The Entanglement Problem for Psychological Hylomorphism

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Abstract: The theory of psychological hylomorphism has recently been advanced by David Charles as a viable alternative to physicalist and dualist theories of mind. According to Charles, a human or animal is a psycho-physical whole whose mental and physical properties are defined with reference to the whole. This is because it is a hylomorphic composite of matter and form, where the form contains the material principles of the composite in its definition. In this paper, we raise a difficulty concerning the *individuation* of forms in light of the quantum theory of matter, asking whether the phenomenon of quantum entanglement gives us reason to doubt that the micro-physical properties of a human or animal derive (solely) from the psycho-physical properties of a middle-sized whole. We suggest several ways of amending the theory of psychological hylomorphism to accommodate entanglement, including a proposal by Simpson, in which the cosmos counts as a psycho-physical whole, and a proposal by Koons, in which distinct substances share a 'group form.'

It is widely recognized that there are difficulties with the physicalist account of how minded middle-sized things, such as human beings and animals, are supposed to fit within the world described by modern physics. Some of these difficulties are well known and entrenched, but fresh arguments against physicalism are forthcoming.[1] The physicalists' hegemony is starting to crack, and other voices are beginning to be heard, including voices from antiquity.

One alternative to physicalism with ancient roots that is being revived is Aristotle's theory of hylomorphism, which conceives humans and animals as composites of matter and form (Simpson 2023a). The term 'hylomorphism' properly refers to a family of theories with a complex history, since there are many different interpretations of Aristotle and his ideas were de-

[1] See Koons and Bealer 2010 for discussions of several well-known problems with physicalism. For two examples of fresh arguments, see Cutter forthcoming and Cutter and Crummett forthcoming.

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veloped in different ways. Our focus here is on a type of *psychological hylomorphism* that applies his ideas about matter and form to the mind-body problem, such as the hylomorphic philosophy of mind advanced in the work of David Charles (2021).

According to Charles, Aristotle conceived humans and animals as psycho-physical wholes. At the fundamental level, they neither have *purely physical* properties nor *purely psychological* properties. Rather, the nature of a psycho-physical whole depends on a form that determines the matter of the composite. Charles thinks of forms as being *essentially embodied* because the form of a composite contains the material principles of the composite *in its definition*. The mind-body problem, from this hylomorphic perspective, is an artefact of a post-Cartesian framework, which defines the mental and physical properties of a human in a way which lacks any reference to a psycho-physical whole. How could such essentially different properties be related systematically?

To avoid the mind-body problem, Charles believes we should adopt a strictly Aristotelian conception of hylomorphism, in which the matter of a hylomorphic whole is determined by a form, and the form of a hylomorphic whole has no separate existence apart from its matter. On this view, the mental or physical properties of a minded middle-sized thing are *abstractions* from the properties of a whole that is inextricably *psycho-physical*. Although a psycho-physical whole is *physically composed* of the micro-physical parts disclosed by our best physics, it is the psycho-physical whole that is *metaphysically basic*. Charles perceives the history of hylomorphism since Aristotle as consisting of innovations which liberalized the notion of a hylomorphic whole, undermining its metaphysical unity, and hence 'paved the way for Descartes to raise his mind-body problem in the form which still perplexes us' today (Charles 2023, 39).

We (the authors) are also interested in applying hylomorphism to the mind-body problem (Koons 2018), in using hylomorphic ideas to explain the teleology of biological systems (Simpson 2023a), and in deploying Aristotelian principles to solve other philosophical problems besides (Simpson, Koons, and Teh 2017; Simpson, Koons, and Orr 2022). We are less sanguine, however, about there being no need for innovation in how Aristotle conceptualized hylomorphic wholes. The aim of this paper is to raise a difficulty for the theory of psychological hylomorphism in light of the quantum theory of matter.

In a world with a quantum wave function, we shall argue, the micro-physical parts of middle-sized things would be 'entangled' with one another, so they would have causal powers that are not (wholly) determined at the level of the middle-sized whole. Some of their causal powers would be determined at the level of the quantum mechanical whole in which they are entangled. In such a world, we submit, the micro-physical properties of a minded middle-sized thing would not be merely abstractions from the *psycho-physical* properties of a *middle-sized whole*. Rather, the micro-physical

properties of any middle-sized thing would depend (at least partially) on the *physical* properties of the *cosmic whole* which is characterized by the wave function. In such a world, we shall argue, it is not possible to *individuate* the forms of psycho-physical wholes without making modifications to the theory of psychological hylomorphism.

We call this the Entanglement Problem for Psychological Hylomorphism. It is not widely recognised.[2] One might think of it as an analogue of the Decombination Problem for cosmopsychism, which concerns how the minds of middle-sized things are individuated in a world which has one cosmic consciousness (Miller 2018; Albahari 2020). We shall argue that the Entanglement Problem also applies to worlds that lack a universal wave function, where the phenomenon of entanglement is limited by 'collapse' processes. We will then consider different ways of modifying the Aristotelian theory of psychological hylomorphism to account for the existence of entanglement in the physical world, including accounts which adapt the Platonic idea of a 'world soul.' The discussion proceeds as follows.

In section 1, we discuss the theory of psychological hylomorphism and the promise it holds for circumventing the mind-body problem. In section 2, we consider the phenomenon of quantum entanglement, focusing on a famous thought-experiment proposed by Einstein and his collaborators that is known today as the EPR Experiment. We argue that, in a world with a universal wave function, middle-sized things have micro-physical parts whose causal powers are not (wholly) determined by their individual forms. We explain why this poses a problem for how the forms of psycho-physical wholes are supposed to be individuated. In section 3, we consider whether this problem extends to worlds that are not characterized by a *single* wave function. We argue that the problem is not resolved simply by postulating a 'collapse' in the wave function.

In section 4, we consider six ways to incorporate the phenomenon of entanglement within the theory of psychological hylomorphism; some of them more radical than others. Several of these modifications postulate the existence of a *cosmic whole* that encodes the wave function, although there is disagreement concerning whether it counts a substance and whether it includes every physical thing among its parts. Two of these accounts imply that the cosmos itself may instantiate mental (or intentional) properties, suggesting a synthesis of hylomorphism and cosmopsychism. In section 5, we offer some concluding comments on the possibility of developing an innovative but empirically adequate version of hylomorphism which can preserve the insights of psychological hylomorphism.

[2] One of us (Simpson) has propounded a theory of Cosmic Hylomorphism to explain quantum entanglement, in which the cosmos is a hylomorphic whole (Simpson 2021a; 2021b; 2023b). We discuss this idea further in section 4.

1

How do minded middle-sized things, such as humans and animals, fit into the physical world? Descartes famously conceived the mind of a human being as a non-physical substance that interacts with their physical body. According to physicalists, however, the world consists of fundamental physical constituents disclosed by our 'best physics,' and the minds of middle-sized things supervene upon their physical constituents. These basic constituents are not conscious entities, and they are spatiotemporally distributed according to laws that are void of intentionality. Physicalism has by and large been standard orthodoxy in philosophy of mind. However, physicalism gives rise to two explanatory gaps:

(i) The Hard Problem of Consciousness concerns how the mere shuffling of physical constituents could give rise to the inner life of phenomenal experience (Chalmers 1995).

(ii) The Problem of Mental Causation concerns how mental properties or states (qua *mental* properties or states) could make a causal difference to physical properties or states, and vice versa (Koons and Bealer 2010).

According to Charles, the trouble with both dualism and physicalism is that they are beholden to a "deeply rooted, post-Cartesian" conception of reality, in which the mental and the physical are conceived as "definitionally separate components" (2021, 3). On the one hand, there are the purely physical constituents of which everything is made, including psychological beings, which are disclosed by our best physics. On the other hand, there are the purely mental lives of psychological beings, which are accessible by introspection. But how are these definitionally separate parts of reality supposed to *interact* with one another in a way that makes a causal difference to how the physical world unfolds? How do they comprise a *unified* psychological being?

Psychological hylomorphists such as Charles seek to construct an alternative to dualism and physicalism by challenging the post-Cartesian assumptions about reality they both hold in common. Charles believes that Aristotle held a distinctive view of the psychological that circumvents the mind-body problem, in which a living being is an "inextricably psychophysical subject" (2021, 8). This entails, on the one hand, that there are no *purely psychological* features that are essential to being emotional, perceiving something, or desiring something, which can be defined without explicit reference to some specific internal physical features or capacities. On the other hand, there are no *purely physical* features or capacities that are essential to being emotional, perceiving something, or desiring something, which can be defined without explicit reference to some relevant psychological features. Being angry, for example, "is not just any type of desire for revenge, but one which, in its nature, is permeated with physical and

psycho-physical features. One cannot, it seems, define the tension, anxiety or excitement essential to this type of desire without reference to bodily states" (Charles 2021, 12).[3]

Therein lies the path to circumventing the problem of mental causation: "It is because it is an embodied type of desire," rather than being a *purely mental* reality, "that [anger] affects our bodies and bodily movements in the way it does" (Charles 2021, 13). Purely mental states or properties lack causal powers because they are merely an abstraction from a more basic and causally powerful psycho-physical state. Likewise, the hard problem of consciousness loses its sting once we recognize that phenomenal experiences are not defined in *purely mental* or psychological terms. That is, assuming we reject Galileo's claim that physical bodies lack the qualities we perceive through our sensory capacities.

The reason Aristotle conceives the minds of psychological beings to be intrinsically physical and their physical constituents to be intrinsically mind-related, according to Charles, is because he is a hylomorphist who holds that a psychological being has a form that is essentially embodied. In his view, the forms of psycho-physical wholes contain matter. A form contains determinable material principles in its definition, and forms have a fundamental role to play in determining the matter of the whole. The matter of a psycho-physical whole is determined by its form such that the type of physical powers it exercises, and the type of physical activities in which it is engaged, "cannot be defined without explicit reference in their definition to some psycho-physical activity" of the whole (Charles 2021, 5). Any purely physical or purely mental features are an *abstraction* from what is psycho-physical and *metaphysically basic*. If we adopt this stance toward reality, then no gap remains between mind and body, and the mind-body problem is dissolved.

Charles is careful to distinguish his interpretation of Aristotle's theory of hylomorphism from other recent adaptations (Charles 2021, 246–253), such as Mark Johnston's (2006), Kathrin Koslicki's (2018), and William Jaworski's (2016): "[Aristotle's] forms cannot be defined as relations between or properties of more basic entities, defined independently of forms," he insists. "Nor can they be defined as 'structures,' if these are understood as relations or properties of this type" (Charles 2021, 247).[4] Such conceptions of hylomorphism undermine the unity of the composite (Marmodoro 2013), misidentifying the form of a substance with the organization of its parts. In Aristotle's hylomorphism, however, "the form . . . is what *explains* why we are structured in a given way" (Charles 2021, 251, emphasis added).

[3] This has the consequence that organisms with very different material compositions (such as the hypothetical silicon-based aliens of science fiction) cannot satisfy the same psychological descriptions. This is implied in the hylomorphist's rejection of the monistic-physicalist approach of functionalizing the mental.

[4] For further discussion of these modern versions of hylomorphism, see Simpson 2023a, chap. 2.

Charles also seeks to address the concern that psychological hylomorphism, which affirms the existence of inextricably psycho-physical entities, is inconsistent with the supposedly scientific view of reality that dominates analytic philosophy (2021, chap. 8), which conceives the world as a vast spatiotemporal mosaic of micro-physical constituents disclosed by our best physics. Charles endorses a similar picture whilst urging a fundamental distinction between what is *compositionally basic* and what is *metaphysically basic*: middle-sized things are composed of micro-physical entities, such as quarks and electrons, but these micro-physical entities are not metaphysically basic. The *physical* properties and powers of a micro-physical entity that is part of a psycho-physical whole derive from the *psycho-physical* properties and powers of this middle-sized whole. It is the psycho-physical whole, not its physical parts, which is metaphysically basic.

In making this fundamental distinction, and in regarding the purely physical properties of a human or animal as *abstractions* from the psycho-physical reality of the whole, Charles believes that the theory of psychological hylomorphism can be shown to be consistent with a scientific view of reality. However, we (the authors) think his version of psychological hylomorphism runs into some difficulties with contemporary physics; in particular, our best theory of matter. To explain why, we will need to discuss the phenomenon of quantum entanglement.

2

As it turns out, the picture of the world as a vast mosaic of micro-physical things, which is widely held among analytic philosophers, does not fit well with contemporary physics. The principal motivation for thinking that the world must be physically composed in this way is the 'classical' assumption that the physical properties of complex things supervene upon the physical properties of their micro-physical parts. Yet the quantum theory of matter differs in a significant way from the classical (pre-quantum) theory of matter that continues to shape the imaginations of many philosophers, including many philosophers of mind.

In quantum mechanics, the physical state of a system is *not* represented by a spatiotemporal distribution of micro-physical properties, but by a vector defined in an abstract high-dimensional space. In non-relativistic quantum mechanics, the state vector of a system of N particles can be expressed as a wave function defined in the $3N$-dimensional 'configuration space' of the particles, where each point in this high-dimensional space picks out a possible configuration of the system. The wave function evolves according to the famous Schrödinger equation and determines the probabilities of the various 'observables' that can be measured. Significantly, different wave functions can be combined into 'entangled' superpositions in which

the total state of the composite system cannot be factored into states of its spatially separated parts.[5]

For example, in the famous 'EPR experiment' involving two quantum-entangled particles, 1 and 2, one of the particles is constrained to be 'spin up' when the other particle is measured to be 'spin down,' and vice versa, however far apart the two particles are separated in space (Einstein et. al. 1935; Bohm 1951).[6] The two particles are sent in opposite directions toward two spatially separated Stern-Gerlach devices, A and B, and each particle is deflected up or down within a device according to its spin (Figure 1). If a particle is 'spin up,' then it has the causal power to be deflected up when it enters such a device; if 'spin down,' a causal power to be deflected down. When a quantum system is in what is called the 'singlet state,' there's a probability of ½ that we will observe particle 1 to be 'spin up' (Up in A) and particle 2 to be 'spin down' (Down in B); and ½ that we will observe particle 1 to be 'spin down' (Down in A), and particle 2 to be 'spin up' (Up in B). As long as the polarizations (ϕ_A and ϕ_B) of the two devices measuring the two particles have both been set to measure vertical spin, these are the only two possible measurement outcomes that we can obtain.

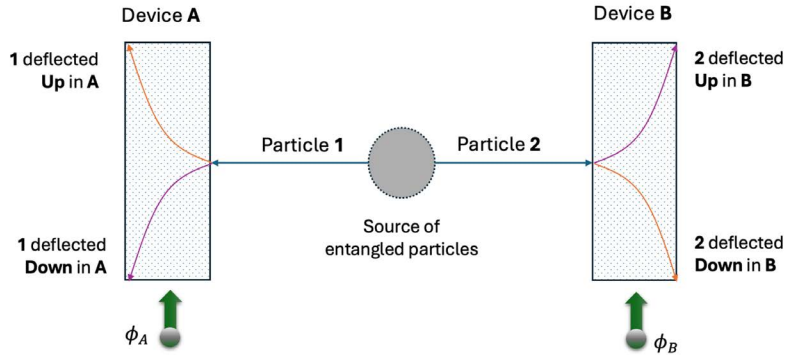

Figure 1. An EPR experiment

This anti-correlation between the two outcomes of these separate wings of the experiment is curious, of course, but it doesn't prove—by itself—that the two-particle system has physical properties which fail to supervene on the physical properties of its micro-physical parts. One might suppose that the process that put the two particles into this state secretly fixes both of their spins before they are measured and always fixes them so they are anti-correlated—like a person who consistently dresses with odd socks. In

[5] Entanglement can be defined formally for a system where the states are vectors in a Hilbert space: given a tensor product structure of the Hilbert space, the state is entangled if and only if it is not a product.

[6] It would be more accurate to call it the 'EPR-Bohm experiment,' since it was Bohm who reformulated the thought-experiment in terms of spin. Yet it is more commonly known as the EPR experiment.

other words, one might suppose that the spins of the two particles, and hence their powers to be deflected up or down when they enter a Stern-Gerlach device, have been *locally determined* at a point prior to either of them being measured—even if we cannot say which particle is 'spin up' prior to the first measurement. According to this reasoning, there is still a fact of the matter about which particle is 'spin up' and which is 'spin down.'

Unfortunately, things are not so simple. Once the two devices being used to detect the spins of the two particles, *A* and *B*, are *rotated* in relation to their axes of polarization (ϕ_A and ϕ_B respectively), so that they are no longer measuring the *vertical* spins of the two particles, the probability of a particle being deflected up or down within one of the devices is no longer ½ but falls somewhere between one or zero. Of course, we can still use quantum mechanics to work out the new probabilities. However, John Bell famously demonstrated that quantum mechanics predicts that the two measurement outcomes will be correlated in a way that depends on the *relative angle* between the two polarizers ($\phi_A - \phi_B$)—a fact which neither of the particles should be in a position to 'know' (Bell 1964). After all, the polarization of one of the devices could have been changed the moment before the particle reached the detector, and the two wings of the experiment are sufficiently far apart to prevent any (sub-luminal) communication between them. The correlations predicted by quantum mechanics are thus inconsistent with the assumption that the spin of each particle was *locally determined* prior to the first measurement. This is no longer merely a thought-experiment. The *non-local correlations* predicted by quantum mechanics for entangled systems have invariably been borne out in scientific experiments, most notably in the experiments of Alain Aspect in the 1980s (Aspect et al. 1982).

The existence of quantum entanglement in our world thus gives us good reason to doubt that all the physical properties of a complex system *supervene* upon the properties of its micro-physical parts. This fact has not escaped philosophers of physics and a few metaphysicians. For example, the fact of quantum entanglement has been marshalled against David Lewis's doctrine of Humean Supervenience (Maudlin 2007).[7] It has also been cited as a good reason for embracing the theory of priority monism instead, in which the only fundamental thing that exists is the physical cosmos as a whole (Schaffer 2010).

Yet the phenomenon of quantum entanglement does not only make trouble for microphysicalists like Lewis, who seek to carve the world into a mosaic of micro-physical things. The problem that we wish to pose to psychological hylomorphists concerns how the *forms* of minded middle-sized things are supposed to be *individuated* in a world in which the micro-physical parts of a middle-sized thing are quantum-entangled. We will focus here on Charles's version of psychological hylomorphism (Charles

[7] Regarding a recent attempt to make Humeanism consistent with entanglement, see Simpson 2021c.

2021), which has been worked out in some detail and makes two significant claims.

(i) The properties of a psycho-physical entity cannot be metaphysically decomposed into *purely physical* and *purely psychological* properties.

(ii) The physical properties of the micro-physical parts of a psycho-physical whole are derivative of the psycho-physical properties of the whole.

Now suppose we consider the case of two human beings, H_1 and H_2, which have the same kind of psycho-physical form. What *individuates* the forms of H_1 and H_2, such that the form of H_1 is numerically distinct from the form of H_2? For a psychological hylomorphist like Charles, who regards the micro-physical parts of a whole as compositionally basic, the *forms* of two psycho-physical wholes are individuated by the set of micro-physical parts that count as being compositionally basic for that particular whole. But why should a set of micro-physical parts count as being compositionally basic in relation to H_1 instead of H_2? Presumably, because the physical properties and powers of *that* particular set of micro-physical parts derive from the form of H_1 rather than the form of H_2.

In a world that is characterized by a wave function, however, the micro-physical parts of middle-sized things are quantum-entangled with one another. In such a world, there will be middle-sized things that have micro-physical parts whose powers are not determined at the level of the middle-sized whole. Rather, the causal powers of these micro-physical parts will be determined at the level of the quantum mechanical whole in which they are entangled. And this quantum-entangled whole may include nothing less than the entire cosmos.

In that case, however, the micro-physical properties of a minded middle-sized thing, such as a human being, would not be determined at the level of the middle-sized whole. It would be a mistake to think of these micro-physical properties as being merely abstractions from the *psycho-physical* properties of a *middle-sized whole*. Rather, these micro-physical properties would depend (at least in part) on the *physical* properties of the *cosmic whole*, which are not reducible to the properties of its micro-physical or middle-sized parts. So, it seems a psychological hylomorphist like Charles is caught on the horns of a dilemma:

(i) either the form of a minded middle-sized thing only determines its *psychological* powers (in which case, he must endorse dualism), or

(ii) minded middle-sized things are merely parts of a *purely physical* whole (in which case, he must endorse physicalism).

Either way, the micro-physical parts of H_1 and H_2 will fail to individuate two psycho-physical forms. This is because the forms of these middle-sized

things are not playing a *metaphysically basic* role in determining the physical properties and powers of their micro-physical parts.

This is a worry for a psychological hylomorphist like Charles, who draws heavily upon the metaphysics of Aristotle yet maintains that his philosophy of mind is a viable contender today. We shall call this the Entanglement Problem for Psychological Hylomorphism. It is not a problem for *physics*, nor is it a problem that philosophers should expect physicists to solve on their behalf. Rather, the Entanglement Problem highlights an inconsistency between what a metaphysical theory implies about the nature of physical reality (locality) and what our best physical theory of matter successfully predicts (non-locality). Is there a way to avoid it?

3

Let us begin by observing that the psychological hylomorphist cannot circumvent this problem simply by claiming to reject 'reductionism.' The Entanglement Problem does not depend on the assumption that *every* physical property is reducible to, or weakly emerges from, the properties of a single quantum system. We are perfectly willing to allow for the possibility that some complex systems have classical-like physical properties that are not subject to entanglement. Even so, such systems will contain micro-physical parts that are quantum-entangled. We are also willing to countenance versions of quantum mechanics that posit something more to micro-physical reality than the wave function. Even so, the wave function will play a significant role in determining the properties of a system. Leaving instrumentalism to one side, can the micro-physical properties of a middle-sized thing be conceived as abstractions from the properties of a middle-sized whole, without contradicting quantum mechanics?

Suppose we take a different tactic. Psychological hylomorphists might deny that their theory is meant to apply to a world with a *universal* wave function; the kind of world we imagined in the previous section. They may urge that, according to textbook quantum mechanics, the wave function is subject to *collapse* whenever a scientist makes a measurement. There may be no fact of the matter about whether the particles comprising a system in the singlet state are 'spin up' or 'spin down,' but after the first measurement, one might think, we can ascribe determinate spin properties to both parts of the system with impunity. Indeed, some physicists, such as Barbara Drossel and George Ellis, consider the idea of a universal wave function to be implausible and empirically unmotivated because it is not something a scientist could measure (Drossel and Ellis 2018).

Whether or not the wave function undergoes a literal 'collapse' remains a disputed question among physicists and philosophers of physics. We do not have the space here to discuss in detail the notorious 'measurement problem' of quantum mechanics, which concerns how a quantum system evolves from being in a state which is indeterminate with respect to some quantity we wish to measure to a state that gives rise to a determinate

outcome. Different versions of quantum mechanics have been articulated that attempt to solve this problem in different ways. Suffice it to say that some versions of quantum mechanics, such as GRW theory (Ghirardi et al. 1986), have postulated a literal collapse in the wave function as part of their solution to the measurement problem, whereas other versions of quantum mechanics, such as de Broglie-Bohm theory (Bohm 1951), have maintained that there is a universal wave function. But is this question of relevance to the Entanglement Problem for Psychological Hylomorphism?

In a world in which every wave function is subject to collapse, we concede, the degree of entanglement will be more limited. For psychological hylomorphists to avoid the Entanglement Problem, however, the relevant question seems to be whether entanglement is *confined* within individual substances. In other words, is there a natural mapping from sets of mutually entangled entities to hylomorphic wholes, such that each set of entangled entities maps to one (and only one) whole? If such a mapping exists, then entanglement might be conceived as a purely *intra-substance* relation, such that any micro-physical parts of a substance that are entangled belong to one and the same substance. In that case, a psychological hylomorphist might maintain that the micro-physical properties of a minded middle-sized thing derive from the properties of this particular whole without quarrelling with quantum mechanics.

In support of the claim that entanglement should be conceived as an intra-substance relation, one might observe that the EPR system we discussed in section 2 involves particles that originate from a *common source*. Perhaps both quantum-entangled particles should be counted as parts of the *same* substance, even when they have become spatially separated from one another by a vast distance. Yet there are other kinds of systems, such as those described in the thought-experiments of Yurke and Stoler (1992a; 1992b), in which *separate sources* of electrons can also produce entanglement. Such cases suggest that entanglement is an *inter-substance* relation, though they are not decisive. Could these electrons be counted as parts of a *new* substance—without trivializing the notion of a substance or the processes through which substances are generated?

One of the difficulties with trying to sort micro-physical entities into distinct groups of entangled entities, where each group corresponds to a different substance, is that quantum entanglement is produced through the interaction of micro-physical entities, and there has been a long history of such interactions since the 'Big Bang.' In an effort to try and depict this situation more precisely, suppose we define a relation R on micro-physical systems where R_{xy} obtains if and only if there is a history of interaction between the entities x and y, and suppose we define a relation E where E_{xy} obtains if and only if the entities x and y are entangled. Let R^* be the transitive closure of R. We can think of the equivalence classes under R^* as 'universes.' If R_{xy} entails E_{xy}, then it follows that everything in our universe will belong to the *same* entanglement group.

The quantum theorist thus has a prima facie case for thinking that all the micro-physical entities comprising the cosmos today are entangled in some way. In the thought-experiments of Yurke and Stoler, when the electrons are said to begin in a 'separable state,' this does not imply that the electrons were not entangled with anything *before* they interacted with one another during the experiment. It only means that they were prepared in a quantum state in which no non-local correlations are detectable between the quantities in question. And in the EPR experiment described in section 2, when the two particles are said to acquire determinate spin values after the first measurement, this does not imply that either of the two particles ceased to be entangled with anything *after* the measurement. It only means that they assumed a state in which no non-local correlations are detectable between the two quantities in question.

Is it reasonable to suppose that a process in nature which collapses the wave function polices entanglement along the lines of distinct substances? It will be necessary for us to consider some of the technical details for a moment. The GRW theory put forward by Ghirardi et al. (1986), for instance, seeks to account for the collapse of the wave function by modifying the quantum dynamics to include a stochastic mechanism that brings about spontaneous localizations. Microsystems composed of a few particles seldom localize spontaneously since the collapse rate is of the order of 10^{16} seconds, which is undetectable for all practical purposes (Bassi et al. 2023). Macrosystems that are composed of many entangled particles, however, localize in a very short time (of the order of 10^{-7} seconds for a system of 10^{23} particles). Any localization in one element of an entangled system precipitates the localization of the other elements, hence the collapse rate of macroscopic objects increases according to the number of their constituents (Clifton and Monton 1999, 700–701).[8]

When we examine the GRW account of how a collapse is supposed to take place, however, we find a mechanism that diminishes rather than destroys those components of the wave function underpinning non-local correlations. Specifically, the mathematical model of the process involves multiplying the wave function undergoing the collapse with a Gaussian function, rendering such correlations undetectable but not 'forgotten.'[9] So it seems such a process is not going to remove entanglement relations connecting the physical parts of complex entities that Aristotelians would ordinarily consider to be distinct substances.

There are other proposals of processes that could produce a collapse in the wave function, however, which may be more effective in limiting the extent of entanglement. For example, Drossel's and Ellis's Contextual Wave Function Collapse theory claims that the bridge between the quantum and the classical worlds is formed by the 'heat bath' of a thermalized

[8] For a review of 'dynamical reduction' schemes of this type, see Bassi and Ghirardi 2003. For a relativistic version of GRW theory, see Tumulka 2006.

[9] Cf. the problem of the tails for GRW theory in Albert and Loewer 1990; Lewis 1995.

system, such as might be found within any macroscopic measuring device (Drossel and Ellis 2018). This heat bath is characterized by a limited temporal and spatial range of unitary time evolution and also by stochasticity. It is coupled to a wider environment that provides a heat sink into which energy is dissipated. It is this coupling of the system with the environment which facilitates the irreversibility that characterises the collapse process and allows entanglement within a system to be 'forgotten.' The stochastic dynamics leads both to a limited memory of the past and a limited temporal and spatial range over which quantum coherence and linear superposition hold.[10] A universal wave function cannot be defined.

Suppose that the domain of quantum theory is patchy in the way Drossel and Ellis suggest, and that a human being is comprised of many such patches. Could a psychological hylomorphist maintain that the micro-physical properties of all the patches comprising a minded middle-sized whole are (solely) derived from the intrinsic properties of this middle-sized whole?

We foresee a difficulty: the 'classicality' of a physical system, according to Contextual Wave Function Collapse theory, is an *extrinsic* feature of the system—something it derives from interaction with its environment. The heat bath depends for its classicality on environmental interactions because events in which particles are localized are irreversible, stochastic, and non-linear; and irreversibility must always be accompanied by an increase in entropy. No increase in entropy is possible in a closed system at equilibrium. But this leads Drossel's and Ellis's theory into a potential regress: if the heat bath of a thermalized macroscopic system (which is supposed to bring about the collapse of the wave function of a quantum system) is not an *intrinsically* classical system, then what holds true for the particles comprising the quantum system holds true for the particles that make up the macroscopic system and its heat bath. In other words, one must step *outside* of a macroscopic system in order to account for the classicality and localization of its components. At what point, then, does one stop appealing to something outside of a system in order to account for its classical features? Presumably, there would have to be some features of the cosmos.[11] In that case it would seem, once again, that it is not (solely) the forms of middle-sized things that are determining the physical properties and powers of their micro-physical parts, but certain classical or determinate features of the cosmos as a whole.

We conclude that the Entanglement Problem for Psychological Hylomorphism does not turn on the assumption that the physical world is characterized by a *universal* wave function which is not subject to collapse. This problem is not averted by adopting a mainstream dynamical collapse theory such as GRW theory or adopting a less standard approach like Con-

[10] Drossel (2017) denies that a thermalised system is described by a many-particle wave function.

[11] Penrose (1996) speculates that gravity is ultimately responsible for the collapse of the wave function.

textual Wave Function Collapse theory. If the psychological hylomorphist wishes to appeal to the collapse of the wave function as the regulative process that is supposed to prevent entanglement from ever occurring between the micro-physical parts of distinct substances, then the response to the Entanglement Problem stands or falls on the details of a theory which—as far as we know—has yet to be articulated.

4

Nonetheless, we do not offer a council of despair. Far from it. We think there are various ways in which the theory of psychological hylomorphism might be modified to accommodate the fact of quantum entanglement, and we shall briefly discuss a number of these possible moves below (cf. Koons 2024). This list is not intended to be exhaustive, and we have excluded some approaches we think will be uncongenial to hylomorphists. Some of these approaches seem more worthwhile to us than others. In each case, there is scope for development.

4.1

A psychological hylomorphist might consider adopting a Leibnizian picture of the world in which every hylomorphic whole encodes all the information contained in the wave function. We can think of each substance as running its own simulation of what is happening in the whole network of substances. In such a world, the micro-physical properties and powers of a psycho-physical whole could derive from the psycho-physical properties of the whole. The basic theory of hylomorphic wholes would not have to be modified to admit entanglement.

One objection that is likely to be raised against this approach to accommodating entanglement, however, is that it involves a *massive overdetermination* of the information that is contained in the wave function. Psychological hylomorphists might respond that this is a price that is worth paying in order to maintain their attractive account of how minded middle-sized things fit within the physical world. They might also observe that overdetermination is present within any deterministic account of the world in which the information contained in one time-slice determines what happens in subsequent time slices. Is overdetermination such a serious difficulty in this case?

One may feel bound to ask, however, why there is never a case of *conflict* concerning what is encoded in each of the substances. Why are they all perfectly harmonized with one another? The situation seems less puzzling if the quantum dynamics is deterministic. In that case, the substances will remain in harmony in virtue of the laws of nature—but only if they all begin with the same initial conditions. On the other hand, suppose the wave function is subject to collapse, and hence the quantum dynamics are indeterministic. In that case, we will have to suppose that they keep one another 'informed.' There will need to be a law of nature concerning the transmission of information across the network.

One might still query why every one of these Leibnizian substances encodes in its nature the very same law governing its simulation. However, such commonalities are going to be found within any Aristotelian account in which laws are embedded in the forms of substances. Concerning this point, there does not appear to be any *naturalistic* explanation. But then, a good Leibnizian is not in the business of making the world 'safe' for atheists.

4.2

A second possible solution might be to treat the wave function as being *jointly determined* by all the world's substances, instead of being something that is encoded within each and every substance. The wave function could be a *structural property* that is instantiated by the total collection, although it would not supervene upon the non-relational properties of the world's substances. Such a solution, assuming it has any explanatory power, would at least avoid the problem of overdetermination, if this is deemed to be such a problem.

However, the fact that the micro-physical properties of all the world's substances just happen to be correlated in the way described by quantum mechanics seems to require a deeper explanation. Why are the world's substances related within *this* structure rather than some other structure? Is there something that structures or relates the world's substances in this particular way? And how does this structure operate in such a way that it constrains the micro-physical properties of the world's substances to obey Schrödinger's equation? Simply positing a special 'structure' is *ad hoc* and does not seem to explain anything.

4.3

A third solution has been suggested by Koons, which involves introducing a new kind of form into Aristotle's ontology: a non-substantial 'group form' (Koons 2024). We should think of a group form as being an accidental form that is shared by a *group* of substances, and which confers certain causal powers on the members of the group that no member of the group would possess by itself.

This theory of group forms may involve only a minor change to the theory of psychological hylomorphism. After all, Aristotle was not a strict ontological individualist, since he recognized that the citizens of a city might exercise various capacities that are irreducibly social in nature (cf. *Politics* I, 1253a8–40; *Nicomachean Ethics* IX, 1170b3–19). Positing a group form instead of a 'structure' also has the virtue of offering an economy of relations. If the wave function is conceived in terms of a structure of external relations between n substances, there will have to be $n(n-1)/2$ nomological connections. In the case of a group form, however, there need only be n connections, since each substance is directly connected to the group form and only indirectly to the other substances. These connections to a single group form offers a more economical account than involving

micro-latent powers in substances (like that of Shoemaker 2002), each of which depends on $(n - 1)$ relations to other substances.

In Koons's original theory (Koons 2024), every maximal set of mutually entangled substances is characterized by a group form, where this form encodes all the information about how the micro-physical parts of this group of substances are mutually entangled. We can think of the wave function for this group as being encoded in its group form. If there is a universal wave function, then there is a single group form that is an accidental form of all the world's substances taken together. If the wave function is subject to some process of collapse, however, would this significantly alter the picture? If everything that interacts remains entangled even if there are collapses, there would still be only a *single* group form.

Such a situation does raise a few puzzles. After all, Aristotelian substances are not everlasting, so it seems odd that a group of substances whose membership is continually changing would continue to instantiate the same 'accidental' group form. Why do they instantiate *this* form instead of another? And if this group form is *accidental* rather than *essential*, then under what circumstances would this group have been united by a *different* form? Of course, such worries arise already in the social context: if a city is an accidental group form, it must somehow persist through changes in the set of its extant citizens. They also appear to arise in the metaphysics of artefacts (Skrzypek 2023).

Nonetheless, these problems do not appear to be insuperable. Group forms (and artefact forms, for that matter) could be individuated by their individual causal histories, especially by their origin events. A form that continually unites a set of substances at the origin could persist as one and the same form, even as the members of the group change over time. This feature cannot in principle be duplicated by Shoemaker's account of micro-latent powers.

One might wonder, however, why a group form fails to *fully unite* the members of the group into a new substance. Can Koons's theory distinguish group forms from substantial forms? There are a couple of strategies we could employ which might secure this distinction. First, perhaps we could think of a group form as being the ultimate joint ground of *some* but not *all* of the causal powers of its substantial members, whereas a substantial form should be the ultimate (joint) grounds of *all* the causal powers of a substance's parts (together with any relevant group forms). This model would allow for a hierarchy of group forms, with some groups belonging to other groups, while forbidding that any substance be part of other substances. Second, perhaps we could rely on the fact that a substantial form encodes the essence of the substance, in such a way that all the causal powers and potentialities of the substance and its parts are derivable from that essence. A group form, in contrast, would be dependent ontologically on the essences of its individual members. In the case of social forms (like that of a city), the form depends on the sociability built into the essence of individual

human beings (i.e., as political animals, to use Aristotle's phrase). Like accidents, social forms and entanglement would lack complete and self-contained real definitions in the strict sense (see *Metaphysics Zeta*, 1030a–b).

4.4

Here is a fourth possibility: the wave function could be encoded in a *cosmic substance*, as in Simpson's theory of Cosmic Hylomorphism (Simpson 2021a and 2021b; Simpson and Pemberton 2022; Simpson 2023b; Moško and Simpson 2024). In this theory, the cosmos is conceived as a hylomorphic whole that is composed of both matter and form. It is a unified entity that persists through change in virtue of having a single 'cosmic form' that determines the powers of its parts. In the 'strict' version of this theory, the cosmic whole is characterized as a *substantial unity*.

The theory of Cosmic Hylomorphism was originally developed with the de Broglie-Bohm version of quantum mechanics in mind (Bohm 1951), although it has a broader domain of application that includes GRW theory (Ghirardi et al. 1986). De Broglie-Bohm theory posits a configuration of particles that compose middle-sized things, such as scientists and their measuring devices, and an equation of motion for the particles that depends on the wave function. According to the theory of Cosmic Hylomorphism, the particles are parts of the cosmic substance, and the wave function represents a power of this substance to choreograph the trajectories of its particles. So, every physical entity is a part of the cosmic substance; the cosmic substance is *mereologically complete*.

One difficulty with treating the cosmic whole as being a substantial unity that is mereologically complete, however, is that it seems to preclude the existence of other substantial unities besides the cosmic whole. Aristotle argues that a substance cannot have other substances as parts without violating the *substantial unity* of the substance. In that case, any minded middle-sized thing, being a part of the cosmic substance, would not count as a substance. So, how do minded middle-sized things, like humans and animals, fit into this picture?

It has been suggested that the theory of Cosmic Hylomorphism might be construed as an alternative to standard versions of the theory of cosmopsychism (Simpson 2024). According to constitutive micropsychists, the consciousness of a middle-sized thing is constituted by the consciousness of their micro-physical parts. For the constitutive cosmopsychist, in contrast, the consciousness of middle-sized things is constituted by a cosmic consciousness. Several panpsychists now identify as cosmopsychists and have worked out detailed theories of cosmopsychism (e.g., Goff 2023). A Cosmic Hylomorphist might similarly conceive the cosmic substance as being a *fundamental* psycho-physical whole in which other *non-fundamental* psycho-physical wholes are grounded, whilst linking consciousness with intentional cognition.

We do not think that many psychological hylomorphists will find this version of Cosmic Hylomorphism attractive without alterations, however, since they regard psycho-physical wholes as being metaphysically basic. Some hylomorphists, like Charles, are also disinclined toward any form of panpsychism (Charles 2021, 2, 274). Furthermore, the theory of cosmopsychism is subject to the 'decombination problem,' which concerns how the minds of middle-sized things are individuated in a world which has one consciousness (Miller 2018; Albahari 2020). It seems a psychological hylomorphist who took this route would end up substituting one individuation problem for another. How can she admit the existence of a cosmic substance without displacing middle-sized substances?

Perhaps a psychological hylomorphist could argue that the cosmic substance counts as the one and only exception to the rule that substances cannot have substances as parts. Might this prohibition be restricted in a principled way to 'local substances' like humans and animals, but suspended for the case of the cosmic substance, which contains the totality of all physical things? A more radical approach would be to abandon this prohibition altogether, taking a leaf out of Scotus's metaphysical playbook. Richard Cross and Thomas Ward have both argued that Scotus retained a coherent conception of substances as metaphysically basic entities, even though he permits a substance to contain other substances as parts (Cross 1998, chap. 4; Ward 2014, chap. 5). Granted, Scotus did not posit the existence of a *cosmic* substance, but there seems to be no reason in principle why he could not have admitted the existence of such an entity within his ontology—especially if he had believed the cosmic substance to have properties that are irreducible to the properties of its parts.

Timothy Pawl and Mark Spencer, motivated by concerns about the consistency of Aristotelian hylomorphism with modern chemistry, have proposed a via media between traditional versions of hylomorphism and Scotus's more radical theory (Pawl and Spencer 2016). They argue that material substances can have *parts* which have substantial forms whilst insisting that a substance can only have one substantial form *as a whole*. Their via media turns on their observation that "substantial forms only inform *matter*" and their rejection of Scotus's claim that "the substantial form of the supposit informs the part substances that make it up" (Pawl and Spencer 2016, 157). We cannot pursue these ideas any further here.

4.5

Here is a fifth suggestion that Alexander Pruss has recently been contemplating.[12] Suppose we retain the concept of a cosmic whole that counts as a substantial unity but drop the assumption that it is mereologically complete. Think of it as a Swiss cheese that contains holes into which other things can fit. According to this approach, there are smaller substances

[12] Personal communication.

which are *embedded* within the cosmic substance but are not *mereological parts* of it (cf. Dumsday 2016). This set of substances includes minded middle-sized things, such as humans and animals.

The challenge for this model is to find a principled way of dividing up physical reality between the cosmic substance and the smaller substances, and to explain how the cosmic substance *interacts* with the smaller substances such that their properties are affected by the wave function. Swiss Cheese Hylomorphists, as we shall now call them, could claim that the wave function is encoded within the cosmic substance, whilst denying that this substance contains *all* the information needed to describe physical reality. After all, there are interpretations of quantum mechanics which stipulate that the wave function alone does not specify the physical state of the world, such as de Broglie-Bohm theory.

Perhaps we could divide up the particles that feature in de Broglie-Bohm theory among all the smaller substances and think of the cosmic substance as something that *causes* the quantum mechanical behavior of the particles. One of the difficulties confronting a causal interpretation of quantum theory, however, is that the wave function is defined in an abstract, high-dimensional configuration space, rather than the three-dimensional space of the particles. How are entities that exist in two different spaces supposed to *causally interact*?

Here is one option: we might conceive the wave-function as a 'multi-field' that exists in the same physical space as the particles, and which determines the trajectories of all the particles (Hubert and Romano 2018). In a world with a wave function and N particles, the multi-field exists as a field in three-dimensional space that assigns properties to all N-tuples of points of space. Using multi-field theory, we suggest, it is possible to construct a version of Swiss Cheese Hylomorphism in which the cosmic substance is identified with a physical multi-field that exists in the same physical space as the particles. The particles are embedded within the cosmic substance, but they are not mereological parts of it. This substance-field exerts a *causal* influence upon all the particles at every moment of time, which tells them how to move, but it does not *constitute* the nature of the particles or the various substances that they comprise.

Unfortunately, another difficulty arises, since communication between the multi-field and the particles is entirely 'one way.' The multi-field does not behave like a classical field in which the particles and the field mutually affect one another—the particles are entirely passive! And in the standard version of de Broglie-Bohm theory, the equation of motion for the particles is deterministic. If middle-sized things, such as humans and animals, are composed of such particles, then they must lack causal powers to make a difference to how the physical world unfolds. For hylomorphists who subscribe to the Eleatic Principle, or for theorists who are opposed to epiphenomenalism on other grounds, this would be a good reason to drop humans and animals from their ontology.

Swiss Cheese Hylomorphism, then, may be best served with an indeterministic version of the quantum dynamics, so that the cosmic substance does not determine everything that takes place. We might suppose that indeterministic changes in the smaller substances are driven by these substances themselves, or at least by these substances acting in concert with the cosmic substance. In any case, the smaller substances should play a part in 'deciding' where their particles go. This theory awaits further development.

4.6

Finally, one of us (Simpson) would like to suggest here a 'liberal' version of Cosmic Hylomorphism in which the cosmic whole is mereologically complete but does not count as a *substantial* unity. If any substances exist, they are smaller than the cosmic whole, which contains them as parts. Since the cosmic whole is a hylomorphic whole with a form which qualifies its parts, the relationship between the cosmic whole and its substantial parts is *constitutive* rather than causal. Nonetheless, the cosmic whole does not count as a substance in the *strict* sense, so admitting substances as parts of the cosmic whole is permissible. Once again, it is the cosmic whole that encodes the wave function.

But how should we conceive the unity of the parts that comprise the cosmic whole? If the cosmic whole does not count as being a *substance* in the strict sense, then why does it count as being a *hylomorphic whole* instead of an *aggregate* of different things? Simpson suggests we could conceive the hylomorphic union of the cosmic form with its parts as being *operational* rather than *substantial*: the parts can only perform (some of) their proper operations in union with the cosmic form, and the cosmic form can only perform (some of) its proper operations through the operations of the parts of the cosmic whole.

This idea is not without historical precedent. Stephen Ogden has recently suggested a similar way of understanding the relationship between human substances and the Active and Potential Intellects in Averroes's philosophy of mind, arguing for the feasibility of a 'liberal hylomorphism' which admits hylomorphic wholes that are not substances (Ogden 2023). According to this theory, it is through the Active and Potential Intellects that humans perform certain higher-level intellectual operations, and they are joined with human substances in an operational rather than a substantial union.

How does this concept of a cosmic form compare with Koons's notion of a group form? Whilst both kinds of forms are *non-substantial*, the cosmic form cannot be an *accidental* form of the cosmic whole, it might be argued, since it is supposed to explain how the laws of quantum physics remain the same in 'small worlds' that have only a few particles (Simpson 2023b). Yet the cosmic whole, in the liberal version of this theory, contains substances among its parts. Does the cosmic form qualify each of these substances as an *accident*? Presumably not, if the cosmic form is essential to their proper operations. And yet it seems reasonable to suppose that there are *other* cos-

mic forms which would enable the proper operations of these substances, if its proper operations do not depend upon the microphysical details of what is encoded within the cosmic form. There are possible worlds with different wave functions in which human beings eat, sleep, and think. Perhaps the cross-world variations in the wave function could be conceived as accidental variations in a single transworld cosmic form.

Like Swiss Cheese Hylomorphism, however, this liberal version of Cosmic Hylomorphism also faces a challenge in specifying how micro-physical reality is supposed to be carved into separate substances, although it does not seek to divide micro-physical reality between a cosmic substance and smaller substances. More specifically, the task is to explain how the smaller substances, being parts of a cosmic whole, and thus constituted by the cosmic form, are supposed to have any physical features or properties that are not determined by the cosmic whole and that have a causal role to play. What gives such entities the sort of independence that is characteristic of being a substance?

Let us briefly consider a possible application of the liberal version of Cosmic Hylomorphism to the de Broglie-Bohm theory. Simpson suggests that, if this version of Cosmic Hylomorphism is applied to a Bohmian version of quantum field theory (Dürr et al. 2004), in which the number of particles in the configuration is no longer fixed, there could be a division of labor in which (1) the cosmic whole constrains all of the particles in existence to move in accordance with the universal wave function and (2) the local substances constrain the creation and annihilation of particles within those regions in which their forms are extant, influencing where and when they are created or annihilated. In this example, the cosmic form only delineates the potential motions of the particles. The local forms of the smaller substances, however, could make a difference by imposing the boundary conditions necessary for any actual motion to take place (cf. Simpson and Horsley 2022). The micro-physical properties of the particles would thus be jointly determined by the cosmic and local forms.

Of course, there may be other ways of specifying the role of cosmic form in the context of different versions of quantum mechanics. In the Everettian version, no particles are posited in the basic ontology yet different 'branches' of the wave function are said to comprise macroscopically distinct 'worlds.' In the sophisticated version advanced by the Oxford Everettians (Wallace 2012), these branches are said to emerge through the physical process of decoherence. Nonetheless, it remains controversial whether the Oxford Everettians have succeeded in providing a coherent interpretation of the probabilities predicted by quantum mechanics for a universe in which every possible measurement outcome actually takes place. Moreover, the continuous splitting of physical reality into separate 'worlds' raises metaphysical problems concerning the existence and identity of macroscopic objects, such as scientists and their measuring devices.

A cosmic form could play a role in explaining how one branch of the wave function gets to be privileged over other branches. One way to understand how it might play this role is by adapting the 'traveling minds' theory of quantum mechanics, which supplements the physical story told by the Everettian with a mental story connecting minds with particular branches of the wave function (Squires 1990; Barrett 1995; cf. Pruss 2017). One might consider the cosmos as a psycho-physical whole using the theory of hylomorphism. If the cosmic mind is like Avicenna's concept of the Active Intellect, as Adamson describes it (Adamson 2023), then perhaps the cosmic mind could have a role to play in bestowing local forms within some branches of the wave function (once they have decohered and become sufficiently distinct). The other worlds would be merely *potential* worlds which were not *in-formed* by the cosmic mind. Suppose any hylomorphic substances within a privileged branch always share a group form, such that these substances always 'travel' together. The Born Rule of quantum mechanics could then specify the probability of a community of *forms* travelling to one branch rather than another (as in Pruss 2017). Of course, this is only a sketch of an idea, and we cannot go into further detail in the elaboration of such metaphysical hypotheses here.

Suffice it to say that the liberal version of Cosmic Hylomorphism that we have sketched also seems worth developing. It offers the tantalizing possibility of harmonizing the Aristotelian theory of hylomorphism with the Platonic idea of a 'world soul,' which may prove fruitful in discussions of a variety of other problems in philosophy of mind and religion.[13]

5.

Let us take stock. We began by considering the merits of the theory of psychological hylomorphism, as Charles (2021) has recently presented it, in which a human or animal is an inextricably psycho-physical whole (section 1). This theory offers an attractive way of circumventing the mind-body problem, building on Aristotle's hylomorphic theory of substances. According to the psychological hylomorphist, a human or animal is a hylomorphic composite of matter and form, where the form contains the material principles of the composite in its definition. Any physical properties predicated of the micro-physical parts of a psycho-physical whole are abstractions from the psycho-physical properties of the whole. It is the psycho-physical whole which is metaphysically basic. In Charles's hylomorphism, mind is restricted to the domain of middle-sized things.

For psychological hylomorphists to offer a viable alternative to physicalism or dualism today, however, we have argued that they must find a way

[13] Developed along certain lines, a theory with a 'world soul' could have implications for accounts of theodicy and mystical experience (Dumsday 2018). A liberal version of Cosmic Hylomorphism that includes 'local' substantial forms, as well as the 'cosmic form,' may also be relevant to contemporary discussions of cosmopsychism in the philosophy of mind (Goff 2023); in particular, the Decombination Problem (Miller 2018; Albahari 2020).

to address the Entanglement Problem, which concerns how the forms of psycho-physical wholes are *individuated* in a world which admits quantum entanglement (section 2). In a world with entanglement, the causal powers (both active and passive) of entangled entities do not supervene upon their local states or properties. The phenomenon of quantum entanglement thus gives us reason to doubt that the physical properties and causal powers of the micro-physical parts of a minded middle-sized thing derive (solely) from the psycho-physical properties of the middle-sized thing as a whole. They may depend upon nothing less than the cosmos as a whole. In that case, how can the *form* of one human being be numerically distinguished from another? We argued that this problem generalizes to worlds where the wave function is subject to 'collapse' (section 3).

We suggested six ways in which a psychological hylomorphist might seek to accommodate the phenomenon of entanglement, a number of which require modifications to the way hylomorphic wholes are conceived and/or additions to the basic ontology (section 4). First, we considered a kind of Leibnizian Hylomorphism, in which every substance encodes the same wave function and their temporal development is harmonized (section 4.1). This solution does not seem to require any modifications to the theory of hylomorphic wholes or any additions to the ontology: the properties and powers of the micro-physical parts of a minded middle-sized thing derive from the psycho-physical properties of the middle-sized thing as a whole. It does appear to require an explicit commitment to theism (a divine mind), however, that may limit its appeal.

Second, we discussed a version of Wave Function Structuralism, in which the world's substances instantiate a 'structure' that encodes the wave function (section 4.2). It was unclear to us how this non-supervenient structure was supposed to influence the physical behaviour of the world's substances. Still, there may be scope for developing an account of structure using recent adaptations of hylomorphism, as in Koslicki 2018 or Jaworski 2016, though Charles argues that these accounts fail to solve the mind-body problem per se.

Third, we reflected on the Hylomorphic Theory of Group Forms that has recently been put forward by Koons (2024), which moots the possibility of a 'group form' shared by substances that encodes the wave function and confers certain causal powers upon the members of the group (section 4.3). This requires an addition to the ontology and a modification of the theory of hylomorphic wholes, since the causal powers of the micro-physical parts of every member of this group are *constituted* in part by the form of the group.

Fourth, we considered a 'strict' version of Cosmic Hylomorphism that Simpson has advanced in earlier work (Simpson 2021a; 2021b; 2023b), in which the cosmos is conceived as a substance which is mereologically complete; every physical entity is a part of it (section 4.4). This requires some significant modifications. In addition to postulating a cosmic substance with a cosmic form that plays a constitutive role in determining

the micro-physical properties and powers of middle-sized things, this strict version of his theory suggests the cosmos as a whole may instantiate mental (intentional) properties. It is not clear that middle-sized psycho-physical wholes can be metaphysically basic, on this view, although there may be cogent ways to address this difficulty.

Fifth, we sampled the idea of Swiss Cheese Hylomorphism that Pruss has recently been contemplating, which also posits a cosmic substance but denies that it is mereologically complete (section 4.5): there are smaller physical substances, like humans and animals, which are not parts of the cosmic substance. Whilst this theory likewise extends the ontology, it explains quantum entanglement in terms of *causal interactions* with the cosmic substance, so it does not require any changes to the theory of hylomorphic wholes. This solution may be limited in its application, however, to quantum theories that posit hidden (physical) variables, like de Broglie-Bohm theory (or to Pruss's own hylomorphic variant of the 'travelling minds' version of quantum mechanics in Pruss 2017).

Finally, we proposed a 'liberal' version of the theory of Cosmic Hylomorphism, in which the cosmos is conceived as a *non-substantial* hylomorphic whole that includes substances among its physical parts (section 4.6). Like the 'strict' version of Cosmic Hylomorphism, it assigns a constitutive role to the cosmic form in determining the properties and powers of the micro-physical parts of middle-sized things. Like the strict version, it may suggest that the cosmos itself counts as a psycho-physical whole.[14] However, this version of Simpson's theory admits the existence of macroscopic psycho-physical wholes that are metaphysically basic.

There may be other options besides those we considered here, and all the theories we have mentioned require further development. Some will fit better with certain versions of quantum mechanics than others. Some seem to entail an expansion of the mental or psychological domain beyond the realm of organic middle-sized things. Once an option has been selected from the complete taxonomy of 'Quantum Hylomorphisms,' however, it should be possible to formulate an adequate theory of how the forms of psycho-physical wholes, like human being and animals, are individuated. But that is work for another paper.

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[14] Goff (2023) intends his version of cosmopsychism as an alternative to classical theism, but the idea of a non-divine 'world soul' is not inconsistent with theism (Dumsday 2018). For a helpful discussion of the world soul tradition within Early Christian thought, see Zachhuber 2022.

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