the second it is reducible to the part-whole relation (i.e., "*x* inheres in *y*" reduces to "*x* is a part of *y*") rather than to the set-theoretical membership. The reason is that a physical object *qua* trope bundle should be construed as the mereological sum and not the class of its constituent tropes. Indeed, even classes of located things are arguably themselves unlocated, while physical objects are clearly located.

We shall now argue that attributes are always recurrent, which implies that the trope view is untenable. Our argument against the trope view applies to both versions. Since attributes are entities which inhere, or can inhere (in any of the two different senses) in some object, in order to show that they are recurrent, we must dwell on the concept of inherence in more detail. Consider our paradigmatic examples of attributes, viz., shades of color, and physical magnitudes such as determinate lengths, masses, temperatures, etc. Notice that all these attributes, even shades of color construed as absolutely determinate attributes, are exact (non-fuzzy) entities in the sense that they constitute systems having well-determined structures. This is clear for physical magnitudes since there is an isomorphism between the magnitudes of a given kind and some subsystem of real numbers.

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[32] This interpretation of Aristotle, for example, is shared by J. L. Ackrill, *Aristotle's Categories and De Interpretatione*, trans. with notes and glossary (Oxford: Oxford University Press, 1963), and by Wedin, *ibid.* But this view has been challenged from Owen's interpretation onwards.

[33] See, C. B. Martin, "Substance Substantiated", *Australasian Journal of Philosophy* **58** (1980), pp. 3 – 10.

[34] See G. F. Stout, "Are the Characteristics of Particular Things Universal or Particular?", *Proceedings of the Aristotelian Society*, supplementary volume **3** (1923), pp. 144 – 22, D. C. Williams, "On the Elements of Being I – II", *The Review of Metaphysics* **7** (1953), nos. 1 – 2, pp. 3 – 18, and K. Campbell, *Abstract Particulars* (Oxford: Basil Blackwell, 1990). For a recent discussion of the trope view, see also A.-S. Maurin, *If Tropes* (Dordrecht: Kluwer, 2002).

On the other hand, qualities, such as shades of color and tones of sound are considered elements of some exact ordering. For example, the shades of physical color constitute a system isomorphic to a subsystem of natural numbers (being thus a well-determined structure) corresponding to the frequencies of electromagnetic waves. On the other hand, the shades of color in the phenomenological sense constitute a system isomorphic to a three-dimensional color space, which is indeed a well-determined structure.

Attributes can be divided into two types, viz., those belonging to a continuous spectrum and those belonging to a discrete one. We mean by the *spectrum* corresponding to a given attribute the structured domain of the attribute kind to which that attribute belongs. If the structured domain is a continuum, the attributes belonging to the domain are of the first type, and, if it is discrete, of the second type. For example, the attribute Vink belongs to a continuous spectrum, viz., the color-shade spectrum, whereas the attribute Two-legged (which would be correlated with the predicate being-two-legged in case the latter were reified) belongs to a discrete spectrum consisting of the would-be attributes zero-legged, one-legged, two-legged, etc. Now an attribute belonging to a continuous spectrum cannot be exactly attributed to any concrete object. To give an example, no concrete entity can have a mass of exactly 2 kg let alone the square root of 2 kg. Indeed let *a* be a physical object. Object *a* consists of microphysical entities, say, its atoms. Let *A* be the set of all atoms constituting *a.* But the elements of such a set *A* are indeterminate; they not only change in time but remain indeterminate at a given time. For if a_i is an atom very close to the boundary of object *a*, there is no objective answer to the question of whether a_i belongs to object *a* or to the environment thereof. Furthermore, the atoms at the boundary of *a* are in perpetual motion, and there is an interchange of atoms between the object *a* and its environment. But the mass of *a* is equal to the sum total of the masses of the atoms constituting that object. Since the number of these atoms, as well as their kind, is indeterminate, the mass in kg of *a* cannot be identical, at any concrete moment of time,[35] to a given real number; what at most can be said is that it is within an interval of real numbers around 2. This is tantamount to saying that the mass of object *a* (at a given time) is *approximately* 2 kg. In general, we are led to construe the relation of inherence between an attribute and a con-

[35] Notice that a concrete moment of time is not a point-like instant but has duration however small it may be. It follows that a concrete object can undergo change even at a given concrete moment of time.

crete object as an approximate rather than an exact attribution. Even some attributes belonging to a discrete spectrum, such as Two-legged, in situations like one's having partly lost one of his legs or having a deformed one, may not be exactly attributed to a concrete object.

On the other hand, attributes with a discrete spectrum, at least in normal situations, can be exactly attributed to the objects in which they inhere. Two-legged (normally considered) would be such an example. As another example of an attribute belonging to a discrete spectrum, spin values can be exactly attributed to electrons in which they inhere. In the light of the distinction between approximate and exact attribution, let us examine the question of whether attributes are recurrent or nonrecurrent.

In case inherence is taken in the sense of approximate attribution, it is plausible to say that an attribute can inhere in more than one object, from which it follows that it is recurrent. For example, many physical objects have a mass of approximately 2 kg. Hence, such a mass is a recurrent attribute and thus not a trope. Notice that if an attribute belonging to a continuous spectrum could be exactly attributed to a concrete object, it would still be logically possible—even though exceedingly improbable—that it inheres in more than one object thus rendering it recurrent.

On the other hand, if inherence is taken in the sense of exact attribution, which is generally the case for attributes belonging to a discrete spectrum, the attributes can naturally inhere in more than one object so that they are recurrent. It follows that there are no nonrecurrent attributes, and thus the trope view is untenable.

Granted that attributes are recurrent; can we maintain that they are located in the union of the locations occupied by the objects in which they inhere? The answer is negative for the following reasons: First, it would be counterintuitive to take a union of scattered locations a unique location, and second, there could still be a different location for the attribute in question. Hence, recurrent attributes are unlocated, from which it follows that they are abstract. In this way, our thesis that attributes are abstract particulars is justified. In so far as an attribute is indeed a recurrent unlocated entity, it cannot really be *in* any given object in the sense of being a constituent of the object in which it inheres. Hence we are conduced to a conception of attributes that is more Platonist than Aristotelian. This conception is strengthened by the fact that one can conceive of attributes, say, shades of colors, which do not inhere in any concrete object.[36]

Having established that attributes are abstract particulars, let us now inquire into the nature of the inherence relation between attributes and objects. An attribute of a given kind may inhere in an object in different ways. A *way of inherence* involves, among others, place, time, and, if required, a system of coordinates. For example, a shade of color, say, Vink, may inhere in an object at a given time with respect to its whole surface (assumed to be uniformly colored), or to the greatest part of its surface (assumed to be uniformly colored), or only to a given part (assumed to be uniformly colored). Similarly, a determinate length, say, 2 m, may inhere in an object at a given time with respect to its proper length, diameter, width, thickness, depth, etc. And, further, it may inhere in a particle at a given time with respect to its *x*-, *y*-, or *z*-coordinate, or in a system of *n* particles at a given time with respect to the *x*-, *y*-, or *z*-coordinate of the 1st, 2nd, . . ., or *n*th particle. The most important characteristic of the inherence relation with respect to a given way is expressed by the following principle, which we shall call *the principle of the unicity of inherence*, and which applies rigorously to physical systems rather than to ordinary physical objects:[37]

> Different attributes of the same kind cannot inhere with respect to the same way in an object.[38]

We define the *domain of bearers D* of the attributes of kind *K* with respect to a way of inherence as the set of objects in which an attribute of kind *K* inheres with respect to the given way. Then it follows from the principle of unicity that any object belonging to the domain *D* bears, with respect to the given way, exactly one attribute of kind *K*. Hence, there is a

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[36] For example, Hume mentions the idea of an unperceived shade of blue in between two perceived ones. See D. Hume, *An Inquiry Concerning Human Understanding* (Indianapolis: The Liberal Arts Press, 1955), pp. 29 – 30. Notice that Hume's remark expresses nothing but the fact that the ordering of the color spectrum is dense. (A linear ordering relation is *dense* just in case there is member of the field of the ordering between any two members related by this ordering.)

[37] In the rest of this section "object" is used in the sense of physical system.

[38] The so-called color-exclusion principle to the effect that no object can at the same time be both red and green all over is a corollary of this fundamental principle.

function, call it *inherence function*,[39] mapping the domain of bearers *D* in the domain of kind *K* such that the value of the function for a given object belonging to *D* is the attribute of kind *K* which inheres with respect to the given way in this object. An inherence function whose values are quantitative attributes (such as lengths, masses, etc.) is called a *quantity*, and the attributes constituting the values of the quantity are called *magnitudes.*

Let us now recapitulate and clarify our conception of attribute, emphasizing the distinction between attributes and attribute kinds on the one hand, and between attributes and predicates (i.e., properties and relations) on the other. For this purpose let us analyze the relationships holding among Color, Pink, Vink, and Socrates (as body).

1. Color and Pink are attribute kinds, and thus ontic universals, whereas Vink is an attribute, hence an abstract particular by virtue of the criteria of reification (i) – (iii). Color subsumes Pink and Vink, whereas Vink inheres in Socrates who is a concrete particular.

2. Vink, being a particular, is an instance of both universals Color and Pink, but Socrates, though a particular too, is not an instance of these universals. The reason is that Socrates is not an attribute but rather an object.

3. There are no attributes of attributes. Though a statement like "Pink is a color" is quite usually considered to mean that Color is an attribute of Pink, this is not so in our conception. First, because none of Pink and Color is an attribute, and, second, because Color subsumes Pink and therefore cannot inhere in Pink. Furthermore, one may take the statement "Vink is a color" to mean that Color is an attribute of Vink, but this is not so; first, because, though Vink is an attribute, color is not, and, second, because Color subsumes Vink and thus cannot inhere it. Furthermore, an attribute cannot inhere in any attribute (of the same or of a different kind), because it can inhere only in objects. The apparent attributes of an attribute are rather attribute kinds which subsume the given attribute. For example, the attribute Vink does not inhere in the shade of orange color Vor, or in the length 2 m so that Vink is not an attribute of either. Hence our view that there are no attributes of attributes seems to be justified.

4. Attributes must also be distinguished from the predicates that are correlated with them. Indeed, in contradistinction to predicates, attributes are neither monadic nor polyadic. For example, the attribute Vink is corre-

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[39] Suppe (*op. cit*., p. 93) calls the inherence functions "parameters." Indeed the arguments of the parameters are physical objects and their values are attributes.

Using the notion of inherence function, we can redefine the attribute name "Vink" as "the shade of color at a given time and place in Socrates' surface."

lated with a monadic predicate, viz., the property of being-vink (vinkness for short). Furthermore, one and the same attribute (say, 2 m) can be correlated both with a monadic and a polyadic predicate (say, being-2-m-long and being-2-m-distant-from). Now the color of Socrates is the attribute Vink and not the property being-vink, or vinkness. Indeed the sentences "The color of Socrates is being-vink" and "The color of Socrates is vinkness" do not make sense. Similarly, the distance between two particles may be the attribute 2 m, but never the dyadic relation being-2-m-distant-from. In general, the values of an inherence function for given objects are attributes but not properties or relations.

5. A Classification of Categories

Our inquiry into the nature of predicates, kinds, and attributes of physical objects results in the following classification of categories, which characterizes the ontology of the physical realm. Note that we replace higher-order kinds by their respective (first-order) reduct.

0. *Entities*
   1. Non-predicable entities: *Things*.
   2. Predicable entities (semantic universals, abstract)*: Predicates* (of any order).
   1.1 Non-subsuming things: *Particulars*.
   1.2 Subsuming things (ontic universals, abstract): *Kinds*.
      2.1 0-place predicates: *Propositions*.
      2.2 *n*-place predicates ($n \geq 1$): *Concepts*
         1.11 Non-inhering particulars: *Objects*.
         1.12 Inhering things (abstract): *Attributes*.
         1.21 Kinds of objects (abstract): *Object kinds*.
         1.22 Kinds of attributes: *Attribute kinds*.
         2.11 Subject-predicate propositions: *Predications*.
         2.12 Propositions with connectives and/or quantifiers: *Complex propositions*.
         2.21 One-place predicates: *Properties* (of any order).
         2.22 Many-place predicates: *Relations-in-intension* (of any order).
            1.111 Located objects: *Physical objects*.
            1.112 Unlocated objects: *Abstract objects*.
            1.1111 Ordinary (physical) objects: *Concrete entities.*

1.1112 Physical systems: *Semiconcrete-semiabstract entities*.