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Abstract

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Several authors have recently proposed "non-well-founded" or "non-anti-symmetric" mereologies. This terminology is relatively new, but at least some of the motivations behing their alternative systems derive from dilemmas that have inspired extensive commentary in the past. For example, is the clay out of which a sculpture is made a proper part of the statue? Most commentators seem to frame their intuitions in the intuitive parameters of part/whole hierarchies, and find some mechanism to reconcile the parts of their intuitions that don't fit simple accounts of parthood. The more radical possibility, which is the subject of this paper, is to re-engineer our conceptual of parthood from the ground up. In particalar, we can drop the assumption that parthood is assymtric or acyclic. Doing so results in a Non-Asymmetric Mereology, or NAM. In NAM, x can be part of but different from y and vice versa.

As far as I can tell, most arguments for NAM derive from statue/clay-like cases where two things seem deeply, metaphysically intertined by not identical. It is said that the statue (call it S) is not identical to the lump of clay (call it C) because C could be altered in ways S cannot — if a fire melts C down to a blob, C is still itself but S disappears. Ergo, an event can destroy S but not destroy C. Conversely, a small piece could fall out of C, leaving a hole then repair with fresh clay, yielding a new lump C'. So S could end up being C' instead of C. But if we define C as just that exact lump of clay, C can't be C' instead of C.[1] Ergo, as Aaoron Cotnoir says, "it is natural to think that a lump of clay and a

statue made from it have all the same proper parts [but not] everything true of the clay [is, arguably] also true of the statue" (p. 397). In sum, Cotnoir and others who have thought about NAM highlight cases where two non-identical things have all the same proper parts. Such examples then lead toward the possibility of parthood being cyclical in some sense (which I'll try to pin down later).

I think statue/clay-like cases, while they do raise important issues, are less than idea as primes for NAM because they seem to invite numerous non-mereological resolutions. For instance, we can say (drawing from Jubien again) that C *instantiats the property* of *being S*; C is S's physical instantiation or realization. We have cognitive attitudes toward C that involve its phyiscal form and nature; we also have cognitive attitudes toward S that thematizes its aesthetic and social facets (qua artwork crafted for public appreciation). Our agreement that C designates S's physical substrate — as described by terminology like C *is a material body instantiating the property of being S* — binds these two cognitive assmblies together, but not in a manner that readily propagates C-parthood to S-parthood or vice-versa. In other words, mereology itself is not a useful philosophical abstraction when too many divergent cognitive registers are involved. Or at least this is an escape hatch which brings us back to conventional mereology via the metaphilosophical claim that there are *other* analyses where the classical mereological models *do* fit our cognitive engagements. Statue/clay-like problems are not problems of mereology

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[1] Another issue: Michael Jubien imagines that the sculptor could just have built S from another lump of clay in his studio, call it D. So, modally, S *could have been* D, but C could not have been D. If we use possible world talk, we can posit a possible world where S id D, but we can't imagine a possible world where C is D. This assumes that a hunk of

matter just is the matter that it is; we're not talking about essential or inessential parts or any object that may be *constituted* by some matter, like Tibbles the cat and his later-amputated tail. In other words, we're assuming that the self-identity of matter, once we ignore any logical properties inhering in its form, is immune from counterfactuals. Matter can be arranged differently, but it can't be different matter. This seem plausible but not self-evident, but in any case it may be a terminological rule in how philosophers often use the word "matter" — and by extnsion phrases like "lump of clay" — especially in discussions like statue/clay (non)identity.

as a theory but problemes of where the theory should be applied.

This won't be my final word on statues an clay, but I will pivot to other examples suggesting how NAM is more pervasive than people realize. The literature seeeems to treat NAM as an exotic, corner-case, enigmatic exception to partonomic common sense: it seems to require special philosophical concentration to conceive of cases where parthood is really symmetric: x is part of y which is part of x. My goal is to argue the opposite: I think *assymetric* mereology is really the special case. Of course, I understand that there's *some* notion of parthood which renders partonomic chains paradoxical. But I think in most common-sense cases where people think they are talking/reasoning about parthood, the kind of mereology they intuitively use has at last the potential to be NAM.

As my first exhibit, I'll mention several plausible and everyday-like sentences:

▼ (1) Mbappe was a big part of the 2018 World Cup.

▼ (2) Mbappe's footballing career is a big part of who Mbappe is.

▼ (3) The 2018 World Cup was a big part of Mbappe's footballing career.

Taken at face value, acqiescing to these sentences and to mereological transivity, the 2018 World Cup is part of Mbappe, and Mbappe is part of the 2018 World Cup; but of course Mbappe is not metaphyiscally identical to the 2018 World Cup. Granted, sometimes part-talk in natural language is metaphorical: we don't hear *my religion is part of me* as megalomaniacal, or *you are part of my life* as prima facie possessive. But if this seemingly metaphorical way of talking is *more* common than our seemingly commonsensical mereology, maybe we need to reconsider whether classical mereology is really the base rather than derived notion.

Indeed, when we talk of y being part of x we rarely seem to talk as if y is *completely* part of x. Perhaps *total* parthood is a degenerate case. In fact, I could make an argument that classical mereology is paradoxical, like this: an intrinsic part of y is *being y*. If y is a proper part of x, by transitivity, *being y* is part of x. But if x is not y, it sounds absurd to say that *being y* is part of x. Now, I'm not actually raising this as an argument, because it can be countered: *being y* is not really "part" of y in the sense technically covered by mereology. Some of the

more "philosophical" interpretations of parthood need to be quarantined from the mereological explanantia. Fair enough. But I think this excecise shows that preserving clasical mereology requires filtering out a lot of notions of parthood based on a prior commitment to assymetry, which becomes circular unless we have a good analysis that the apocryphal "notions of parthood" are in some definable sense atypical or deflationary.

Transitivity is problemmatic in many ways; Mbappe's left foot has th property *being a foot*, which if it is part of the foot is not part of Mbappe. And Mbappe's foot is (arguably) not part of the team. Still, we'd like to preserve parthood-transitivity as much as possible. However, it seems that no matter how narrowly a part differs from the whole, it picks up some kernl of propositional differnce that blocks transivity without some complex concptual patchwork: if we define parthood without a lot of conceptual detail *no y* not identical to x, however modestly, can ever be a proper part of x full stop.

That y is part of x does not seem to preclude y bearing predicative details that x lacks: for instance, if the camera zooms in on Mbappe it is not picturing the whole team, so although Mbappe is part of the team, Mbappe, but not the team, is covered by the predicate "being at the focus of the camera angle" at some moment. Of course, we already know that Mbappe is not *entirely* inside the team, so the proposect of Mbappe having propositional attributes which the team lacks is not concerting. But a camera angle can show Mbappe's *head*, which we might think to say is "part of" Mbappe in a stronger sense, or his *right side*, which seems even less independent. Indeed any picture of Mbappe shows part of him, making that part uniquely predicated as *what shown in this picture*. I cite these as further examples of conceptual subtleties that can trip up strictly "subsuming" mereologies — where an axiomatic distinction is made between *proper parthood* and *overlap*.

Usually when we hear part-like talk, we seem to instinctively look for overlap-style relations rather than subsuming inclusion of something smaller into something larger. That's why we don't hear it as odd or metaphorical if something apparently larger is presented as a part rather than a whole:

▼ (4) Phenomenology is only part of Merleau-Ponty's ouevre.

▼ (5) Iraq and Afghanistan are only part of CENTCOMM's responsibility.

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▼ (6) Tomorrow's chicken soup (with the leftover chicken in it) is my favorite part of the chicken.

If we're doing formal semantics, we might want to say that the propositional form of these examples is a matter of overlap rather than proper parthood. But something like *Phenomenology overlapped with Merleau-Ponty's ouvre*, or vice-versa, sounds awkward in comparison. At the very least we have an apparent datum that semantic structures involving overlap often seem to invite surface articulations involving explicit parthood. From the angle of NAM set against Classical mereology, of course, overlap and parthood have a significant difference: overlap is symmetric while parthood is not.

I'll give another example set on the lost continent of Atlantis, to be concrete in a hypothetical way. Suppose the continent's largest newspaper, the Atlantis Times, creates a consortium of semi-autonomous local newspapers in smaller Atlantian towns. We can then consider the Consortium to be part of the Atlantis Times: perhaps its offices are in the Times's headquarters, and the Times funds, administrates, and legally controls the Consortium. But we can also say that the Times is part of the Consortium, if the Consortium includes a portfolio of papers one of which is the Times itself.

For a final introductory example, consider a web portal which includes a collection of resources. Suppose one of those resources is another web portals which in turn includes a collection of resources — one of which is th original portal! Reading "includes" as "has as part", this is clearly a partonomic cycle. Indeed the whole "web" ideology is that resources link up in complex and dense (and often circular) ways.

I think these kinds of examples are both representative of "folk" mereology and structures where non-anti-symtry is a more effective modeling assumption than anti-symetry. In that case NAM is not the theory of a few ersatz cases but rather a general framework from which, if desired, classical mereology could be recoverd as, so to speak, a proper part.

So here I will present my thoughts on what a "generalized" non-anti-symmetric mereology can look like and how it might be practically — i.e., technologically — applied. Then I'll revisit philosophical terrain like the sculpture/clay conundrum.

1 "Criteriological" and "Expository" Mereology

In order to demonstrate a pragmatic, common-sensical NAM proposal, I will consider logical or conceptual relations which *seem* like mereological relations but which *also* seem like they involve a "cyclical" notion of parthood. To facilitate discussion I will use the symbol $\triangleright$ to mean "has as proper part", giving $\triangleright$ different names in the course of debating which parthood-concepts are most appropriate. So parthood is modeled via $\triangleright$ read left-to-right. I will restrict attention to cases where both (*) $x \triangleright y$ and $y \triangleright x$. I'll assume by definition that $\triangleright$ is "proper", i.e. nothing is $\triangleright$ itself, so in (*) necessarily x is not identical to y. By this setup $\triangleright$ is not transitive, since x *nhpp* x, but call *chpp* the transitive closure of $\triangleright$. Then (*) exemplifies a case where x *chpp* x.

Consider the Atlantis example. I posed that as in effect the Consortium is an *administrative part* of the Atlantis Times, but the Times is a "constituant" part of the Consortium: if list th papers in the consortium, this list would include the Times. Granted, these are not exactly the same notion of mereology, so we could treat this kind of case as an anomaly due to two different mereological relations which happen to conflict. Of course, y can be part of x on some criteria but not others: French Guyana is part of Europe politically but part of South America geographically.

However, there are millions of notions of parthood, and mereology is not very semantically useful if we can only very rarely mix such notions together to form complex ideas. Problems like the violinist's arm — which is not part of the orchestra — suggest that transitivity between two *conceptually different* kinds of parthood needs be somehow restricted, but we should leave open the possibility that concptually different mereologies can still find *some* propositional connections. This means trying to build in to the mereological thory a sense of the conceptual structure of the parhood relations thereby theorized.

I'll start by defining $\triangleright$ in conceptualbterms as something like: "has as proper part by all relevant criteria". In other words, $x \triangleright y$ means *y is part of x by all criteria relevant to x*. This does not exclude the mere Ontological possibility that some part of y may be outside x; but any such parts are of no importance for x — i.e.,

for any propositions of practical significance for people engaged with x insofar and duing the time that they are engaged with x. On Atlantis, the Consortium is an "administrative" part of the Times, and let's imagine that for all practical purpose, for everyone working for or otherwise engaged with the Times, the Consortium is just "part" of the times (no conceptual qualification needed).

But notice that $\triangleright$ hereby conceptualized could easily be symmetric. We could have both $x \triangleright y$ and $y \triangleright x$, if x is part of y by all criteria *relevant to y*. The fact that we are evaluating criteria relative to the whole allows $\triangleright$ to be inverted, since the former part then *becomes* the whole and relevance-criteria are assessed on *its* terms. For employees of the Consortium — those who promote, deliver, index, or represent the papers, or whatever — the Times may be just one of several papers in the portfolio. By *their* criteria, the Times is part of the Consortium, not the other way around.

Someone looking from outsie might prefer to say that neither institution is truly a proper part of the other. Their vantage point compels them to consider *both* parts' criteria, and in this holistic sense there may be parts of the Consortium that are not practically speaking parts of the Times, and vice-versa. It might seem then that the "real" picture involves no proper parthood on either side — and therefore no NAM.

That analysis is not wrong *per se*, but it may pare down parthood relations unacceptably. After all, when are the occasions where we say that y is part of x *completely*, in every sense? An institute inside an acadmic department may be spatially and administratively part — its offices inside the building; its staff demed departmental staff. But the institute might develop curricula, plan events, embrace intellectual paradigms, and form a social circle somewhat autonomous from and tanegential to the department. A specialized imprint of a publishing house may prioritize disciplines different from the larger company. Usually parthood implies some level of autonomy, in real situations, because we usually don't expend the conceptual and bureaucratic effort to keep track of some mere part if the part's behavior or properties is fully predictable from the whole. A semi-autonomous part can still be a part — mereology can permit autonomy; indeed this is a defining characteristic of complex systems — but once we allow parts' autonomy it is easy

to soon realize aspects of those parts that make them no longer seem *completely* part of their wholes. We do jot have to abandon mereology completely if we argue that those residual parts are not *relevant* to the whole, and therefore do not interfere with propositional attitudes concerning the relationship of th whole's terms.

This definition of mereology is arguably more robust, because it allows conceptually different mereological relations to be unified. The administrative nature of the Times including the Consortium can coexist with the "compositional" nature of the Consortium including the Times, as part of one mereological system. The key detail here is that we allow $\triangleright$-rlations to exclude "irrelvant" parts — which of course means we introduce a criteria of relevance, which can "filter" the Universe. If any x is a whole, it can consider ys as its parts on the basis of filtering away irrelevant details. Therefore $x \triangleright y$ does not force all y-parts to also be x-parts (like, say, *being y* qua metaphysical part of y), but just that any stray z not be a *potentially relevant* part of x.

I'll call the version of $\triangleright$ just outlined "criteriological" because it depends on relevance-criteria localized to each whole. Note that $\triangleright$ decays to "Classical" mereology if we stipulat that there is only one global set of relevance criteria across all wholes in the analysis. Thus classical mereology is a restricted form of this "criteriological" mereology.

Next, I'll generalize further. As I said, things are not usually *completely part* of other things. Usually the appearance of complete parthood is an illusion conjured by how parthood relations are disclosed. For example, surely Kyrian Mbappe is part of les Bleus. But how do we know this? Presumably we see his name on a list of les Bleu's roster, or perhaps see him on the pitch with the squad. But the former case is not actually a warrant (with no further logic) for Mbappe being *part of* les Bleus; it is rather *Mbappe's name* being listed as *a member of les Bleus' roster*. We use the referntial relation between his *name* and Mbappe himself to project to the idea of the player being part of the team.

But this referential indirection carries all the potential for criteriological criteria I have discussed. There is a sense of Mbappe being part of les Bleus relevant to les Bleus — their training, formation, taticts, marketing, popularity, etc. Obviously not every part of Mbappe is relevant to the team; he does not train with them

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every minute. He has a whole other career at Paris St.-Germain. But aside from the cognitive complxity of tracing in what sense he is part of les Bleus, there is a nagging problem of defining what *Mbappe is part of les Bleus* actually *means*. Maybe this is simpler in well-defined contexts: surely he is part of the squad when he lines up in the starting eleven and the ball is kicked off. But surely also Mbappe being part of les Bleus is a more general phenomenon than just those moments on the pitch.

In real life, a concept like an athlete being part of a team can actually involve complex legal, financial, and procedural criteria, so it may require a detailed contract to state rather precisely what *being part of a team* actually means. However, supporters know the players on their teams without knowing the requisite contractual minutiae; in short, a fan's acquaintance with their team's history enables them to summon a list of current or past players on demand. Ask a fan who is part of the team, and they will rattle off a list of names. In this sense, they are conceiving a kind of parthood which we might call *enumerative*: $x \rhd y$ if we would (under ordinary circumstances) include y when enumerating a list of x's parts.

Technically, though, an "enumerative" mereology is "indirect": we use, say, y's *name* on a *list* of x's parts as proxy for y being part of x. Presumably y's name is on the list because it *is* part of x, at least on some criteria. But as such criteriological relevance is built in to the list construction. To enumerate the parts of x we are not committed to those parts being wholly subsumed under x; just that they are *members of* x in some salient context. An x *taking* mereological rlations is then a matter of x bing concptually figured as a collection, aggregate, or set. Of course, wholes can be conceived as multiples in different ways: all players in a sports franchise's history is one kind of plurality; the current roster is another; all the team's employees is a third.

I would argue that the most common kinds of mereologies in paractice are some variations on this theme: to conceive x as a *whole* means to conceive it as a *plurality*, which introducs the posibility of numerating its members, which thereby become its *parts*. But rarely are part/whol relations thereby conceived where the whole "surrounds" the part, absorbing it so that mereological partiality vs. totality can be readily resolved, like a room

being part of a house. Usually the members of x qua plurality bear instead some functional and integrative relation to x in some context.

In that sense "enumerative" mereology may seem to be incomplete, because the very act of conceiving a y in its functional role as a member of x seems to color how we are disposed to y; we seem interested in y as member of x rather than on its own terms. In practice, however, conceptualizing many things — as least initially — as members of some multiple seems epistemologically unavoidable. Most people would never know of Kylian Mbappe *except* as a forward for les Bleus. Usually we are introduced to things viareference to a containing whole, and usually that whole is figured as a plurality, collection, or type (rather thanb as a physical or spatial part, say): we are introduced to a friend's cousin as a member of her family; we learn of a new young athlete when he is drafted by a team; we learn about our friend's dog by first being told his breed. Epistemologically the aggregate-whole gives us an entré which we can then follow up by learning about the part/member on its own terms.

Merology in this kind of situation then models a kind of epistemological sequencing, tracing how our cognitive attention can migrate from whole to part. It is asy to see how parthood in this context can come out circular, because the pursuit of knowldge often circles back on itself. We learn about Mbappe because of our interest in les Bleus; then we learn about Mbappe's carrer, of which the 2018 World Cup was an important part; but then we circle back to les Bleus. Mbappe is part of an "epistemological" whole in the sense of our desiring to learn a relatively complete picture of French international fotball. Mbappe is part of any encyclopediac treatment of les Bleus; likewise, les Bleus is part of any encyclopediac treatment of Mbappe. I might call this *encyclopediac* mereology. Encyclopedias, indeed, are almost essentially cyclical in how references link back and forth. But everyday language suggests that these information networks can be undersrood as a mereology; we can readily accept sentences like:

▾ (7) Husserl is part of that Encyclopedia's article on Matheamtical Foundations.

▾ (8) That Encyclopedia of Analytic Philosophy includes Husserl but not Brentano.

▾ (9) Iraq is a big part of Bush's legacy.

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Of course, Iraq is not literally part of Bush's legacy or of CENTCOM, as if these were geographic territories. But the *idea* of Iraq, or in some sense "reponsibility for" Iraq, finds a place there conceptually.

Granted that only a hard-core idealist would equate the mereological relations of the *idea* of somthing with that thing's own mereological rlations. Surely the *idea* of Iraq is part of many things that Iraq itself is not part of. But in fact many practical applications of mereological theories depend on tracing mereological relations in a network of *ideas*, or at least something cerebral and/or computational rather than physical: Web Ontologies, Information Systems, and so forth. Consider the case of a web portal W whose reasources include a portal W' which links back to W. In general, web portals *contain* resources in the sense that they link to or provide access to web resources — resources that are not necessarily "part of" the entry-point in the enginering sense of being on the same servers, or being URL subdomains. So *to be part of* in an Information Space I (I'll use this as a generic word for database, portal, Information System, etc.) generally means that I provides access to, provides a kind of structrued entryway to (e.g. a searchable front-end), or "exposes" some affiliatd resource R. Here saying R is part of I also means that I *links to* R, which suggests R and I are peers rather than granularly mismatched.

In short, in structures that might be conceived as Information Spaces, the commensense picture that mereology implies a difference in scale — parts are at least somewhat smaller than wholes — seems readily contradicted. It might be argued that this is a eccentric feature of mereology in "Information Spaces" which, as essentially cognitive domains (albeit somwhat deperesonalized and mchanized technologically) don't obey the usual laws of mreology. But Information Technology is atly where many philosophers are now trying to embed mereology (or mereotopology) as a technical artifact, so the kind of mereological relation germane to IT should be taken seriously as a candidate for mereology in general.

Taking a cue from the "linked data" nature of Information Spaces, the underlying model of parthood in this kind of theory might involve some kind of epistemological linkage, where access to or information about parts is part of the epistemological interface afforded to their wholes. Mbappe as part of les Blues means, for instance, that an information-source profiling les Blues should link or provide entry to a comparable source profiling Mbappe. As a notion of parthood, this contains an extra layer of indirection, since we can distinguish a *link to y* from y: an encyclopedia entry on les Blues which Mbappe is a part ot actually contains a *link* to Mbappe. And we get informed of Mbappe being part of les Bleus' roster by seeing his *name* on a list. Thus mereological relations often involve an intermediary name, link, or designation which stands in for an actually autonomous part in partonomic contexts.

To make this somewhat formal, we need two relations: first, a notation like $\mathfrak{p} \Rrightarrow y$ which I'll call (borrowing a term from Cognitive Grammar) "profiles". The relation of a $\mathfrak{p}$ profiling a y could be read, according to context, as the conceptual tie between a web address, computer pointer, or other technological reference-artifact and its target; or the designatory relation between a proper names and their objects; or a more cognitive form of reference. Then I'll introduce a whole-to-profile relation $\succ$ such that $x \succ \mathfrak{p}$ can read *x contains $\mathfrak{p}$, which profiles something (other than x)*. Combining $\succ$ and $\rhd$ yields a three-part double relation like $x \succ \mathfrak{p} \Rrightarrow y$, for *x contains $\mathfrak{p}$, a profile of y*. Then finally a version of $\rhd$ can be defined as this three-part relation abstracting $\mathfrak{p}$: $x \rhd y$ becomes *x contains a profile of y*.

This particular version of $\rhd$ may be useful because it is adaptable. It accomodates systems where profiles of y either are or aren't *parts* of y, according to familiar mereological criteria. Dependeing on how that goes, this latest $\rhd$ could model "croteriological" mereology: suppose the profile of y in x is the only part or aspect of y which is relevant to x. Then $\mathfrak{p} \Rrightarrow y$ acts as a relevance filter, the profile selecting salient parts of y and excluding residual parts from mereological consideration. Then $x \succ \mathfrak{p} \Rrightarrow y$ can be read as x encompassing all parts of y when filtered by p. Either $\mathfrak{p}$ expressly operates to isolate x-relevant aspects, or x-relevance is derived from a filtering according to more general criteria, like the properties of a restaurant being subdivided into culinary, operational, nutritional, and architectural dimensions — i.e., a restaurant has architecturally relevant parts, operationally relevant parts, etc.

I will do further analysis however of the alternative model where profiles are *not* in general parts of what they profile. Instead, a profile is like an epistemological or technological device that "exposes" or permits access

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to something else, like a pointer to a region of computer memory. I'll call this model "Expository" mereology. The canonical idea of parthood is now that y is a *proper part of* x if and insofar as x "exposes" or provides an information link to y.

1.1   *Normalizing Arbtitraily Granular Mereologies*

One potential benefit of the Expository model is that it may be applicable to and/or reflective of how technology concretely implements ereologucal systems. I contend that any classical mereology can be directly mapped to an Expository mereology: take any classical parthood instance $x \triangleright y$. Designate a profile for y inside x, say, $\mathfrak{p}_x$. Then reinterpret $x \triangleright y$ to mean $x \succ \mathfrak{p} \triangleright\!\!\!+ y$ where $\mathfrak{p}$ is $\mathfrak{p}_x$, along with a restriction that any y can have at most one profile, and has *exactly one* profile if it has a (classical) whole — actually this one profile is part of the whole *in lieu of y*.

So expository mereology includes Classical mereology as a special case, but it allows for generalizations which patch over conceptual objections that may be raised to Classical mereology in its unadulturated form. In practice the maxim that each y has only on profile may be too restrictive. Instead, multiple divergent wholes may overlap with y in different ways and contexts. For instanc, Mbappe is part of les Blus, and also PSG, the Afro-French community, the Mbappe family, etc. Granted, this may be changing the subject somewhat: "overlap-systems" charactrized by generally complex entities that overklap in different modes and contexts are a different area of philosophy that mereology. But in reality thse two theories are intertwined: many conceptual phenomena can be approached both from a mereological perspective and an "overlap" perspective. The two kinds of thories may be viewed on a spectrum, with mereology merging as we attend more to the filtering effects of $x \triangleright y$ parthood, the relation either witnessing or effectuating our disposition to ignore non-x parts of y.

To put it differently, arguably any mereological system is an overlap-system which we are able to filter or simplify to reduce cases of practically inconsequential externality that would otherwise block proper parthood. If almost always y is *never* an *completely subsumed* part of x then (classical) $x \triangleright y$ has to reference some kind of theory that

y's non-x parts are inconsequential. So "relevance" can be like a knob tuning in mereological or overlap theories depending on whether we are more or less sympathetic of filtering: mereologies emerge when we tolerate filtering non-x y-parts in $x \triangleright y$ as practically appropriate, and overlap theories arise from merologies when we realize that filtering skirts around legitimate Ontological, cognitive, conceptual, or natural-language/pragmatic concerns. I think that the system of operators $\succ$, $\triangleright\!\!\!\!\triangleright$, and $\triangleright$ (when defined from the other two) models both mereological and overlap systems and accordingly can unify both kinds of thories.

Aside from this philosophical case, however, there is a practical benefit to the "Expository" definition of $\triangleright$ which applies to Classical as well as non-antisymmetric mereologies. Note that according to Classical measures of parthood, Expository mereology only has parthood relations between wholes and *profiles*, and moreover we can assert with no loss of generality that [rofiles themselves do not *contain* (as opposed to "point to") other parts. I assume a semantics where profiles are not themselves organized data structures, but rather referential atoms leading to (arbitrarily complex) structures outside themselves. Proper reference in, say, natural language is not quite so simple — consider first and last names — but we crtainly do seem to have a conceptual ability to coalesce cognitive quanta with almost no internal structuration, save for designating intellectually complex structures; and with this mechanism build up arbitrarily complex cognitive models. Analogouslt, computer software uses pointers to build up arbitrarily complex data structures without unworkable amounts of memory manipulation. Our ability to designate complex wholes with simpler icons — consider cities as dots on a map, or facial portraits as links to bibliographies — sure is a key enabler of complxity in our conceptual and semiotic systems.

In short, we los no complexity when we envision "profiles" as intellectual quanta whose only signification is as a rational bridge to something else; i.e., in a mereological system, profiles ned notbhave their own parts. Accordingly, on Classical terms, we have only one "wholes" layer and only one "parts" layer: there are wholes whose parts are profiles, and profiles refer to other wholes. This two-layer architecture takes the plac of a classical system where partonomic nesting may be arbitrarily deep. Of course, $\triangleright$-chains can be arbitrarily long, but in Expository mereology — although $\triangleright$ *conceptually* models

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parthood — the relata in $x \triangleright y$ are not considered to be on intrinsically different scales. The $\succ$ relation *is* across levels, but in $x \triangleright y$ we go from a whole x to a *profile* and then back to another whole. This is not to rule out some scale of size within the order of wholes, but that detail is not intrinsic to the system.

I contend this kind of model with limited granular levels is a more accurate representation of how Information System actually work, consiering the design of resource networks (like the World Wide wen) and software systems (with objects and pointers) or (relational) database architcture (with tables and primary keys). It is technologically simpler to have only two or three levels of organization and model complex structures via some kind of pointer or indirect (e.g., foreign-key) reference. Internally, technology that interacts direcly with multi-level, hierarchical information — consider an XML database — transforms this structure into something more like an object-graph (consider an XML Document Object Model).

I will generalize the two-level model a small bit, with the following rationale: on occasion the intuition that profiles point toward *one* target may be too restrictive. Suppose $\mathfrak{p}$ profiles a *set*, s. We could treat s as a whole and models its members via their own profiles in s, but then we hav an extra layer of indirection that may serve no modeling purpose. For this reason I allow that there may be a level higher-scale than wholes, which I'll call *frames*. This results in a three-level system: a higher level with frames, a lower level with profiles, and an intermdiary level which contains most of the primary objects of investagtion or conceptualization. Profiles can target multiple objects at this mid-level by targeting a frame rather than a single object. The significance of frames emerges in some semantic and technological contexts where we want to distinguish between relatively dispersed collections and complx wholes with some organizational oherence, such that we are inclined in many contexts to treat them as singular. That is, arbitrarily collating any collection into a whole may dilute a model's ability to distincguish between intgrated whols that often function as singles, from fiat wholes that arrant encircling in a specific context but do not on most criteria cohere as individuals. So as not to bias "wholeness" toward either coherent or fiat aggregates, I propose a "frame" level for "fiat" wholes distinguised, as a system feature, from intermdiate wholes with significant *individual*

coherence.

With this addendum, Expository mereology then becomes a three-level system. Arbitrarily complex scales of granularity can be modeled *within* the levels, particularly at the intermediate level, but the formal model can express a technological design where only those three levels need to be implemented as computational primitives.

A consequence of this design is that arbitrarily complex mereological systems can be encoded in hierarchy with only three levels, a process I'll call "normalization". This process is philosophically analogous to normalizing a hierarchical document database to a computationally more malleable graph database. Moreover, I will close this section by noting that the Expository mereology relation is quite naturally non-anti-symmtric: if x contains a profile of y there is no restriction against y containing a profile of x. With that in mind I'll refer to an Expository mereology using the general three-level model and its associated non-anti-symmtric $\triangleright$ relation as an "N3" model or encoding.[2]

2 Mereology and Externalism

One way to approach mreology as a philosophical topic is to define different mreological systems, including cases where these differences can be observed "axiomatically": the presence or absence of an anti-symmetry restriction on parthood, for example. To make this exercise worthwhile, it is then necessary to describe the philosophical or practical implications of th logical divergence: is the system with one logical form vs. another a more faithful model of thought, or a more useful directive for technology, or somehow better scientifically? After all, it's not like the rules of mereology are written in the cosmic order; mereology is not an empirical science.

A related question is whether a given mereological theory is intended to represent how we, as humans, *think about* parthood, or to represent part/whole relations which have some causative or compositional role in nature. Given a partonomic assertion — that a leaf is part of a tree, say — we can read this as a description

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[2]I don't propose this term outside the present writing because it conflicts with N3 in the Semantic Web — a notation for graph structures. N3 mereologies are actually a superset of N3-expressible data structures, where the second N3 is the Semantic Web term.

of conceptual attitudes: that most people (by virtue of perceptual gestalts or lexicosemantic pressures or subconscious internalization of others' enactive-conceptual habits or some other means) instictively see and comport to the leaf as part of the tree (and the tree as inclduing and encompassing its laves). We can also read this parthood as saying that *literally*, as a feature in how leaf and tree exists according to biological and physical laws, the latter encompasses the former.

Certainly these two senses are not completely independent. We probably would not entertain mereological attitudes without some pragmatic or physical sense that these attitudes are grounded in reality — that the part we ascribe to a whole does indeed behave as if under the constraints of parthood. On the other hand, insofar there are "physical" criteria of parthood, we presumably learn of them alongside other scientifizable aspects of phenomena, so that mereology becomes part of the overall package of our scientific model-building. At that point we may try to isolate partonomy as one important, recurreing facet of scientific models and specify how, or the different ways in which, parthood is thematized within scientific explanations or proto-scientific intuition.

But still, the difference between partness as a matter of concptual attitudes versus (in some sense) nomic given is consequential for how we read individual parthood assertions. Given $x \rhd y$, do we see this as matching x and y to physical (or at least extramental) objects? Or does it mean that in our cognitive engagements with x we experienc or believe x to include y? If we read *the leaf is part of the tree* wholly extramentrally, we have to explain the rferential logic of "the leaf" and "the tree"; i.e., what sort of entities these ar esuch that they can be compactly signified. We could be fully realistic about (mentally) external things — let's agree there really is a tree out there that many people see and therefore can be a topic of discussion. We still have to explain how there is a referential pattern which grounds use of notation like "the tree" as part of logically sensical assertions (including mereological ones). We presumably see the tree as a gestalt unifying perceptions of its trunk, branches, and leaves, but plugging this unadorned sense into the parthood assertion becomes circular, since the leaves then become *part of* the referential grounding of *the tree*, which empties the assertion of any content. Mereology would cease to be a philosophically relevant topic if its assertions were wholly on the order of, say,

the number 11 being part of the set {11, 22, 33}.

Note that the problem of referential circularity does not necessarily arise in the same way when we think of mereology as a cognitive phenomenon. I don't think it is trivial to the point of meaningless to ask if our *concept* of 11 is part of our *concept* of the set {11, 22, 33}. Philosophy is a concptual activity, so it is simplest to read philosophical theories as models of other conceptual activities. Of course, however, usually our conceptual activity tries to stay oriented to extramental reality, so philosophy captures the structre of conceptualizations somehow interfaced with reality, and philosophy's own concepts and notations and quantifications to some degree represents this dual appointment: sometimes we're talking about cerebral artifacts and sometimes we're talking about real things intended by (using *intend* phenomenologically) cognitive acts. In practice, it can be hard to disentangle the cerebral and (by discursive intent and cognitive ontention) extramental artifacts as referential patterns, or quantification domains for logically-structured units that arise in the course of argumentation (like $x \rhd y$).

To clarify these points, consider for a moment the famous Putnam Twin Earth discussion. As the scenario is describes, Twin Earth harbors an XYZ substance functionally identical (for all purposes relevant to Twin Earthers) but compositionally different from H_2O. We can then entertain questions about whether Twin Earthers' water-concept — which apparntly refers to a different Natural Kind — is the same as our water-concept.

This setup makes several assumptions of its own. First, it assumes that we have a canonical water-concept, and that it (either essentially or incidentally) refers to a Natural Kind which is the substance H_2O. This is a simplifying assumption in multiple rspects; one of which is that H_2O itslf encompasses several different chemically distinguishable substances (if we consider various forms of heavy water). Second, evern our everyday water-concept is divided across different contexts: we would probably call both ocean water and tap water in a bucket a *bucket of water*, but we probably wouldn't call ocean water in a glass a *glass of water*. So our "water" is probanly a fusion of several different concepts, the stuff in oceans and saline lakes plus the stuff in freshwater lakes and rivers (including the potable stuff that by aqualogical engineering is delivered to our taps).

The water in some saline lakes is actually much less

"pure" than blood plasma in a hospital, yet we are not inclined to call plasma "water". On the other hand, exceptionally pure water — distilled water — is not even a prototypical kind of water; that's why it needs a special concept. So any trivial equation between *water* and H_2O is problemmatic.

Meanwhile, the Twin Earth discussion is also noncommittal about how XYZ is supposed to differ from H_2O. We can imagine the XYZ components as very similar to Hydrogen and Oxygen — for instance, imagine XYZ as a relabeling of DHO, or "semi-heavy" water with one Deuterium atom. I don't think we should have trouble as accepting that XYZ is then just another kind of water (like heavy and semi-heavy water). Or perhaps Twin Earth has some new subatomic particl that can clink to Hydrogen and make it 'X'/, like the extra neutron that makes Hydrogen into Deuterium. Perhaps, that is, XYZ is functionally similar to water beause its constituent parts are similar to earthly Hydrogen and Oxygen. As with heavy water, there is alrady a precedent for expanding our earthly water-concept to accomodate more complex chemical models of the water molecule.

I think the Twin Earth disucssion only really has philosophical weight if we assume that XYZ components are *significantly* different than Hydrogen and Oxygen. Of course, we also have to assume that XYZ behaves enough like earthly water that these differencs have no practical effect for Twin Earthers. Among other things, we have to assume that they are technologically more primitive than we are. After all, among the functional characteristics of water for us is that we can derive Hydrogen and Oxygen from it; assuming XYZ are not just special kinds of Hydrogen and Oxygen, presumably this is not true of XYZ. This could easily bias our assessment of Twin Earthers' water-concept, because *we* know that there are functionally salient differencs between XYZ and H_2O. Perhaps we can't help but imagine that eventually Twin Earthers' knowldge may eventually reach the point where the differencs become relevant to us, just as many years passed before humanity learned about Hydrogen and Oxygen; then of course the assumption that their water is (relative to their own needs) functionally identical to ours (is we factor out the level of our practical engagement with water that surpasses their technological capabilities) breaks down.

Intuitively, no doubt, we consider both functional and physical/material criteria when circumscribing the extent and intent of concepts. If I take coffee at a vegan friend's house and ask for milk, it is not impolite for her to bring almond milk. That is, we are prepared to subsume "almond milk" under the concept "milk" in som contexts. However, we are reluctant to draw concepts based solely on functional resemblance, ihnoring obvious compositional differences such as those between milk and almond milk. Surely this is due in part because compositional differences, whilr they may be irrelavant in *some* contexts, are usually relevant in other contexts. For instance, milk and almond milk are nutritionally biologically different.

Our functional and "compositional" criteria for concepts are not usually in tension, because usually there is enough coorelation between the two kinds of differences that, over a broad set of contexts, they tend to reinforce each other. That is, there are contxts where functional resemblance seems to warrant concptual unification even pace apparent compositional differences. Thre are other contexts where functional *differences* might supercede compositional similitude: think *aluminum foil* or *copper wire* compared to blocks of aluminum or copper (or, concepts like *statue* and *pot* are different from each other and from *clay*). Of course, in these last examples, matrial form — shape and arrangement — contributes to functionally different behaior, so we can include physical morphology as properties as brute composition (consider, though, the special value accorded to statues and objects d'art of reputable creators, rooted in properties of provenance that are orthogonal to both physical constitution and material form). But, in any case, we also have linguistic and situational faculties to construct contextually "local" maps of concepts — how *in this context* concpets subsume or fit together in particular ways — without confusing these local pictures for global schema. With sufficient integration of many contexts, our intellectual and linguistic dispositions tend to (collectively as a language- or social-community) converge on a mapping of conceot's boundaries and inclusion/subsumption that reflects both functional and physical/material criteria with neither set of criteria dominating the other.

Putnam's Twin Earth experiment invites us to imagine scenarios where the approximate synergy between functional and compositional criteria breaks down. In a hypothetical case where functional resemblance persists despite (significant) compositional differences, and one a

wide scale across contexts, are we prepared to find conceptual unity (siding with the functional resemblance) or conceptual bifurcation (siding with the compositional difference)? At one level, this is hard to thematize straight-on, because the very construction of the case-study seems to undermine its requisite presuppositions. As I said, I think the thought-experiment is most thought-inducing even we assume significant enough difference between XYZ and H_2O as compositional substrata of water (or twater); so with chemical knowledge akin to ours, XYZ *doesn't* behave like water. So there are meaningful contexts where functional resemblance *does* break down. We have to assume however that these contexts are not relevant on Twin Earth because Twin Earthers don't have, say, equipment to separate water into Hydrogen and Oxygen (or, analogously, XYZ into X, Y, and Z).

I think what began as a disucssion about *concepts* ends up rally being a discussion about *contexts.* There are of course local contexts where non-standard concept maps are drawn (like milk/almond-milk). As I have argued, we are competent in juggling local and "global" conceptual maps ("maps" in the sense of how conceptual "territory" is partitioned), exercising a mixture of linguistic and situational understanding; a partition in rational communities sharing language, norms, and the pragmatics of everyday life. Therefore we mark nonstandard conceptual maps to as *local* to given contexts, whereas we also have a sense of concepts as intellectually global resources, which adjust for local nuances in predetermined ways. Our concept "*water*", for example, is presumably a federation of narrower concepts (notably saltwater and freshwater) which we unify for both physical and functional reasons: while not pure, the primary substance in both cases is H_2O (which is actually third concept *subsumed by* water), motivating the unification, plus they have functional similarities in many (albeit not all) contexts. So, by panning out from local contexts into a globally trant-contxt conceptualization that is the best compromise between global generality and local specificity, a canonical concept merges which unifies other concepts but also has some internal integrity (i.e., the identification of water with H_2O grounds our conceptual norms in established science). The panning from local to global conexts is then a key semantic detail in establishing "canonical" versions of concepts.

I think the real force of Twin Earth is that it intoduces two different possibilities to "panning to global context".

Global becomes relative: do we mean to generalize Twin Earth contexts only to those which ar e likely to be efficacious on Twin Earth itself? That is, should we assume that there will never be a global context affecting Twin Earthers' conceptualization of water that would establish a ground for contrasting this concept with (earthly) H_2O? In that case, an "internalist" might say that twater is the same concpt as water, applying the maxim that conceptual boundaries are drawn to reflect the interplay between function and composition as we pan from local to global contexts. No matter how "high" we pan out, on this argument, we will never encounter a situation where compositional difference triggers a potential functional difference that was lurking gehind local functional resemblance — analogous to how the biological difference between milk and almond milk is bound to arise in many contexts, whether or not it is locally relevant. But water/twater differs from milk/almond milk because (according to the setup) there is *no* context we can encounter when we "pan out" from local to global which makes the water/twater difference consequential.

Conversely, we can read the same scenario differently and propose that "Global" cannot be read in such a retricted sense. The global context or context-synthesis available to Twin Earthers — the level of abstraction beyond their local contexts — is not th *real* global context, since *over and above that*, by stipulation, *we* provide an encompassing global context of which Twin Earthers' global context is just a part. For *us*, the difference between XYZ and H_2O is functional, not just compositional: the thought experiment stipulates (or should do so) that the two substances are compositionally different enough that functional differences would arise in contexts that depend on splitting water into its constituent parts (if X, Y, and Z are just slight variations on Hydrogen and Oxygen, or chemically transform to Hydrogen and Oxygen, I think the discussion becomes moot; on par with water/heavy water, which doesn't involve any extraterrestrial stories). What makes Twin Earth (stipulationally) unique is that *its* global context is not global enough from *our* vantage point.

We can certainly debate whether Twin Earth's context still deserves to be called "global". If it does, I think we end up with an Internalist theory, since we're saying that criteria of globalness should be measured against the cognitive resources of a rational community: if there's no context where compositional difference is practically

relevant, then we may as well use functional criteria alone to establish concept partitioning. Conversely, if we say Twin Earth's context is *not* authentically global, I think we ar eled to an Externalist theory. If two conceptual cores refer to different physical kinds, and we can range over every possible context (without regard for how cognition is groundd in the practical machinery of knowledge acquisition), the we can certainly say that compositionally different kinds represent referentially or extensionally different concepts.

But, I would argue, tjis is really a debate about Externalism and Internalism vis-à-vis *contexts*, and specifically about *globality* of context. When we pan out from local contexts, do we reach "global" when we reach the horizon of conceptualization context that is empirically possible for the relevant cognitive community? Are latent functional differences beyond this horizon factors in concept-identity? Internalists basically say that this horizon *is* the global context, so "global" is an attribute relative to the epistemological possibilities of any cognitiv community. If ther is no epistemologically possible world where a stipulated compositional difference becomes dunctional — i.e. there is no possible world where the knowledge of the difference can be reached from a community's present epistemological state — then we can say that in the "epistemologically possible horizon" there is no context which "functionalizes" the compositional difference. Then there is no point in saying that such a horizon is *not* global. But if we are allowed to imagine that any epistemological being whatsoever an "look down upon" that horizon and see beyond it — in other words, that globalness is an external to any one mind (or any one community's cognitive resources) — we end up being "contextual externalists", sassuming that the only real "global" context is the maximal context which is metaphysically possible, where everything knowable is factoreed in, such as the functional consequences of any compositional differencs. In either case, any notion of competing externalist and internalist intuitions about *concepts* appear to piggyback on corresponding intuitions about (global horizons of) *contexts*.

Perhaps my line of reasoning here feels like I am presupposing the answer: the true externalist claim is that concepts which bear (even unbeonownst to those who have the concepts) referential relations to compositionally different kinds are different concepts *irrespective of* whether functional differences can (even *potentially*)

follow. However, I question whether compositional difference can be completely free of functional differences in *all contexts*; function and composition are at least somewhat interdependent, so it's hard to imagine the complete absence of contexts where this interdependence does not imply compositional difference that propagate to functional difference. One can be an Externalist in saying that concepts can be differentiated on the basis of compositional differences even outside the epistemological horizons of concept-holders; but an Internalist in the *rationale* for this Externalism — that with a sufficiently wide horizon of contexts (and sufficiently epistemologically endowed cognitive agents for whom these contexts are environing) compositional differences eventually become functionally noticeable.

In addition — more relevant to mereology — someone might react to my talking about how we *draw* conceptual boundaries; that we *choose* whether and in what circumstances to unify (e.g.) saltwater and freshwater into a canonjical water-concept. This style of argument may seem to be vaguely internalist from the get-go, because if we define conceptual architecture as a mental exercise it's hard to give due credence to concepts' potential extramental reality. There are, of course, extramental factors influencing (e.g.) our water-concept. Heavy water isotopes could potentially complicate a simplistic mapping of *water* to H_2O but as a matter of empirical fact ordinary H_2O is by far the most common form on H_2O on our planet. Ocean water and freshwater have chemical differences, but they share the property of being predominantly H_2O. Moreover, they are unified by metereological cycles and behavioral similairities that supercede their chemical differences — ocean water cycles to freshwater as rain, and rivers drain into the ocean. The individuation of the concept *water* depends on these geological and metereological systms as much as by "water = H_2O" chemistry; this is perhaps why plasma (which is more watery than salt water) has no conceptual status as water.

These facts don't imply that we have no choice in which conceptual distinctions to recognize, or ignore; the space of *potential* concepts, as defined by whatever scientific regimes apply (chmistry, biology, geology, and so forth) may be finer-grained than our everydayconcepts. On the other hand, we also have cases like a statue whose value changd depending on whether it is believed to be the work of a great artist; social constructs like artistic

or accidental provenance (consider a baseball that, by coincidence of being hit for a historic home run, becomes a collector's item) can introduce conceptual distinctions sometime more granular than warranted by science. But while human concept-mapping may be coarser or (occasionally) finer-grained, we cannot rationally entertain conceptual systems that would deviate too radically from what is scientifically warranted. Perhaps we could say that behind every practical concept-system there is a most scientifically transparent grounding, a systm where spurious social distinctions (like artistic provenance) are bracketed, but material differencs (even ones that may seem parenthetical to even most scientific conrtexts, like water/heavy water) are reprsented. This would then be the extramental background upon which are human concepts are established, and each human concept-system can be treated as modifying this background by unifying highly granular concepts into more general canonical concepts on practical terms, or occasionally superimposing scientifically-spurious criteria to split background-concepts into finer shadings. Arguably, it is a valid philosophical exercise to uncover the scientific grounding behind the culturally reletive, socially ephemeral play of conceptual mergers and bifurcations above it.

We can develop a philosophically non-trivial theory of concept "mapping" considering only cognitive attitudes — for example, the balance between funtional and scientific considerations that shapes a community's choics (sometimes deliberate, sometimes emergent) about when to unify or to divid concpts. The fact that these choices are made against an extramental nomic order can be seen as a relevant detail but not a defining theme of the analysis. On the other hand, parallel to that, we can consider a theory of concepts that considers our relative autonomy in *choosing* concept-boundaries to be a complicating detail, and the core analysis to engage the extramental constraints. Neither theory is better than the other on any purely speculative ground that I can think of — execpt that I think we need to formulate a notion of "extramental constraints" properly.

To the degree that our theory of concepts recognizes a domain of extramental fact — as in the Externalist implication that the chemical form of water/twater *could* affect whther they ar ethe sam concept — we need to pair the analysis of concepts with analysis of the relevant empirical conditions and how our scientific understanding should guide th concept theory. After all, the

very possibility that water/twater's chemical differences could make them *different concepts* — that our decision whether or not to *treat* them as the same concept does not *make* them the same concept — implies that there is at least one system of concepts whose boundaries are drawn independent of actual human conceptual acitivy. This is not a prima facie untenable paradigm, but it needs to be supported with a sufficient level of scientific backing. Which is fine, except that some analyses may seem to state simplistic referential norms as proxies for a realistic scientific analysis.

For example — leaving aside our relative autonomy and centering on empirical givens that extramentally shape the possibilities of our water concept(s) — the relevant background is not mrely that water is H_2O. In other words, even if we consider (or narrow analysis to the strata where) concepts are extramental, we can't just say that the concept *water* is H_2O irrespective of cognitive choice (or that we could create our own human concpts adding or subtracting details but we're doing so on a foundational concept-system where water is H_2O). Surely even in most purely scientific contexts water is not *pure* H_2O. Nor can we use some sort of fuzzy logic — substances close enough to pure H_2O below some threshold concentration of other compounds should be deemed water — because then plasma becomes water and some salt water becomes non-water. Nor can we say that we choose what to consider water by combining things like concentration levels with functional/behavioral criteria, because the whole point of the exercise is to analyze concepts at a layer outside intellectual *choice*.

What we *can* say is that water-criteria lie at the intersection or multiple sciences: geology, limnology, meteorology, chemistry, biology, not to mention hydrology itself. Water (unlike plasma, say) falls as rain, erodes cliffs, and flows down rivers. What makes the extramental dimension of the water-concpt viable is the synergy btween these different sciencs, or rather the natural phenomena they study. This extramentality can be philosophically lusive, perhaps, because a robust theory of water's extramental nature would seem to rely on expert testimony, and therefore to some degree on expert opinion, which seems to conflict with our effort to isolate the water-concept not that we can *choose* to reify, but that we are *compelled* to reify by empirical conditions. But at least the hypothtical scientists are testifying under the guise of reporting extramental reality to the best of our

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ability, trying to cancel the autonomy (and therefore potential arbitrariness at least vis-à-vis scientific criteria) of human concptualizing as much as possible.

To the degree that this scientific process is possible, we have at least a picture of how an "extramental" thory of the water-concept could proceed. But this theory is possible because we do not consider the problem as a matter of *reference* — i.e., of determining what the signifier "water" refers to, yielding accounts like water *refers to* H_2O. Instad, we ar e trying to isolate the factors that make *water* a conceptually coherent phenomenon involved with different sorts of natural processes: water as a meteorological substance (a factor in weather-patterns), as a geological substance, and so forth.

I use the water-concept as a case-study because I think there are analogous trahjecrories in mereology: here also we can develop theories which either foreground or background extramental empirica. For example, a nail is part of a toe, and presumably the end of a nail which can be snipped off is (beforehand) part of the nail. But what is th status of the mreological sum of the body and the snipped-off nail-part? Is this an actual whole? Presumably in a nontrivial mereolosgical system not every combination of parts is necessarily a whole; otherwise there would be no room for a separate class of whole — the mreology would be just a set theory with some universe of members. So we can ask whether body-plus-snipped-nail-part is a nontrivial whole. Certainly there is a period of time when it was evidently nontrivial; does having been *in the past* non-trivial make the *current* whole non-trivial? It would sem on thatbtheory that very possible mereological sum involving myself and every snipped-nail-part or every cut-hair I've lost over the years then becomes non-trivial, which seems extravagant.

On the other hand, is that snipped sum *is* trivial, it onc was not trivial, so snipping the nail made some mereological sum go from being a non-trivial whole to being a "mere" trivial sum (call it $Triv$). We then need to articulate what is going on with such a change: $Triv$ is no longer physically connected, it no longer functions as a natural unit, and so forth. I juxtapose this case with the water example because I think (even though one analysis belongs to mereology and another to semantics and the theory of concepts) similar tropes come into play. We can debate whether it is mental or extramental

that $Triv$ is trivial; whether the quality of triviality is our *judging* that some sums are not worth our attention, or *choosing* not to conceptualize them as wholes; or whether we are compelled to these choices by empirical fact. We can debate whether beneath ourculturally regulated mereological attituds there is an extramental mereology guiding our cognitively selective mereology, just as empirical facts compel some maps to be more realistic than others. The intersection of scientific, cognitive, and philosophical criteria in comparing $Triv$ to the nontrivial pre- and post-snip toe resonate with the relevant criteria in the water/twater distinction.

2.1 So, Mereology and Externalism

Suppose I clip a nail, and call the now-trivial sum $Triv$ as before, and the non-trivial rest of myself Me. We want to explain why $Triv$ is trivial and Me is not. We also want to explain why my friends think of me as Me and not as $Triv$ (even if they see the nail-part that belongds now to $Triv$ but not to Me).

Analogously, suppose I designate the conceptual sum A to be a substance which is either or water or orange juice (suppose those are the two choices available on an airplane). Presumably A is a trivial concptual sum, because there is no scientifically reasonable (or even functionally reasonable) conceptual unification of water and orange juice (this is different than saltwater-and-freshwater, or H_2O and Deuterium Dioxide, or even milk and almond milk, or for that matter water and twater). But why is water-plus-orange-juice *trivial*?

To the extent that we are reasoning in an Internalist spirit, this is obvious: there is no enactive situation where A would be usefully treated as one concept and not the logical-or of two distinct concpts. There is no compelling scientific case for A. There is no functional similarity between water and orange juice strong enough to make them interchangable like (sometimes) milk and almond milk. In short, there is no criterion among the functional, situational, and scientific considerations we bring to bear on concept-maps that would make us *want* to draw A as an integral conceptual region.

However, if we are working in an Externalist mindset, we want to say that A is not a natural *kind*; that there is no scientific basis for unifying water and orange juice.

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Presumably we have no trouble making this assumption bcause there does not seem to be any scientific discipline, any nexus of sciences' topics, that would project onto A with any conceptual identity. Water is a non-trivial concpt because it is a meteorological, biological, geological, limnological substance; A is not any of those things. A is trivial becasuse there is no "ology" that makes A an "-ological" substance.

Anologously, $Triv$ is trivial as a mereological sum by a similar account of why A is trivial as a conceptual sum. There is no "ology" that makes $Triv$ an "-ological" whole. By contrast Me is a biological whole (and arguably psychological, sociological, and so forth). So the key factor in mereological triviality or holistic integrity would seem to be the presence or absence of an "ology" that renders the mereological sum into a concordant "-ological" whole.

I'll refer to this hypothsis as the *multiscientific* model of mereology. On this model, what distinguishes whols from trivial mereological sums is that wholes can be reasonably judged as entities in the terms of one or (in the general case) more than one science. A whole is non-trivial if it is an "-ological" whole whre we can plug in one or more sciences to get the relevant "-ologies". I'll say that such a whole is *multscientific*. So we can develop mereological thories rooted in cognition, and consider only whether we perceive some putative sum as a whole according to individual or collective cognition. In that sense any mereological expression quantifies over cognitive things: an $x \triangleright y$ means that x and y are *my conception of* or *my cognition of* something; and in this conception I eprceive (feel, sense, whatever) y to be part of (included in, circumscribed by) x. If we want to get outside the intramental boundary of this way of talking, I think, our alternative to *cognitive* wholes is *multiscientific* wholes: this is the kind of mereological Externalism which I think is philosophically consistent.

This partition of the philosophical options — cognitive vs. multscientific wholeness — may seem reasonable, but it imposes a discipline on philosophical discussions that can seem to complicate our intuitive discussions about mereology. For example, if I perceive a statue preserving its identity after losing a small piece, I don't think of the mereological integrity of the now slightly-smaller statue (but not the statue plues the broken-off piece) as merely a conceptual choice, or an artifact of cognitiv framing:

that the piece *looks* detached from the whole, but if the gestalt were a little perceptually different — say, the broken-off piece were resting on the statue — I could go back to thinking of the larger sum as the relevant whole. I feel that my cognitive-mereological attitudes are constrained by physical conditions and situations.

So we probably hav a sense — generalizing from "my" impressions just noted — that, while mereology has an important cognitive dimension, a complete theory of mereology has to address how we experience mereology inbthe cognitive realm as constrained by some extramental mereological order. That would sem to tak us, in the case of a sculpture/clay example, to look at the sculpture not just through the lens of its cognitive stature — not just as a cognitive (viz., cultural, asthetic, intellectual) artifact — but as a material object whose nature is subject to extramental norms. It is qua material thing — qua lump of clay, say — that the sculpture carries out an extramental existence that make some mereological formulae concerning the statue more permissible than others, in a way we cannot fully command by the rlative autonomy of our drawing concptual boundaries. There is, in short, something extramental about the statue and therefore something subject to norms outside the play of cognitive frames. So we get disucssions about the statue as lump-of-clay as well as archaeological artifact, or the lump as a proper part of the statue, or both lump and statue as proper parts of some social-physical hybrid object. However the argument runs the "lump of clay" motif sems to svre as proxy for the extramental self-sufficiency of the statue.

Elsewhere we may have language about objects as collections of molecules or atoms, or "material extents", or some other way to signify extra-mentality. That is, to disucss the etramental dimnsion of mereology we have to signify the extramental dimension of cognized *things*, and this sems to involve some languag to the effect that "extramental" means *physical* according to a particular image of physicality: extension in space(time), composition of smaller physical parts, possessing geomtric shape, and so forth. This general language of physicality — more a connected group of philosophical tropes perhaps than an explicit theory — is different in tenor than the formulation I have given here: namely, *multiscientific*. In its extramentality the sculpture is not (at least in the crucial details) a "lump of clay" or a collection of atoms or any other proxy designation of "physicalness". Rather

the sculpture is an archaeological object, perhaps also mineralogical, morphological, and so forth — its own "ologies" — and the mereological controversies about the sculpture's essence or nontriviality are really questions about what it means to be (say) an archaeological whole; a whole qua archaeological object.

I think questions about "multiscientific" stature or integralness sometimes get camouflaged by referential or quantificational issues. Next sction I will clarify what I have in mind here and what are I think the consequnces.

3 Multiscientific Objects

A statue and the small piece that has fallen off of it is at best a "trivial" mereological sum because it is not a "meaningful" whole — it is not an anarchaeological object, say, while the statue now missing the piece *is* an anarchaeological whol. Similarly, Me after a nail-clip is a biological object, while $Triv$ (Me plues the piece of nail) is not a biological whole.

Also, the (current) statue is additionally a minerological whole in the sense that clay minerology affects its properties (e.g., its fragility). The sum of the statue and the piece is probably not an analogous minerological whole (it is not a single clay object). Parallelwise, $Triv$ is certainly a *psychological* object as Me is; I don't feel sensations from the snipped-nail part, see it as myself, and so forth.

A clear case for mereological integrity or nontriviality seems to be the convergence of multiple sciences: the sculpture is *archaeological* and *minerological*; Me is *biological* and *psychological*. The interesting or bonafide wholes here integrate properties of different sciences, or different ontologial registers. So $Triv$ may instantiate biological properties (say, even the snipped-nail-part is composed of cells) and th statue-plus-piece instantiates minerological properties (even th piece is composed of clay). But our attention — both literal perceptual attention and figurative philosophical attention — is drawn to the objects that tie between several ontologial registers (which is presumably a precondition of objects lieing in the circle of the human life world and horizon of cognitiv engagement).

Given the recurring interest in sculpture/clay examples, I'll focus on this case: the sculpture (unlike, say, the piece that has fallen off, alone or in combination with th larger whole) is actually an integral archaeological object (plus minerological, physical, aesthetic, and commercial). As such it instantiates different kinds of properties: archaeological (created during a particular historical era), minerological (composed of clay), physical (weight, dimensions such as maximum width, breadth, and height), aesthetic (artistic value and provenance), commercial (having a monetary value for insurance purposes; contributing to the traffic and revenue of the museum which houses it). Note that some of these aspects are interdependent: e.g., objects cannot be archaeological and minerological without being physical.

I will assume for the moment that archaeological, minerological, commercial objects, etc., exist: i.e., that it is unproblemmatic to take for granted that our world contains an arsenal of objects in numerous different ontological registers. This ontology gives rise to a kind of types quantification: when assrting properties about an object, we can identify the register (or one of the registers) where an object belongs. In effect we say things like *there exists an archaeological object such that...* or *there exists an minerological object such that....* Let's say that for a register R we can have R-quantifiers that can iterate over things which have an R-aspect. Thus an archaeological objct is one that can be in the domain of an archaeological-quantifier.

Objects in multiple registers — each of which can be called a "facet" — are in the domain of different sorts of quantifers, or of combined quantifers. If R and R' are registers, then an R/R'-quantifier iterats over things that have a facet as R and also a facet as R'. Inter-register dependence means that some quantifiers are necessarily mixed: an archaeoloical-quantifer is necessarily actually an R/R'-quantifier where R is archaeology and R' is physicality.

I believe that a notion of R-quantifiers is a natural correlate of what I am calling "multiscientific mereology". Indeed, perhaps we can ntrench the notion as a kind of "R-quantifier mereology". On this account, wholes intrinsically are wholes in one or multiple registers: there are biological wholes, archaeological wholes, and so forth. Any partness fact or assertion contains an embedded R-quantifier: that a statue contains a horse, say, means that

the statue *qua archaeological object* includes a depiction of a horse. Thus in any $x \vartriangleright y$ (at least if x is not a trivial mereological sum, assuming our mereological system can even represent formulae involving trivial sums) there is an implicit R from which x is drawn via an implicit R-quantifier (and the R may actually be a mix of registers).

I'll say that an R-quantifier mereology is one where *any* whole that can be part of $x \vartriangleright y$ formulae has an implicit R-quantifier, and therefore has an R-facet for some R (or a mixture of R-facets). On a multiscientific account, most or all cognitively significant R-quantifiers actually involve a mixture of facets. The universe of quantification is therefore partitioned into different regions because quantification itself is sprad over different Rs (and the granularity increases because each mixture of Rs gives rise to a different sort of quantifier.

3.1 R-*Quantification and Non-Antisymmerty*

Adding R-quantification casts a different perspective on discussions of NAM, such as Cotnoir's. He points out that statue/clay examples can potentially lead to symmetric parthood: "the clay is an improper part of the statue and the statue is an improper part of the clay" [**?**, p. 401] (I'll add, statue and clay need not be metaphysically identical). My account would express the analogous situation via "mixed quantifers": the R-quantifier which can select the statue is actually a mixture of an archaeological-quantifier and a minerological-quantifier. Thus by the very formulation of any mereological relation wherein the statue is the whole (the left-hand side of $x \vartriangleright y$), the statue has archaeological and minerological tfactes, because it falls under the scope of a quantifier which *requires* those facets.

On the face of it, then, the relationship of facets to one another is not itself mereological (even allowing for *improper* parthood). How could we say that the clay-facet, for example, is a part of the sculpture-facet? That is, in a archaeological/minerological-quantifier, can the minerological facet be "part of" the archaeological facet? I think a reasonable R-quantifier mereology could block that kind of formula because there is no apparent R-quantifier that would come into play to express it. After all, the sculprture belongs to a domain of quantification which intrinsically mixes (at last) two facets; to formulate parthood *between* those facets would seem to require switching to a different domain of quantification.

It is reasonable, perhaps, that a mixed-domain quantification can be combined with quantification involving the integrated facets in isolation. So if I say that the sculpture is an archaeological-and-minerological object, perhaps I should allow the sculpture's archaeological facet in isolation to be included in a archaeological-quantification domain which is not limited to minereological objects (not every sculpture, for instance — consider ice-sculptures — is executed in a minerological medium).

Certainly we need some semantics for migrating between different R-quantification domains, because we do have reasonable conceptualizations like *this ice sculpture replicates that clay sculpture* or *this photograph shows that clay sculpture.* However, the "rules" for such "cross-R" domain-switching may be relatively restricted; we ar not forced to theorize mereological systems where the component Rs in a mixed-register domain can be generically factored out to their own quantification-domains.

Moreover, this restriction captures why R-quantification produces a more regulated mereological structrs, because ther are limited "parthood" rlations between Rs in a mixture themselves. In an R/R'-quantification such as archaeological-minerological, it might be said that the specified domains (archaeological and minerological) are "parts" of the mixed R which governs the quantification accessing the sculpture. In other words, the quantifier applicable to the sculpture seems like a "quantificational sum" of the archaeological and minerological domains. Analogously, the sculpture seems like a "conceptual sum" of aesthetic and physical properties. However, even though "summation" invites notions of membership and inclusion, we do not automatically proceed from conceptual sums to mereological sums: we can consider the conceptual sum of milk and almond milk without treating a glass of milk as a token of a milk/almond-milk disjunctive-or'ed substance, wherein milk-related-properties would be parts of hypothetical milk-or-almond-milk related propertes. Analogously, even if we accept the language of an R-quantifier as a "quantificational sum" of two finer domains, we can deny that this summation translates to *mereological* relations between facets in the finer and

the mixed domains.

Suppose we *could* formulate that both clay and sculpture are parts of some enveloping whole which has both sculptural and clay-like aspects. With R-quantification, this would require a distinct domain of quantification which I have yet theorized — I'll call it X. Of course, the actual domain for the sculpture combines (at least) archaeological and minerological, but this mixture is not X, because we want the various *factes* to be *part of* the X-object in the internal vocabulary of a mereology. I have allowed that R-mixtures are in some sense "quantificational sums" but blocked a concurrent mereological summation: we can't necssarily take the *mereological sum* of an archaeological-facet and a minerological-facet even (or especially) if they are facets of "the same object" (a unit of iteration under one quantifir). Someone might find that restriction arbitrary.

In particular, someone might argue that domains of quantification should be arbitrarily generalizable. For example, archaeological, minerological, biological, and psychological objects are all among the things that exist, so we seem invited to quantify over "things that exist", as a generalized domain abstracting from finer R-domains. So quantifying over this general domain — say, X-quantification — models a different semantic pattern than R-quantification. Whereas R-quantification reflects expressions like *there is a sculpture such that...*, X-quantification corresponds to the more symbolic logical formulation like *there exists $\underline{x}$ such that....*

It might seem as if X-quantification can be logically converted to R-quantification by, in effect, treating the R-quantifier as a predicate under the scope of the (purported) X-quantifier. So from *there is a sculpture that...* we can get something like *there exists an $\underline{x}$ such that, $\underline{x}$ is a sculpture and....* And also like *there exists an $\underline{x}$ such that, $\underline{x}$ is a molded expanse of clay and...* — in other words, we are logically lifting an $\underline{x}$ from the sculpture/clay and transcribing sculptureness and clayness as predicates on this $\underline{x}$.

From that point we can see how mereological controversies arise, because now $\underline{x}$ is logically neither sculpture nor clay but some kind of generic token of thing-ness of which sculptureness and clayness can be preicated. That is, $\underline{x}$ is an X-object, under the domain of a quantifier without any ontological structure or specificity. If an X-object can be a whole, then we have mereologi-

cal relations outside the regulations of R-quantification. For instance, we have a stated theory of why $Triv$ is trivial; because there is R-quantifier, for any R, which covers $Triv$ (or at last there is no multiscientific mixture of Rs that would render $Triv$ a "multiscientific" whole). However, it seems rasonable to allow that $Triv$ is an X-object, because by definition X-quantification does not impose ontological structure on its domain of iteration.

I contend, then, that problems about trivial wholes are interrelated with problems about X-quantification. If there is only R-quantification, then there are only nontrivial wholes, because there are no quantifiers whose domain encompasses trivial mereological sums.

Whether or not this setup seems intuitive may depend on our beliefs about quantification. If we are already committed to the idea that X-quantification is possible — or that phikosophers have to give a good reason for excluding this generic quantification — then my reasoning could well be deemed circular. I am presupposing the mereological restrictions that should fall out of a theory, by restriction how quantification works; thus I avoid problemmatic objects by eliminating the quantifiers that could quantify over them, but this may seem like eliminating problems by fiat.

We can consider, then, arguments for and against unrestricted or X-quantification. On the one hand, formal logic certainly leaves quantification open-ended. It's not clear what we should read into that philosophically — after all, logic is a study of abstract domains, rather than empical universe of statues and toes and such. Also, even in mathematics you have type-theoreric paradigms which are consistent with type-restricted quantification; no mathematical object is recognized which cannot be given a corresponding type (which excludes unrestricted set-formation). So quantification is limited to quantification over "fibers" induced by the value-to-type mapping. With a sufficiently expressive type theory, the category of types becomes effectively isomorphic to the collection of domains of quantification. In other words, universal quantification is not universally accepted even in logic and maethamtics. Granted, though, type-restricted quantification is not the predominant logical construct.

Another philosophical case for X-quantification is that recognizing only R-quantification *without abstracting to*

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an unrestricted "*X*-domain" would seem to leave the *R*-domains bearing a lot of weight. It is one thing to quantify over a set of objects bearing biological properties; it is another to stablish a rule of quantification presupposing that there is some essential register in existence containing all and only biological objects. We moderns presumably reject thoughts of an *elan vital* or any other metaphysical essence that suffuces biological wholes to make them a distinct order of reality. Even more so should we be skeptical of models implying a minerological *elan*, a psychological *elan*, and so forth. Rather we assume that there is an underlying physical reality — atoms and molecules and a small set of force fields — and that objects of physical composition take on biological or minerological proprties, which *makes* them biological or minerological objects. I'll call this the "*elan*" problem.

From the arguing-against-unresteicted-quantification side, the "*elan* problem" can be turned on its head. As stated, there is no *elan vital* which makes biological objects biological, or minerological objects mineral. Instead, at sufficiently small scales, all matter reveals itself as having the same minimal constituents (subatomic particles plus Standard Model forces, say). That is, we may believe we can avoid the *elan* problem by elevating a kind of subatomic-physics talk as the prestige dialect, an ontologically neutral way of talking about all physical things without mysteriously essentializing biological or any other higher-scale properties. In this vein, unrestricted quantification — at least with respect to physical reality — is essentially quantification over that subatomic domain.

But such an inscription of *X*-quantification has its own blind-spots. The objects of the subatomic domain are not metaphysical essencs outside the play of science; they are posits of a specific science, subatomic (and quantum) physics. Objects do not just "contain" quarks and electrons like bricks in a wall; the actual subatomic realm is apparently complexly structured by forces and quantum indeterminacy, where particles have some approximate and dispersive existence. When we knock on would we're not really encountering protons; there is a system of microphysical charges that creates the illusion of hardness.

So we can't really capture the idea of unstructured materiality — a minimal unit of physical presence which lies conceptually outside any *elan*; which is too small to be biological, say — we can't capture such an idea of an *ur*-particle by plugging in the latest scientific theories of the smallest constituents of the universe. The quantum model is subject to refinement, after all. And philosophers who talk of objects as "collections of molecules", say, are not really proposing that molecular chemistry is an operational part of their theory. Rather, this language tends to use talk of atoms and moleculres — or, say, of material extension — as proxies for a picture of "ur-particles", of an imagined smallest unit of physical nature.

These ur-particles are essentially a philosophical fiction; they don't align with elementary particles recognized by physics, though we can plug various hypotheses (like string theory) to give then scientific detail. But it's not like philosophers present ur-particles as an emprical claim and look for science to substantiate it. Rather, ur-particles are a way of talking: having (on metaphysical as much as empirical grounds) rejected the idea of *elan*s, and also *accepted* the idea of physical things being (down to some tiny scale) made of smaller physical things, the concptual merger of these ideas creates the notion of an "ur-particle": something so small as to be individible and therefore unstructured, and something lacking any *elan* that would make it biological, minerological, or scientific in any sense of being an object *of* a science.

Larger objects then become figured as mereological sums of ur-particles, which in turn raises problems due to the dynamic nature of macroscopic objects (and their sheer differences in scale to "ur-particles"). Even leaving aside the point that ur-particles do not actually exist — they are conceptual proxies for a messier subatomic reality — we cannot simplistically equate biological objects (or objects of any other macroscopic register) with mereological sums of ur-particles. Through breathing, discharge of skin cells, the dynamics of our microbiome, and so forth, the boundary between our own molecules and the external world is (at sufficiently magnified scales) fluid and indeterminate. Indeed, consider any colored object: having color means that it absorbs some light from the environment, and emits heat; the perpetual exchange of photons between bodies and their surroundings prohibits and direct enumeration (even in principle) of the ur-particles thst would "make up" an object.

Meanwhile, we still have to account for why (only)

some mereological sums of ur-particles are non-trivial. Presumably sufficintly scattered sums are trivial, but we can't assume any physically connected mass of ur-particles is non-trivial (even if we accept the approximation that solid objects are not *really*) solid. A glass on top a table forms a connected but, we'd say, physically trivial sum. A metal chain has possible states where it is not connected (one of the rings not touching any others) but it is, even while in those states, non-trivial. A bucket of sand or glas of water have states where physical forces will destructure them (the water or sand spill out), but we may want to consider the glass-and-water or bucket-and-sand to be nontrivial sums. In short, the criterion of triviality — even just in the register of everyday objects — requires explicit consideration of physical forces promoting an object's integrity.

In short, while it may be appealing to adopt a discource of "ur-particles" which ncapsulates our atomistic and non-*elan* intuitions, this conceptual model does not really address concerns like the "*elan* problem" and it raises a host of new problems. Quantification over non-trivial mereological sums of ur-particles does not seem like a philosophical improvement over R-quantification, even if this seems to lead us back to the question of how to think tgrough R-quantifiers without conjuring a realm of R-elans.

Ultimately, I think the answer to this question lies not in philosophy alone but in the interface between philosophy and science(s). The question of what forces and autopoietic regulation allows R-objects to sustain as non-trivial wholes is complex, and depends on laws and dynamics investigated by R-sciences themselves. We do not have a succinct logical statement of what makes R-quantified mereological wholes non-trivial. This does not mean we fall back on spooky *elans*; but rather that, for a given R-quantifier, we can form (with sufficient scientific input) a *theory* of non-triviality in the R-domain. Biologists, for example, do not rely on unexamined *elans* to demarcate the realm of living things; this is an scientific question, in light of astrobiological possibilities. So biology itself taks on the question of under which circumstances an object is a *biological* object. Similarly, psychologists can debate the proper demarcation of psychological objects (is a brain-dead patient still a psychological object, say); archaeologists the demarcation of archaeological objects (e.g., as compared to collectibles), and so forth.

Of course, these scientists are not trying to distinguish trivial from non-trivial mereological sums, but sciences do include theories of their proper reach; that is, we can argue philosophically equipped with an inventory of tgeories drawn from multiple sciences, of what makes a biological object biological, etc. While a prima facie claim that sums with no R-quantifier just are trivial, a rstriction that seems question-begging, seems at best philosophically incomplete, we can complete the [icture by introducing constitutive theories developed by sciences to identify their ontic extent. For any R-domain, we can assume that there is a scientific theory of R-ness; of the conditions where objects are R-objects. These theories may be provisional an *a posteriori*, but they can complement an underlying mereological theory: a whole is non-trivial if it lies in the domain of an E-quantifier, and we can philosophically defer to a suite of empirical theories delimiting R-objects for different R's; the corresponding "R-theories" may lie outside philosophy proper, but they are not intellectually vacant *elans*.

3.2 R-*Quantification and Cognitive Frames*

My analysis of R-quantification has been driven by a desire to theorize "Extramental" mereology. For those who intuit that mereological relations are really modeling how we cognitively (perceptually, conceptually, etc.) engage with objects, the mtaphysical problems of triviality may never arise. Non-trivial wholes in *cognitive* mereologya re non-trivial because we have innate perceptual tendencies and learned concptualizations that dispose us to treat some wholes as integral. We can study different aspects of our whole- (or part-) forming dispositions: basic perceptual continuity, force-dynamic intuition, situational undertsanding, and so forth. Indeed, a theory of mereological intuition will likely overlap with an outline of Cognitive Grammar. But in any case the cognitive criteria for non-triviality lie in our cognitive acts of synthesis and analysis, at the intersection of perceptual, situational, conceptual, and enactive criteria.

Quantification becomes an issue when we want to get beyond mereology within cognitive frames and define mreological relations as extramental features compelling or at least influencing the cognitive manifestations of mreology. In that sense we need to refer to physical objects

in their extramental existence and observe thir wholeness when it applies. Without the ambient cognitive discrimination which marks some cognized phenomena as wholes, we then have to introduce new criteria such that non-trivial mereological sums can be posited in reality so that they can be notated in formulae like $x \rhd y$. We then face the question of how to properly restrict quantification for terms like the x in $x \rhd y$ so that only empirically/scientifically meaningful, naturally intergal, non-trivial wholes are modeled by $x \rhd y$ like formulae.

In sbort, I propose R-quantification not as thestarting point of a mereological theory but in conjunction with *cognitive* mereology: we want to pass beyond a theory wherein mereological rlations ar *only* cognitive without thereby ending up in vague ur-particle-like talk where verything extra-mental is a mereological sum of some hypothized minimal quantum of physical reality. The problem with *unrestricted* quantification is that it seems to construct a simplistic register for the extra-mental: everything which is outside the mind is a sum of "stuff" and therefore its physical (i.e., exyramental) reality is ontologically carried by all the stuff (e.g., ur-particles) composing it.

In effect, when passing beyond the cognitive register to the extramental, a mereological argument could reach for a convenient designation of physicality for "anything which is not mental"; e.g., ur-particles. Then ur-particles, or "being composed of ur-particles", become conceptual proxy for extramentality. Since we then have all the ingredients to build ur-particle sums, it seems as if the very gesture of siteing mereology outside cognition compels us toward unrestricted quantification. If the essence of being extramental is being composed of ur-particles, then as soon as our mereological universe vntures outside the mind it picks up ur-particles and therefore the prospect of mereological sums of ur-particles. Granted, we can introduce notions like *biological properties* to corral the interesting sums from the trivial ones, but this is a superstructure layered on to a mereological system which allows a lot of trivial "X-quantified" wholes.

The problem in this intellectual trajectory is an intuition that extramentality automatically takes into a territory of ur-particles, as if we have to philosophically construct some minimal quantum of th xtramental world. We can instead say that extramental objects are R-quantified for various Rs: outside the mind are

biological, minerological, archaeological objeects, and so forth. These are extramental registers because our cognition does not *make* biological objects biological, for example, although there may be a synergy between out inclination to perceive objects framed in particular ways and their biological (etc.) status. Extramentality is not summarily dispatched by a fictional ur-particle, a conceptual proxy for "minimal unit of extramental existence", but rather through a multiscientific patchwork of ontological registers which permit extramental quantification to be restricted. For sake of disucssion, I'll call this multiscientific pathwork the R-patchwork.

I'd like to argue that the R-patchwork functions alot like cognitive frames. The R-patchwork contributes xtramentally as cognitive frames contribute mentally: both project order onto existent/cognized phenomena; both select a realm of non-trivial wholes; both buttress a scaffolding of restricted quantification with interrelations and mixing between quantification domains. The structure of cognitive frames, at least from the vantage point of mereological analysis, seems architecturally resonant with the integrated structure of sciences, especially in their "patchwork" interconnections where sciences unify into our empirical picture of the world.

Perhaps this rsonance is not surpising: science is shaped by cognition even if it concerns itself with extramental reality. Our cognitive patterns and propensities set the scientific agenda; the origins of biology, for instance, lie in our construal that living things behave in the world differently than inorganic matter. Scientific discipline guids toward mpirical modeos that can be tested apart from human beliefs and prejudics, but the structural outline of the sciencs and their interrelationships still draws on the contrasts between different regions of existence as we cognize them.

In short, the extramental realm is not devoid of cognitive structure; it's just that in our sciences of empirical reality we try to accept cognitive structure as a scaffolding to pass beyond, testing mental images (like scientific models) so they may remain as tools for formulating and communicating scientific theories but disproving models and impressions which sem intuitive on cognitive terms but end up being empirically misleading, like optical illusionsn or the sun's rotation around the earth. Extramental reality is not essentially *non-cognitive*, which is not to say that our cognitive actions "create" extramen-

tal rality, but rather that our intellectual establishment of rational exercises which excavate the extramental from the envelop of cognition remains influenced by the structural order of the cognitive realm.

As such, bracketing that order — formulating a symbolic language wholly removed from cognitive strucrure — is not a prerequiste of extramentality. Quantifying outside the cognitive ralm does not mean an unrestricted quantification with no intellectual structure, or within a quantification domain that does noy trace back (as in biology) at some level to cognitive artitudes. Extramental implies a disciplinencorrecting for cognitive prejudice, but not a radically non-cognitive world or a world (an ur-particle space with arbitrarty composition, say) radically devoid of intellectual structure.

4   Mereology and Models

The upshot of my argument lat section was that the realm of mereloguical theory should be divided into *cognitive* and *multiscientific*. Criteria of mereological non-trivialoty are derived in the first case from *cognitive frames*, and in the second case from an "*R*-patchwork": a patchwork of scientific theories delimiting the extent of different scientific registers and the dynamics and autopoesis sustaining the integrtity of (in various domains) non-trivial wholes. Moreover, there is a structural resonance and interpenetration between cognitive frames and the "*R*-patchwork".

Whether from the perspective of cognitive frames or the "extramental" perspective of the *R*-patchwork, mreological theories can be rasonably elaborated in parallel to theories of the cognitive/ontological status of wholes participating in $x \rhd y$ style parthood assertions. Any formalization of parthood relations can assume that all wholes have some integral unity that can be described on cognitive or scientific grounds (or really multiscientific, because any macroscopic object has properties at the intersection of different sciencs, like physics and biology and/or chemistry).

Of course, we can investigate mereologies as abstract, axiomatic logical systems. I contend however that such essentially mathematical theories have only limited applicability to philosophy. In particular, what would be *models* of these theories in the logical sense? Imagine

a collection of "voxels" — three-dimensional indivisible cubes with two states (*empty* or *full*). Two (orthogonally) adjacent voxels can be said to form a "block", and in general a set of connected voxels to form a "connected block", say. The system of connected blocks then forms a classical mereological model where proper parthood is voxel set inclusion. Let's call this a "Voxel Mereology".

Some picture like this may feel like a natural bridge between logical-axiomatic mereological theories and philosophical analysis. The rason is that a Voxel Mereology undeniably instantiates Classical Mereology and also fits our intuitive picture of physical reality. In our folk phsyics, we experience objects as resisting force and sustaining shape as if they were composed of hard little bricks. And we can match this intuitive picture to actual science by imagining voxels sized to the small units of quantifying possible, e.g., the Planck scale. Science suggests that there is indeed a scale of reality finer than which there is no possible scientific measurement, information, or discrimination.

Such quantum analogies however are of limited value in scientifically validating the "voxel" picture. Space itself at the Planck scale does not fit the ambient Euclidean topology that voxels presuppose; nor is there a precise quantum distinction between "matter" and "emptiness". So we can't just assume our voxel picture plugs in to quantum physics. Instead, Voxel Mereology is at best a brdige — it encapsulates how we *experience* physical reality while also offering a rough conceptual figuration of physical principles, like the idea of a smallest measurable unit of space. Rather than as an analogy to the quantum realm, Voxel Mereology is perhaps most likely a sdescribing in approximate detail the Emergent Properties of ordinary macroscopic physical objects. Compact solids do tend to behave as if composed of hard "bricks" on a scale fine enough to mold to their convex geometry.

Having said that, *parthood* within macroscopic physical objects does not really work like little lego pieces being lifted apart. Usually parthood reflects some functional or manufactured assemblage; the knob on a drawer, the cap on a bottle; the twig on a branch, etc. Parts can of course break off with no apparent functional integrity: if the bottom of a table leg spliters away, or a small tree branch is blown apart from the tree, the surface where the detachment occurs will presumably evince a jagged,

apparently random edge. Setting the "voxel" scale small enough can still model the geometry of the parts, but that seems besides the point. In reality, patterns of braks ar enot completely random; they reflect stress points and accumulated forces acting upon the larger object, and the geometry of the detached part reflects the structures of thse forces. Like the patterns formed by water spilling over a surface, complexity and semi-randomness still has some mathematically tractable background.

In short, a "voxel" model has rlativly limited usefulness even as an approximate picture of solid wholes. While connected voxel-blocks are not unrealistic discrete approximations of three-dimnsional shaops, voxels are less appropriate for representing part-whole relationships: a model of parthood (in the context of solid physical objects) is better organized around functional or mechanical constructs. There are parts induced by the accumulative processes which form wholes, like twigs on a branch. There are also parts deriving from stressors, fault-tolerance, and other material qualities of solid substance in the sense of materials science, where lines of force and/or vulerability can dispose pieces of a whole to become semi-detached, giving them some autonomy as defined parts in the whole. But properly modeling these material tendencies presumably involves mathematical formations like vector fields, where the voxel dicretization is at best tangential. Even if connected voxel-blocks can model inducd parts as well has wholes, it is not clear what physical reality such a model would capture; it is more like a predefined conceptual scheme imposed on a mostly unrelated physical situation.

So "Voxel Mereology", as a straightforward model of an axiomatic Classical Mereology, has at least dubious merit as a model of physical states of affairs. We could try to refine the model in a more scientifically rigorous way — in the direction of mereotopology, for example, allowing n-dimensional generalizations of voxels and/or infinite subdivision. So we could have a system whose elements have varying dimensions (perhaps to a maximum of four, representing temporal change) and smaller-dimensional objects can be part of larger-dimensional ones. Moreover, any objects of non-zero dimension can potentially have proper parts; there are no "atoms". This picture may be more appropriate for topological or differential-geometric representations of surfaces and manifolds as they would apply to science. To have a useful notion of parthood we may want to restrict partonomic assertions to parts

which are not too "bizarre" — perhaps to connected open or closed manifolds, excluding "fractal" shapes of fractional dimension, or infinitely scattered subsets. By way of naming a juxtaposition with "Voxel Mereology", I'll call this theory "Manifold Merology".

Certainly topological spaces can be a foundation for Classical Mereology models. As with voxels, though, we need to consider how applicable these models are to empirical phenomena. The topology of manifolds may be a better (e.g., non-discrete) approximation of material objects' nature; for instance solids' outer bounday is reasonably seen as a 2-manifold immersed in 3-space. There still is not a prfect isomorphism between material parts and submanifolds, however. Granted, to a reasonable approximation every recognizable part of an object has a corresponding submanifold. For sake of discussion, suppose we equate all wholes and parts to their 2-manifold surface (and assume parts are three-dimensional submanifolds of three-dimensional wholes). Assume the surface of a part either overlaps with the surface of a whole or else is entirely inside the whole (that is, assume we are using a version of the Region Connected Calculus). The system of parts in relation to wholes is then an example of a system of submanifolds in relation to manifolds. However, the system of manifolds has some properties that may not be dsired in a mereological thory. For instance, for a submanifold properly contained in a larger manifold, a sufficiently small deformation of the smaller manifold yields a new manifold also contained in the larger.

The mereological equivalent to this property is that if $x \triangleright y$, there is an infinite space of topological deformations of y yielding a y's that, without some extra criteria, will also be in x. We can of courdr stipulate that only some submanifolds correspond to actual parts, but then the formalization of submanifolds is only one dimension in the description of parthood. Whereas Voxel Mereology was a flawed model of (solid, material) objects because its discrete architecture was at best a rather arbitrary structure superimposed on physical forms, Manifold Mereology has limits of applicability for essentially the opposite reason: mathematical continuity allows for infinitessimal modifications of geometric forms in ways that have no physical meaning.

Both the Voxel and the Manifold pictures are only indirectly representations of "solid matter"; they are actually

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models of geometric extension, figured either discretely or continuously. The "voxel" as a binary empty-or-filled spatial region is an idealization; but physical surfaces as 2-manifolds is an idealization also. Physical solids do not have a crisp boundary where their interior ends and surroundings space begins, such that exterior surfaces can be mathematically embodied in 2-manifolds. This may be a reasonable approximation for some solids, just as the voxel "little brick" picture is somtimes mostly appropriate. But neither are physically oriented theories of how matter actually extends in and relates to surrounding space. Instead, they are mathematical formulations of extension per se, as geometric primitive. This may yield valuably mathematics — consider differential geometry as a theory of physical procsses on objects' surface, or even tools like NURBS Non-Uniform Rational B-Spline, a feature of Computer-Aided Design and Computer Graphics) for computarionally modeling solid geometry. But mathematical formalizations always have at best an indirect relation to physical phenomena.

This may suggest an intrinsic limit to any axiomatic mreology invoked as part of a philosophical treatment of parts and wholes: any *model* of such a system has to be interpreted as a model (to some approximation) of physical wholes. But the most natural mereological models are likely to be mathematical systems, like discrete geometries or topologies — perhaps with certain mereologically-inspired restrictions (e.g. distincguishing connected submanifolds from submanifolds in general) — or perhaps algebraic models, like lattices. In any case we then need a further accpunt of the relation between 4the mathematical idealization and physical reality. So the mereological system is removed at two steps from physical phenomena, which means the philosophical analysis has to preovide at least two "bridge" theories alongside the formal statemeent of the mereological system, to explain why the proposed axiomatization is a philosophical subject-matter.

The tenor of this line of analysis is not rstricted to mereology; I would make similar arguments about the theory of concepts, say, or "truth-theoretic" semantics. Given an axiomatic system like Formal Concept Analysis, we need to explain how models of that theory actually relate to conceptualization as a phenomenon of human intellect. Formal Concept Analysis engages a structural morphology of concepts not very different from the build-

ing blocks of a mereology; intensional "features" and extensional "examples" jointly characterize cpncepts, which can then be merged together or split apart. For example, merging the feature-set of two concepts, and then selecting all examples which have all (or a sufficient number of) the combined features, represents an "addition" between concpts (a variation is to consider examples with *common* features of two concepts: so a potential milk-plus-almond-milk concpt would have as examples any liquid exhibiting the features milk and almond milk have in common).

Formal Concept Analysis may provide an interesting systmatization of discriminitive or evolutionary factors shaping how humans intuit and modify concpts. There are other formal concept models as well, such as prototype-based models, or the idea of mapping concepts to rgions in qualitative spaces, featured in Conceptual Space Theory. These various theores can be combined; for example, Formal Concept Analysis can be extended with prototype criteria such that features and examples are weighted in terms of how essential they are to the relevant concept (as features) or how characteristic they are (as examples). The most representative prototypes of a concept are (on such a model) ones that strongly reflect the features most indicative of the concept. These criteria of weights and prototypes can be adjoined to the feature/example matrix of Formal Concept Analysis, yielding an axiomatic system which may model, to some approximation, human conceptual activity.

When we start to compare these formal models with actual conceptual patterns, however — for instance in Cognitive Semantics or Cognitive Grammar — the models start to seem unnaturally simplistic and superimposed. It's not that structural analysis of cognitive representations is impossible; but rather that each structure tends to have its own *sui generis* rationale, and trying to trace cognitive gestalts to an axiomatic foundation starts to feel, at best, reductionistic.

Analogously, a "truth-theoretic" model of linguistic meaning — mapping sentences to logical formulae or to truth conditions — have intuitive appeal but also many apparent counter-examples. A full discussion is beyond the scope of this paper, but I'll give some of my favorite examples demonstrating why truth-theoretic readings are, in my opinion, at best incomplete:

▼ (10) Everyone sang along to two songs.

- ▼ (11) Everyone performed two songs.
- ▼ (12) New Yorkers live in one of five boroughs.
- ▼ (13) New Yorkers often gripe about long commutes.
- ▼ (14) New Yorkers reliably vote Democratic.
- ▼ (15) Student after student came out against the tuition hikes.
- ▼ (16) A critical mass of students came out against the tuition hikes.
- ▼ (17) Students' anger about tuition hikes may have reached a tipping point.

If a truth-theoretic model is accurate, it should be possible to capture the approximate signifying content of each of these sentencs by expressing them in logical form; or at least show a systematic translation of syrface linguistic structure to truth-making conditions. I want to argue that every of these sentences fail the test.

Start with (10). The most natural interpretation to my ear — i.e., I imagine the kind of scenario where (10) is most likely to be epressed — involves some sort of concert which included two particularly popular songs, that most people in the audience could sing along with. On that reading, there were *exactly two songs* and the sentence does not commmit to *literally* everyone singing them. Conversely, (11) strikes me as talking about musicians onstage rather than the audience, and suggesting that each performer had a two-song set; i.e., each performed two *different* songs.

So, I hear a wide-scope reading for "two songs" in (10) but a narrow scope in (11). What I want to emphasize is *why* we would make that judgment: there is norhing in the sentence itself that points toward a wider or narrower scope. Instead this follows from a pragmatic construal of the verbs involved: to *perform* seems to bind the verb to its subject more tightly than *sing along*. The situationsl model most appropriate for *perform* leans toward narrow scope, while the situationsl model for *sing along* leans toward wide scope.

In (12), a reasonable interpretation is that, according to the sentence, *all* New Yorkers live in one of five boroughs. Indeed, the territory of New York is precisely partitioned into five boroughs. On the other hand, (13) does not appear to commit to referencing literally *all* New Yorkers; meanwhile it also appears to use the phrase "New Yorkers" differently than (12), to mean generically people who work in New York or live in th New York metro area. In the case of (14) we hear "New Yorkers"

narrowly as in (12), because voting relates a person to their actual place of residence (not where they work or their metro area). However, the implicit quantifier in (14) is *most*, not *all*; it does jot fit our conceptual picture of "voting" to imagine one party winning *all* votes. Again, these contrasts are not produced by sentence or phrasal-form; they are instead driven by lexical peculiarities of words like *borough*, *commute*, and *vote*.

In the last three sentencs, we can similarly hear an implied quantifier to the effect that *many* students are complaining or unhappy about some tuition increases. But each sentence adds a shading on the generic form like *many students complained*: in (15) the speaker tries to connote the pervasiveness of students' anger by giving it a temporal figure. She suggests how a temporal recurrence of some phenomenon reinforces our sense of its extent; not only is it aserted that many students are unhappy, but that this fact is reiterate multiple times by the repeated occurance of some particular student expression unhappiness. The verbiage used to describe that unhappiness, also — *come out against* — carries an extra spatial or narrative dimension than a plainer alternative like "complained". To *come out against* implies a public, maybe even activist display of anger. In (16), a similar figuration of *many* imposes an interpretive attitude on the sentence: to refer to *many* as a *critical mass* implies not just magnitude, but *enough* magnitude to effectuate something: (16) might be said of a case where student protests forced a school to cancel planned hikes. And (17) is similarly implying that some threshold may be crossed, without indicating (at least within the sentence) what the speaker thinks might happen then.

These readings do not dispute that each sentence in (??)-(17) have a logical substance that could be modeled as quantified assertions, using the appropriate quantifiers in each case (*every* performer/audience member; *all* New Yorkers; *most* New Yorkers; *many* students). Lexical variation (like "New Yorker" meaning both a resident of the city and the metro area) has to be accounted for, as does scope variation (like an *everyone ... two songs* case, where "everyone" as "space builder" introduce both a global and a local space such that scopes must be resolved for the rest of the sentence). I grant, however, that an underlying predicate logic can be enriched to represent these added scope and lexical details. So I believe that, at least among the sentences I've analyzed, we *can* construct a logical representation which captures

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at last some of the intended meaning of the sentencs.

However, this by itself does not strike me as legitimating a truth-thoretic semantics. One reason is that the actual words chosen provide shades of meaning — narrative or figurative construals, interpretive connotations, visual imagery — which add communicative content that cannot be readily modeled within logical details themselves. In the "many students" examples, different formations taking the palce of *many* present different interpretations or figurations of the described states of affairs. These added details, however, can still be said to have a logical structure: for instance the *critical mass* language implies the speaker thinks thesher number of students complaining *caused* something to happen. As such, the interpretive or figurative implications of the word-choices can be seen as a compact or rhetorically effective way to denote an underlying logical structure. We can even in these cases find a propositional content; except, the language itself uses figurative or connotative devices to actually refer us toward that content.

My broader claim is that there is no effectively logical transformation *from* the linguistic content as presented *to* the constituent elements of the relevant, signified propositional content. What *rules* are we following when we hear "sing along" as having wide scope and "perform" as having narrow scope? Or hear the implicit quantifier in (14) and (**??**) as *most*, but in (14) is *all*?

I am prepared to admit that a truth-thoretic *semantics* need not be a truth-theoretic *grammar*; that is, we can say that sentences haveva propositionaln content that semantics should isolate, even if there is only an indirect mapping from the surface-level linguistic performance to th predicate structure which, in many cases, we could see as sentences' *meaning.* Linguistic expressions do not, in general, structurally recapitulate the form of propositional asserions laid out mechanistically. Truth-theoretic models could still have semantic validity if we say that situational awareness and sensitivity to rhtorical nuance allows us to proceed, perhaps circuitously and interpretively, from language acts to predicate structures. The predicate logic of language is not so baldly apparent that we can program computers to understand language, but everything that seems not-quite-logical about language — its reliance on connotation and figuration — could, we might speculate, be cordoned off as an economy of *grammar.* We speak figuratively because it is grammatically

more efficient — and, partly for this reason, rhetorically more persuasive — to designate propositional content indirectly, rather than speaking in surface forms mimicking predicate algebra.

However, my analysis suggests that the indirection of the expression-to-proposition path is *not* just grammatical. As I argued, our disposition to read logical formations as one way and not another — wide scope or narrow, *most* or *all* — depends in part on the semantics lexically embedded in words like (in these cases) *borough*, *commute*, *vote*, or phrases like *critical mass* and *tipping point*. Our belief that parsing a sentence includes mapping down to a propositional intention does not help us trace the semantic effects which different word-senses contribute to this process. In short, the cognitive structures which must receive language — the situational awareness and interpretive empathy that tunes us toward communicative intent — is not only manifest in how linguistic form translates to propositional signification. It is also embedded in the lexical specificity of word-senses themselves.

Taking these analyses together, I am trying to describe cases where philosophers have turned to some logical, axiomatizable system to compose a model judged for its value as a philosophical sketch of some kind: a model of parthood as a precis of part/whole relations among physical phenomena; a fature/example statistic as a Formal Concept space; a prototyped and dimensionalized feature-space as a Conceptual Space theory. In each of these cases we have to consider how a model for the logical *system* could also be a *philosophical* model; an explanatory tool or simplifying idealization that casts philosophical light on cognitive or physical phenomena.

Philosophical models do not need to be models of physical objects or systems direcly; they could encapsulate or productively simplify how we perceive or conceptualize external reality. In that case we want to question the cognituve place for the *logical* model — the model-of-the-logical-system in the model-thoretic sense. For instance, is actual human conceptual process a model of Formal Concept Analysis in its guise as an axiomatic system whose formmulae can b realized in axiomatic models? Do concepts as cognitive entities model those axiomatics?

Or if we look for extramental models, to what extent can physical objects and systems realize axiomatic structures? Certainly sciences present models (often use-

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ful and, on that basis, probably relatively accurate) of physical phenomena, and often do so via mathematical structures that are logical modles of an axiomatic system. So the relevant scientifically studied phenomena become indirectly associated with the stipulated axiomatic. But as I have argued, the logic is two stps removed from the phenomena; at best the siting of logical structures in empirical reality — the idea that material systems ralize structures that can be abstractly specified — depends on complex scientific investigation. It requires detailed analysis to show how a terrain of scientific givens — the populations of species in an ecosystem, say — play out as exemples of a logically hypotheized (e.g. in this case Darwinian or genetic) theory.

Scientific models are therefore thoretical utilizations of axiomatic structures (usually via a mathematical intermediary), and provable consequencs of the axiomatic system can factor in to scientific reasoning. But scientific models are not "logical" models in the sense that science gives us sets that axiomatically realize logical systems by grounding quantification domains that allow positions in logical formulae to be inhabited. The logical model-theoretic picture — that axiomatic systems get instantiated in sets of entities into which logical symbols quantify — is at best only abstractly applicable to scientific models, which do not yield a physical reality composed of "sets" whose members can be unproblemmatically labeled with logical symbols.

To the degree that logical systems have even indirect axiomatic realization in philosophically salient contexts, then, they have to be "routed" either through cognition or through "science". Either an axiomatic schema represents (perhaps with some deliberate simpification) how we cognize some region of phenomena, or else it models how the phenomena behave irrespective our cognitive inclinations (of course, it can do both in mutual influence). But either we have to see axiomatic systems embedded in structures sutured in cognitive structure, or we have to see axiomatic systems embedded in scientific theories of phenomenal composition and behavior. In any case axiomatic models have to "latch on to" cognitive and/or scientific models to have a philosophical resonance.

This effectively metaphilosophical ideology, I think, includes mereology as an (important) special case. Introducing mereology via an axiomatic system is quite common, even in philosophy. But I'd argue that the philosophical value of an axiomatized mereological system is dependent on how and whether it can latch on to the requisite cognitive and/or scientific models to make its own, axiomatic model-building something more concrete than afforded by set-based model theory in pure logic.

This brings me to my final case for NAM: nonantisymmetric mereologies have more or better *concrete models* than Classical mreologies. I'll call this the Model-Theoretic Argument: when we look at *concrete* models in cognitive or scientifically-described systems — not just imagined models like "Voxel Mereology" which are more about notating philosophical intuitions than philosophical exposés of thought or reality — non-antisymmertry, not antisymmetry, predominates.

4.1 *Concreteness and Computation*

I would be remiss to draw a contrast between *abstract* and *concrete* models without mntioning the emergent field of "Ontology Engineering" and the role of mereology therein. Arguably, mereology in these contexts is neither abstract like logical-axiomatic models, nor concrete in the sense of "routing" through cognitive or scientific models. Ontologies — as this term applies in computer science and Information Systems — are computational artifacts, effectively documents in a special-purpose language, enabling programmers and scientists to define and annotate data structures so as to describe logical patterns obtaining within data. Ontologies allow data to be correctly shared and reproduced, and also sometimes to be logically analyzed, identifying structures within a data set that can be extracted via logical rules. Embedding logical axioms, including those of mereology, in data modeling frameworks therefoe becomes part of an overall data nanagement technology. Logical analysis becomes a part of data analytics in general.

Ontologies are abstract prototypes; they play a determinative modeling role only in conjunction with actual data sets. Also, although computer programs can perform some "reasoning" on modeled data sets, the explicit correlation between Ontologies and empirical data depends on people consciously aligning data structures to Ontologies' types and relations. Data sets annotated via formal Ontologies therefore reprsent deliberate human

attempts to relate conceptual and empirical tsructures — they are both cognitively and scientifically concrete.

Consider, for sake of demonstration, a derivation of the fact that an ingrown toenail should qualify as a malady of the foot. An Ontology might represent ingrown toenails afflicting toes, and also that toes are part of the foot, without identifying an ingrown toenail as a malady of the foot per se. Someone searching a database for foot afflictions, however, might well expect cases of ingrown toenails to be among the search results. Thus mereological rules can extend the semantic reach of an information system.

But that semantics depends first on conscious design of Ontologies to represent things like disease classifications and part/whole relations, and also on human c;assification activity. Someone has to specifically notate that a patient's condition exemplifies an ingrown toenail. The Information System is designed around human practice, according to different operational needs: entering a disagnostic code in a medical record, for example, and then querying a database to gather a set of results such as cases of diagnoses filtereed by some condition (say, conditions that might be treated by a podiatrist). An Information System — its technology as well as its actual data — can evolve in response to operational preferences. In short, deductive reasoning like *ingrown toenail is a kind of foot malady* is desired not out of some abstract concern for logical completeness, but it fits operational needs to pair a data entry about a patient with an ingrown toenail matching a potential database query about podiatric diagnoses.

Mereology is, accordingly, part of an overall logical structure designed to facilitate the operational requirements of adding and filtering data from information spaces. This adds a further dimension to mereological analysis, because the mereology (along with other logical relations) becomes part of an engineered system, where we have prior anticipation of *how* we want the system to perform. We identify specific kinds of inferences which should be engineered into the system based on anticipated preferences of human users.

To clarify, we can recognize in an Information System at least two different classes of "behaviors": *input* and *output*. Input behaviors are the system's implementations, and the interactions it affords, for people entering new data (say a doctor entering a new ingrown-toenail

diagnosis); output behaviors are implementations and afforances for getting information out of the systm, such as by queries (perhaps, a list of patints with podiatric diagnoses). We can add *internal* behaviors involving internal processing to link inputs and outputs in (according to users' expectation) correct ways. The system-outputs are products of the cumulative history of its inputs up to the point where output behavior is requisite. For example, the prior input of an ingrown-toenail diagnosis constitutes *relevant* input history for a query (demanding output behavior) for podiatric diagnoses.

So mereology and other logical relations play a role when it comes to identifying *input history* that is *relevant* for a certain output rquest. Logical reasoning expands the space of input history which will be considered relevant in a given output-context. This points to an interpretation of mereology in terms of *relevance*; properties or assertions involving a part (e.g., diagnoses) are relevant to corresponding whole.

Notionally, then, mereology serves as a kind of semantic enrichment of a system whose essential nature is a mapping from *input history* to *output behavior*.

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