

Forms are not Structures but the Grounds of Structure:

How Grounding Theory Illuminates Hylomorphism (and Vice Versa)

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There is clearly some intimate relation between Aristotelian *form* and the structure or organization of a composite thing. In recent years, some neo-Aristotelian philosophers (e.g., Eleonore Stump, Kit Fine, Mark Johnston, William Jaworski¹) have proposed that this relation is simply identity: forms *are* structures. I will argue both that Aristotelian forms (especially substantial forms) are essential elements in an adequate ontology and that they form a *sui generis* category. Substantial forms are not identical to the structure of composite substances: instead, they are metaphysical components of substances that constitute the metaphysical *ground* of that structure, in a sense of *ground* that has been rehabilitated in recent years by Kit Fine, Jonathan Schaffer, Gideon Rosen, Jon Litland, and others. Forms are that *in virtue of which* substances are structured internally as they are.

In section I, I will briefly discuss and defend an Aristotelian solution to the problem of universals. It's critically important to discuss the concept of form within the context of

¹ Only Jaworski (2012, 2016) is explicitly committed to the forms = structures thesis. Stump (1995) speaks of “configurational properties,” Johnston (2006) of “relational properties,” and Fine (1999) of “variable embodiments” of “relational properties,” but I understand them all as defending something equivalent to Jaworski’s identification.

Aristotle's answer to Plato's problem of the one over the many. Then (in section II) I will present seven arguments for the thesis that forms ground internal structure. I conclude by considering how my neo-Aristotelian theory is compatible with modern science, especially with quantum theory (section III).

I. Moderate Realism and Constituent Ontology

It's important to remember where the idea of *form* (eidos, morphe) came from. For Aristotle, form was not originally conceived as a solution to the mind/body problem, or to the problem of material composition. Aristotle's notion of form is a direct descendant of Plato's Forms, introduced as a solution to the problem of universals, the problem of explaining the existence of samenesses through plurality (the One over the Many).

Aristotle immanentizes Plato's other-worldly Forms as individual essences, thereby creating a genuine alternative to both Nominalism (the rejection of any explanation of non-numerical sameness) and Realism (Plato's postulation of non-individual Forms as the grounds of sameness). Aristotle's alternative is attractive because of the serious problems that attend the two alternatives.

What's wrong with Nominalism?

There are essentially two kinds of Nominalism that are worthy of consideration: Ostrich Nominalism and Resemblance Nominalism (as David Lewis recognized, natural-class

Nominalism is nothing but a notational variant of Resemblance Nominalism). Ostrich Nominalists refuse to offer any general account of non-numerical sameness. To say that two things are similar or *the same* in some non-numerical sense is simply to say that they are both red or both kangaroos or whatever. Each form of similarity is metaphysically *sui generis*. This is a viable position, but as Bryan Pickel and Nicholas Mantegani (2012) have recently argued (see also our discussion of this in Koons and Pickavance 2014), Ostrich Nominalism comes at a very high cost in terms of qualitative economy or parsimony, since it treats every natural kind as a metaphysical primitive.

Resemblance Nominalism avoids this cost by offering a single, general account of sameness in terms of a metaphysically primitive comparative resemblance relation. Of course, such an account is not an explanation of similarity, but simply a recognition of similarity as a general phenomenon, while treating it as metaphysically primitive (i.e., inexplicable). There are at least three serious problems with Resemblance Nominalism (see Koons & Pickavance 2014, for a detailed account):

(i) Resemblance Nominalism reverses the proper order of explanation. Things are similar because they are in some way intrinsically the same; they are not the same because they resemble each other. Resemblance Nominalism has to treat similarity as though it were an external and not internal relation.

(ii) The problem of imperfect community (first identified by Nelson Goodman 1951/1977) requires for its solution both possibilism (the postulation of possible but not

actual entities) and either tropes (including generic or determinable tropes) or fantastic complexity in the structure of the resemblance relation (along the lines of Lewis 1983 or Rodriguez-Pereyra 2002),

(iii) Resemblance Nominalism cannot explain the structural facts about the resemblance relation, namely, that it is necessarily symmetric and transitive (in the limit of perfect resemblance).

What's wrong with Platonism?

There are also good reasons for being dissatisfied with the postulation of universals as grounds of similarity (the Platonist or realist strategy). Realism comes in two varieties: relational and constituent Platonism, depending on whether instantiation or participation is understood as a relation between two disjoint entities (relational realism) or a particular is supposed to instantiate a universal by literally containing it as a part (constituent realism). Some constituent realists have labeled their account 'Aristotelian' (David Armstrong) or have offered such an account as an interpretation of Aristotle's theory (Michael Loux). On my view, constituent realism is really a variety of Platonism, and I will offer quite a different interpretation of Aristotle's solution to the problem of the One and the Many in his *Metaphysics*.

The principal problem with relational realism is the objection from intrinsicity (discussed in Oliver 1996). Relational realists must deny that any particular has any

intrinsic properties. What we take to be paradigms of intrinsic properties, like shape, volume, mass, or charge, are really extrinsic properties that depend on the thing's relation to the relevant universal (a disjoint entity). In addition, for relational realists universals have a somewhat strange mode of existence ("outside" of space and time), making it unclear how universals can be responsible for particulars' having the characters they have.

There are two or three difficulties with constituent realism. First, there is the oddity of having universals wholly located in many different places in the same time. As Plato noted in *Parmenides*, this means that each universal is somehow "separated" from itself, which seems impossible. Second, as many scholastic philosophers argued, constituent realism entails the existence of odd causal connections between disjoint and widely separated particulars. For example, if both Plato and Socrates are pale, then it is impossible to annihilate Plato thoroughly without destroying part of Socrates (namely, the universal that they share). Third, it is difficult to explain how a mere bundle of universals could constitute a particular, or how the mere combination of some universals with a bare particular (like some prime or signate matter) could constitute a single, unified particular.

Aristotelian "moderate realism"

Consequently, there is some reason to look for an alternative to these familiar solutions to the problem of universals. In my view, Aristotle offers such an alternative in the central books of the *Metaphysics* (Zeta, Eta, and Theta). Aristotle is usually classified as a

“moderate realist,” but his view is actually a version of *nominalism* as this is defined in the contemporary debate, in the sense that Aristotle’s account denies the existence of universals, except as intentional objects of the intellect. For Aristotle, everything real is particular.

Unlike ostrich nominalism, Aristotle does offer a general account of generic sameness. Unlike resemblance nominalism, Aristotle’s theory does not rely on a primitive relation of similarity or comparative resemblance. Instead, his account involves one primitive relations, formal causation, and the distinction between actuality and potentiality.

Each particular (whether a substance or an accident) has its own individual form. Two particulars are the same in species just in case they have forms that are equipollent, that is, forms that are potential formal causes (PFCs) for exactly the same particulars:

(D1) x and y are *conspecific* if and only if they have equipollent formal causes.

(D2) x and y are *equipollent* formal causes if and only if, for all z , x is (at least) potentially a formal cause of z if and only if y is (at least) potentially a formal cause of z .

For the sake of brevity, I will hereafter drop the qualification “at least” and I will refer simply to *potential formal causes*, with the understanding that a thing’s actual formal cause also counts (for my purposes) as one of its potential formal causes.

Aristotle's theory is not just a theory of when two particulars belong to the same *infima species*. His theory gives rise in a very simple and natural way to a Porphyrian tree of genera, with the categories (substance, quality, quantity, and so on) as the most general or broadest genera. As I understand Aristotle's account, he introduces a second kind of fundamental entity, in addition to forms, namely, *differentiae*. Each particular P has a single, simple form F , but F 's power to act as P 's formal cause has to be explained in terms of the prior action of a series of *differentiae*, which have progressively transformed F from a merely categorical form into a specific one. The *differentiae* have acted on the form in a specific order, corresponding to a path through the Porphyrian tree (from categorical root to specific leaf). This order doesn't correspond to a temporal order, but rather to a purely metaphysical or causal ordering, in the sense that some *differentiae* depend for their action upon the prior action of other *differentiae*.

Two forms F_1 and F_2 belong to a common genus that is n levels above the level of species just in case there is a series of *differentiae* of length n that could transform F_1 into a state of equipollence with F_2 .

(D3) x and y are *congeneric at level n* if and only if they have formal causes that are n levels removed from equipollence.

(D4) x and y are *n levels removed from equipollence* if and only if, for all z , there is a sequence S of n *differentiae* with the potential of transforming x into a potential cause of z

if and only if there is a sequence S' of n differentiae with the potential of transforming y into a potential formal cause of z .

Each substance contains a single, individual substantial form, which has been enabled to do its formal-causal work by a series of individual substantial differentiae.

Each of these entities (forms and differentiae) has a real metaphysical role to play. Each differentia actualizes the potential of a form at level $n+1$ to be a form at of level n , and the final differentia for each substance actualizes the potential of a form at level 1 to be *the* formal cause of that substance.

How is this Aristotelian theory superior to standard resemblance nominalism (with or without tropes)? Most importantly, there is on Aristotle's account no primitive external relation corresponding to *similarity*.

Instead, Aristotle's explanation of similarity parallels that of Platonism: instead of sharing a *single* universal, two similar particulars share a *family* of equipollent formal causes (one of which actually informs one of the particulars and potentially informs the other, a second of which does the reverse). In this picture, forms are modifying tropes, not modular tropes (to use Robert Garcia's distinction—Garcia 2015): that is, a form *makes* its particular belong to that particular's species. The form is not *itself* a member of the species. Thus, two forms do not resemble each other; rather, they are the ground for the resemblance of the particulars of which they are the formal causes.

Therefore, the Aristotelian account is a kind of *reduplicative* version of Platonism: the sameness of two particulars is grounded in their being formed (either actually or potentially) by the very same forms.

Why then isn't this just a profligate version of Platonism? Wouldn't Platonism be preferable on grounds of parsimony or economy? Why posit many individual forms when a single universal will do?

Admittedly, the Aristotelian theory is less parsimonious than Platonism, although this is only true with respect to quantitative economy (the sheer number of entities), which is must less important than qualitative economy (as measured by the number of fundamental kinds of entities). In addition, Aristotelianism brings with it several compensating advantages. It doesn't require any kind of action at a distance or multi-located universals, and it doesn't require universals as necessary, eternal existents with some odd, extra-spatial and extra-mental mode of existence.

Is there a problem for the Aristotelian in accounting for the symmetry and transitivity of the potential formal-causal relation, just as resemblance nominalists have a problem accounting for the symmetry and transitivity of perfect resemblance? If the form of x is a potential formal cause of y , why is the form of y also a potential formal cause of x ? And, if the form of x is a PFC of y , and the form of y a PFC of z , why is the form of x also a PFC of z ?

These facts can be explained in terms of the fact that what each form does in the actual world to its actual patient is exactly what it would do potentially to any potential patient. There are no contingent accidents that can affect the core formal operation of a form. So, if x is actually and y potentially the formal cause of some z , they must be (at least) potentially the formal causes of exactly the same particulars.

II. Forms are not Structures but the Grounds of Structure

A number of recent proponents of hylomorphism have defended the identification of forms with structures. I take a structure to be something like a set or plurality of facts, either concrete facts (about particular entities) or abstract facts (about an abstract n -tuple of entities). These facts would always involve more than one particular (the structure's role-fillers) and would include both relational facts (about the spatial relations and relative trajectories of those particulars) and facts about the intrinsic properties of the structure's role-fillers. I have seven arguments for thinking that Aristotelian forms cannot be structures:²

- A. Forms must be solutions to the problem of the One over the Many
- B. Substantial forms must be the ultimate grounds or explanation for the per se unity of substances.

² David Oderberg (2014) reaches a similarly negative conclusion, but for quite different reasons.

- C. Substantial forms must be the grounds for diachrony unity or persistence
- D. Forms are needed to distinguish substances from groups of substances
- E. Forms are needed to justify a principle of formal economy
- F. Forms are needed to explain why composite substances aren't metaphysically redundant
- G. Substantial forms explain why composite substances aren't causally redundant.

A. From forms as solutions to the problem of the One over the Many

If forms are formal causes, as explained in section I, then they cannot consist of facts, since facts are composed or constituted by instantiation relations between particulars and properties. Forms are supposed to be the ultimate *solution* for the sharing of universals or natures. Hence, they cannot consist in entities (like facts) whose internal constitution *presupposes* the instantiation of properties by particulars (such as the role-fillers of a structure). In other words, forms are supposed to be the fundamental ground or explanation for the similarity or generic sameness of particulars, which is, in turn, the ground for the existence and correct attribution of general properties. Facts presuppose the existence and attributability of general properties. A fortiori, sets or pluralities of facts also presuppose these things. Hence, forms cannot be facts or pluralities of facts.

1. Forms are the fundamental grounds of similarity.
2. Facts are not the fundamental grounds of similarity.
3. Sets or pluralities of facts are not the fundamental grounds of similarity.

4. Structures are facts or sets of pluralities of facts.
5. Therefore, forms are not structures.

B. Forms as grounds for the per se unity of composite substances

For Aristotelians, a composite substance is one thing per se. It is not in reality a plurality of things that we think of or treat as one, as in the case of artifacts or conventionally delimited regions of nature (like Mt. Blanc or the Mississippi River). A substance has real unity in itself. Since it is the form that makes the substance to be a substance, it is reasonable to infer that the form must be an ultimate source of unity. In general, only simple things can be ultimate sources of unity. A composite thing could be a source of unity only if something else is the ground of its unity.

Thus, forms are simple, but structures are typically complex. The structure of a compound substance is always composite itself and so cannot be the ultimate source of the substance's unity.

Koslicki disagrees. In her 2008 account, a form unifies by imposing certain "structural constraints" on a plurality of material components. For a whole substance to be unified is for its material components to *satisfy* the structural constraints imposed by the formal components associated with the kind to which it belongs. However, Koslicki simply dodges the obvious follow-up question: what unifies the formal components associated

with a natural kind? Without a principled answer to that question, we have made no progress toward accounting for the unity of substances.

On my alternative account of hylomorphism, no such problem arises. Each substantial form is not a complex structure but the simple metaphysical element that grounds that complex structure. Both the structure and the materials so structured are unified by their having a common, simple formal cause.

This is an attractive and simple account of per se unity. There are, however, two genuine alternatives to the theory of simple forms:

1. Substantial unity emerges through the cooperation of simple proper parts.
2. The composite substance isn't really composite: the material parts are annihilated in the process of generation—an account defended by Theodore Scaltsas 1994, Alexander Pruss 2007, and Anna Marmodoro 2013. I'll call this the SPM account.

SPM account violates the substrate constraint of *Physics*, Book II. All change requires a persisting substrate, something that exists both before and after the change. In a forthcoming book (Koons and Pickavance 2016), Tim Pickavance and I defend this substrate principle using David Lewis's Patchwork Principle: if any local change could occur without substrate, there could be a world and a time, and even a dense interval of time, involving constant change without any substrate. But this is impossible: in such a

world, there would be nothing throughout the interval to tie together enduring places or successive moments, and so no real passage of time at all.

But what is wrong with the first alternative? Why can't unity come about or emerge as a result of the unified cooperation of the many parts? To take a simple example, why couldn't there be two simple things A and B, such that A has the natural power to unify under certain circumstances with B, and B has the complementary natural power to unify in those same circumstances with A? In this picture, there doesn't have to be a single unifier: instead, the many unified things are themselves mutual unifiers.

However, this would require a very improbable and ad hoc pre-established harmony among the powers of the many mutually unifying parts--a coordinated distribution of mutually exercisable powers. This problem ramifies as the number of components to be unified increases. It becomes quite untenable when billions of components must unite with each other.

The simple form theory offers a much simpler account: it locates the source of the persistent unity of each substance in a single agent, the substantial form. The presence of the many material parts serves merely as the patient of the formal action, as enabling conditions for the exercise of the form's formal powers. These enabling conditions are built into the form itself, requiring no prior mutual agreement.

To have a complete theory of the unity of complex substances, we need to account for unity at two points in time: the unity of the substance at its moment of generation, and the continued unity of the substance as it persists through time. Aristotle's theory offers us two agents to meet these two needs: an efficient agent, to account for the generation of the compound substance, and a form, to account for its persistence as a unit through time.

C. Forms as grounds for diachronic unity or persistence of compound substances

There are two kinds of unity that an Aristotelian theory of compound substances must account for: the synchronic unity of the material components at each moment in time, and the diachronic persistence of the substance through time.

In recognition of this fact, Professor Jaworski insists that forms are dynamic, not static (Jaworski 2012, 2016).

But what is a "dynamic" structure?

A dynamic structure cannot be just a set of four-dimensional relations among events and states. We must also give an account of the substance's counterfactual potentialities for persistence (as Howard Robinson 2014 points out).

In recognition of this point, Kit Fine identified substances with a triple consisting of a set of material components, an original static structure, and a "principle," which is a function

from times and worlds to static structures. A substance persists just in case its set of material components realizes the appropriate static structure at each time and world, as dictated by its “principle.” There are at least two problems with such an account. First, it makes it impossible to account for substances that are mereologically inconstant, that is, ones that gain or lose material components over time. More importantly, as Fine recognized, this introduces a purely conceptual component to the existence and persistence of substances. Principles are not metaphysical simples: if they are simple at all, it is as a purely mathematical entity (a function). There are infinitely many such functions, connecting arbitrary structures with any world or time. The resulting persisting substances have no per se unity. They are simply things that we can count as unified across time by reference to an arbitrary mathematical function.

In a similar way, one could appeal to Koslicki’s constraints as a ground for persistence. Constraints can be both synchronic and diachronic. But once again we face the question, what unifies the constraints? If the constraints are grounded in a single, simple entity of some kind (i.e., a substantial form), then our problem is solved. Otherwise, no progress has been made.

Just as it is plausible to suppose that the ultimate ground of synchronic unity must be mereologically simple, so it is plausible to suppose that the ultimate ground of diachronic unity must be intrinsically unchangeable. Structures undergo intrinsic change—they can even undergo mereological change, gaining or losing components. Therefore, structures cannot be ultimate ground of persistence.

D. Forms are needed to distinguish substances from mere groups of substances

Groups of substances can have forms—e.g., the city or *polis*. However, the forms of groups are accidental and not substantial forms. The members of a group (like a city) are substances in their own right, and a substance cannot contain other substances as proper parts.

A group like a city can persist through mereological change—it can gain or lose members while maintaining its own identity. Hence, a group cannot be identified with a particular set or rigid plurality of substances. How, then, are groups different metaphysically speaking from substances?

First, membership in a group can alter the causal powers of the group's members, but groups do not have causal powers of their own, either active or passive. We might speak of groups' "doing" things or being "altered" by the actions of others, but this is always merely shorthand for actions and passions of the group's members. Groups change only by virtue of changes in their members, and they act only by virtue of the actions of their members. Their so-called actions and passions are wholly grounded (in a merely conceptual way) in the actions and passions of the members, in the sense that the latter are the only truthmakers for the corresponding propositions about the group.

If forms are merely structures, then it is impossible to make this distinction. Groups have structures just as substances do.

E. Forms are needed to justify a principle of formal economy

Since formal causation is a real, explanation-bearing relation, theoretical economy or parsimony demands that we minimize our postulation of this relation. A more economical theory, so long as it saves the same phenomena and has other theoretical virtues to the same degree, is always to be preferred.

Aristotle's Razor: A Principle of Formal Economy. Other things being equal, prefer the theory that posits the smallest number of forms of substances, integral parts of substances, and groups of substances (that is, substantial forms, substance-part forms, and group forms).

However, if forms were merely structures, there would be no reason to embrace such a principle of economy. There would be no reason not to adopt a plenitudinous theory of structures: namely, the theory according to which any set of facts is a structure. Structures don't actually do any metaphysical work, over and above the facts that constitute them. Hence, there is no reason not to count any set of facts as a structure.

- The left half of my body has a structure.

- There is a structure that consists in the internal facts about the moon and the Eiffel Tower, plus their distance in space.
- The arrangement of pieces of bubble gum in the world is a structure.
- The number of hydrogen atoms in the world is a structure.
- The number and arrangement in the world of Hirsch's incars is a structure (where an *incar* is an automobile insofar as it is inside a garage).
- And each individual incar has an incar structure, which persists as long as the car stays within the garage.

F. Forms are needed to explain why composite substances aren't metaphysically redundant

Let's distinguish between *micro-forms* and *macro-forms*. Micro-forms are extremely simple structures, involving only mereologically simple role-fillers. Each micro-form is either the set of intrinsic facts about some mereologically simple micro-particle, or a single binary fact about the relative positions and velocities of two such micro-particles. Assuming that physics is descriptively and causally complete, the set of micro-forms is an adequate basis for all of the world's causal explanations.

Any form that isn't a micro-form is a macro-form. The forms of composite substances, such as organisms, are all macro-forms. Given Aristotle's Razor, why posit any macro-forms at all? Prima facie, they would seem entirely redundant.

There is only one reason for positing macro-forms: doing so can reduce the number of ungrounded or metaphysically fundamental forms. Let's call this the First Amendment to Aristotle's Razor:

The First Amendment. It is permissible to posit additional substantial forms if by doing so the number of ungrounded forms can be reduced.

Thus, macro-forms, including the substantial forms of organisms, are permissible additions to our ontology if and only if they can be hypothesized to be the grounds of the forms of their constituent micro-particles. This is in fact what Aristotle and Aristotelians do suppose: facts about a substance's parts, their internal character and their mutual arrangement, are wholly grounded in the substantial form of the macroscopic substance.

However, this grounding of micro-forms by macro-forms makes no sense if forms are structures. If forms are structures, then a macro-form is nothing more than a *conjunction* of its constituent micro-forms. It is a settled axiom of grounding theory that conjunctive facts are grounded in their conjuncts, not vice versa. It is only on the supposition that forms are the grounds of structure that metaphysically prior macro-forms make sense. On that view, the macro-form is the ground for each of the micro-structures and thereby also for the macroscopic structure.

G. Substantial forms explain why complex substances are not causally redundant

Trenton Merricks, in *Persons and Objects* (2013), pointed out that there causal redundancy provides a good reason to reject the real existence of many composite objects. If the actions and passions of a composite object can be completely explained in terms of the causal powers and spatial relations of an object's simple, microscopic parts, then attributing any causal power at all to the composite seems utterly redundant, an objectionable kind of double-counting. But if composite objects without emergent powers pull no causal weight, then we have no good reason to suppose that they enjoy any real existence.

Now all Aristotelian hylomorphists are causal pluralists. We want to allow for causation at multiple levels of composition, physical, chemical, biological. There are only three ways of accomplishing this:

1. **The interactionist model.** The microscopic parts retain all their ordinary causal powers. The whole (or some immaterial component like the soul) interacts causally with those parts and perhaps also directly with some of the immediate environment.
2. **Microphysicalism-macrocausation compatibilism.** The microscopic parts retain all their ordinary powers, and the microphysical level is causally complete—so there is no interaction between those microscopic parts and anything else, whether immaterial or holistic. This involves a kind of supervenient parallelism, dismissing the sort of redundancy worries raised by Merricks.

3. **The replacement model.** Either the microscopic parts themselves or their active and passive causal powers are annihilated and replaced by numerically distinct entities or powers, with the new powers essentially tied to the existence and nature of the composite whole. The whole acts through the parts: there is no interaction, but also no causal closure at the bottom. There are two sub-varieties of the replacement model: the SPM account mentioned above and my 2014 theory of *staunch hylomorphism*.

It is obvious that there is a perfect, metaphysically necessary correlation between microphysical states and states of larger-scale composite entities (like molecules or organisms). It is pretty clear that the shape, size, and internal composition of a large compound substance supervene on the locations, trajectories, and natures of its component parts. On any of the non-interactionist models (2 and 3, compatibilism or the replacement model), the causal powers (both active and passive) of the whole also supervene on the causal powers of the parts. Hence, we have complete macro-on-micro supervenience on those two models.

Ismael and Schaffer (2014) have recently argued that where we have metaphysically necessary supervenience, we should infer the existence of corresponding metaphysical grounding relations. They call this principle the Grounding Inference, building on an analogy with Hans Reichenbach Common Cause Inference, which permits us to infer a common cause from a robust nomological correlation.

Grounding Inference: If non-identical entities *a* and *b* are modally connected, then

either (i) *a* grounds *b*, or (ii) *b* grounds *a*, or (iii) *a* and *b* are joint results of some common ground *c*.

On option 3, the replacement model, these grounding relations run, at least partially, from whole to part: the whole at least partially grounds the causal powers of the simple microscopic parts. In contrast, the compatibilist must hold that the state of the whole is wholly grounded in the states and relations of the parts, in order to preserve the real causal closure of the microphysical.

In fact, compatibilism in this sense could be defined as the thesis that real causal agency on the part of macroscopic substances is compatible with *microphysicalism*:

Microphysicalism. Every truth (causal and otherwise) about any macroscopic substance is wholly grounded in the *microphysical* facts, including binary and ternary spatial relations among microparticles and intrinsic properties of those microparticles. Moreover, the grounding is *purely conceptual*, licensing a *reduction* of macrophysical things to their microphysical part and their spatial relations.³

³ Tim Pickavance and I have argued (Koons and Pickavance 2016) that we should distinguish between merely conceptual grounding and extra-conceptual grounding. In the first case, certain truths (or facts about the application of concepts) are grounded in some facts, while in the second case facts about the grounded things are grounded in some other facts. In the first case, it is the essences of our concepts that license the grounding relation, while in the second case, it is the essences of the grounded objects themselves (their real essences) that license the grounding relation. Consequently, merely conceptual grounding supports a kind of ontological reduction: we need only recognize the real

In recent years, a number of us have argued that such compatibilism requires a neo-Humean, counterfactualist account of causation—that it can't be wedded to a causal-powers ontology. See, for example, O'Connor and Churchill (2010a, 2010b), Koons (2010, pp. 304-6), and Judisch (2010).

On the Aristotelian theory, the causal powers of a substance are conferred upon it by its substantial and accidental forms. Each of these is simple and stands in a simple formal-causation relation to the whole substance. There are also accidental forms that formally-cause the natures of the microscopic parts. However, if the microphysical level is causally complete and metaphysically fundamental, there is no room for any formal causation, and therefore no room for any active or passive causal power at the macroscopic level.

I will illustrate this sort of argument by developing some words that Plato attributes to Socrates in *The Phaedo* into an argument against the compatibility of microphysicalism and intentional or rational agency (98c-99b):

And it seemed to me it was very much as if one should say that Socrates does with intelligence whatever he does, and then, in trying to give the causes of the

existence of our concepts of the grounded things, not the things themselves. Extra-conceptual grounding is inconsistent with ontological reduction, since it entails the real existence of the grounded entities. I will assume that microphysicalism includes a commitment to reduction and, therefore, to the purely conceptual grounding of macrophysical truths by microphysical facts.

particular thing I do, should say first that I am now sitting here because my body is composed of bones and sinews, and the bones are hard and have joints which divide them and the sinews can be contracted and relaxed and, with the flesh and the skin which contains them all, are laid about the bones; and so, as the bones are hung loose in their ligaments, the sinews, by relaxing and contracting, make me able to bend my limbs now, and that is the cause of my sitting here with my legs bent... and should fail to mention the real causes, which are, that the Athenians decided that it was best to condemn me, and therefore I have decided that it was best for me to sit here and that it is right for me to stay and undergo whatever penalty they order.

For, by Dog, I fancy these bones and sinews of mine would have been in Megara or Boeotia long ago, carried thither by an opinion of what was best, if I did not think it was better and nobler to endure any penalty the city may inflict rather than to escape and run away. But it is most absurd to call things of that sort causes. If anyone were to say that I could not have done what I thought proper if I had not bones and sinews and other things that I have, he would be right. But to say that those things are the cause of my doing what I do, and that I act with intelligence but not from the choice of what is best, would be an extremely careless way of talking. Whoever talks in that way is unable to make a distinction and to see that in reality a cause is one thing, and the thing without which the cause could never be a cause is quite another thing.

We can reconstruct Plato's argument using the notion of metaphysical grounding.

P1. If rational agency is real, then I have rational intentions.

P2. The content of any of my rational intentions is wholly grounded in what reasonably seems best to me to do.

P3. What reasonably seems best to me to do is at least partly grounded in the real values of things.⁴

P4. So, if I have real agency, then there are intentions of mine whose contents are at least partly grounded in the real values of things. (From P1-P3)

P5. None of the real values of things are partly (weakly) grounded by the microphysical facts.⁵ (Weak grounding is the reflexive counterpart to grounding—see Fine 2012.)

P6. If microphysicalism is true, none of the microphysical facts are partly (weakly) grounded in the facts about the real values of things, since those microphysical facts are metaphysically fundamental (ungrounded).

⁴ I am assuming that it's obvious that my intentions are not *causally* connected to the real values of things. If that were a possibility, then I would have to add a premise to the effect that the microphysical facts (and whatever is wholly grounded in them) are not causally connected to the real values of things, which also seems quite plausible.

⁵ I am not denying that the value of *particular* objects, events, and situations are partially grounded in the particular microphysical facts (as reflected in Moore's principle of the supervenience of evaluative facts on natural facts). By "the value of things" I mean the value of *general* properties and property-configurations: the value of health in general, for example, and not the value of the state of someone's body at a time. I am claiming that the facts about which *kinds* of thing favor which *kinds* of action are not grounded in the microphysical facts.

P7. No Over-Grounding: If x is wholly grounded in the y 's and partly grounded in the z 's, then either some of the y 's are partly (weakly) grounded in the z 's or the some of the z 's in the y 's.

P8. So, if I have real agency, the contents of my intentions are not wholly grounded in the microphysical facts. (From P4-P7)

P9. Therefore, if I have real agency, microphysicalism is false.

The first three premises are predicated on the idea (ably defended in recent years by Jonathan Dancy) that our intentions can be sensitive to reasons, considered as objective facts about what actions are favored in various circumstances.

Compatibilists have essentially two options in response to this argument: they can deny the existence of real or objective values altogether, or they can claim that objective values are somehow wholly grounded in the microphysical facts. Neither seems promising.

Jonathan Dancy, Christina Korsgaard and many others in recent years have created powerful objections to a Humean subjectivism about value. And, in any case, it seems that subjective values must ultimately be grounded in objective value, if reason is to have any normative force at all. Even if one supposes that particular things are good for an agent only because he or she desires them, one must still suppose that desires are the sort of thing that (other things being equal) ought to be satisfied—that there is something objectively worthy about seeking to satisfy them.

Compatibilists might attempt to combine the second option with a *tu quoque* argument directed to the Aristotelian hylomorphist. One might suppose that objective values are grounded in whatever the hylomorphist takes them to be grounded in—say, the structure of human nature—and then postulate that this intermediate level of teleologically ordered human nature is itself wholly grounded in the microphysical facts (including evolutionary history and natural selection). This response would miss its mark, since the most plausible Aristotelian account of objective value would take the structure of human nature (as the nature of a *rational* animal) to be partly grounded in the real values of things, and not vice versa. Aristotelian hylomorphists have traditionally taken the rational nature of human beings to be partially grounded in universal truths (like the real values of things) and only partly grounded in the natures of our microscopic parts. In addition, there are strong objections to the grounding of the teleology of the human mind in microphysical facts, as I have argued (Koons 2010). In addition, the best microphysicalist account of the mind is functionalism, but functionalism cannot work unless the whole organism possesses fundamental causal powers (Koons and Pruss forthcoming).

What about real chemical or biological agency? The Phaedo-style argument will not have the same force in these cases, since it is not so obvious that the relevant kind of value or *telos* isn't wholly grounded in the microphysical facts. Nonetheless, the existence of real rational agency gives us reason to prefer the replacement model to the compatibilist model, and so we have reason to apply the replacement model also at the intermediate levels of composition.

Thus, the best solution to the problem of securing the causal non-redundancy of composite objects is the replacement model, in which the powers of the parts must be fundamentally transformed. Their ordinary causal powers are replaced by numerically distinct powers that are wholly grounded in the nature of the whole substance.⁶

What is responsible for this transformation or replacement? The substantial form.

Why not structure? Because a structure is defined in terms of certain relationships among the parts. That very structure cannot be responsible for the causal powers of those parts without vicious circularity. The structure is metaphysically downstream from the causal powers and relations of the material parts: the explanation of the annihilation and replacement of the ordinary causal powers of those parts must be metaphysically prior to the structure.

⁶ Doesn't this account also violate the substrate constraint of *Physics* II? How can the material components survive the destruction and replacement of their causal powers? How can they survive the ontological demotion from substance to proper part of a substance? In my view, each microparticle has an enduring nature that enables it to have one set of causal powers when an autonomous substance and another set of powers when it is incorporated into a composite substance (like a molecule or an organism). When the composite organism corrupts, the potentiality for the component microparticles to be substances in their own right re-asserts itself.

Supervenience is at least somewhat trivial in the Replacement Model, since the microphysical states bear the imprint of their grounding macroscopic forms. The microscopic properties and powers are not the same properties and powers that would be found in microparticles in the “wild,” outside composite substances, although they may act in ways that are microscopically indistinguishable from the ways that do act on the outside. And, the Replacement version of Hylomorphism does not require the postulation of any additional fundamental forces beyond the familiar four (gravitational, electromagnetic, weak and strong nuclear forces). Nonetheless, the macroscopic forms do make a difference because they ground the precise spatial locations of the microparticles, without which the laws of conservation would have nothing to operate on.

IV. Is Staunch Hylomorphism Consistent with Modern Science?

Yes, but not with every metaphysical *interpretation* or *elaboration* of modern science.

Modern science (Galilean-Newtonian-Maxwellian) did not refute hylomorphism. Science cannot definitively settle questions of metaphysical grounding. Nonetheless, scientific knowledge can be relevant to the plausibility of competing metaphysical frameworks. A scientific paradigm can make certain acts of metaphysical imagination seem almost irresistible. In the case of the Newton-Maxwell paradigm, it was the Laplacian picture of microphysicalism that took hold of our metaphysical imaginations.

In this picture, space is a uniform, rigid, and unbreakable medium, with each microparticle (imagined as a dimensionless point) occupying a precise and determinate position at each instant of time, moving inexorably according to deterministic laws.⁷

Given this picture, microphysicalism seemed unavoidable. If everything supervenes on the microphysical and the microphysical states (including the precise binary spatial relations between microparticles) are all metaphysically fundamental (ungrounded), then everything must be wholly grounded by those microphysical states. This is obviously incompatible with the Replacement Model and with staunch hylomorphism.

However, microphysicalism is not a plausible account of *quantum* physics. The quantum revolution has changed everything—in a way that is not yet well understood by metaphysicians or philosophers of mind.

A. Quantum Holism and Non-Separable States

In quantum mechanics, many multi-particle systems (with very large numbers of particles) can be mutually entangled in such a way that the state of the whole system is non-separable. This means that the state of the whole system does not supervene on the

⁷ As we know now, the Newton-Maxwell laws were far from entailing determinism. Determinism follows in classical physics only if we impose a maximum velocity and assume that matter is finite in its complexity--without fractal locations--and that it forever avoids situations of perfect symmetry. Most importantly, classical determinism depended on the assumption that every point-particle of matter has a precise and determinate location at each instant, an empirically untestable hypothesis.

states of the individual particles, nor even on the states of any of its proper sub-systems. Entangled systems are irreducible holistic in their character. They constitute decisive refutations of microphysicalism in the quantum world.

Alternative interpretations of quantum mechanics make no difference on this point: quantum holism (or non-separability) holds equally on the Copenhagen, Everett, and Bohm interpretations, and on GRW or other objective collapse theories. In addition, holism is an even stronger and more pervasive phenomenon in quantum field theory, the most advanced and fundamental form of quantum mechanics.

I'm not claiming that non-separability verifies hylomorphism. Quantum mechanics as a physical theory does not entail that there are metaphysically fundamental states at the chemical, biological, or psychological levels. However, by no longer supporting the microphysical picture, quantum mechanics frees the metaphysical imagination to revive the hylomorphic picture of the world.

B. The Measurement Problem and Violations of Macro-Micro Supervenience

On many interpretations of quantum mechanics (in fact, on all interpretations except Bohmian mechanics), the microscopic objects do not typically have definite, determinate locations at each point in time. In fact, for both decoherence-based Many-Worlds and GRW-style objective collapse theories, particles *never* have precise and determinate locations or trajectories (even immediately after collapse). In quantum field theory,

individual quanta are radically non-localizable: they can never be located within any finite volume. As a result, the locations, volumes, and shapes of macroscopic objects do not supervene on microscopic locations in the straightforward way that they did in the classical model, in which the location of a macro-object is just the sum of the locations of its parts.

It is plausible to think that, if the macroscopic locations do not supervene on the microscopic locations in this mereologically straightforward way, they cannot supervene on them at all. In addition, given the lack of definite location at the microphysical level and the fact that it is a conceptual truth that all macroscopic objects do have delimitable locations at each moment of their existence, it is hard to see how the macroscopic facts could be *conceptually* grounded in the microscopic facts.

There are only two possibilities: it could be that macroscopic objects have delimited (although possibly vague) locations that supervene on the indefinite locations of their microscopic parts, or it could be that the locations of macroscopic objects do not supervene on the locations of their microphysical parts at all.

The second option would be absolutely fatal for microphysicalism. Although macro-micro supervenience is not sufficient for the complete grounding of the macroscopic on the microphysical, it is certainly necessary for such grounding.

The first option is not much better, since it would require, in addition to the microscopic facts, an account of how limited locations of macro-objects can be determined by the unlimited locations of their parts. It would seem that some ontological truths above and beyond the microphysical realm would be needed to guide this determination. Appealing to vagueness at the macroscopic level will not help, since such an appeal would still require an account of ontological or semantic vagueness for the macroscopic objects. The standard treatment of semantic vagueness, the supervaluation model, will not work, since on that model no proposition limiting the location of any macroscopic object would ever be *super-true*. Therefore, the microphysicalist would need some substantive account of ontological vagueness at the macroscopic level, which would require macroscopic substances to have real essences that are conceptually irreducible to pure physics. This would block a purely conceptual grounding of macroscopic objects in the microphysical realm and so again contradict microphysicalism (understood as including the ontological reduction of macrophysical objects to the microphysical—see footnote 3 above). It is quite implausible to suppose that our ordinary concepts of macrophysical objects contain strong enough constraints to determine the location of those objects, given only the quantum microphysical facts, since those ordinary concepts were fully formed long before the discovery of quantum mechanics. What we need to discover is the real essences of macroscopic substances in order to find out how it is that their locations can be grounded (either partly or wholly) in the quantum facts.

Consequently, if macroscopic objects ever have even relatively determinate locations, we must have a failure of microphysicalism.

Once again, the falsity of microphysicalism does not entail hylomorphism. However, the failure of microphysicalism leaves plenty of room, both empirically and theoretically, for Aristotelian forms of both chemical and biological natures to do their own distinctive work of helping to explain (in a non-redundant way) the locations and behaviors of composite substances.

C. Empirically Adequate Hylomorphic Interpretations of QM

The very fact that we face now a plethora of competing interpretations of quantum mechanics puts the relationship between physics and metaphysics on a very different footing from the one they had under the classical paradigm. Microphysicalism was the only plausible interpretation of classical physics. In contrast, some interpretations of quantum mechanics are extremely friendly to hylomorphism. Two in particular: the traveling minds interpretation of Barrett 1995 and Pruss 2014, and the dappled world interpretation of Cartwright 1999. Both are empirically consistent with quantum mechanics and metaphysically compatible with staunch hylomorphism.

The dappled world version of hylomorphism is an interpretation of QM inspired by some remarks of Heisenberg (1958), and defended by Nancy Cartwright (1999) and Stanley Grove (2008). On this view, the world consists of a variety of domains, each at a different level of scale. Most of these domains are fully classical, consisting of entities with mutually compatible or *commutative* properties. At most one domain is accurately described by

quantum mechanics. Since location does not (for quantum objects) “commute” with other observables, like momentum, the quantum objects are only intermittently located in ordinary, three-dimensional space, although they always retain a probability of interacting with classical objects at a definite location. Interaction between quantum properties and classical properties (including those of experimenters and their instruments) precipitates an objective collapse of the quantum object’s wavefunction, as a result of the joint exercise of the relevant causal powers of the object and the instruments, and not because of the involvement of human consciousness and choice.

Here is how Nancy Cartwright describes this pluralist view:

...quantum realists should take the quantum state seriously as a genuine feature of reality and not take it as an instrumentalist would, as a convenient way of summarising information about other kinds of properties. Nor should they insist that other descriptions cannot be assigned besides quantum descriptions. For that is to suppose not only that the theory is true but that it provides a complete description of everything of interest in reality. (Cartwright 1999, p. 232)

The Barrett-Pruss Traveling-Minds interpretation can be modified, for the purposes of defending hylomorphism, into the Traveling-Substantial-Forms interpretation. On Pruss’s picture, there is a single quantum wavefunction which describes the state of the whole of quantum reality and which evolves according to a unified, deterministic function (based

on Schrödinger's equation). However, this quantum reality is not the whole of reality, nor does the macroscopic world supervene upon it.

This quantum wavefunction can (setting aside quantum field theory for the time being) be taken as ascribing potential positions to each of the world's quantum particles. Some of the potential positions of some particles are strongly correlated with those of other particles, through a process known as *decoherence* (mentioned above). This decoherence process can be thought of as delimiting a very large set of alternative consistent histories of the world's particles. On Pruss's view, just one of these histories has a metaphysically privileged status, forming the basis for the real composition of material bodies, including living organisms. Even though this history is not *microphysically* privileged, acting simply on a par with all other consistent histories in the uniform evolution of the quantum world, it is *ontologically* distinguished by the fact that it, and it alone, corresponds to a world of real composite objects. Pruss in effect uses facts about "special question of composition" (to use Peter van Inwagen's phrase) to single out one micro-history as the material basis for a world of macroscopic objects (van Inwagen 1995).

Although Pruss's world is microscopically deterministic, the macroscopic world is dynamically indeterministic, since the consistent history that underlies that world at one time can later "branch" into several, disjoint histories. The substantial forms of macroscopic objects travel together down just one of those branches, in a way that is not determined at the quantum level, and which may be undetermined at the macro level as well, although macroscopic agency (including acts of free will) may contribute to

determining the direction of “travel.” When a composite body interacts with quantum system and the branch splits into two new branches, the joint direction taken by the substantial forms must respect Born’s rule, which determines the probability of the forms’ taking any given branch to be the square of that branch’s wave amplitude. This doesn’t mean, however, that macroscopic propensities are wholly determined by microscopic probabilities. For example, the composite bodies and their macroscopic processes might induce correlations among micro-events that make those events’ joint probabilities other than the product of their individual probabilities.

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