AMERICAN UNIVERSITY OF BEIRUT

STAR STUFF AND FORMS: HYLOMORPHISM AND MEREOLOGY

by
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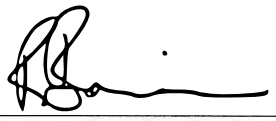

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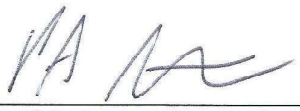

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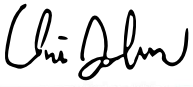

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ABSTRACT
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Hylomorphism, regardless of its historical associations, is the doctrine that form and matter are both ontologically fundamental constituents of objects in this world. It has been a viable ontological project in the last few decades for it provides an alternative to reductionist theories, as well as emergentist ones. Hylomorphism however, has its own unsettled controversies. One of which whether form and matter stand in parthood relations towards the compound and towards each other in the compound. This controversy contains two main intricately related questions: first, whether form and matter are parts of a hylomorphic compound. Second, the question of what is a 'part.'. The study of parthood relations, known as mereology (after the Greek μεροϛ/meros meaning 'part'), within a hylomorphic compound forces us to consider the literature on mereology, especially the attempts of formalization of mereological relations. It seems, however, that standard formal mereologies do not reflect the relations of matter and form we have in a hylomorphic compound. Thus, if Hylomorphism is true, then we need to find a new theory of mereology. This thesis aims at introducing a version of Hylomorphism I call Scientific Hylomorphism with a refined understanding of form and matter and which makes use of classical extensional mereology but an alternative mereology constructed in the thesis I call Morphological Mereology for the sake of describing parthood relations within a hylomorphic compound. Ultimately, this thesis aims to contribute to a longer project of developing and formalizing a new hylomorphic theory.

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CHAPTER I

INTRODUCTION

Mereology (after the Greek μεροϛ/meros meaning'part')[1] as it appears in contemporary ontology is a study of the relations between parts and wholes and between parts themselves within a whole. Questions about mereology however, as most philosophical questions, date back to Greek philosophers. Relations of parts and wholes have been discussed since the pre-Socratics, Plato[2] and Aristotle. Philosophers were interested, since then, in the nature of the relationship between the many elements being mixed to form wholes, a relationship that is also often expressed as a relationship between the one and the many.[3] The idea of mixtures, however, nests for these philosophers and especially for Aristotle several problems. For instance, in some mixtures, elements seem to pass away and wholes seem to be generated. Furthermore, as Aristotle himself notices:

There is, indeed, a difficulty about part and whole, perhaps not relevant to the present argument, yet deserving consideration on its own account, namely, whether the part and the whole are one or more than one, and in what way they can be one or many, and, if they are more than one, in what way they are more than one. (*Phy*.1.2, 185bll) These questions of Aristotle did not die after him, as mereology remained a topic of philosophical discourse. In the 20th century, however, great effort has been put in

[1] The first philosopher to use this term was Stanisław Leśniewski in his 'O podstawach matematyki' translated as 'On the Foundations of Mathematics' (1927)

[2] See for example Plato's *Parmenides.*

[3] See for example Halper's One and Many in Aristotle's Metaphysics.

formalizing large portions of fields of philosophy, one of which was mereology. At the same time, a neo-Aristotelian movement emerged attempting to resurrect several of Aristotle's main notions.

A. Aristotelian Hylomorphism

Aristotle contemplates complex objects concluding that "the combining constituents not only coalesce, having formerly existed in separation, but also can be separated out from the compound" (GC 327a32). This seems to nest for Aristotle several ontological questions, on generation and corruption of parts and wholes, but also on what is unity. In *Met*. Z.17, Aristotle distinguishes between two kinds of combinations or complex objects. A complex object is to be understood here in the broadest sense. So, a human, a bouquet, a table, a party and a hand are all complex objects. The distinction Aristotle gives is between two kinds of these complex objects, heaps (σωρός) and wholes. Heaps are merely aggregates of matter. As he puts it:

> Evidently even the things that are thought to be substances, most are only potencies–both the parts of animals ... and earth and fire and air; for none of them is a unity; but as it were a mere heap, till they are worked up and some unity is made of them. (*Met.*1040b5-10)

Wholes, on the other hand, for Aristotle are substances composited of *matter* and *form*. What distinguishes wholes from heaps is that the former 'are worked up' thus they have 'some unity.' Wholes seem to be, for Aristotle, genuine 'one's (ἕν), unlike heaps which are merely bundled matter by spatial coincidence, that is, they are merely beside each other. The distinguishing feature which makes wholes' 'worked up' is that wholes "contain something else" over and above the matter. This additional component is the form or the essence (εἶδος). Being a composite of *matter* and *form* is what makes

a combination 'one;' this doctrine that compound wholes are made of *matter* and *form* came to be known as hylomorphism (from the Greek *hulê* matter and *morphê* form). Now, speaking of a composite as that which has form and matter within it, seems to suggest that form and matter are parts of the hylomomorphic compound. However, whether both matter and form are parts in the same sense has been a controversial topic among hylomorphism scholars as we will see later.

B. Contemporary Hylomorphism and Parts

In the wake of contemporary hylomorphic theories, several controversies appeared in interpreting parthood relations in hylomorphic compounds. Different scholars emphasized different quotes by Aristotle to support their claims. Others also explained hylomorphic parthood relations without abstruse Aristotelian resources. Let us first lay down the ground of the different views on this matter in contemporary philosophy:

Kathrin Koslicki (2006) took a literal understanding of Aristotle, where form and matter are both parts of a substance. She makes central to her hylomorphism the claim that the material and formal components of a mereologically complex object are proper parts of the whole they compose (Koslicki, 2008), emphasizing quotes from Aristotle like the following:

> But do some also of the elements in the formula pre-exist? Well, we describe in both ways what bronze circles are; we describe both the matter by saying it is bronze, and the form by saying that it is such and such a figure; and figure is the proximate genus in which it is placed. The bronze circle, then, has its matter in its formula. (*Met.*1033a1)

Johnston (2006), on the contrary, believes that form is not part of the substance depending on what is often called the 'regress argument'[4] which is also inspired by Aristotle:

> Since, then, that something [present in wholes but absent in heaps] must be either an element or composed of elements, (1) if it is an element the same argument will again apply, for flesh will consist of this and fire and earth and something still further, so that the process will go on to infinity, while (2) if it is a compound, clearly it will be a compound not of one but of many (or else it will itself be that one), so that again in this case we can use the same argument as in the case of flesh or of the syllable. (*Met*.1041.9-25;)

Unlike these philosophers, I am not concerned in this thesis with exegetical or interpretive controversies. I take hylomorphism to be merely the doctrine that form and matter are both ontologically fundamental constituents of objects in this world. However, how to understand parthood within a hylomorphic framework is the major topic of this thesis, where I will be taking Johnston's view on this as you will see later on.

Starting from here, I wish to construct a formal representation of the mereological commitments of hylomorphism. I believe a rigorous formalization of hylomorphism's mereology could answer many of the questions about hylomorphism itself. Thus, it doesn't matter whether Aristotle turns out to believe that some component is part of the compound or not. What I owe to Aristotle in this thesis is the most basic intuition of hylomorphism as defined above and another controversial claim I will try to challenge:

> A part may be a part either of the form (i.e. the essence), or of the compound of the form and the matter, or of the matter itself. But only the parts of the form are parts of the formula. (*Met.* 1035b30)

[4] See for instance Koslicki 2006

The goal of this thesis, thus, is to establish a clearer version of hylomorphism through looking at its mereological commitments in the light of contemporary mereological tools. In the second chapter, I will be presenting briefly some motivations to believe hylomorphism is a viable doctrine by looking at couple of its applications. Then in the third, I will investigate what is often called *standard mereology* with its commitments and axioms, before I criticize it in the fourth chapter, which will be devoted to explaining how I understand hylomorphism, or what I shall call Scientific Hylomorphism. After that, I will present, in the fifth chapter, a formal presentation of hylomorphic mereology including sub-parthood relations within form and matter not only within compounds of matter and form. This I will call Morphological Mereology. Finally, in the sixth and final chapter, I will draw some conclusions about hylomorphism from the previous chapter. By the end of the thesis, I hope to have shown that if scientific hylomorphism is true, then standard mereology is insufficient and that a hylomorphic mereology could be established for the sake of describing parthood relations in hylomorphism, which in turn proves to be a very useful tool in distinguishing heaps from wholes, and matter from form.

CHAPTER II

WHY HYLOMORPHISM?

Some philosophers find ideas like hylomorphism outdated and in strong opposition to their fundamental understanding of metaphysics. However, the revival of hylomorphism gave chance to new approaches to metaphysics with multiple applications of hylomorphism that proved viability of the new idea. In this chapter, I will run the reader through some applications of hylomorphism and the problems it addresses aiming at justifying why hylomorphism should be taken seriously.

A. Hylomorphism in Philosophy of Mind

Hylomorphism has been brought into philosophy of mind, most popularly by William Jaworsky (2016) who suggest that hylomorphism occupies a moderate position between substance or property dualism on one hand and reductive or non-reductive physicalism on the other hand. Jaworsky posits *structure* or *form* as a primitive first-order explanatory non-physical principle. Instead of explaining mental properties by physical properties and linguistic acrobatics, and instead of positing a primitive notion of the mental; hylomorphism offers *structure*, a well-known and common term in biology and chemistry textbooks, which is not merely physical but has a very intimate relationship with it. Jaworsky finds that hylomorphism is not only an alternative to physicalism and dualism, but also thinks that it is a better alternative than emergentist theories of the mind. This contemporary application of hylomorphism is just meant to show in what ways philosophers nowadays invest in hylomorphism and why some of them believe hylomorphism is true.

B. Hylomorphism as an explanation of change

Hylomorphism was first presented as a theory that explains change and it is still a viable argument in core. Basically, one way of showing what hylomorphism does is ask the following question: How could something change and still be itself? Aristotle's answer is that there is something that makes the thing what it is and there is something that is changing within the thing. In other words, change does not require the annihilation of what there is and the generation ex-nihilo of something else. Every object is a hylomorphic compound consisting of a matter that underlies changes and form which is the thing gained or lost during change. Any change that occurs to the same object is a change in its form, or its accidental form, to be more accurate, while the matter subsists as the thing losing and acquiring forms. If a change caused the thing to change entirely, like when a chair is changed into a table, then we could say the substantial form has changed. When I change the color of my car, it is supposedly still the same car. The change in the color is a change in the accidental form. The matter of the car, that is, the material components, subsisted the change. The purpose of this brief explanation about change is to know why people think hylomorphism is a serious theory. This is a classical application of hylomorphism as opposed to the more contemporary application in philosophy of mind. I will provide more relevant applications further in this thesis and as I introduce my Scientific Hylomorphism.

CHAPTER III

STANDARD MEREOLOGY (CEM)

Before I delve into Scientific Hylomorphism, I need to prepare the reader by introducing a very interesting formal tool. Among different kinds of formal systems, philosophers of the 20th century attempted to axiomatize the fundamental features of any formal system, where different axioms supposedly distinguish each system from another. This is apparent in modal systems for instance.[5] When it comes to mereology, contemporary philosophers have established a formal system that describes mereology or parthood relations through the last century. It will be important, now, to get familiar with what standard or classical extensional mereology (CEM) is exactly and what is it supposed to explain. Since mereology is about a certain kind of relations, i.e., parthood, and since relations in general were the subject of many formalization projects, one must expect that the great work done by formal philosophers on the formalization of mereology might be significant. Philosophers like Leśniewski, Leonard and Goodman (1940) formulated what will become a *standard mereology* which assumes a basic first order logic with fundamental tautologies, then formulates some relations that describe mereology and act as its axioms:

Let 'P' be a relation of parthood:

- P is reflexive iff Pxx, i.e., for all x, x is part of itself
- P is transitive iff $(Pxy \wedge Pyz) \rightarrow Pxz$, i.e., for all x,y,z, if x is part of y and y is part of z, then x is part of z.
- P is antisymmetric iff $(Pxy \wedge Pyx) \rightarrow x=y$, i.e., for all x,y, if x is part of y and y is part of x, then x and y are one and the same thing.

[5] See for example "Epistemic Logic and Epistemology" by Wesley Holliday.

These axioms are considered by some to be the "constitutive of the meaning of 'part'".[6] It is important to mention here that the more common-sense conception of part as not part of itself is called a proper part, as opposed to a broader usage of the word part above. Many of the intuitions about 'parts' conveyed in CEM do not reflect the common-sensical intuitions we have because CEM is an application of set theory and therefore follows some of the technical definitions in set theory. This explains why for example, a part is part of itself, just like a set is always a subset of itself. But these notions are not usually a problem because there are always technical distinctions that could be made to make these conceptions clearer, like the distinction between a part and a proper part, which is the more common sensical understanding of a part. Nevertheless, whether CEM is neutral and purely formal is far from being conventional among philosophers.[7] There are many reasons to think CEM does not work, and we will see some of these in this thesis. However, up till now, these axioms are supposed to describe any parthood relation in ontology. As I proceed in this paper, I will investigate whether CEM is compatible with hylomorphism. But before we know whether CEM succeeds in describing parthood relations in a hylomorphic compound, and having introduced CEM, let us take a look at how I understand hylomorphism.

[6] See Simons, P. M., Parts. A Study in Ontology, Clarendon Press, Oxford, 1987.

[7] Attempts to produce alternative mereologies or non-standard mereologies is a project that could be traced in the works of Fine 1982, Harte 2002, Johnston 2006 and Koslicki 2008.

CHAPTER IV

SCIENTIFIC HYLOMORPHISM

After entertaining briefly why one would take hylomorphism seriously in Chapter I, it is time now to think of what I mean by hylomorphism and why I find my version of hylomorphism more plausible than other hylomorphisms. In this section, I will put forward my account of Scientific Hylomorphism how I understand form, matter and in what relations they stand to each other and to the hylomorphic whole. The hylomorphism I present here is a serious and classical hylomorphism in the sense that I agree with the intuitions of Aristotle about form as

i. a fundamental ontological category or that it is ontologically primitive, which makes my hylomorphism serious
ii. a principle of unity, and
iii. the essence of a whole, these two latter points make this version of hylomorphism classical in the sense that it preserves Aristotelian roles of the form.

But unlike most ambiguous definitions of form put forward by contemporary hylomorphists, I advocate an understanding of form as a structure that has non-reducible existence and that gives wholes their higher-level properties. Matter cannot be understood independently of form and vice versa; this is why I will start by illustrating both in an ideal example inspired by Organic Chemistry. Two molecules of the same elements, say, consisting of x amount of carbon atoms could have totally different properties because of the different structure or configuration of the atoms. C_x, for

instance, with its atoms arranged in a hexagonal structure is graphite with its set of properties P_G. C_X, having its atoms arranged in a crystal structure, on the other hand, is diamond with its set of properties P_D. P_G and P_D are very different although they are the properties of the same exact matter. What really distinguishes graphite from diamond is the molecular structure of the atoms which give graphite its chemical properties like its black streak and its 1-2 mohs hardness etc. and give diamond its colorless streak and its 10 mohs hardness.

Three points of philosophical significance should be noticed here, first, is that the structure is what defined the identifying properties of the molecule, thus, establishing the point (iii) that form is the essence of the whole. Second, is that the structure is the determinant of the molecule's borders that distinguishes it from its environment to make it a whole, thus, establishing a unity of the molecule as an illustration of (ii). Third, is that there is nothing about carbon atoms in themselves that make them acquire this structure; it is rather external forces like temperature and pressure that en-formed the atoms with the structure. This third point shows us that structural relations between the atoms cannot be reduced to the atoms or properties of the atoms. In other words, nothing about the atoms themselves determine the holistic properties of the diamond, thus, an illustration of (i) that form is ontologically irreducible to matter, thus primitive. This hylomorphism presented here expresses the chemical level; however, similar analysis could be done on simpler objects constituting the atoms themselves but also on more complex higher-level entities.

On an atomic level, the role of structure is also a determinant of the atomic properties. While the mass of the atom is equal to the mass of its components, i.e. the subatomic particles (protons, neutrons and electrons), other properties like the atom's

potential energy is immediately dependent on the electronic configuration, that is, the positions of the electrons within an atom. Here again, we see that the spatial structure or configuration plays an important role in the making of major properties of any whole. On a macro level, the structure is not of less importance. Jaworsky quotes a biology textbook that shows this point:

> Life is highly organized into a hierarchy of structural levels, with each level building on the levels below it. . . . Biological order exists at all levels . . . [A]toms . . . are ordered into complex biological molecules. Many of the molecules of life are arranged into minute structures called organelles, which are in turn the components of cells. Cells are [in turn] subunits of organisms . . . The organism we recognize as an animal or plant is not a random collection of individual cells, but a multicellular cooperative . . . With each step upward in the hierarchy of biological order, novel properties emerge that were not present at the simpler levels of organization . . . A molecule such as a protein has attributes not exhibited by any of its component atoms, and a cell is certainly much more than a bag of molecules. If the intricate organization of the human brain is disrupted by a head injury, that organ will cease to function properly . . . And an organism is a living whole greater than the sum of its parts . . . [W]e cannot fully explain a higher level of order by breaking it down into its parts. (Campbell 1996: 2–4, as cited in Jaworsky 2016)

To make the point about the inability of explaining higher level properties by lower-level properties, known as the explanatory gap, we can imagine simply how much an explanation of a heart attack, for instance, using molecular or atomic language to a patient, provides nothing but confusion and does not contribute to the understanding of the biological processes. The only way the heart attack could be explained is to use terminology at the same biological level of process. This explanation on the biological level cannot, thus, be meaningfully reduced to an explanation on a fundamental level. In other words, explaining the processes of a heart attack by describing what is happening using the terminology of atoms, electrons and molecules does not convey the relevant meaning conveyed when talking biologically about the heart attack using terminology

on the biological level. Replacing the 'an artery is blocked by plaque' by a sentence describing the same process but using quantum mechanics for instance does not convey the intended meaning.

In this section, I introduced form as I understand it within what I am calling 'Scientific Hylomorphism.' I showed that besides matter, structures or configurations of matter play major roles in the making of what properties a whole has and consequently in what a whole is. More clarity to my definitions of form, matter and hylomorphic compounds will be achieved as I proceed in this chapter and when I examine the mereological aspect of hylomorphism in chapter V.

A. Some Hylomorphisms

Since I understand hylomorphism as universally applicable to all physical objects and not exclusive to substances, I find myself in opposition to the understanding that Koons (2014) provides in his 'staunch hylomorphism.' By making hylomorphism exclusive to substances, and by substances Koons means living beings, he doesn't only limit the universal nature of the hylomorphic theory that makes it more appealing and competitive, he also creates a sharp distinction between living beings and non-living beings. While my hylomorphism admits this biological uniqueness of living beings, it doesn't explain it by denying hylomorphism to nonliving objects but by showing how the much more complex hylomorphic relations distinguish the living from the non-living.

Kit Fine (1999), on the other hand, having no distinction between substances and non-substances, introduces rigid embodiments such that whenever there is a relation R among objects a,b,c, etc. there is a rigid embodiment, proliferating rigid embodiments

infinitely. He then introduces variable embodiments that are mereologically incontinent, that is, they can gain or lose parts. But each manifestation of these variable embodiments is itself a rigid embodiment which proliferates his embodiments even more. While I agree with Fine that the distinction between substances and non-substances is unessential to hylomorphism, I will provide in the coming sections and chapter an alternative distinction between heaps and wholes inspired by Aristotle's own distinction to mark some features that some objects have without appealing to rigid and variable embodiments.

As for Koslicki (2008), her literal conception of a substance as composed of matter and form, a concrete and an abstract universal, without allowing form to play any unifying role, stands at odds with my understanding of hylomorphic mereology as I will show in the next section when visiting 'the regress argument,' and also with my more serious conception of form as a constraint in some sense.

These are my prima facie reasons to think that my hylomorphism is different from these major versions of hylomorphism. In the coming sections and chapters, I will make clear how and why my understanding of hylomorphism differs from the other contemporary hylomorphic conceptions.

B. The Regress Argument

At this point, after I have defined my notions and have gone over some versions of hylomorphism, I shall proceed to present the relationships in which matter and form stand to each other and their relationship to the whole. It is necessary first to assert that I find the regress argument, first mentioned by Aristotle, a convincing argument to the fact that the principle of unity, that is, that which makes an object one, cannot be part of

the whole it unifies. If it were a part, then we will need something else that unifies this part and the other parts of the compound. And since I conceive form to be the principle of unity, I do not hesitate to reject that form is a part of the compound, following in this many hylomorphists like Johnston and Marmodoro (2013), opposing in that Koslicki as noted above.

> What is the cause of unity? In the case of all things which have several parts and in which the totality is not, as it were, a mere heap, but the whole is something besides the parts, there is a cause. (*Met.*1045a6-10)
>
> Since that something must be either an element or composed of elements, (1) if it is an element the same argument will again apply, for flesh will consist of this and fire and earth and something still further, so that the process will go on to infinity, while (2) if it is a compound, clearly it will be a compound not of one but of many (or else it will itself be that one), so that again in this case we can use the same argument as in the case of flesh or of the syllable. (*Met.*1041.9-25;)

This is to say that a principle of unity is something other than the parts of the individual object; it is actually this exact principle which makes the object one. The principle of unity is not a part in the same sense as the things that constitute the unit. It belongs to a different category. If the form was a part of the hylomorphic compound, then the question remains, what is it that makes the parts of the compound and the form one?

But it will definitely be odd to claim that form is not in any sense a part of the compound. While it is not a part in the sense of how matter is a part of the compound, it is in some sense referred to as 'in the compound' or it is 'said of the compound.' If someone asks me where the crystal structure is, I will point down on the diamond just as if someone is asking me where the carbon atoms are. But what if someone were to ask me what a diamond is made of? I will have to say carbon atoms. To be more precise, it is carbon atoms structured in a crystal manner. Though, I would not say diamond is

made of carbon atoms and crystal structures, because the conjunction of the structure and the atoms is not similar to the conjunction of the elements to each other. To elaborate this point, it will be helpful to express the way in which matter and form relate to the compound formally. In such cases, the compound could be described as a cross categorial compound because it involves both matter and form as two distinct categories. My attempt to describe relations within cross categorial compounds will come up in chapter chapter V. But for starters, let us examine classical extended mereology (CEM) which supposedly provides us with axioms that express all parthood relations within any compound. Following our scientific hylomorphism, I will investigate now whether the axioms of CEM express the parthood relations of matter and form within a hylomorphic cross categorial compound and also within matter and form themselves. Here is first a reminder of the major axioms of CEM:

Let 'P' be a relation of parthood:

- P is reflexive iff Pxx, i.e. for all x, x is part of itself
- P is transitive iff $(Pxy \wedge Pyz) \rightarrow Pxz$, i.e. for all x,y,z, if x is part of y and y is part of z, then x is part of z
- P is antisymmetric iff $(Pxy \wedge Pyx) \rightarrow x=y$, i.e. for all x,y, if x is part of y and y is part of x, then x and y are one and the same thing.

C. The Privileged Ontology Argument

The major question raised that splits the hylomorphic understanding of mereology from standard mereology is the question of what to include in a whole. The weakness in CEM doesn't lie merely in some axiomatic descriptions of parthood relations, it is rather in what it doesn't tell us about the whole. Unlike CEM that provides a set-like understanding of mereology, hylomorphism gives reason to why these members of the set are considered a whole. Consider the state of affairs where I,

sitting on a chair in front of a desk, am writing a thesis on my laptop, what makes me think that the proper division of the elements in this state of affairs is as such? How did I decide that there are these wholes: the laptop, the chair, the desk and I? Why wouldn't I consider the set of me and my chair as one instead? Or the chair and computer as one? How do we come to decide what is a whole and what not? CEM does not tell us what unifies different things; it lacks any sort of explanation of our intuitive divisions of objects, our putative (recognized, pointed at) object of reference. Its aforementioned axioms fail to show us which objects should we consider as constituting a whole and which objects do not.[8] Hylomorphism however, provides an explanation of how we sort things, a way in which we have no reason to believe it doesn't express the real divisions. It is form that gives privilege to certain objects, the privilege of a meaningful unity, while the sums of parts that are presented by CEM allow random sums of things that could be meaningless. Thus, when I talk about hylomorphic compounds in the coming sections, it is necessary that we understand those as privileged wholes, not as fiat wholes or merely random sums of objects, but where form plays a role in constraining the different meaningful combinations. I mean by meaningful combinations, those which we can indicate or refer to, like the combination of objects constituting a laptop as opposed to the random combination of a laptop and a chair that constitute no meaningful entity, or an entity we cannot refer to, an entity that we cannot say anything meaningful about. The combination constituting the laptop has a privilege over the combination consisting of the laptop and the chair. Investigating further what makes a combination putative thus meaningful reveals to us the potential of hylomorphism as a

[8] More on this in the next chapter.

definition of regular putative objects. An object, which is naturally a compound or a combination of elements, is meaningful and putative only if it is an internally unified metaphysical unity. And an object is as such only if it has a form as a functionally defined principle, the presence of which unifies the elements of the whole.

D. CEM and Matter

Now that we know how CEM fails to explain wholes, we can proceed further into examining how its axiomatic descriptions fail also to describe the parthood relations of parts within hylomorphic wholes (cross categorial compounds). Let us start by taking matter and see whether CEM applies to the relations within matter. The matter of a diamond or a graphite is in both cases the x number of carbon atoms. Every carbon atom is of course part of itself in the sense of improper parthood that is axiomatized above with the reflexivity axiom.[9] All extended particles of the carbon atom, i.e. the matter of the carbon atom, are also parts of the x amount of carbon atoms and thus a part of the graphite and diamond they constitute. We know this because the mass of the diamond is equal to the mass of the carbon atoms within it. Therefore, what is a part of a carbon atom is also a part of a diamond or a graphite, making transitivity an applicable axiom as well in this case. This applicability also extends to antisymmetry which is itself supposedly derivable from reflexivity and the improper parthood conception. Therefore, CEM seems to successfully describe the relation of matter within matter. However, as we will see what works for matter does not seem to work for form.

[9] See definition of proper parts in chapter **VI**.

E. CEM, Form and the Heaps

To recall, a diamond differs from a graphite because of the difference in their form. Diamond has a crystal structure and graphite has a hexagonal structure. But what is it to be a part of the structure? There are really no parts in any structure, at least nothing close to the CEM sense or even any intuitive sense of part. The structure is really a primitive ontological category that cannot be divided. To clarify this point, let us entertain the options of what could act as a part of the form. First of all, one could claim that a crystal structure for instance has mini triangle structures constituting it. In fact, any constituent of a structure is a part as far as an imaginary square is part of a rectangle. A structure could be split into sub-shapes by mental imagination, but this doesn't entail that any of these sub-shapes are actual parts of the structure. Spatial parts separated by imagination are fiat parts, like when imagining that a triangle is a part of a rectangle. While a rectangle could be divided into two triangles, it does not mean that these triangles are parts. Otherwise, one could divide a rectangle in infinite ways rendering the parts of a rectangle infinite. Another possibility is that what enters into the definition of a structure is a part. Similarly, the words that constitute any linguistic definition of any form is usually a descriptive statement of the appearance of the form, an instantiated form; and since the form is only known when associated with matter, any definition of form includes a reference to some matter. However, the form in itself is distinct from the matter, and can in fact be mentally conceived independently in the same sense that grammar is distinct from the words; it is actually what gives words the sense, but it can never appear except through words. Therefore, in the same manner that grammar does not have words as parts in it, form doesn't have matter as part of it. While this might not apply to all languages, there is always something like grammar

such as syntax or order in languages that play a similar role.[10] These are the two possibilities for parts of form, and I would be happy to discuss another if present. But if I am right about form lacking any parts, then the axiom of transitivity in CEM does not fit this hylomorphic picture.

Form can however constitute, only within a hylomorphic compound, a larger object. I mean there is a hierarchy of hylomorphic compounds. A hylomorphic compound could itself be a part of a larger hylomorphic compound. This brings us to the question of the parthood relations of hylomorphic compounds within a larger compound. Take for example, a big single-stoned diamond. It is constituted of many molecules, each of which having their matter and form. The big single stoned diamond is an aggregate of thousands of molecules i.e., sub hylomorphic compounds. Whenever several hylomorphic entities are brought together, their properties might be passed over to what they constitute, i.e., the larger hylomorphic compound. For instance, the mass of pile of dust is equal to the mass of the sum of each and every dust particle. Similarly, the mass of the big single stoned diamond is equal to the sum of the masses of the carbon molecules constituting the diamond. If all the properties of the aggregate or the higher-level entity can be explained through the lower-level or sub-hylomorphic entities, then this higher-level entity is nothing more than a heap, to follow the Aristotelian tradition's terminology. But unlike Aristotle, and other hylomorphists, I do not admit heaps as originally understood as aggregates of matter, unqualified. For Aristotle, a heap is merely an aggregate of matter that does not possess a form which gives the aggregate its essence and function. On the contrary, under the understanding

[10] I am indebted to Christopher Johns who informed me on this matter.

laid above of the hylomorphic relationships on the chemical level which basically constitutes all objects, any compound regardless of how big or small it is may qualify to have a form. A pile of dust, under my version of scientific hylomorphism, is a heap, not in the sense of an aggregate of matter lacking form, but in the sense of an aggregate of sub-hylomorphic entities (sub-compounds of form and matter) forming a larger compound where these sub-hylomorphic entities hold classical mereological relationships to each other, i.e. similar to those in the "CEM and Matter" section. In other words, a heap in scientific hylomorphism is an aggregate of sub-hylomorphic compounds as opposed to an aggregate of matter in Aristotle. To distinguish heaps from wholes, I will use formal devices in the coming chapter that will clarify the difference and explain my version of hylomorphism.

F. Genuine Wholes

It is not always the case that the higher-level entity can be explained entirely through the lower level hylomorphic entities. Some aggregates have properties that are not determined by the entities they are constituted from but by the configuration that these lower-level entities stand in relation to each other. Water, for instance, is not merely H_2O molecules, but H_2O molecules in a certain configuration or set of configurations that guarantee the properties of water such as viscosity and temperature. In other words, the properties of hydrogen alone and oxygen alone do not pass over to water. Whether quantum mechanics proves to us that the properties of water are explainable through the study of the atoms themselves or not, does not affect the fact that the structure plays a role in the emerging properties of water. Liquidity for instance, is clearly something explainable through the spatial relations of the particles. The talk of

reducing the spatial relations to intrinsic properties in the particles does not necessarily render the talk of configurations irrelevant, because it does not entail that there are no configuration-dependent properties. Nevertheless, taking the water phenomenon on its face value, it would be easy to distinguish the significant and enormous difference between the properties of hydrogen and oxygen atoms before bonding in a molecule and the properties of water, i.e., after the bonding. Many properties of hydrogen alone disappear, and new properties of water emerge. Instead of appealing to emergent theories, hylomorphism presents itself as an alternative explanation to the effect that form is the truthmaker of the higher-level properties.

In this section, I showed that while there could be parts in matter, form is a primitive notion that cannot be divided. However, a hylomorphic compound as a whole can be a part of the larger higher-level whole. In this case, the higher-level compound, although necessarily a privileged one, might either be a heap where the parts of the heap stand to each other in standard parthood relationships, or the higher-level compound might turn out to be not only privileged but also a genuine whole, of which its parts stand to each other in non-classical relations. The following will be an attempt to put forward a formal characterization of the parthood relations of sub hylomorphic entities within a genuine whole which I will call the *morphological mereology* which will have axioms different from those of *classical mereology (CEM)*.

CHAPTER V

MORPHOLOGICAL MEREOLOGY

At this point, I will proceed to formulate parthood relations within higher level entities called genuine wholes consisting of sub hylomorphic compounds. In contrast with the axioms of mereology, such higher-level entities are not explained by hylomorphists through the transitivity parthood relation, that is, properties of molecules within an organ do not explain properties of an organism according to hylomorphists. More importantly, properties of the higher level such as sight are not established except in the state where certain organs stand to each other in certain morphological relationships. Thus, the function of seeing is not a property in the eye organ, but in the configuration of the organs. It is not to say that the configuration itself is the function, but rather the truthmaker of the function.

A. Truthmaking

We could start discovering the notion of truthmaking by raising the question of 'what is truth?' When philosophers talk about truth, they often bring up the talk about propositions. Propositions are abstract things that could be expressed by statements and are either true or false. What makes a proposition true or false in the world is what we call a truthmaker. When we say 'grass is green,' what makes this proposition true is the way things are in the world, more precisely, it is the existence of grass in a certain way. The fact that many propositions about diamonds having the configuration of diamond as the truthmaker, as explained earlier, is only a prima facie reason to identify forms with

truthmakers. Thus, a deeper investigation of the truthmaking theory is necessary to observe the features of this identification. Unlike Truthmaker Maximalism theory, which holds that every proposition has a truthmaker, inflating the ontology infinitely, Scientific hylomorphism only needs to commit to a more modest atomic truthmaker theory, maybe not a strong one though, where complex propositions or conjunctions of propositions need not have a truthmaker over and above the truthmakers of its components. The conjunction 'p & q' says that 'the grass is green' and 'the ocean is salty' needs no further truthmaker other than the truth makers of each part of the conjunction. However, conjunctions that describe genuine wholes do in fact have a truthmaker over and above the truthmakers of the parts of the conjunction, which makes my theory committed to a weak atomism. Think of a conjunction of the propositions describing the partial processes of Plato while writing. Let C_w be the conjunction of propositions p_1, p_2, p_n. Each proposition in the conjunction, for instance, p_1: 'the heart is pumping' has a truthmaker. The truthmaker of p_1 is distinct from that of p_2, say that 'the eye is seeing,' and both are parts of the conjunction of the propositions of C_w.[11] But the truthmaker of the proposition 'Plato is writing' is distinct from the conjunction of the truthmakers of all the propositions about the human during writing. Deciding whether Plato is writing or not does not require knowledge of all the truthmakers constituting C_w. The proposition that 'Plato is writing' is epistemologically independent of the truthmakers of C_w or at least independent of some of them. Note though that if writing seems a weak example, one could take any proposition involving a property which its truthmaker does not follow epistemologically from the conjunction of the truthmakers

[11] This is not to say that p_1 and p_2 could not be treated exactly as C_w.

of a conjunction or partial propositions. To go back to our original example about diamond, the truthmaker of the conjunction of the propositions about the carbon atoms constituting the diamond is not identical with any proposition about the diamond itself. In other words, the set of all truthmakers of propositions about the carbon atoms is not the truthmaker of propositions about diamond as a whole. While the form could be represented by a set of propositions perhaps, it does not mean that it is reducible to these propositions. In the same way that a fundamental physics description of a heart attack does not convey the intended meaning of a heart attack, the set of propositions about the particles of the diamond does not convey the features of the diamond as a whole. Therefore, a weak atomic truthmaker theory like this as opposed to a maximalist one is sufficient to explain hylomorphism.

It is important here to understand that we are talking about propositions about genuine wholes rather than about heaps. So yes, the truthmaker of the conjunction 'the computer is on the table' and 'the mouse is on the table' is nothing more than the truthmakers of each conjunct. There is nothing more to the story of the computer and mouse other than the story of each of them. This similarly applies when we talk about any aggregate of objects that don't form together a genuine whole – more on this distinction when I formalize the theory. All this allows me to make use of the truthmaker tool to describe scientific hylomorphism. A truthmaker can reflect the same purpose of hylomorphism, that is, explaining that some aggregates are not simply particles, but include something further. Truthmakers as I explained them here are what make me think that forms are primitive. By primitive, I mean that they cannot be reduced to something more basic, or that they are metaphysically primitive. Identifying forms with atomic truthmakers allows us to understand in which sense a form is

primitive; it is independent of the truthmakers of its constituents. Therefore, I find describing forms as truthmakers a promising step. This is not to say that this is a necessary logical entailment 'F↔p' because F (form) and p (proposition) belong to different categories.

B. Morphological Mereology Formalized

Making use of formal methods in philosophy can be a key to analyze and develop clear notions. My objective of my formalization is to provide a formal alternative of distinguishing genuine wholes from heaps. In other words, I am trying to show how the idea of a functional unity differs from a random combination by looking at the difference between the two on the mereological level. Based on classical set theory, philosophers came up with classical extended mereology (CEM) in order to explain all parthood relationships. CEM is basically set theory reformulated in a way that is more suitable for the philosophical discussion and formalization of mereology. I will show in the following that we need to provide an alternative to CEM to describe parthood relations in a Hylomorphic framework. I will show that while CEM can describe parthood relations of matter alone,[12] it cannot describe the parthood relations of form and I will try to use an edited version of set theory[13] that could explain the parthood relations of form in Hylomorphism:

A hylomorphic compound is a set H of objects (matter) where the members of this set are the objects x,y,z,h of H:{x,y,z,h…}, satisfying the following conditions:

[12] This has been established before in IV.D but I will argue in another way in what follows.

[13] Note that the role of set theory, whether as classically presented or as I present, is merely descriptive.

1. Every object x stands in spatio-temporal relationships to all other objects y,z…, by spatio-temporal relations I mean things like x being measurably distant from y or that x exists simultaneously with y…
2. The form is not an independent member of the set, but rather its principle of unity. The form and the member objects are of different categories. The form cannot be derived from the set. It is rather what gives a set the privilege to be a genuine object.
3. The set of all meaningful spatio-temporal relationships is the form.[14]
4. A spatio-temporal relationship is meaningful if and only if it is a truthmaker of a property, a property here understood as a predicate.

The major idea here is that not any set of objects is a hylomorphic compound, but every hylomorphic compound is a set, or rather some specific kind of sets, where the members of this set stand in truthmaking spatio-temporal relationships to each other. Therefore, a set of random objects, say person-laptop, is not a hylomorphic compound, because the relationship of the members is a spatio-temporal one that does not allow us to say anything meaningful about this set. On the other hand, wooden planks arranged into a table is a hylomorphic compound because the planks stand to each other in meaningful spatio-temporal relations that make several properties true of the table, such as its ability to hold things.

This gets more interesting when we apply this formal tool to compounds of multiple levels. If we take a human being for instance, where a human is a hylomorphic

[14] The sense I am using the word set here is substantially different from the sense of set in set theory, as a set is a mere heap while the form is a unified thing.

compound with sub-hylomorphic compounds like the heart, which also has further smaller sub-hylomorphic compounds, we find the following:

The set Ⱨ, for human, of organs x,y,z,h … where these organs are the only members of this set, such that every organ is itself a set of its constituting matter. While x,y,z,h… are matter with respect to the human, they are a hylomorphic compound in themselves with respect to their matter and form. The form being not a member of the set, but rather the set of meaningful spatio-temporal relationships between the organs, is a truthmaker of several properties or functions.

Transitivity could be observed in standard set theory or CEM when talking about matter so if we take set Ⱨ:{x,y,z,h…} such that h:{x_1, y_1, z_1,…}, then if $x_1 \subset h$ then $x_1 \subset$ Ⱨ.

The set theory which CEM stands on is suitable for describing the mereological relationships of matter, an example of which is transitivity. However, the form of h that is, the set ʃ: {r_1, r_2, r_3,…} of meaningful spatio-temporal relationships between the different members of h is neither a member of Ⱨ. That is, while the form of h is the truthmaker of at least some properties and functions like redness or pumping blood, these properties and functions could not be said of Ⱨ. All the properties and functions of Ⱨ are only said of the first level members of Ⱨ and their meaningful spatio-temporal relations.

Therefore, it is not the case that if r ⊂ ʃ then r ⊂Ⱨ; neither is if r ⊂ ʃ then r ⊂ Ⱶ, where Ⱶ is the form of the higher level hylomorphic compound. That is, it is not the case that if a meaningful relation (a truthmaker of some property) is part of the form of the human then this meaningful relation is part of the human. Since I established that form is neither a member of the set nor does the CEM rules apply to it, there should be a way

of describing the relation of form to matter, i.e. to the members of the hylomorphic set. Now since form and matter belong to different categories, a hylomorphic compound is called a cross categorial compound where form and matter could be described as cross categorial parts. The relationship between form and matter cannot be described through CEM. However, through morphological mereology (MM), the relationship can be described by means of the following axioms. The formalization in what follows, although difficult to grasp if one is not used to them, is necessary because it is heavily used in the literature and because it clarifies subtle distinctions, but one could skip them to read the explanation following each axiom:

1- Cross Categorically Irreflexive: $\neg$ CCPff & $\neg$ CCPmm. It is not the case that f (form) or m (matter) are cross categorial parts of themselves.

2- Cross Categorial Supplementation: $PPxy \rightarrow \exists z(Pzy \wedge \neg Ozx)$ where PPxy is a proper parthood relation such that: $PPxy =_{df} Pxy \wedge \neg x=y$[15] and Ozx is an overlapping relation such that: $Ozx =_{df} \exists z(Pzx \wedge Pzy)$.[16] Cross Categorial supplementation means that a whole y must contain within it at least two parts x and z, where x and z are form and matter (not necessarily respectively).

3- Intransitivity (not antitransitivity)[17]: $\exists x \exists y \exists z(Pxy \wedge Pyz \wedge \neg Pxz)$, i.e., there are x,y,z, where x is part of y and y is part of z, and still x is not part of z.

[15] If x is a proper part of y, then x is not y. Compare with regular reflexivity in CEM.

[16] z and x are overlapping if there is a z that belongs to both x and y.

[17] Antitransitivity will imply that a part cannot be transitive, which is not the case because parts of matter are transitive.

4- Disjointness: $Dmf =_{df} \neg Omf$, i.e., form and matter are disjoint or not overlapping. There is no element that is a both part of matter and form simultaneously.

These axioms describe the parthood relations of form and matter in a cross categorial compound or a compound of form and matter that I have been also calling a genuine whole. MM allows, or actually necessitates, the existence of two kinds or two categories of parts that are mutually exclusive, while in CEM all parts should be of the same category. Parthood in MM is intransitive as opposed to transitive in CEM. When it comes to form, there is nothing as form within a form. Every level of form is genuinely primitive, and the parts of the form are merely the meaningful spatio-temporal relations, as described before, with no further level of parthood. Together with the five conditions of a hylomorphic compound, MM provides a clear criterion of what a whole is, unlike CEM which does not have any criteria of what a whole includes and excludes.[18]

Let us see now how MM describes our previous examples. The Diamond is a cross categorial compound or a genuine whole. What makes it so, is that it is an aggregate of many particles where all its particles (its matter) are assembled in a way (the form) that made the diamond a putative object that one could describe by many propositions. These propositions are of the diamond as a functional whole and cannot be reduced to propositions about the particles. The particles and the way the particles are arranged are two different things, the particles themselves do not determine how they will be arranged and thus what properties the whole will have. The former belongs to a category distinct from the latter, namely, matter and form. What distinguishes the two

[18] Review the section of The Privileged Ontology.

could be understood by looking at the mereological behavior of these two and their parts, if any. Matter behaves in a way that resembles members within a set, a particle that is a part of the carbon atom is a part of the diamond. The form does not have any real parts as we saw earlier. When a hylomorphic compound constitutes a larger hylomorphic compound, the form of the former is not a part of the latter, it is intransitive. The form of a carbon atom, which is the truthmaker of the propositions about the carbon atom does not pass over to the diamond, because the propositions about the carbon atom do not pass over to the diamond. We can see, therefore, that the concept of parthood in MM is very different from the concept of parthood in CEM which applies to parthood of matter within matter only.

To sum up what I established in this chapter, I started by explaining the different roles form plays in a genuine compound. I advocated a view of form as a truthmaker of properties as a follow up to my first chapter. Then I dealt with another major role of form as the principle of unity of a compound. I proposed a formal representation using a conditioned set theory to describe matter, form and the compound in which I described in what sense a form is the principle of unity rather than a part of a compound. I finally described through axioms in what sense form and matter are said to be parts of a whole in a cross categorial compound.

CHAPTER VI

CONCLUSION

The purpose that I hope the thesis has served has two sides. First, I hope that it has given motivation to think hylomorphism is a serious theory. I hope I have achieved this by the presentation I provided of Scientific hylomorphism and by the smooth ability of hylomorphism to describe wholes and parts as we understand them. The second side is that related to mereology. If hylomorphism is right about how it describes objects, then the standard theory of mereology fails to describe parthood relations and wholes. I hope to have shown clearly that standard mereology, which could possibly be refuted also from a non-hylomorphic point of view, is not compatible with hylomorphism. Then on that basis, I attempted to formulate hylomorphism in a way that explains parthood relations within a hylomorphic compound. This also allowed me to present a possible axiomatic description of how a hylomorphic mereology or what I called Morphological Mereology could look like, something that has not been given enough attention by contemporary hylomorphists. Scientific Hylomorphism, together with Morphological Mereology, aim to show how hylomorphism is a dynamic theory with these features:

- Ability to explain our intuitive impressions about what is an object and what is not. In other words, what a real or a genuine whole is and what a fiat or a heap is.
- Ability to generate a mereology that is more accurate than the standard theory of mereology.
- Ability to explain how matter and form are different through looking at their different mereological behaviors.

Perhaps the next time we hear a scientist saying that we are made of stardust, we must interrupt and say: well, stardust and forms.

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