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PHIL 5397: Essentialism term paper
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Restricted Mereology and Wholes as Essential to Their Parts

Half a bee, philosophically,
must eo ipso half not be
But half a bee has got to be,
vis-à-vis its entity
—D'you see?
—Monty Python, "Eric the Half-A-Bee"

I.

The relation of parts to whole can seem to be the very straightforward one of simple addition. The converse relation of whole to parts, then, is just that of decomposition. From this point of view, it seems most natural to say that the identity of a whole supervenes on its parts. Which parts? Why, all of them; a summative relation of parts to wholes implies that the parts are "fungible," in a sense, which in turn implies that they all contribute equally (perhaps provided the whole is divided up into parts of equal volume or mass). In that case, the extent to which a part determines a whole's identity is just the extent, spatially or massively, to which the part is a part of the whole. So all of a whole's parts would be needed, down to the last simple, to be sufficient to determine the identity of the whole. So, it would be unprincipled to distinguish among which parts are needed for a sufficient determination of identity for the whole. It naturally follows is that all of a thing's parts are essential to it.

This philosophically rather straightforward, if commonsensically counterintuitive, doctrine about the relation of a whole to its parts was perhaps first explicitly formulated and defended by Roderick Chisholm, who called it *mereological essentialism* (1973;

1976: Appendix B) or *parts as essential to their wholes* (PEW). Part of Chisholm's defense of PEW was contrasting it with a thesis he termed, "complete, unbridled mereological inessentialism" (1976: 147) (CUMI), which says that any whole could have been composed of any parts whatever; for example, a certain table could have been composed of a horse and my left arm, or every hydrogen atom in the ocean, or any collection of objects (or object) one could name.[1]

Chisholm's contrast of CUMI with PEW seems to indicate that he considered the parts actually had by a whole as constituting a thing's essence, in the modal, transworld sense. But the "essentiality" involved is to be not only transworld, but intraworld, so to speak, in which case a whole, strictly speaking, does not survive the loss of its parts. Thus, when a whole loses a part, it goes out of existence and is replaced by a new thing coming into existence. Chisholm described the persisting object that undergoes loss and possible replacement of parts as a popular fiction, strictly speaking to be considered an *ens successivum:* a succession of numerically distinct objects.

Chisholm said that PEW "ought to seem obvious." (1976: 147) It does seem to be a natural consequence of Leibniz's Law, yet, as Chisholm admitted, "the principle appears to conflict with certain other truths which...would *also* seem to be obvious." (ibid.) These "obvious truths" seem to be that an object can persist—that is, not go out of existence—through gain or loss of parts. This is what those seem to have in mind who assert, without argument, that mereological essentialism is "false" (one philosopher's result is another's *reductio*). Others have agreed with Chisholm in the suggestion that

[1] Pointing to CUMI actually seems a bit of a red herring in the context of a defense of PEW (see Willard 1994), but leave that aside for present purposes.

PEW would be more palatable if suitably restricted by certain formal or other criteria (Plantinga 1975; Willard 1994).

At least some of those who deny PEW still hold to some form of it while wanting to maintain that some objects may persist through loss or gain or parts. This comes in the form of four-dimensionalism, or perdurance theory, as championed by such as David Lewis (1986) and Ted Sider (2001). According to four-dimensionalism, things persist by *perduring,* which involves having, in addition to spatial parts, numerically different temporal parts. These temporal parts are free to differ from one another while being parts of the same four-dimensional object, so one temporal part can differ from another in the having of different parts while the four-dimensional object persists by perduring through a succession of temporal parts. Yet each temporal part can be considered subject to mereological essentialism, at least in the intraworld sense—the appeal to temporal parts to solve such as the "problem of temporary intrinsics" seems to presuppose this.

The transworld version of PEW seems to entail the intraworld version determinative of persistence conditions, but the converse does not hold. In fact, most who hold to a similar thesis about persistence conditions as involved in PEW, and for similar reasons as motivates PEW, deny that a thing necessarily has all the parts it actually has (this is where counterpart theory comes in).[2] Chisholm, on the other hand, while maintaining PEW, eschewed four-dimensionalism (1976: Appendix A). This seems to be simply because he did not like the notion of temporal parts per se, but here is the point I have been building to: PEW, and in its train four-dimensionalism, follow most naturally from a thesis that Chisholm did not seem to espouse: *unrestricted mereology* (UM), according to which any two or more things compose some whole, a *fusion,* that has all of

[2] The central exemplar of this cluster of positions is David Lewis.

them as parts. One alternative to UM is *restricted mereology* (RM), the thesis that parts compose a whole only when they enter into (a) certain relation(s) with each other.[3] Although Chisholm did not at all address the question of restricted versus unrestricted mereology, he certainly seems to have assumed some form of RM. PEW follows most naturally from UM because of the fact that UM has objects be fusions, which are defined as mereological sums of their parts, just as described in the approach mooted at the beginning of this paper. So, the question then arises of how or whether PEW follows from RM. Furthermore, it seems reasonable to think that a theory of RM might also provide a basis on which a restriction of PEW could be derived, as is desirable anyway. Such a theory would also illustrate an important and interesting link between questions of mereology and of persistence.

In the remainder of this paper, I will be concerned with exploring the notion of RM with respect to the question of mereological essentialism. In section two, I will discuss how an intuitive requirement for RM leads also to a thesis of *wholes as essential to their parts* (WEP). I will formalize WEP and examine it with respect to PEW. In section three, I will formalize RM, and give attention to the specific notion of wholes involved in RM-entailed WEP. In section four, I will show how apply RM-entailed WEP might apply to inanimate objects, and in section five to organisms. On WEP, PEW will turn out to apply to one of these, but not the other, a result which should, I think, make clearer the options open to the three-dimensionalist with respect to persistence. In section

[3] Although, again, Plantinga and Willard in their respective articles did not explicitly discuss the question of restricted mereology, the issues they did bring up all but spell out the need for it to be raised. For example, Plantinga's proposed definition of the "S-part relation" includes the relation *R,* which includes some property P such that if *x* bears *R* to *y,* then *x* is a *part* of *y* (Plantinga 1975: 473). What Plantinga pretty clearly had in mind here is restricted mereology, where *R* represents the restriction that marks out genuine parts, and P is the criterion for such restriction. Efforts to characterize the relation *R* are the pursuit of a theory of RM.

six I will take stock of what the theory of RM does with respect to the desiderata of such that has been propounded by others, and compare the ontological outlooks involved in UM and RM.

II.

As already noted, on UM, the existence, and therefore identity, of any non-simple thing is fixed as the fusion of whatever parts it has—in fact, importantly, it is the parts that come "first," *from which* we get the whole. Since objects on UM are basically fusions, and parts[4] are taken as primitive and wholes constructed out of them unrestrictedly, what else would the identity of the wholes consist in if not *those* parts? On UM, fusions are supposed to have ontological import, so they need criteria of identity. If a fusion's criteria of identity were not just its parts per composition as identity, its identity conditions would be empty.

On the supposition of UM, then, a physical object, being a fusion, will have all of its parts essentially, so PEW will be true of it (in at least the intraworld sense). PEW can be stated formally (where t stands for times, and the modified quantifier $\exists_t$ and predicate P_t denote time-indexed existence and time-indexed parthood, respectively) as follows.

(PEW) $(\forall y)(\forall z)[](Pyz \supset [](\exists!z \supset (\forall t)((\exists_t x)(x = z) \supset P_t yz))))$[5]

If wholes are not to be mere automatic fusions, what else could mark them out? As Peter van Inwagen has pointed out (1990: §3), the most immediately intuitive answer, that a whole must be such that its parts have to all be in contact with some other part, does not work so well as one might hope. An alternative would be to say that parts must

[4] Throughout this paper, I will mean "proper part" for all instances of "part."
[5] This formulation is adapted from Peter Simons' *strong mereological essentialism* (1987: 272).

undergo changes of some kind, so that they enter into interesting sorts of combinations on which genuine wholes would emerge. Actually, if one accepts some notion of *entia succesiva*, based on mereological essentialism or some other criterion, one actually thereby has materials for making sense of RM. If RM requires that objects undergo changes to become bona fide parts of wholes, then this is a turning of PEW on its head: we get *wholes as essential to their parts* (WEP). (Note that WEP is not itself a criterion of RM, but should be said, according to the present treatment, to follow from an independently-motivated principle of RM.) WEP may be expressed formally as follows, with some suitable rearrangements of the materials in (PEW).

(WEP) $(\forall z)[](([](\exists y(\mathrm{P}yz) \supset (\forall t)((\exists_t x)(x = y) \supset \mathrm{P}_t yz)))$

The standard, mereological-summative, approach defines wholes in terms of parts. But if we want to know what makes for parthood in the first place, without assuming fusions, this can seem backwards. By (WEP), however, we get a kind of definition of *part* in terms of the whole that has it. UM simply says that all objects are most basically mereological sums, or fusions, which is very much in tension with commonsense ideas about the different *kinds* of entities there are, such as organisms, artifacts, and "stuffs"—everything is pretty trivially a mereological sum (van Inwagen 2006), but this tells us nothing about what each such thing is *like*. What's worse, unless one countenances structural properties, there is reason to think that mereological sums themselves aren't like *anything* (Elder 2008). One attraction of WEP, however, is that it allows for characterization of a whole thing in terms of something other than its constituent parts—say, in terms of an Aristotelian substance, instead.

Neither PEW nor WEP formally entails the other, but they are also mutually compatible. All that the formal expressions of the two tell us is that one or both may be true, depending on the specific principle of RM involved. For example, on the present interpretation of UM, PEW is true while WEP would be trivially false as long as necessitarianism is rejected. On WEP, the falsity of UM suggests that PEW is at least an open question. So, given RM and WEP, it remains to be seen from the relevant parthood relation, "P*yz*" in (WEP), whether PEW also follows from that same principle of RM.

On the present conception of RM, an answer to Peter van Inwagen's *General Composition Question* (1990: 38–51)—what is composition?—will be that it is *a relation among parts that are in mutual ontic dependency*. The details of an answer to the Special Composition Question (SCQ) (ibid: 21–32), which asks for a single principle of RM, remains to be worked out.[6]

III.

What might a principle of RM look like, besides entailing WEP? Classical mereology encapsulates the most general concept of parthood, so any restricted notion of parthood will have to be formulated as a special case of such. And, there is the condition of mutual intrinsic change among parts as *entia succesiva* mooted above. This is wanted because if parts must change to be incorporated into a bona fide whole, one should say that some other part must also change in that process: for, the causal agent of such change will be some part of the whole, and that agent would naturally undergo change in order to effect

[6] As far as I know, no one has put this kind of thesis as "wholes as essential to their parts," but the general idea has already been at work elsewhere in this very connection, as other writers have also converged on this topic. These include Peter Simons (1987: §9; 2006: §§4–6), Mark Johnston (2006: §§4–6), and Ingvar Johansson (Johansson et al. 2005). The idea is also operative in the too-often-overlooked Rescher and Oppenheim (1955).

change. This is one way, at least, of answering the question of RM by invoking the relation of mutual ontic dependence suggested in the previous section.

Preliminarily, let's say that this process of becoming a restricted part is accounted for by some symmetrical relation, R, between some two parts, which holds as a result of that change. Let $P_r yz$ be restricted parthood of *y* of the whole *z*. (RP–), then, expresses a minimal requirement for restricted parts—call them *r-parts.*

(RP–) $P_r yz$ (*y* is an *r-part* of *z*) $=_{df} (\exists x)(Pxz \,\&\, Rxy)$

Note that (1) "classical," spatial[7] parthood, P*xz*, is stipulated in the definition for one of the parts, and (2) we do not actually need to stipulate that both *x* and *y* are spatial parts of *z*, nor does it matter whether *x* or *y* appears in the definiens as the spatial part of *z.* In any case, by multiple application of (RP–), all r-parts of *z* will perforce be spatial parts of *z*: by substitution of the referents of *x* and *y* of some application of (RP–) into *y* and *x*, respectively, on another application of (RP–), it will ensure that each part is both a spatial part and an r-part. And, for more than two parts, R holding transitively through pairs of parts ensures the same. We thus exploit the symmetry of R in order to have r-parts be mutually definable in terms of spatial parthood.

What about the nature of the relation R? We said earlier that composition is, according to this theory of RM, a relation among parts that are in mutual ontic dependence: neither can exist without the other existing. R can thus be replaced with an explicit condition for such, as in (RP).

[7] The "parts" of classical mereology are not necessarily spatial parts, but for physical objects spatial parthood is the most general sense of parthood, corresponding to classical parthood. I will therefore use the term "spatial" parthood as classical parthood applied to physical objects.

(RP) $P_r yz =_{df} (\exists x)(\exists y)(\exists z)(Pxz \,\&\, ((\exists v)(v = x) \leftrightarrow (\exists w)(w = y)))$

Now, (RP) by itself is pretty demure about the nature of *z*s, "restricted wholes," or *r-wholes,* as I shall call them. We can say, at least, that a minimal instance of an r-whole will have exactly two r-parts, so a general definition of an r-whole must meet this minimal requirement. The definition would simply go as follows.

z is an *r-whole* $=_{df} (\exists x)(\exists y)(\exists z)(P_r xz \,\&\, P_r yz)$

For r-wholes with more than two r-parts, the necessary condition for r-wholes just given will be met, but sufficient conditions will only be met by multiple application of (RP), covering each spatial part of *z* that stands in the mutual ontic dependence relation to some other part of *z*.

It is easily seen that the requirement (RP) on r-parts results in WEP for the part-whole relation. It may well be wondered, at this point, whether we need to revise the formal statement (WEP) to replace the classically-based parthood criteria with restricted parthood, $P_r yz$. However, we don't; and in fact shouldn't, on pain of redundancy. We just need to stipulate that the wholes in (WEP) are specifically r-wholes. Then, given (RP), (WEP) holds because the spatial parts of whatever wholes there are will only overlap their r-parts. (So, an r-whole will be essential to its spatial parts, just because they include all and only its r-parts, which are only such by inclusion in the r-whole.) In other words, if a *y* is not an r-part of *z*, then a fortiori it won't be a spatial part of *z* either, because *z* won't include it.

Just as r-parts were defined in terms of the most general concept of parts—classical parthood—by analogy we can think of r-wholes as preliminarily meeting some

minimal requirement of classical wholes. I take that minimal requirement of wholes to be, as Jaegwon Kim puts it, "mereological supervenience, the thesis that properties of wholes supervene on the properties and relations characterizing their parts.…It seems likely that mereological supervenience represents a metaphysically fundamental, *sui generis* form of dependence." (1993: 166) It is also reasonable to think, I would say, that as a *sui generis* form of dependence, mereological supervenience can be manifested in a number of ways. The fusions of UM, exactly parallel with the classical-mereology wholes of which they are constructed, supervene on their parts in a maximally strong sense of mereological supervenience (as in (Armstrong 1997: 12–3)). Analogously, r-wholes will supervene on their r-parts, but in some specific, weaker, and more interesting sense than that of mere fusions, to be characterized by the nature of the r-parts as such. For any r-whole z with r-parts $\{x_1, x_2, \dots, x_n\}$, the properties of z will be determined by (but not necessarily identical to) the sum total of the properties of and relations between $\{x_1, x_2, \dots, x_n\}$. Such supervenience will in general entail WEP but not PEW. I am not as interested in formalizing such a relation further as I am in exploring various cases of such (as I will in sections four and five), but before that, there is more that should be said about the nature of r-wholes in general terms.

The sum total of the many r-parts will be subvenient to, and determine, the character of the one r-whole. The UM analog to this principle is supervenience of whole on parts due to determination by simple identity (Baxter 1988), or strong analogy to identity (Lewis 1991: 81–7; Armstrong 1997: 12–3). By these lights we can understand the composition as identity thesis, and Ted Sider's extended argument for UM-based mereological essentialism related to the "intimacy" of the parthood relation (2007). It is

important to note, though, that classical-mereology-informed considerations such as Sider's—stage-setting as they are for four-dimensionalism—do not go through if the assimilation of composition directly to classical parthood that goes with UM is not assumed. For, as was noted in the previous section, although mereological essentialism follows from a natural ontological interpretation on the (UF) axiom of UM, that axiom is a further stipulation on minimal, "ground" mereology (Varzi 2009: §2.2). Meanwhile, RM makes use of the classical parthood of ground mereology, but mereological essentialism does not follow simply from the invocation of classical parthood (Van Inwagen 2006).

Furthermore, on the approach taken here, the sense of *whole* involved in RM will be a different one from that claimed in terms of UM. RM and UM result in two competing, complete ontologies. Questions of persistence of such wholes that there be must therefore be decided according to which thesis one accepts. For example, it will be no good for an adherent of UM to point out to one pursuing the project of RM that something or other cannot strictly persist just because of its changing its parts—for this will certainly be true of fusions, but not necessarily of r-wholes. The RM-ist, in fact, should say that there are no fusions, at least insofar as fusions are left totally unmotivated in light of RM. The purpose of invoking fusions, after all, is to carve up the world by fiat in light of UM, generating an ontology that the thoroughgoing RM-ist should reject wholesale. Moreover, if mereology is restricted, then a corollary should be that it is *not unrestricted.* Another way of putting this point is that the UM-ist's and RM-ist's answers to the GCQ will differ. The UM-ist might put her characteristic answer by saying that composition is classical mereology. The RM-ist, on the other hand, will answer that

composition is r-parthood. This fundamental difference in outlooks must be recognized at the outset before meaningful debate can ensue. I will have more to say about these fundamental differences in section six.

The real crux of the matter of RM is capturing the nature of the r-wholes in terms of the r-parts, most especially in order to determine whether PEW holds for such wholes. Formally, (RP), (WEP), and the resulting general picture of an r-whole leaves this question open. r-parthood is potentially multiply-realizable (cf. (Hawley 2006)), so there may be kinds of r-wholes for which PEW holds, and others for which it is does not. It is up to the nature of such r-wholes themselves to determine the answer to such questions. It is now time see what particular cases of r-wholes might have to tell us about themselves.

IV.

In this section I will pursue the application of the present theory of RM to inanimate objects, and in the next section look at the case of organisms.

Mutual ontic dependence between parts could be secured by treating them as *entia succesiva* themselves, as I suggested in section two. The most obvious candidates for such are parts that are inanimate material objects that, like the objects they compose, owe their identity to being just so composed. Thus, both parts and objects would be *entia succesiva.* This basic idea has already been broached in the context of philosophy of chemistry, in terms of chemical closure and coherence (Earley 1998; Earley 2000). Perhaps most vividly to the present purpose, Joe Earley has said, “An adequate theory of wholes and parts (mereology) must take into account that when individuals enter combinations of interesting sorts they no longer are the very same individuals that existed prior to the composition. It appears that no such formal theory now *actually* exists.”

(2005: 85) The RM theory presented in the previous section is pursuant to this very idea. When one attends to the details of the chemical principles of bonding, it can be rather easily seen how it is in consonance with the present theory of RM.

Granted, letting chemistry tell us what it takes for atoms to be chemically bonded is one thing, and giving the whole task of philosophical explication of the nature of composition over to chemistry is another. To one who would attempt the latter move, Ned Markosian has objected that the contention that "sciences such as microphysics, physical chemistry, and biology can help us to answer SCQ…is puzzling to me because those sciences are, after all, empirical sciences, whereas a correct answer to SCQ would have to express a proposition that is necessarily true." (1998) With this I agree; what I am suggesting here, rather, is that composition of physical objects as described by chemistry and physical science serves as an *instance* of the general principles outlined in the previous section. With that in mind, we can examine the details of the chemical picture of composition to see how *they* can be understood in light of (RP).

To start from the bottom up, what does it take for elementary particles to compose something? Electrons, to the best of our current knowledge, are simples. Nucleons—neutrons and protons—consist of even smaller entities, quarks, but it is impossible to break nucleons apart and thus separate the quarks individually (this is known as the *confinement* principle). This would seem to be a case in which *those* quarks can't exist *at all* except as constituents of *that* nucleon, and therefore they should be considered r-parts. And insofar as that is the case, we should grant r-wholeness to nucleons.

We now proceed to the level of atoms. When nucleons fuse to form a nucleus, a certain (very large, for the masses involved) amount of energy is involved. As is well

known, this is the energy that is released if the nucleus is artificially split. The energy inherent in the nuclear binding forces of nucleons is due to the nucleons themselves, which subsequently interact by exchanging gluons. Therefore, there are changes in the intrinsic properties of nucleons when they form an atomic nucleus (cf. (Simons 2006: §§5.1, 6.1)). With electrons, there is a release of energy when an electron enters a quantum orbital around a nucleus, so likewise there is an intrinsic change that makes an electron an *ens per alia* with a free electron antecedent to it. And, likewise for all electrons that might be found in an atom. Electrons, being simples, cannot undergo mereological change (save annihilation), and if there is any intrinsic change to be had in a simple like an electron, the energetic change involved in incorporation into a quantum orbital (or involved in a transition to a different orbital, for that matter) should qualify. We now have atoms as r-wholes.

When atoms form a chemical bond, there is a transaction or sharing of electrons in which energy is released. So, once again, we have a case of r-parts composing an r-whole in the form of a group of bonded atoms. This includes covalent molecules, the lattice network of an ionic compound crystal, and any homogeneous sample of metal. For covalent molecules, there may be still another level of restricted composition, in which intermolecular forces between molecules cause them to cohere into objects such as sugar crystals or samples of water. I will only say here that such as possible cases: an attempt to settle whether this is so would take more chemistry than philosophy per se (see (Earley 2005)).

The character of an r-whole's supervenience on its r-parts is such that the unity of an r-whole is analogous to, and derivative of, that of the r-parts as a group. Such is the

nature of the one-many relation between whole and parts in general, and thus, as was mentioned in the previous section, is the relation between whole and parts analogous to the case of UM as derived directly from classical mereology. For inanimate objects, then, as described by chemistry, the criterion of identity at work for each level of r-wholes is that of simply being so composed in a certain configuration that was the result of the change involved in the r-parts coming into existence as *entia per alia* (cf. (Johnston 2006: §7)). Therefore, in addition to WEP, PEW turns out to be true for inanimate objects just as Chisholm held that it did. And because under PEW a whole becomes numerically different when it loses a part, the conjunction of WEP and PEW for objects requires that a part of a whole becomes numerically different when a different part of the same whole is lost by the whole. This may seem unpalatable and unduly restrictive, but in fact it can be defended on independent chemical principles, although I will do no more on that principle's behalf here than to issue the promissory note.

But couldn't there be things that are ontically interdependent per (RP) but spatially separated, therefore not counting as intuitively restricted parts of a whole? What about two objects that collide and thereby intrinsically change, then fly apart forever without ever colliding into anything else? Such things, according to this theory, do thereby compose an r-whole. This kind of worry is only a real concern, though, if the sorts of things that satisfy the condition pervasively fail to meet intuitive criteria for restricted parthood, which in turn leads to serious doubts as to whether it is anything unique to parthood that we have captured by this theory. For example, we might say that if two *atoms* participated in such an event, then they become parts of an r-whole. But are atoms that bounce off one another thereby changed, as in the proposed counterexample?

Well, no: atoms are so constituted as to have causal powers that are specially suited for chemical bonding. Thus, if there is intrinsic change in two atoms that collide, it will be due to their forming a chemical bond, and thus they will compose an intuitive whole and not a spatially discontinuous one. A collision between atoms that does not result in the formation of a bond, on the other hand, is simply one in which they bounce off each other with no intrinsic change to either. Collision between atoms in the gas phase is part of the characteristic pressure manifested in a sample of gas, but this is a statistical effect of the sample as an aggregate (not an r-whole), extrinsic to any particular atom or set of atoms per se. So in that application, there's no worry of objects being composed due to the same principle whether they become part of a contiguous whole or not.

With respect to the composition of macro objects out of other macro objects, the possibility of spatially discontinuous r-wholes becomes more of a reality. Consider two cars that crash into one another and are totaled as a result.[8] Most would say that this results in an intrinsic change to the cars. Then, by the *entia succesiva* principle, two new objects have thereby come into existence. Furthermore, as such they qualify as r-parts according to (RP), so they would compose an r-whole so long as they remained in the exact state they caused each other to be in. And, so long as they do remain in that exact state, the r-whole would endure as such regardless of the spatial separation between the two crashed cars. I, for one, see nothing wrong with this, for this may explain some consequent tendency to treat such objects as considered wholes. For example, consider a set of objects that are involved in a crime, such as collectively become *entia per alia* where the *alia* are all of the other objects so involved. One may want these to be preserved exactly as found, as a set of evidential objects related to the crime. Such

[8] Grant for the sake of argument that cars are r-wholes, or substitute some other macro-level object.

objects may then be considered to compose an r-whole in that they attain a certain metaphysical significance in virtue of participating in a single event together.

On the other hand, there are objects that might be intuitively said to compose a whole by means of *fastening* (Van Inwagen 1990: 56–8; Markosian 1998; Markosian 2007: §6))—such as a bolt screwed onto a nut—but that don't undergo any intrinsic change by doing so and so don't qualify as r-parts according to the *ens per alia* criterion. But, consider a bolt and nut as components of a single artifact, each component of which was designed to "go together." Since each component is made for the other, one may well say that neither would exist without the other, which would qualify them as r-parts of an r-whole. But if such components are mass-produced, like bolts and nuts, it is only the components as types, rather than the particular tokens themselves, that can be strictly considered as r-parts in this way. So we might think of any particular pairing of bolt and nut as an "ersatz" r-whole, whereas we can think of components of a unique, custom-made artifact—where the part-tokens *themselves* are made for each other—as r-parts in a stricter sense, conferring a stricter sense of r-wholeness to unique artifacts. Thus, the token-sense, as opposed to type-sense, in which unique artifacts can be considered r-wholes, may (similarly as above with cases of material evidence) explain a consequent tendency to treat custom-made artifacts as more special than mass-produced ones.

In summary so far, chemical bonding does the trick for composing r-wholes in a way such that the theoretic criterion for composition, by means of parts as *entia succesiva,* cleanly lines up with the intuitive requirements for such. For higher-order objects like artifacts, the same principle may hold even if parts are thereafter separated. In another sense, (RP) can be applied to parts that are custom-made for, and designed for a

particular interaction with, each other, which also involves mutual ontic dependence. Both kinds of application can give us "scattered" objects of certain considered kinds, but not unrestricted ones. (RP) therefore works to mark out genuine metaphysical distinctions between certain aggregates and others that does not simply reduce to "our intuitive restrictions…[, which] are a product of our relatively narrow interests and purposes." (Hudson 2003: 92)

V.

The nature of the composition of organisms, although as a matter of fact requiring chemical components, is quite distinct from that pertaining to inanimate objects. I will herein explain how, in terms of the same general principles introduced in section three that applied to inanimate objects. WEP applies very naturally to organisms, as we shall see, a fact that has been noted before (although not in so many words) (Johansson et al. 2005; Simons 2006; Johnston 2006: §6).

The parts of a single living cell—for now, think of a single-celled organism—operate in living coordination that enables the existence of the whole, according to an encoded plan in the DNA of the cell that brings the parts into existence. The parts support the existence of a whole, and the coordination of the parts as a whole is what supports the existence of the r-parts, so delineated: the cell's organelles. The r-parts undergo changes in that nutrients are taken into the cell to support them, and waste products expelled from the cell. Thus, the living coordination principle that qualifies the parts of a cell as r-parts is distinct from that which captures the varieties of physical bonding that effect intrinsic change in the r-parts and sub-r-parts of an inanimate object. This is apparent in terms of facts of molecular biology: a cell as an organism is dependent on its particular parts only

insofar as they perpetuate the life of the cell. While some of the cell's parts undergo change, the cell continues functioning, that is to say, living, in its characteristic way. Of course, the r-parts of the cell are such that they cannot be completely disrupted without the entire cell—the r-whole—dying and thereby ceasing to exist. Therefore, WEP is true for the cell, but not PEW in its full generality.

Consider now a multicellular organism, such as myself, with each of my cells as r-parts of the whole that is myself. As single-celled organisms do, each of my cells undergoes activities in accordance with the instructions encoded in the DNA in its nucleus. But what about the question of cells as r-parts—isn't it pretty implausible to suggest that some two of the trillions of my cells are in mutual ontic dependence per (RP)? Actually, any pair of cells that resulted from division of a single antecedent cell stand in just such a relation as *x* and *y* of (RP). Although this is a surprising way to find mutual ontic dependence manifested, it is certainly true of two cells that resulted from a single cellular fission that neither would exist without the other! Of course, this requires the assumption that neither of the individual cells resulting from a cellular fission is identical with the single antecedent cell. But I think this is a pretty natural assumption, especially compared with the alternatives.

Cell division is also important to the persistence of multicellular organisms. Neither of the two cells that resulted from a single event of cell division should be said to be identical with the antecedent cell, but what happened to the single antecedent cell? A plausible preliminary answer is that it ceased to exist (cf. van Inwagen on zygotes (1990: 152–3)), but a closer look at the details of the process suggests another answer. The process of cell division is a smooth, unbroken process wherein the cell's parts rearrange

themselves in such a way as to result in two new cells. *Those* resulting individual cells are certainly new entities that come into existence, being persisting entities as were their predecessor, as is any single cell. Consider these further facts. (1) The smooth and unbroken process of cell division is such that, if one wanted to say that the cell ceases to exist by doing so, there is the problem of not having any cutoff point at which one to say that that definitely occurs. (2) Cell division is part of the natural activity of the single cell: it is best understood as one of the activities by which it perpetuates itself as described above, and therefore isn't a case of cell *death,* the *disruption* of the cell's life. (3) As noted in the previous paragraph, the two cells resulting in a cell division are r-parts of an r-whole with exactly those two cells as r-parts. I propose that the best way to account for these facts is by saying that a pair of cells, *considered as an r-whole,* is identical with its antecedent single cell. This is one way in which a cell, an r-whole, persists, in which WEP holds, and PEW does not. The whole persists through a change of parts.

Every cell that now composes me is a result of cell division as described above. Consider all of these cells, and run back the clock to a time very shortly after my conception. If one were able to take a complete account of the whole process, what one would observe is very many cell division events—for each of which, as we have said, the result of the division is identical with its predecessor—going all the way back to the division of a zygote. Now, let's look at this process more closely. Running the clock forward again, we have the identity through time of a zygote with a succeeding pair of cells. When each of that pair divides, there is a slight complication: the cells as r-wholes persisted through division just as the zygote did, but what happened to the r-whole that was the pair? *Now* is there reason to think that it ceases to endure? The four cells that

result from this second division is an r-whole with the two pairs of cells as its r-parts, and those pairs, in turn, are likewise each an r-whole with exactly two cells as r-parts. So, parallel with the case of the persistence of the zygote through its division, it seems that we should say that the r-whole persists again through this second division. Through this successive process, the existence of the original zygotic r-whole persists in the form of the totality of cells descended from it.[9] By transitivity of identity, the identity through time of the zygote is secured throughout the process. Therefore, it looks as if there is reason to say that, *pace* van Inwagen (ibid.), I was once a zygote.[10]

But there are a couple of not-inconsiderable obstacles to that conclusions that I can think of. After several cell divisions descended from a zygote, there is still just a *blastula,* a "blob of cells," and each of those cells functions more or less independently of the others. The persistence conditions of the blastula certainly seem to be secure as long as its parts keep enduring (even as they keep adding parts to themselves). But what if it loses cells in the process? If endurance of such fails, though, of course, all bets for my having once been a zygote are off. A maximally strict criterion of persistence would be to

[9] There are two points to acknowledge and be clear about here: (1) As new r-wholes-that-are-r-parts successively come into existence in the process described, successive "layers" of "undetached parts" come into existence. But they are *not* the *arbitrary* undetached parts denied by van Inwagen (Van Inwagen 1981). (2) Now that we have countenanced these layers of undetached parts, it should be clear that nontransitive mereology is involved, since each r-whole involved has exactly two r-parts, which in turn have r-parts that are not r-parts of the r-whole two "levels up." This was also the case for inanimate objects, with their atoms and subatomic particles, as many will have no doubt noticed. Some may find the notion of nontransitive mereology alarming, but rest assured that nontransitivity only applies for r-parts: classical, spatial parts remain as transitive as they ever were. As well, nontransitive mereology is actually not a terribly undesirable or impractical notion to have on hand (Johansson 2004).

[10] The following are some other consequences of the reasoning that leads to a full-grown human being having once a zygote, which I will, as we say, leave as an exercise to the reader to deduce: (1) A colony of bacteria that are all descended from a single bacterium is identical with that bacterium, (2) I could have been two people, or three people (but *not one of* those people), (3) identical twins could have been one person, and (4) identical twins together compose an r-whole. Some might consider some or all of these flat-out unacceptable, but consider: it's an undeniable fact of identical twins that neither would exist (more exactly, never would have come into existence) without the other, provided that neither would have been identical with the single person they could have been.

say that if a blastula loses one of its cells, it falls to the status of an *ens succesivum* like an inanimate object, while a maximally permissive criterion might be to say that it endures as long as any one of its cells does. To be honest, I am not sure what to say about how fragile the persistence of a blastula might be.

But here's the real spoiler: there is also the question of whether *I*, now, am the kind of thing that has exactly two r-parts, just like a blastula. What has characterized my life since a very early stage of development is that given cell differentiation, each cell's activities contribute their part to the life of the overall organism that is me. My genome—the total package of DNA that collectively determines my characteristics—is duplicated *in toto* in each of my cells (not unlike Leibnizian monads), so each exists only with the whole "in mind," so to speak. Each cell is nourished and maintained by the collective activity of my cells as a whole. When cells detach from me, they die (and vice versa), but *I* don't thereby die. In fact, there are much larger parts, so delineated, that can detach from me without *me* dying—a hand or leg, for instance (provided I don't die of bleeding or other complications, of course). My persistence is thus fundamentally underwritten by the characteristic homeostatic processes of a single organism, analogous with that of a single cell. This is the way in which we should say that the r-whole that is me supervenes on its r-parts in a manner analogous to, and derivative of, the specific nature of the r-parts. In this way, I can definitely survive a loss of parts; I do so constantly. So, at least since the time when the unified process of a multicellular organism was underway among my cells, WEP has applied to me, but not PEW. And since the *kind* of thing *I* am is a fully-fledged multicellular organism, and not some kind of huge, complicated blastula, I am pretty strongly inclined to think that this points to the conclusion that I was never a

zygote, nor a blastula (the same conclusion as van Inwagen's, for essentially similar reasons; cf. (Lane 2003)). Cell division has continued apace throughout my life, furnishing me with r-parts, as described above. But it seems that my persistence as an r-whole is of a fundamentally different nature from that of a blastula, although a blastula does stand in the ancestral to me in a relation that might be thought to be analogous in some way to that between a caterpillar and a butterfly.

So, some of the results of applying the general principles of section three to organisms are clearer than others; the points about the composition and persistence of multicellular organisms I would like to emphasize most of all are, in summary, these.

(1) Cell division results in a pair of cells that together are an r-whole with exactly the two cells as r-parts. That r-whole is identical with the single cell that stands in the ancestral to it, and persists through subsequent cell divisions.

(2) An organism as a whole that is essential to its parts results from a principle quite different from that which we saw involved in chemical bonding: it seems quite possible that there could exist an organism that carries on its life functions in just this way without its parts even being in contact.

(3) Although WEP holds for a cell, and for a multicellular organism, PEW clearly does not, at least not in its full generality. On the particular principle of RM by which an organism is composed, an organism can tolerate the loss of smaller parts as long as the living activity of the organism can still continue. Individual cells of a multicellular organism eventually slough off and die, but before that they also divide and perpetuate the genome they carry, and thereby also the entire organism, for which there is therefore

reason to think of as an enduring whole, *qua* organism, for which fusions, stages, and the other usual accoutrements of four-dimensionalism are completely otiose.

Chisholm, however, applied his principle of PEW directly to persons, whose persistence through time was to be explained in terms of an *ens succesivum.* Interestingly, this approach led Chisholm to seriously consider that one's strictly persisting self, if there is to be one, could be a small, perhaps microscopic particle, that endured unchanged throughout one's life (1978). If this were true, I would have to say that, in the "strict and philosophical sense," I am a microscopic particle weighing less than a milligram. However, given an examination of what kind of thing I am in light of WEP, this extreme measure does not result; indeed, according to the criterion of RM that is manifest in the case of organisms, it is entirely unmotivated. The principle of RM for organisms is about the most ideal example one could want of a case in which WEP clearly holds but PEW does not. Very interestingly, this shows that Chisholm's conclusions about personal persistence were exactly the reverse of the facts of the matter.

VI.

To conclude, I will step back to give an overview of how the present theory of RM comports with what one should want in general in such a theory. Also, I will take a big-picture look at how the RM-motivated approach to composition and identity taken in this paper is stacked up against the alternative—universalism and four-dimensionalism—as part and parcel of a complete material ontology.

One thing that a theory of RM needs to take account of is that if mereology is restricted, parthood is not automatic, and so things have to be able to *become* parts. "Becoming" can be taken into account in terms of *entia succesiva* and existence. This

theory fulfills that desideratum in terms of r-parts. But in all of the talk of "intrinsic change" that is involved in r-parthood, it may have begun to worry some readers that we have simply substituted one perplexing topic for another. I don't think that there's much cause for worry, however. After all, four-dimensionalists help themselves to the notion of intrinsic change so as to motivate their characteristic notion of perdurance. Furthermore, I don't think that the notion of intrinsicness is so murky as to give us no help in deciding when restricted composition takes place. Most of the foregoing examples in the previous two sections, after all, I will expect to be fairly intuitive examples of intrinsic change as well as of restricted composition.[11] Even taking into account whatever problems with intrinsicness this theory of RM will inherit, one should still say that a philosophical advance has been made in explaining composition in terms of mutual ontic dependency and intrinsic change.

It may have been noticed that the notion of supervenience appealed to in r-wholes like organisms, which can persist through changes in parts, is quite a bit weaker than most extant supervenience concepts. The form of dependence involved may, indeed, be considered more of a species of *emergence.* The idea that persisting individuals as such are also emergent ones has been suggested before (O'Connor and Jacobs 2003), and the present conception of persisting individuals may be considered as part and parcel of that general notion.

The separate existence of a whole from its parts or the summation is something that is desirable to have, and to have an independent justification for, as has been

[11] Van Inwagen discusses the distinction in just the way that is relevant here: "The distinction between intrinsic and relational properties is sometimes explained in terms of the concept of a 'real change in a thing': if the gain or loss of a property would be a real change in a thing, then that property is intrinsic; otherwise, it is relational." (2002: 33)

recognized since Aristotle but underexplored by analytic metaphysicians (but see (Koslicki 2006; Johnston 2006; Simons 2006)), but UM doesn't do this except by fiat. The theory of RM presented here is one on which, indeed, you get "over-and-above-ness" for wholes. This is evidenced by the mere fact of organisms being able to persist through changes in parts, but holds for r-wholes for which PEW is true, as well.

The idea of the relation of wholes to parts being determined by the kind of thing the whole is also present in Aristotle's *Metaphysics*, in various places in Book *Z* (especially Ch. 13, **1039a**). According to Aristotle, each thing is a unified *substance* such that no proper part of it is also a substance—for if there were, there would be two coinciding and different substances, which conflicts with the Aristotelian notion of substance and essence: literally, *what-it-was-to-be-that-thing*.[12] However, the present account of wholes allows—indeed, requires—the r-parts to be things—Aristotelian substances—in their own right; however, the Aristotelian idea that two substances cannot coincide is retained in the present theory by the notion of wholes as "over and above" their parts ontologically. In terms of purely spatial mereology, granted, the substances of r-whole and r-parts overlap in that they share space, but this isn't necessarily inimical to the broadly Aristotelian notion of substance; nor was Aristotle apparently particularly concerned with the modern logic of purely spatial mereology.

As well, wholes have the priority in determining the parts rather than vice versa, which Aristotle's account also shares. Aristotle's substance theory also shares with the present account the kind of view toward wholes expressed in Peter van Inwagen's denial

[12] This is Hugh Lawson-Tancred's (Aristotle 1998) translation from the Greek that is usually rendered *essence*. My best guess as to the significance of the past tense "was" in that locution is that it refers to the role of the formal essence in the original coming into being of a thing. This is another point of contact with the present theory, which also makes an essential place for the coming into being of a thing, as discussed above.

of the existence of "arbitrary undetached parts" (1981). As noted above in footnote 9, undetached parts are countenanced under this theory, but not *arbitrary* undetached parts. Rather, they are the *naïve parts* discussed by David Sanford (1993): parts that are themselves wholes.

Finally, the RM approach advocated here is one that allows for a much more interesting and illuminating story about what kinds of things there are than is available on UM. The common UM-informed approach of letting the job of ontology fall squarely into the lap of mereology leads to having to say that I, the outermost two thirds of my left arm, my car, and the fusion of all the planets in our solar system are on an exact ontological par with each other. This approach seems to suggest that it is a matter of *pure* convention or stipulation as to what *kinds* of things there are. Not only is this uncongenial, it is not even plausible. If things really differ in the slightest from one another at rock bottom, in their own intrinsic properties, then how could these differences be irrelevant to their compositional potential? What we do, in fact, find in the world is a variety of kinds of simples, which combine in certain characteristic ways to give rise to even more kinds of things, as has been described above. The UM-ist has to maintain that the necessary principles of composition in this world—that is, automatic by dint of extensional mereology—are just the same as those in another possible world that contains only billiard-ball-like "Democritean atoms."[13] The present theory of RM, meanwhile, gives an answer to the questions "What am I?" and "Under what conditions do I persist through time?" in a way that is manifestly in accord with all experience and other sources

[13] Unfortunately, all of the evidence indicates that most metaphysicians, as van Inwagen indicates for his own case, "do (their) picture-thinking with Democritean atoms" (Van Inwagen 1990: 165).

of knowledge. I am a whole that is essential to its parts; each part depends on the collective activity of the parts, but not all of the parts are essential to my survival. Shave a cell from my arm, no sweat. Cut off an ear, and I'll live another day. But remove my head or my heart, and I'm done for. On the other hand, the UM-ist/four-dimensionalist tells a story of my persistence according to a scheme in which none of these basic facts about *me, qua* human being, plays any essential role.

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