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Science without Levels

Abstract: It is widely held among reductionists and anti-reductionists alike that the sciences are divisible into hierarchies of levels. Despite recent challenges to nomological hierarchies, it is nonetheless assumed that objects can be allocated into mereological levels, and properties into supervening sets. I challenge this, arguing that any division of such entities into levels must satisfy certain conditions, but that these conditions are mutually incompatible. I first consider Jaegwon Kim's recent criticisms of Oppenheim and Putnam's picture of levels, and raise difficulties with his proposed revisions. I then argue that there can be no division of objects or properties into levels that even nearly satisfy the intuitive characteristics of a compositional hierarchy, and extend the problem to supervenience hierarchies as well.

In what follows I challenge the doctrine that objects or scientific properties can be divided into layers or levels. This thesis has been widely held in various forms, with roots stretching back to the classification schemes of Bacon, D'Alembert and Comte, if not to Aristotle. The classic contemporary presentation of the division of objects into levels is Oppenheim and Putnam's "Unity of Science as a Working Hypothesis."[1] While that paper argues for intertheoretic reduction, opponents of reduction are also typically committed to level hierarchies. For instance, in a recent defense of anti-reductionism, Ned Block speaks of levels of properties, each of which stands in a supervenience relation to the next lower level even while not being reducible to it:

[1] Oppenheim and Putnam (1958)

> The following is plausible: Socrates' pain supervenes on his neurological properties and his neurological properties supervene on the biochemical properties of his brain, and the biochemistry of his brain supervenes on the atomic-physical properties of his brain, and the atomic physics of his brain supervenes on the elementary-particle properties of his brain.[2]

In many other contexts, levels also play an important role. One that has recently received a good deal of attention is in the question of whether there is or must be a "fundamental" level of physics, which has key implications for characterizing physicalism, as well as for the ontological status of mid-sized entities.[3]

Some philosophers have recently discussed potential divergences among different kinds of level hierarchies. Nancy Cartwright and William Wimsatt have challenged different aspects of nomological hierarchies in particular,[4] and Jaegwon Kim has challenged the idea that the mereological, supervenience, and "realization" hierarchies are aligned with one another.[5]

In this paper I argue against levels on more general grounds. Focusing on mereological and supervenience hierarchies, I argue that any division of entities into levels must satisfy a few key conditions, but that these conditions are mutually incompatible.

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[2] Block (2003), p. 8. Fodor and Putnam also can be understood as committed to levels, in Fodor (1974); Putnam (1975).

[3] Hellman and Thompson (1975); Dehmelt (1989); van Inwagen (1990); Pettit (1993); Sider (1993); Zimmerman (1996); Schaffer (2003).

[4] Wimsatt (1976); Cartwright (1983); Wimsatt (1994); Cartwright (1999).

[5] On these claims and the definition of realization hierarchies, cf. Kim (1998); Schaffer (2003).

Kim versus Oppenheim-Putnam

Oppenheim and Putnam present a set of mereological criteria for the division of objects into levels. Recently, Jaegwon Kim has scrutinized these and shown that they are problematic in a number of ways. In response, he proposes a revised picture to make sense of levels.[6] While his criticisms are sound, Kim's positive suggestions are flawed. Seeing where Kim goes wrong helps bring out some key characteristics of "level-like" orderings that we can then demonstrate cannot be satisfied.

Oppenheim and Putnam propose six conditions of adequacy for the arrangement of levels:[7]

> (1) There must be several levels.
> (2) The number of levels must be finite.
> (3) There must be a unique lowest level.
> (4) Anything of a level except the lowest must possess a decomposition into things belonging to the next lower level. In this sense each level will be as it were a "common denominator" for the level immediately above it.
> (5) Nothing on any level should have a part on any higher level.
> (6) The levels must be selected in a way which is "natural" and justifiable from the standpoint of present-day empirical science.

In addition to these conditions, they add a further stipulation, which I will call the "downward inclusion principle":

> (DIP) Any whole which possesses a decomposition into parts all of which are on a given level, will be counted as also belonging to that level. However, the highest level to which a thing belongs will be considered the "proper" level of the thing.

Oppenheim and Putnam then present a hierarchy of object-types: social groups, multicellular living things, cells, molecules, atoms, elementary particles. Corresponding

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[6] Kim (2002)

[7] Oppenheim and Putnam (1958), pp. 9-10.

to each is a scientific field, and they propose that although it is unrealistic to expect theories in all the sciences to be reducible to the lowest level, we may nonetheless hold out hope that theories in each level will be reducible to ones in the next lower level.

Kim points out three problems with the Oppenheim-Putnam ordering: conditions (5) and (DIP) are inconsistent; condition (4) excludes most actual entities from the hierarchy; and the ordering incorrectly arranges objects in a single ladder, rather than a branched hierarchy.

1. The inconsistency of conditions (5) and (DIP)

The downward inclusion principle implies that the full hierarchy is a pyramid, with social groups alone at the top level and all entities at the bottommost one.

Condition (5), on the other hand, stipulates that nothing on a level should have a part on a higher level. Kim suggests that it is (5) that is too strong: condition (5) seems an arbitrary stipulation on the notion of a level, while (DIP) seems to follow immediately from the plausible thesis that composed objects are exhaustively determined by their compositions.[8] A different intuitive reason for favoring (DIP) over (5) is that if we regard levels as determining sciences, then it is plausible that the science of the bottommost level applies to all entities, while fields such as biology and sociology apply to only some entities.

However, even without (5), (DIP) is unsatisfactory, for three reasons. First, since everything in a level j>1 is already included in level j-1, the decomposition of the entities at level j into those at a lower level is trivialized. Objects at higher levels are simply

[8] This principle can be interpreted in a variety of ways, and it does not take the strongest of them – e.g., strong compositional identity – to imply (DIP). On compositional identity principles, see. Sider (2007).

decomposable into themselves, at the lower levels. Second, if as Kim suggests the delineation of levels also determines a domain of properties and laws, the downward inclusion principle also makes laws redundant across levels. Third, (DIP) implies the lower-level decomposition even of entities for which we stipulate that they are not decomposable. For instance, suppose we stipulate that some strong form of dualism is true, and that spirit-objects are in the domain of actual objects. Supposing one were then to propose a division of objects in the domain such that these entities were at level 7, above the social groups. By (DIP), then all these entities would be contained at every lower level, thus making it trivial that the level-7 entities are composed by entities at each lower level.

2. Most entities excluded by condition (4)

This condition, which Kim dubs "homogeneous decomposition," is that anything on a given level must be fully decomposed into things at the next lower level. He notes that homogeneous decomposition has the unhappy consequence of excluding most biological organisms from the hierarchy, since most organisms contain "free" molecules that are not part of cells, for instance in bodily fluids. Kim also observes that Oppenheim and Putnam acknowledge a version of this point, but that they incorrectly dismiss it by assuming that only unnatural composites of entities will fail to decompose homogeneously.[9]

Kim's response is to refine the Oppenheim-Putnam ladder by replacing (4) with a weaker principle (call it 4'): each object at any level higher than the lowest level must have a full decomposition into parts all of which belong to *any* of the lower levels.

[9] Oppenheim and Putnam (1958), p. 11; Kim (2002), p. 14.

This revision too is flawed. First, notice that if we had retained (DIP), then the decomposition of a level into the next lower level is trivial, whether (4) is weakened to (4') or not. Even abandoning (DIP), however, the weakened decomposition principle has its own problems. (4') allows that the things at level j may include things decomposable into any lower level. Thus since atoms are decomposable into elementary particles, atoms are included in levels 6, 5, 4, and 3, as well as 2. And so on. Condition (4') thus admits an inverted pyramid (excluding the bottommost layer) as an acceptable ordering of levels.

This weakening of homogeneous decomposition also allows higher level entities to be introduced at any level of the hierarchy whatsoever. An ordering in which social groups are on a lower level than multicellular organisms, for instance, satisfies condition (4'), since both social groups and multicellular organisms are decomposable into elementary particles. In fact, (4') is compatible with any arbitrary ordering above the bottommost level, so long as the higher entities are composed out of elementary particles.

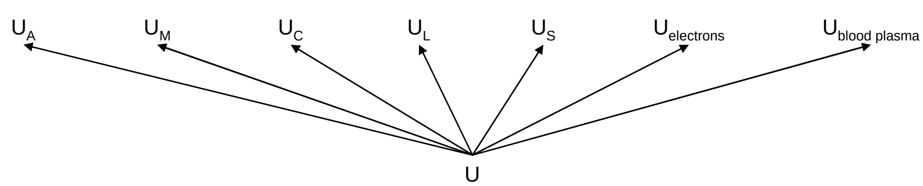
3. The hierarchy as a ladder

Finally, Kim points out that there are counterintuitive consequences of regarding the mereological hierarchy of levels as a single ladder, rather than a branching hierarchy. For instance, all inorganic things, such as computers and all their constituent parts, are included at level 1 in the Oppenheim-Putnam hierarchy. It is implausible that there should be just a single-ladder hierarchy, as opposed to a branching hierarchy of nested subdomains, U of physics, U_A of atoms and aggregates of atoms, and so on.

Kim himself notes a critical problem with his picture of a branching hierarchy. He observes that because of the "free molecule problem," $U_{Living\text{-}things}$ is not actually properly included in U_{Cells}. His response, however, is puzzling:

> Organisms are generated ultimately from molecules, of course, but it is important to recognize cells as an intermediate point because cells form a significant nomic kind, and the biological functions and behaviors of organisms seem perspicaciously explainable in terms of the properties and behaviors of cells.[10]

One curious thing is that clearly it is not only entities in U_L that have a "free lower-entity" problem. Cells are not only composed of molecules, but also of free atoms; and molecules not only of atoms, but of free elementary particles. Moreover, it is not clear why we should think that entities in U_L themselves do not include only free molecules, but also free atoms and free elementary particles. If U_L is not a subdomain of U_C, then it is not likely to be a subdomains of $U_{Molecules}$ or U_{Atoms} either. Without treating the "free lower-entity" problem, the hierarchy of overlapping subdomains of U is not a tree, but a shrub:



It is not clear why U_C, for instance, should be considered an intermediate level between U and U_L, while the domain of electrons and aggregates of electrons, or the domain of blood plasma, should not, since organisms are in part composed of electrons and of plasma, as they are of cells. In proposing that entities are arranged in a hierarchy of levels, it is not enough to have a top and a bottom level: we need to be able to make sense of intermediate levels as well.

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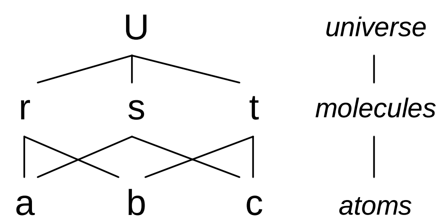
[10] Kim (2002), p. 17.

Parthood orderings, composition orderings, and level hierarchies

Some people assume, I think, that the ordering of objects by the parthood relation is itself a kind of level hierarchy. After all, the parthood relation on a set of objects is a hierarchy, in the sense of being a partial ordering on that set. This is often depicted with a Hasse diagram of the ordering of objects composed from a set of three atoms, often with the "levels" of the diagram labeled:[11]



Obviously, the ordering of levels depicted in the diagram is different from the parthood ordering: the parthood ordering is a hierarchy of objects, while a level hierarchy is an ordering on equivalence classes of objects.

The diagram is misleading, though, in suggesting that there is a natural level hierarchy that falls out of the parthood ordering. This is partly an artifact of the limitation to three atoms, and partly an artifact of the use of a Hasse diagram. A Hasse diagram does not include all the "parthood" lines, but depicts a transitive reduction of the relation. Thus there are many Hasse diagrams for a typical partial ordering, and many ways such diagrams can suggest that levels be delineated. Also misleading is that labeling the diagram suggests that in a bigger diagram, when we moved up a level past the level labeled "molecules," that we would come perhaps to one labeled "cells." But of course, with no further specification of structure, it is molecules all the way up.

[11] E.g., Schaffer (2006).

For the purpose of dividing objects into levels, it is not only the breakdown of entities in their parts that matters to a level ordering, but how they are composed of those parts, or which constituents of the entities are bound to one another. This is needed even to make sense of the "free molecule" problem. A given water molecule as part of an organism may be "free" if it is not a constituent of a cell, or it may not be free at all, but simply part of a cell. How the organism is decomposed into its parts – i.e., whether it is decomposable into elements of the next lower level or not – turns on this sort of structural issue.

In order to determine whether there can be an ordering of entities into levels, three questions need to be addressed:

1. What is the space of objects to be ordered into classes? Can we appropriately distinguish ones that are composed differently, even with identical elementary compositions?
2. What conditions must an ordering of equivalence classes of these objects satisfy, in order to be an acceptable "level" hierarchy for use in the relevant philosophical and scientific contexts?
3. Are there equivalence classes and an ordering on them that satisfy the conditions?

The argument I will make is that even on generous interpretations of 1 and 2, the answer to 3 is no. In brief, the reason is that some decomposition restriction is required to avoid trivializing levels, but any reasonable one means that many entities will have to be left out, even with overlapping branches.

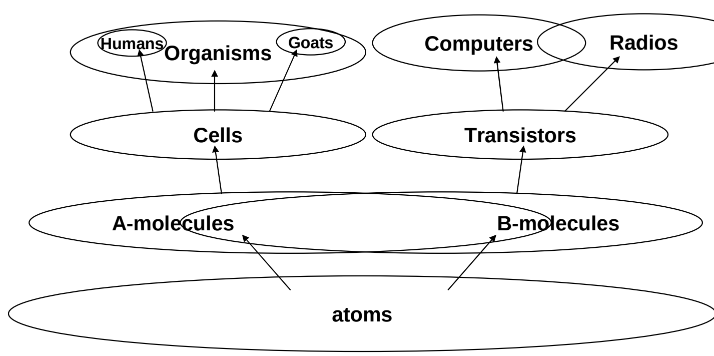
There is a rather natural treatment of objects so as to capture their compositional structure: treat objects as graphs of smaller parts. The simplest way to do this is from the bottom up, with an iterative construction. For present purposes, we will assume that there is a "fundamental" class *E* of n elementary particles.[12] Starting with the first domain $D_0=E$, successive domains $D_1 \ldots D_n$ are composed out of subsets of the previous domain. The entire hierarchy of powersets, however, would include many impossible objects, i.e., objects that are graphs of overlapping components. Let us therefore define the iterated sets succeeding D_0 with: $D_i = \{T : T \subseteq D_{i-1} \wedge \forall x, y \in T(\neg Oxy)\}$, that is, the set of nonoverlapping subsets. This generates sets of entities with compositional structure from the preceding iterations intact. Although the elements of a set D_i are not contained in D_{i+1}, all the elements in D_i have a structurally redundant element in D_{i+1}, i.e., each singleton containing the respective member of D_i. We can thus regard D_n as the set of all objects.

The number of these objects is far smaller than the n^{th} iterated powerset of *E:* the nonoverlapping condition means that large subsets of *E* do not tend to generate objects, and in the higher iterations, there are few new structurally distinct objects generated. Still, the number of objects in D_n is large. One way of regarding D_n is in terms of partitions of subsets of *E*. A given object, that is, is modeled as a partitioning of a subset of the elementary particles, with the partitions arranged in a partial ordering. This is a way of representing that a given electron may be contained in some water molecule, which in turn may be contained in a cell. This is of course a simplified model of objects, but it at least incorporates a modicum of structure, so as to account for the distinction

[12] The assumption of a fundamental level simplifies things, but the base set can be taken to be any intermediate level, whether or not it is fundamental.

between entities that are bound in larger entities and those that are free.

Now, let the domain of all objects *S* be D_n, with redundant structure (such as irrelevant brackets or repeated containment) simplified, and let s be the cardinality of *S*. Now consider the arrangement of *S* into levels. Levels are nonempty sets of objects; let $\mathscr{L}$ be the set of all levels. The *lower-level-than* relation $\prec$ is a binary relation on $\mathscr{L}$. Presuming that levels can branch,[13] we will not require that the ordering of levels be a complete or linear ordering, but rather take $\prec$ to be a partial ordering. Let L_0 be the lowest level of the level hierarchy; it contains *E*, but we can allow that it may include other things as well (i.e., $E \subseteq L_0$). The idea is that a branching hierarchy intuitively should look something like this:



It is useful to consider the branching hierarchy as being composed of non-branching but overlapping "pyramids" of levels. For any partial ordering with L_0 as the lower common bound of every pair of classes, we can isolate complete suborderings, all of which have L_0 in common as their lowest level, e.g., atoms→A-molecules→cells→humans, and atoms→A-molecules→cells→organisms, and so on. A pyramid, then, can be defined as a set S^i of objects, classified into a set of levels $\mathscr{L}^i \subseteq \mathscr{L}$,

[13] And potentially recombine; cf. Kim (2002), p.17.

with $\prec$ completely ordering the levels in each pyramid in $\mathscr{L}^i$. Then L^i_j is the jth level of pyramid i, $S^i = \bigcup L^i_j$ and $S = \bigcup S^i$, where $L^i_0 = L_0$.

Now, there are three conditions on levels within pyramids, two of which are non-negotiable, and one that comes in various strengths:

A. Intra-pyramid levels are mutually exclusive

Although there may be a large number of overlapping pyramids, the problems with (4') and (DIP) demonstrate that the reduction from one level to another is trivialized if the classes *within* a given pyramid are not mutually exclusive:

(Excl) $\forall i, j, k((j \neq k) \rightarrow L^i_j \cap L^i_k = \varnothing)$.

B. Levels respect the parthood ordering

If the level hierarchy is meant to be a mereological hierarchy, then there can be no reversals from the parthood ordering of objects to their projection into levels. That is, no item at a higher level is part of an entity at a lower level:

(Resp) $\forall i, j, k[(j > k) \rightarrow \neg(\exists x \in L^i_j \exists y \in L^i_k (Pxy))]$

C. Constraints on decomposition

In constructing a system of levels, we do not only want to ensure that preceding levels are parts of higher levels, but we also require conditions on how entities are composed. Kim's (4') is such a principle – that every entity be composed of entities at levels below it – but it is too weak. First I will revisit homogeneous decomposition.

Applied to pyramids, homogeneous decomposition is the condition that every element on a level is composed by nonoverlapping elements of the level immediately below it, i.e.,

(Hom Dec) $\forall i, j, k[(j > k) \rightarrow \forall x \in L_j^i \exists Y \subseteq L_k^i (COMP(Y, x)))]$,

where COMP(Y,x) is the "composition" relation holding between a set of objects Y and an object x, holding just when Y is a set of nonoverlapping objects that compose x.

The free molecule problem can be regarded as one of coverage: decomposition restrictions generate the required dependence of a level on the next-lower one, but these restrictions prevent any given pyramid from covering all of *S.* A branching ordering, however, offers a potential way out of this dilemma. So long as we do not insist that there is a single ladder of levels, but allow multiple overlapping pyramids, we might be hopeful that we can rescue homogeneous decomposition. The hope is that even though homogeneous decomposition rules out too many objects for a single hierarchy of objects to be acceptable, the system of levels as a union of homogenously decomposing pyramids as a whole might cover all or most objects in the world.

Unfortunately, the hope that the branching or overlapping-pyramid hierarchy will save homogeneous decomposition is in vain. In a realistically diverse world, there is only one way to cover the objects even with overlapping homogeneously decomposing pyramids of levels: to have a huge number of pyramids. With an unlimited number of pyramids, any diverse set of objects can be covered; but this is just another way of trivializing the hierarchy of levels. This can be expressed as a kind of "impossibility theorem": it is impossible to have (a) nonintersecting levels within a pyramid; (b) homogeneous decomposition of a level to the next-lower level within a pyramid; (c) complete or near-complete coverage by pyramids; and (d) a non-exploding number of pyramids.

Using the definitions above, and assuming conditions (Excl) and (Hom Dec),[14] it follows that: If the size of L_0 is n then each S^i consists of at most $n \cdot 2^n$ elements. Thus if we assume that S is covered by N pyramids, then $N > s/(n \cdot 2^n)$. But s grows superexponentially with n, so even though the individual pyramids S^i grow large quickly, for large n, N is huge.

Intuitively the reasoning is straightforward. Recall that *S* is the set of partitions of subsets of *E*. Consider only the set of partitions of *E* itself: the cardinality of that set alone grows exponentially (i.e., the n^{th} Bell number); and *S* contains the ordered graphs of partitions of all subsets of *E*. Homogeneous decomposition, on the other hand, limits the parts that can figure into the composition of entities at a level to exclude all the ones at the previous levels. This restriction means that while L_1^i can be the full set of subsets of L_0, the growth of the subsequent levels in a pyramid are restricted to being partitions selected from the previous level alone.

This construction involves a world with a plenum of objects, consisting of all combinations of elements of L_0. The actual world, of course, has a tiny subset of *S*. Nonetheless, the same reasoning applies. For a world having many objects, there is a probability approaching zero that the objects in that world are homogeneously decomposing, and the probability approaches 1 that the number of pyramids needs to be very large relative to the number of objects.

If the world is to be divisible into levels, there is a tradeoff between coverage and decomposition restrictions. The natural question then is whether there is any kind of reasonable balance between the two. Entirely unrestricted decomposition is Kim's (4'),

[14] (Resp) is implied by (Hom Dec), and so is redundant here.

and we have seen the problem with this. The issue with a middle ground, however, is that even a small restriction on decomposition has dire consequences for generating a gap between the coverage of pyramids and the combinatorial explosion of entities in S. Even the weakest decomposition conditions that retain at least some dependence of a level on the next lower level will impose an increasing restriction on the combinations that can occur in higher levels. With the superexponential growth of S, it will take more than a linear increase in the number of pyramids to make up the difference from the missing combinations resulting from this restriction. Any restriction on what is allowed from lower levels into higher ones cuts down severely on the objects that can be constructed at higher levels.

The fundamental tradeoff is that if we restrict the decomposition admissible within pyramids, then we need to add an exploding number of pyramids, to capture the entities that have been left out. But if we have no restriction on decomposition, then we are left with levels that are not level-like. We are left with an unhappy trilemma: (a) either impose nearly no restrictions on interlevel decomposition, in which case intermediate levels consist of almost anything or nothing; or (b) have the number of levels approach the number of entities, in which case levels are trivialized; or (c) leave out most entities, in which case levels are useless.

Supervenience hierarchies and the subject-matter of levels

The preceding considerations can be applied straightforwardly to demonstrate the impossibility of a supervenience hierarchy as well. A supervenience hierarchy is typically taken to be a hierarchy of property-sets, rather than sets of objects.

To make sense of such a hierarchy, we must delineate the property sets that are to stand in supervenience relations to one another. There are many ways of delineating property-sets, but when we speak of a set of properties such as neurological, biochemical, or atomic-physical properties, I would suggest that these property sets are determined by classes of objects, in something like the following way: r is a neurological property iff it is a property that only objects having neurons as parts can have. Or r is a biochemical property iff it is a property that only objects having biochemical molecules as parts can have. This means that neurons can have neurological properties, as can brain-lobes and brains and people, but molecules cannot. Neurons and enzymes can have biochemical properties, but atoms and quarks cannot. (Some modification to this characterization may be required to accommodate relational properties appropriately.)

If the property-sets in a supervenience hierarchy are determined along such or similar lines, then there is a problem: the supervenience hierarchy is parasitic on a prior discrimination of objects into levels. And if we take a property set to supervene on the property set preceding it in the hierarchy, then this requires not just any level-like hierarchy of objects, but a hierarchy in which the objects at a level in a pyramid homogenously decompose on objects at the preceding level in the pyramid, i.e., a hierarchy satisfying (Hom Dec). For suppose homogeneous decomposition does not hold, e.g., suppose that neurons do not homogeneously decompose into biomolecules. Then we cannot expect neurological properties to supervene on biomolecular ones.[15]

The same exclusivity considerations apply for levels of a supervenience hierarchy as they do for a compositional hierarchy, if we do not want to trivialize the hierarchy.

[15] Homogeneous decomposition may not be enough, if composition does not exhaust supervenience (cf. Bennett (2004); Koslicki (2004)), but it is surely a requirement.

We cannot admit all the physical properties into each level, for instance, or else we guarantee the supervenience of higher levels on the ones below them, regardless of what else is in the level. Moreover, as with the compositional hierarchy, we cannot simply have a level supervene on all levels below it, on pain of admitting nearly empty intermediate levels. Thus the supervenience hierarchy is plausibly simply a projection of the compositional hierarchy into the properties that apply to those objects. And if supervenience on the previous level is a requirement of the property hierarchy, then nothing short of homogeneous decomposition will do. If as I have argued we cannot construct an adequate compositional hierarchy at all, and certainly not one that satisfies the homogeneous decomposition condition, then there cannot be a supervenience hierarchy either.

Conclusion

Unless we restrict domains to negligible fractions of the world, or unless the world is implausibly conducive to our orderings, there simply is no hierarchy of the domains of the sciences. The failure of levels does not entail the failure of all intertheoretic reduction. What it does mean, however, is that the lower or reducing theory must either be a bottommost theory, i.e., part of physics, or else is likely to be an ad-hoc assemblage of objects, properties, and laws. One key place for which this has practical application is in the practice of the social sciences. Many philosophers of social science have advocated "methodological individualism," an approach that is often assumed to privilege reductions of social phenomena in terms of individuals and individualistic properties. The impossibility of stratifying the world into levels makes it overwhelmingly likely that such an entity or property-base will be inadequate for social explanation. Rather, any reduction from a higher level to intermediate levels is likely to be far more heterogeneous.

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