Is Form Structure?

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1. INTRODUCTION

The central distinction in Aristotelian metaphysics, without which there can be no such system, is that between form and matter. Hylemorphism is the theory of what they are, how they are related, and how substances are analysed in their terms. There are many aspects of hylemorphism that invite exploration, continued interpretation, and refinement. The central distinction in Aristotelian metaphysics, without which there can be no such system, is that between form and matter. Hylemorphism is the theory of what they are, how they are related, and how substances are analysed in their terms. There are many aspects of hylemorphism that invite exploration, continued interpretation, and refinement. Here I am focused on a more specific issue, organized around the crucial question of whether the form/matter distinction can be translated into terms that many contemporary analytic metaphysicians may find more palatable. The question has been brought to centre stage by the important recent work of Kathrin Koslicki,[1] who with great refinement and suggestiveness has interpreted hylemorphism in terms of the distinction between structure and content. My interest here is the attempt to identify form as structure, hence my concentration on the formal half of the form/matter distinction. Before tackling her interpretation directly, however, I want to set out a little background.

In its primary application, the distinction between form and matter applies in a quite literal way to material substances. Every material substance is a literal compound of two elements—prime matter and substantial form. Prime matter is the underlying substrate, itself wholly undifferentiated, which form actualizes to produce a material substance, be it inorganic, such as a lump of rock or a molecule of water, or organic, such as a bacterium, a tree, or a cow.

With this primary application in place, the Aristotelian is able to use the distinction in various secondary or derivative ways to explicate other kinds of object. We can, for instance, understand a proposition as consisting of matter—concepts, terms, connectives, operators—and form, namely the structure or arrangement of those material elements into a meaningful whole. Or we can speak of a piece of music as having notes (e.g. of a certain pitch, duration, loudness) as material elements and a certain arrangement or structure as form. The

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distinction can even be used in moral philosophy and action theory. What differentiates my accidentally stubbing my toe against your heel and my kicking you deliberately in the foot because I don't like you is that in the first case the matter of the behaviour, namely the simple violent movement of my toe against a part of your body, is not accompanied by the sort of formal element that makes it an assault in the second case, namely intent, or deliberateness, or something similar.

This third case takes the form-matter distinction and applies it in an analogical way, albeit one that is useful and illuminating. There are no *objects* being *structured* or *arranged*; there is a bodily movement, and it either is or is not characterized by an intention. To speak of the intention as *structuring* the bodily movement might have some purchase, but it is more suggestive than literal. In the musical and propositional cases, there is still something literal derived from the primary application to material substance, but only part of what is literal in the primary case is carried over. In the primary case, the matter really is *matter* (albeit not of the kind philosophers unsympathetic to Aristotelianism will recognize). In the musical and propositional cases, the arranged objects are not literally material (though they have material instantiations in terms of audible sounds, marks on paper, and the like). They are abstract objects (not necessarily universals), conceptual entities, logical beings—to use an older, Scholastic way of talking.

What I have said so far is all congenial to Aristotelian ears, and it is to the credit of Kathrin Koslicki that she has used the notion of structure in an effort to make hylemorphism more acceptable to contemporary metaphysicians. Her approach, however, is problematic precisely because she converts the form/matter distinction into the structure/content distinction.[2] For Koslicki, if hylemorphism is to be both intelligible and plausible, what was matter for Aristotle has to be understood as content, and the concept of form must be interpreted simply as structure. The case of action shows how the distinctions might come apart. Whereas both Koslicki and I would hold that a bodily movement is not literally structured by an intention, she would conclude (though she does not discuss the case and I can only make an assumption) that the form/matter distinction has no application whatsoever to that sort of case. Unless we can find something that is the content and something else that is the structure, no hylemorphic analysis of action is possible; at best, the hylemorphist speaks only *metaphorically.* I would conclude, however, that this is a correct way of looking at the situation only if form just is structure. We would both agree that the application to actions is non-literal. Koslicki would call it a metaphor at best; I would say that it is non-literal only inasmuch as it is *analogical:* Where there is real matter there is genuine form, and this is the primary case of material substance. Other cases are secondary in various ways and to various degrees; the musical and propositional are closer to the case of substance than that of bodily movement and intention. But this does not prevent intention being the formal element to a bodily movement's matter in a non-metaphorical, albeit analogical, sense: Intention gives a certain specificity to a bodily movement that makes it an *essentially different* kind of thing from a bodily movement not characterized by an intention. Only if form must be *structure* would the Aristotelian fail to see

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how a hylemorphic analysis might have more than merely heuristic value in this sort of case.

The laudable attempt, then, to sanitise the form/matter distinction for contemporary ears by equating it with the structure/content distinction comes at a cost. I do not think we can simply equate form with structure and matter with content; the remainder of this essay is devoted to arguing why.

2. WHAT IS STRUCTURE?

Koslicki tells us that "what lies at the heart of the notion of structure is ultimately the distinction [. . .] between what is taken as *variable* in a given domain and what is taken as *invariable,* relative to a set of admissible transformations".[3] The structure of something is its invariable component: It is not identical to but is paradigmatically expressed or defined by a set of rules (axioms, principles, further definitions) that specify the type and configuration of the elements that make up the content that bears the structure. This content is variable; as long as the elements of the content are of the right type and in the right places (both specified by the structural rules), a structured whole of a certain kind will always be present. Koslicki's favourite metaphor, borrowed from Verity Harte,[4] is that of "slots" constituting spaces within a structure where certain content elements fit according to the rules defining the structure. One of Harte's examples,[5] taken from Plato[6] and elaborated by Koslicki,[7] is linguistic: Syntactic structures are given by a set of rules specifying which linguistic elements occupy which places within a linguistic sequence such that a well-formed, that is, grammatical, sequence is the result. The simple noun-verb-noun structure contains three slots that can be occupied (as the description makes plain) only by certain kinds of content element if a well-formed sequence is to be produced. "Dogs like books", "Books like dogs", "Jim loves Jane" are all well formed precisely because the slots in the structure are filled in the right way. A sequence, of course, can be well formed syntactically without expressing something semantically proper. Another of Harte's examples,[8] discussed in some detail by Koslicki,[9] is a dinner party with a specific seating arrangement: There must be an even number of guests, equally divided between males and females, seated alternately by gender: male-female-male-female and so on. Again, the structure of the seating plan contains slots or places that can be filled only in a certain way if the structure is to be concretely realized. A third example discussed by Koslicki[10] is chemical structure. A water molecule, for instance, is a compound consisting of content elements—two hydrogen atoms and an oxygen atom—fitting into a structure that requires each hydrogen atom to bond covalently with the single oxygen atom.

We can see from these sorts of examples the way in which Koslicki understands the structure/content distinction. Indeed, her explanation is plausible as a general account of structure and derives its inspiration from the work of Rescher and Oppenheim,[11] who identify the three elements of (i) parts, (ii) domain

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of positions, and (iii) assignment of parts to positions as the constituents of a structured whole. On this analysis, we should understand the parts as the content and identify the structure itself with the domain and assignment, the domain to be thought of as the slots or places for the parts, and the assignment as representable by a set of rules, principles, definitions, and so on. For all that we might flesh out this basic account of structure in various ways, it does seem a good starting point for analysis. That said, it by no means follows that we can unproblematically carry over the account to an analysis of form. We need first to understand what form is, and we have to embed the account firmly in the Aristotelian-Scholastic tradition to which it belongs.

3. WHAT IS FORM?

At first, it might seem that structure and form are not identical because structure is an essentially *mathematical* notion and form is not. Another way of putting the point is to claim that, whereas structure is an essentially *quantitative* concept, form is essentially *qualitative.* This line of objection is, however, mistaken. Form should be understood as a *determining principle* of the actuality of something. As the Aristotelian says, every object is a this-such: It has a quiddity, a *whatness* such that there will always be and must be an answer to the question "What is it?" if it is an actual thing at all. We might not be able to *say* what it is—given our finite minds, our limited language and conceptual repertoire, our fallible powers of investigation—but, to put it somewhat rhetorically, if it is some thing, it must be *something* (as in something or other).

There is nothing essentially qualitative in the idea of form as so understood. It all depends on what we are talking about or investigating. Mathematical objects, if they have structure, will ipso facto have purely mathematical structure, where this includes geometry. If the structure is what determines the essence of the object as a structure-content compound, it should be regarded as the *form* of the object. Triangles have a certain form, as do ratios and quadratic equations. In a standard case, the mathematician can specify a domain and a set of axioms such that if the objects in the domain satisfy the axioms, they realize a certain structure.[12] This structure should be considered the form of the object in question—the determining principle that gives you the answer to the question "What is it?" asked of the object.

Here we must note a subtle but important distinction. Although form *gives* you the answer to the "what" question, it is not *identical* to the answer. The answer to the "what" question is the *definition* of the object, and the definition expresses the *essence.* The essence is not the form. Where there is a form-matter compound, the essence is expressed by the definition of that compound in terms of its form and matter *in combination.* If I tell you that gold is a metal whose atomic constituents have atomic number 79, I am giving you the definition of gold in terms of both its matter and its form, its matter being, in strictly Aristotelian terms, prime matter or underlying pure potentiality—the same for all material

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substances—and the form being the actualizing principle that determines the matter to be, precisely, a metal with atomic constituents having atomic number 79. We do not need to state explicitly that gold is prime matter with the substantial form of a metal whose atomic constituents have atomic number 79, any more than we would start the definition of a fish by saying, and without presupposing any Aristotelian doctrine of prime matter, that a fish is a material object which. . . . That a fish, or a human, or a lump of gold, is a material object is understood. For the Aristotelian, that they are all composed partly of prime matter is understood. This might make one wonder how an Aristotelian can even separate form from matter so as to be able to say *what* the formal component is. The answer is that in a sense he cannot. It is not as though the form can be held up for inspection independently of the matter and then given its *own* definition. To think that the form itself must have an essence other than that of a determining principle of actuality is a conceptual mistake. If you want to know what the form of gold is, all you need to know is that it is the determining principle of the actuality of matter such that, in combination with matter, the result (not temporal or causal—purely metaphysical) is a metal whose atomic constituents have atomic number 79.

Now, to return to the mathematical case, I said that we should regard the form of a mathematical object to be its structure—on the assumptions that the object has a structure and that the structure determines its essence in combination with a given content. But the structure is not the essence, since the essence includes the content. The essence of a mathematical object is to be a structure-content compound. Here we have a parallel with form as I have explained it: The form of a material substance is not the essence, because the essence includes the matter. The essence of a material substance is to be a form-matter compound. Just as in the material case, in mathematics we do not have to make explicit reference to the content. We can say—as we usually do—that a quadratic equation is an equation of the form $ax^2 + bx + c = 0$, where it is implicit that a, b, c, and x take numerical values. Or we can say—as we usually do not—that a quadratic equation is a combination of numerical constants and variables in the relation $ax^2 + bx + c = 0$ or some such equivalent way of stating it.

In the material case, as I claimed, you cannot hold the form up for inspection, as it were, without thinking of it as something essentially compounded with matter. You can think of the form as a universal, to be sure; the form of gold is the universal principle that determines anything that has it to be a metal whose atomic constituents have atomic number 79. But, in so doing, you must understand the form (if you grasp it at all) to be true only of a further material component such that the result is an object belonging to a certain species (or substantial kind, as contemporary Aristotelians like to say). Similarly, in the mathematical case you cannot hold the structure (i.e. form) of a quadratic equation up for inspection without thinking of it as something that essentially composes with a numerical content to yield an equation of this kind. Still, as with the material case, you can think of the structure as *abstracted* from its correlative

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content, that is, as a universal mathematical form that determines any instance of the appropriate content to be the content of a quadratic equation.

This brief but important digression allows us to get a better grip on the parallel between form and structure. Both compose with another element—matter and content, respectively—to yield a certain kind of object. More precisely, the mathematical case (as do the linguistic and musical) shows the structure-content relation just to *be* an instance of the more general form-matter relation. The matter of a quadratic equation is not literal matter as in the case of gold, but neither is this way of speaking in the mathematical case mere metaphor. Rather, it is analogical: Equations have numerical matter, and this is a genuine kind of matter, just as we speak non-metaphorically of the matter of a speech, the subject-matter of an essay, and so on. Nevertheless, if we take literal matter to be just the stuff of which material substances are composed, then these other ways of talking of matter are non-literal as well.

Now, I take it that structure is an essentially quantitative notion; the structure of a given content concerns and concerns only the mathematical properties of that content broadly construed, in which I include the geometrical properties and/or any properties that concern only the arrangement or configuration of the content. Syntactic well-formedness in language and logic, the pitch relations between musical notes, the distance between some elements in a sequence, the shape of a polygon: These and others exemplify quantitative features of things, whether purely numerical or else mathematical in the broader sense that involves such concepts as configuration, arrangement, position, direction, and dimension. If we have the content, whether it be a set of specific objects or some range of specific objects (e.g. real numbers as values of some variable in an equation), we are—I will assume—in a position to specify the structural properties of those content elements, if there is a structure that they possess. For mathematical objects this can be done in the way outlined earlier and as Koslicki sketches it in her brief account of mathematical structure. The same can be said for musical, logical, and linguistic structure. In all of these cases, we have a specific content—notes, propositions or sub-propositional elements such as variables and quantifiers, lexical elements or sub-lexical morphemes—and can demonstrate how those content elements are arranged or configured to yield a structure-content compound such as a melody, a complex or compound logical formula, a phrase or sentence, and so on.

In all of these cases, it is plausible to identify the structure of the compound with its form. In other words, what unites the content elements into a structural whole just is the determining principle that actualizes the content as part of a compound with an essence. If structure is essentially quantitative, as I also assume, then we can plausibly assert that mathematical, musical, linguistic, and logical compounds all have an essentially quantitative structure or form. Form can, then, be a purely quantitative notion when applied to those objects for which a quantitative essence can be specified. The quantitative essence will be *these* items with *this* structure. It would be a mistake to claim that such an essence need not be purely quantitative since the content elements

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(e.g. morphemes) cannot be specified purely quantitatively. For it is not the content elements *themselves* whose essence we are interested in when considering the essence of the structure-content compound. We are concerned with the essence of the compound, and *this* can be specified purely quantitatively as a structure on certain elements.

The moral of the story so far is that form is not a purely qualitative notion. Quite simply, it depends on what object you have in mind. The form of a thing might be no more than its structure, and the sorts of examples Koslicki gives—apart from chemical structure, to which I will return—are of just the kinds of object for which the identification of form and structure seems right. But this is not enough to make good the general identification of form and structure, as Koslicki intends. Form is not a purely qualitative notion; it may have a quantitative component, and it may even have an *exclusively* quantitative component in some cases. But some cases are not good enough. For a general identification, it would have to be the case that form never had a qualitative component, in other words that structure, in the way defined earlier, always exhausted the formal component of a thing's essence. The concept of structure could, of course, be sufficiently loosened and broadened to the extent that it also embraced the qualitative components of form, but this would be a cheap victory that evacuated the concept of anything distinctive that would make a form-structure identification metaphysically interesting. The issue, rather, is whether structure as defined here can be identified with form in all cases. I submit that it cannot, for at least two reasons: The first concerns the fixing of content in the structure-content distinction, and the second concerns the irreducibly qualitative aspect of form in the central cases of interest—material substances. In this essay I discuss the first problem.

4. THE CONTENT-FIXING PROBLEM

Key to the structure-content distinction is the idea that there is a separately identifiable content whose structure can be specified. So, in Harte's dinner party example we have the guests to fill the "slots" in the arrangement: They exemplify the relevant structure if and only if they are seated alternately by gender. In the linguistic case, we have the lexical content—the words whose structure will result either in a well-formed sentence of a certain kind or will not.[13]

The problem—call it the *content-fixing problem*—is that this picture of how content is differentiated from structure does not work so well for material substances, the core of the Aristotelian ontology. Indeed, as an ad hominem point, it is telling that, for all Koslicki's intention of describing a neo-Aristotelian hylemorphic metaphysic in terms of structure and content, the examples with which she ends her study, apart from the chemical one to which I will advert shortly, are *not* examples of material substances.

In a word, the problem is this: How is the content of a material substance to be fixed? It if cannot, then neither can the structure. From which it would

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follow that there simply *is* no viable structure-content distinction to ground a neo-Aristotelian ontology of material substances, leaving the whole project empty and unmotivated. So let us consider an example. Koslicki's case study of chemical structure is that of the water molecule. She tells us that the "formal components" of an H_2O molecule "dictate that a whole of this kind must be composed of a single oxygen atom and two hydrogen atoms, arranged in the particular configuration of chemical bonding, which requires the atoms in question to share electrons".[14] Again, "the material components of which an H_2O molecule consists, viz., the two hydrogen atoms and the single oxygen atom, must always exhibit the relation of chemical bonding, for as long as they compose an H_2O molecule".[15] And further, "specimens of the kind *H_2O molecule* come into existence when two hydrogen atoms and one oxygen atom enter into a particular configuration of chemical bonding".[16]

From this, it is clear that Koslicki regards the atoms of hydrogen and oxygen as the content of the water molecule and the bonding configuration as the structure. But she could as plausibly have regarded the *quarks* in the molecule as the content and *their* configuration as the structure. From what physics tells us,[17] protons and neutrons are made of quarks. Protons consist of two up quarks and a down quark, with a charge summing to +1. Neutrons consist of an up and two down quarks, with the charge summing to 0. The quarks are held together by gluons, the particles that carry the strong nuclear force. Adding an orbiting electron to a proton gives us a hydrogen atom. Eight protons, eight neutrons, and eight electrons give us an oxygen atom. Since an H_2O molecule comprises two hydrogen atoms bonded to an oxygen atom, the molecule will consist of twenty-eight up quarks, twenty-six down quarks, and ten electrons. Moreover, these quarks have to be configured in exactly the right way. If any part of the quark configuration just sketched were different, there would not be a water molecule. Now, the structure on the quarks in an H_2O molecule is different from the structure on the atoms in an H_2O molecule. The first includes relations between the quarks in the nucleons—protons and neutrons—of each nucleus. The second does not; it includes only the relations among the three atoms. Different contents yield different structures.

Why can't the structural hylemorphist (as I will call the defender of Koslicki's position) reply that the structure and content depend on the way you look at or "carve up" the object in question? Could she not say that if you think of the water molecule as being made of quarks, then its structure will be such-and-such, whereas if you think of it as made up of atoms, its structure will be so-and-so? The problem is that the structural hylemorphist sees structure and content as the way in which form and matter should be interpreted. On the Aristotelian view, there is only a single form and matter for each hylemorphic compound. The form and matter a substance possesses in no way depend on how anyone "carves up" the entity in question. If it did, what would block the conclusion that form and matter were not *real* constituents of the substance, as Koslicki (in the guise of structure and content) and the classical Aristotelian both contend? Here we have the makings of a dilemma. Koslicki rightly

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claims that form is a genuine *part* of the substance.[18] Yet it is hard to hold onto this claim while at the same time multiplying forms according to the numerous (infinite?) contents available for choice. For the forms (structures) to be real components, so do the contents. Hence, the structural hylemorphist has to hold that the content of the water molecule is atoms *and* that it is nucleons (and electrons) *and* that it is quarks (and electrons) *and* that it is something else if, for instance, we find that quarks are themselves mereologically complex. Yet this involves patent double counting, for what is being claimed is that the molecule is made of atoms *and* made of nucleons (and electrons) *and* made of quarks (and electrons), and. . . . Clearly this is not the right way to understand the composition of a molecule. The correct way is to say that it is made of atoms *which* are made of nucleons (and electrons) *which* are made of quarks (and electrons),[19] and so on if we can go further. In other words, multiple structures require the double counting of content, which is unacceptable if the contents are supposed to be as real as the structures. But if it is only a matter of choosing to "carve up" the molecule in one way rather than another, the structures are not real components of substance but somehow relative to perspective or choice. This avenue is no more palatable than the first. I turn now to some further clarifications, distinguishing the content-fixing problem from some other problems and pointing out an incorrect way of responding to it.

5. WHAT THE CONTENT-FIXING PROBLEM IS NOT

5.1 Unicity of Form

It is a standard doctrine of Aristotelian hylemorphism, at least as elaborated by Aquinas, that each substance has one and only one substantial form. So, for example, a cow does not have a number of distinct forms such as the form of an animal, the form of a mammal, and the specific form of a cow. Rather, it has a single form, the form of a cow, in virtue of which it is also an animal and a mammal, among other things. All of the genera it belongs to (including *material substance*) are determined by its bovine form. There is no space to defend the doctrine here.[20] All I wish to point out is that the content-fixing problem is not the same as the objection that structural hylemorphism is committed to denying the unicity of (substantial) form. It certainly looks as though it is so committed if the structural hylemorphist asserts that for every plausible candidate for the content elements of a material substance—including quarks and atoms in the H_2O molecule—there is a distinct structure. If there is no good reason to choose one over the other as *the* content of the substance, then if both are regarded as contents there will be more than one structure that the substance is said to possess. If structure is form, then the structural hylemorphist is in effect claiming that the substance has more than one form, thus denying unicity (with all the problems that entails).

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Still, there is at least one other way to go, as suggested earlier. The structural hylemorphist can claim that what structure a substance has "just depends" on what you take to be the content, and what you take to be the content will be determined by, say, what you're interested in scientifically or from some other perspective. On this view, the water molecule, for example, does not have both a structure on the quarks and a structure on the atoms pure and simple. Rather, it is the case that *if* you take the quarks as the content, then it has *this* structure; but if you take the atoms as the content, then it has *that* structure. There is thus no straight denial of unicity. To be sure, taking this relativized route is highly implausible, but that is another matter. The content-fixing problem is precisely the problem of how one is to decide which of a number of given candidates is *the* content of a substance such that one is then able to determine what is *the* structure of that substance. Some approaches to solving this problem seem to entail the denial of unicity, but the problem itself is not that the structural hylemorphist denies unicity.

5.2 Hierarchy of Composition

Mereologically complex material substances have parts that are themselves mereologically complex, and the complex parts themselves have further complex parts. (The exception, from what physics tells us, is hadrons, on the assumption—which we can grant for present purposes—that the quarks making them up are mereologically simple.) Koslicki calls this the hierarchical nature of composition,[21] claiming as part of her structural hylemorphism that the parts of complex substances have a structure-content composition along with the substances they compose. The formal components of the parts are, by the transitivity of parthood, also parts of the substances, but they are not what she calls "formal components *simpliciter*", by which she means that they are not the formal components that specify how the material components of the substance in question have to be "put together"[22] in order for a substance of that kind to exist.

The idea that a substance has formal components as literal parts *in addition* to the form that actualizes it as a substance of a certain kind will strike most Aristotelians as strange. What rôle do these "derivative formal components"[23] play? They do not compose the substance; what composes the substance are its own form and matter. Forms (tautologically) *inform* that to which they belong. But these derivative forms belong to substances without informing them (as opposed to informing their parts).

Here is a way Koslicki might avoid positing derivative forms: Just say that the structure of the molecule (to continue our usual example) is a structure on the quarks and that any so-called derivative form is really only a *substructure* of the quark structure. Now, instead of derivative forms being parts of whole substances (without doing any informing or composing of the whole substances, like idle ontological wheels), what we will have is substructures (at the sub-molecular level, whether quarks or nucleons) as parts of the *structure*

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of the whole substance, not as parts of the substance itself. Note that this proposal is more in line with classical form/matter theory, according to which any sub-molecular forms are only aspects of the overall substantial form of the molecule, not forms that compose the substance (in a "derivative" way) along with the form "simpliciter" that specifies the substantial kind to which the molecule belongs.[24]

My main reason for making this proposal, however, is to show how the content-fixing problem is not the result of a failure to acknowledge the hierarchy of composition. Recall that the content-fixing problem is that there is no principled way of identifying the unique content of a material substance, hence no way of identifying the unique structure. The structural hylemorphist might reply that if you take into account the hierarchy of composition, the problem vanishes. Molecules are complex, and so are their parts. Hence, we can retain the triangular molecular structure of a water molecule as *the* structure of that substance, with the two hydrogen atoms and the single oxygen atom as *the* content. To ask why a structure on the quarks is not *the* structure is to miss the fact that composition is hierarchical; within each atom there is further structure, down to the quarks. Add this further structure and you end up with a structure that is *isomorphic* to the originally proposed quark structure. But this nested structure is not *the* structure of the molecule, for the latter is no more than a structure on the atoms.

Nevertheless, this will not do. For, as we saw, the quark structure does not yield sub-molecular structures as *parts* of the molecule along with its molecular structure, as on the hierarchical picture. Rather, it yields *substructures* of the molecular structure. More generally, if the claim is that the unique structure of the molecule is the structure on the atoms, then no quark structure enters *at all* into the description of this structure. Rather, the unique structure is, purely and simply, the triangular bonding structure among three atoms. If, by contrast, the quark structure is the unique structure of the molecule, then sub-molecular (and sub-atomic) quark structure *does* enter into the description of this molecular structure. We can still acknowledge a hierarchy of structure in the sense that the quark structure is mediated by atoms composed by those quarks. But the quark structure is not extrinsic to the molecular structure on the atoms, as it would be if it were merely a nested structure lower in the compositional hierarchy. Rather, it *is* the molecular structure—a structure not on atoms but on quarks. Hence, there is no isomorphism between a molecular structure on atoms and a molecular structure on quarks. These are two different structures on two different contents. The problem, as I have stated, is how to choose between them on metaphysical principle.

5.3 Reductionism

Is the solution to the content-fixing problem dependent on where we should stand on reductionism? If physical reality is all just quarks (again, let us keep it simple and leave out electrons, gluons, and so on), then surely we have a

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principled reason for choosing the quark structure as the unique structure of the molecule. If reality is not all just quarks, then we have to move to a higher level, with the obvious place to stop being atoms and their inter-atomic bonding structure.

I submit that the problem cuts across any reductionism/anti-reductionism debate. Aristotelians are not known for being reductionists. But an Aristotelian could still in good conscience prefer the quark structure, on the grounds not that *all* there is are quarks but that quarks are still the ultimate building blocks of the universe. After all, the Big Bang story is that hadrons came into existence from a quark (and gluon) "soup". So, if we look at it chronologically, and using Koslicki's terminology, atoms were "built" or "put together" out of quarks. But that does not mean quarks are all there are.

On the other hand, an Aristotelian might prefer the inter-atomic structure on the grounds that as far as anyone knows it is not possible now to "build" or "put together" a water molecule out of quarks; you need atoms. In any case, given their anti-reductionist leanings, Aristotelians will typically defer to the autonomous special sciences: Chemists study atoms (and so do physicists); chemistry is an autonomous special science (here, fill in with your preferred defence of autonomy); so there are atoms, whatever they are made of, and molecules (also studied by chemists), and the chemists tell us that molecules have an atomic structure. End of story, minus a few details.

Similarly, reductionists might plausibly choose the quark structure if they think that quarks are the "fundamental level" at which non-redundant laws and causal powers exist and on which all the other laws and powers supervene.[25] But they might choose the inter-atomic structure if they hold to a weaker kind of reductionism, say one according to which only some ideal, never-to-be-completed sub-atomic physics would explain the powers and laws existing at the atomic and molecular levels. Absent this, the molecule's atomic structure is all we need to account for what the molecule is and how it behaves.

Reductionism, then, cannot solve the content-fixing problem for the structural hylemorphist.

6. SOME CONCLUDING ISSUES

6.1 The Analogical Cases

Suppose the content-fixing problem is genuine. Doesn't it apply equally to any attempt to analyse music, logic, and language in terms of a compound essence of structure and content? Yet are these not the most convincing examples of structural hylemorphism at work?

I have assumed for the purposes of this discussion that that the problem does not apply to these cases. The assumption can be motivated, however. Each of language, music, and logic appears to have natural atomic units (in the loose

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sense of "atomic")—units such that if you go within them to find further structure, you find entities of a different kind altogether. Language has words as the essentially smallest, free-standing units of meaning. If you analyse more deeply than the word you find sub-lexical, bound morphemes that essentially do not stand alone semantically, such as "-ed" and "-tion" (as in "jumped" and "realization"). So we have a natural place at which to carve a sentence into structure and content.

Similarly, music has notes as natural, atomic units—the things you can play and hear just as you can play and hear musical phrases, melodies, and symphonies. Go within the note and you find something entirely different, namely constituent qualities such as pitch, loudness, and timbre. These are not sounds but *aspects* or *features* of sounds, just as bound morphemes are not free-standing units of meaning like words, noun and verb phrases, and sentences: They are *elements* or *ingredients* of free-standing units of meaning.

For a long time (too long, for Aristotelians), it has been taboo in philosophy to speak of *the* essence of logic, as opposed to that of different logical systems (for all the canonical status of first-order logic with identity). We can respect the taboo, however, and still note that for each logical system there is again a natural atomic unit on which a correlative structure operates. In propositional logic, it is the proposition. In predicate logic, it is predicates, variables, and constants. In traditional Aristotelian syllogistic, it is the term. The syncategorematic elements, be they the propositional connectives with or without quantifiers and the identity sign or the quantifiers, copula and negation (as in syllogistic), provide the structure on/configuration of the content of the system in question. Go within the atomic content elements and you either find nothing or you find elements not treated by that system (though they might be by another). Again, there seems to be a natural place at which to carve up structure and content.

In the case of a paradigmatic material substance such as our water molecule, however, there does not seem to be a natural place to carve, in the following sense: You start with a molecular substance; you find particles as constituents (atoms); you find more particles constituting the atoms (nucleons and electrons); and you find yet more particles constituting the nucleons (quarks and gluons). However deeply you go, it's just more particles. This makes the case importantly different from the analogical ones just discussed.

On the other hand, suppose all of this is wrong, and the content-fixing problem does apply equally to these analogical sorts of case—music, language, logic, and perhaps others. All that results is that structural hylemorphism fares even worse than it does already. It would force the structural hylemorphist back to the drawing board for all cases, not just that of material substance.

6.2 Should the Hylemorphist Deny Structure Altogether?

The short answer is—of course not. It might seem as though the content-fixing problem does away with structure altogether. If it is wrong to speak of

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the structure of the H_2O molecule, then is it not equally wrong to say that it has *a* structure at all? This would be an absurd result. Of course we can reply that not having a unique structure fails to imply the lack of any structure at all, but that might be thought to miss the point. If the hylemorphist is committed to saying that the molecule has *many* structures, then this just looks hopelessly relativistic, or conventionalist, or anti-realist, or plain vague. So much for metaphysicians' giving natural science a strong foundation.

I respond that none of these epithets deserves to be thrown at an advocate of the many structures of the water molecule. None of these structures (atomic, nucleonic, quark) is *competing* with another. Each is a real structure with a certain, very specific content. The structures no more compete with one another for the title of "The Water Molecule's *Real* Structure" than the respective contents compete for the title of "The Water Molecule's *Real* Content". To be sure, if you are interested in the relations between the atoms, you need to look at the inter-atomic bonding structure. If it is the quarks that interest you, then look at the quark structure and study quark-molecular calculations. But none of this means that these structures, ontologically speaking, are a matter of what anyone is interested in (even if the interest is for good scientific reasons). These structures are simply all of a piece—aspects of the *form* of the water molecule. One form, many structures and many contents—and much else.

6.3 The Qualitative Problem

If the content-fixing problem as applied to the humble water molecule has demonstrated severe worries about Koslickian structure-content hylemorphism, how much more will it show the weakness of this approach when applied to living things?

What is the structure of a horse? And what is the content? Of course this animal has a structure, of the kind you read about in textbooks of equine physiology: body plan, bone configuration, nervous system, cardiovascular system, and so on. The physiologist will happily and correctly talk of all of this as parts of *the* structure of the horse. The classical hylemorphist will translate this into talk of aspects of *the* form of the horse. And he will add more, since mere structure in the sense of configuration of parts is far too *static* a concept to tell you all there is about the form of an animal: There are its characteristic functions and behaviour, its dispositions, instincts, tendencies, actions and reactions, and all the rest of which ethology is made. These *dynamic* notions have to be added to the relatively static structural notions to get us to something like an account of the form of a living thing. The other side of the same issue is that the structural hylemorphist has no principled way of settling on *the* content of a horse. If it has a unique structure in the sense of configuration of elements, what are those elements? Horse flesh and bones? Organs? Cells? Proteins? Genes? Molecules? Atoms? Or maybe quarks again?

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The enterprise looks rather hopeless, but a central point needs to be made here. Most of these candidate content elements come *too late* in the metaphysical analysis for them to count as viable. Genes, for example, already contain the information required to express the equine phenotype. In Aristotelian terms, to talk of horse structure as a structure on genes misses the point that much (by no means all) of what the hylemorphist wants to say about the form of the horse is already *in the genes.* Once you have identified genes as the content, you can no longer pretend that the structure on those genes is the form. Rather, you have already split up the form into a structure and a putative content, which from the Aristotelian point of view is both categorially confused and metaphysically mistaken. And if genes come too late in the analysis to play the rôle of content, *a fortiori* do proteins, cells, organs, horse flesh and bones, and the like.

Well, perhaps the structural hylemorphist could fall back on molecules, atoms, and quarks? As we have seen, this certainly will not eliminate the content-fixing problem, but again for the classical Aristotelian all of these come too late as well, at least for living things.[26] All of these constituents of the organism have no independent function; they are parts and parts only of the living thing to which they belong, their functions and operations being determined completely by the whole. This does not mean that there are no atoms or molecules in a horse. It means that these elements exist in a *virtual* rather than a *real* sense within the organism. Everything they do is directed to the functioning of the organism. Take an atom out of a horse, and the atom literally ceases to exist, being replaced by a substance, namely a *real* atom of the same kind. Needless to say, these are big claims that will have to be made good elsewhere.

The remarks in this sub-section all converge on what I call the "qualitative problem" for any purely structural account of form. There is just too much in the notion of form for structure to be a viable surrogate, let alone what Aristotle, or Aquinas, or their legions of followers *really* meant when they talked about form. Form has an irreducibly qualitative aspect, supplementing its quantitative aspects which can usefully be called structure, or better structural features. Taken together—taken *holistically*—we get a picture of the form of a substance. We focus on one to the exclusion of the other at our peril. Again, however, the qualitative problem must await fuller treatment on another occasion.

NOTES

1. K. Koslicki, *The Structure of Objects* (Oxford: Oxford University Press, 2008).
2. Her most explicit statement is on p. 237 of *Structure,* where she says: "The closest synonym to the term 'structure' is probably 'form', which I have in the preceding sections assumed to be interchangeable with it; I will continue to do so in what follows."

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3. *Ibid.,* 236.
4. V. Harte, *Plato on Parts and Wholes: The Metaphysics of Structure* (Oxford: Clarendon Press, 2002).
5. *Ibid.,* 173.
6. Plato, *Sophist,* 261d1–262e1, in *Plato: Complete Works,* ed. J. M. Cooper (Indianapolis: Hackett, 1997), 301–302.
7. Koslicki, *Structure,* 248–252.
8. Harte, *Plato on Parts and Wholes,* 159–167.
9. Koslicki, *Structure,* 115–116, 235–236.
10. *Ibid.,* 244–246, 255.
11. N. Rescher and P. Oppenheim, "Logical Analysis of Gestalt Concepts", *British Journal for the Philosophy of Science* 6 (1955): 89–106.
12. See further Koslicki, *Structure,* 240–241.
13. I leave aside for simplicity's sake issues concerning type structures and token structures. Token structures are exemplified by particular entities or ranges of entities (if there is a variable slot). Type structures have only variable slots, but some of these are what we might call second-order variable. The type structure of a quadratic equation is $ax^2 + bx + c = 0$. The slots for constants take particular numbers, but as a type structure each constant slot is variable, giving different token structures such as $7x^2 + 3x + 1 = 0$, $4x^2 + 2x + 9 = 0$, and so on. The variable slots of the type structure should be thought of as akin to Quine's schematic letters (*Philosophy of Logic,* 2nd ed. [Cambridge, MA: Harvard University Press, 1986]), simulating variable terms which then, at the token level, take a range of numbers.
14. Koslicki, *Structure,* 173.
15. *Ibid.,* 189.
16. *Ibid.*, 197. See also p. 255 for further elaboration concerning the shape of the molecular bond.
17. Suppose the whole story is incorrect. Still, something like it *could* be true, and, since neo-Aristotelians are concerned with essences, the fact that content is not fixed across all possible worlds is enough to show that the essence of a substance cannot be given by a structure-content formulation.
18. Koslicki, *Structure,* 179–186. She uses this claim to provide a mereological solution to the problem of distinguishing between spatio-temporally coincident objects such as a statue and a lump of clay, where the lump is itself a proper part of the statue. Her case relies crucially on a fundamental principle of mereology, the Weak Supplementation Principle, which I criticise in "Survivalism, Corruptionism, and Mereology", *European Journal for the Philosophy of Religion* 4 (2012): 1–26.
19. A slightly awkward way of describing it, but the point is clear enough.
20. I defend the doctrine at some length in my *Real Essentialism* (London: Routledge, 2007), 68–71.
21. Discussed in Koslicki, *Structure,* 186–188.
22. *Ibid.,* 187.
23. *Ibid.*
24. As throughout this paper, I use the term "aspect" in a metaphysically neutral way that does not imply anything about whether substantial forms are simple or complex. I discuss this difficult issue a little in "Essence and Properties", *Erkenntnis* 75 (2011): 85–111, but further discussion must be left for another occasion.
25. See A. Bird, *Nature's Metaphysics* (Oxford: Clarendon Press, 2007) for this characterization of the fundamental level.
26. Not just for living things, in my view. See *Real Essentialism,* 71.

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