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Hylomorphism and the Causal Closure of the Physical

João Pinheiro da Silva[1]

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Abstract
Howard Robinson has criticized the contemporary revival of hylomorphism for, on the one hand, accepting the causal closure of the physical, while, on the other, ascribing a real and irreducible causal role to forms or structures. If the world is causally closed under physics, it makes no sense to postulate a structure that actively affects the distribution and motion of matter. After carefully formulating what I call Robinson's *causal closure argument against hylomorphism*, I demonstrate that the argument fails because it presupposes an overly strict conception of causal closure of the microphysical, according to which every physical effect is completely determined by, and has a complete explanation in terms of, bottom-level microphysical entities and their interactions governed by fundamental physical laws. Based on two case studies – one from physics (the Fractional Quantum Hall Effect), the other from microbiology (information control in microorganisms) – I argue that the argument fails, yet a more modest (and scientifically defensible) version of closure remains intact. This version of closure secures that no non-physical forces supplement the inventory of fundamental physics while allowing higher-level constraints to be causally efficacious by constraining which among multiple microphysically compatible possibilities is actualized. This means that a reformulated version of closure, capable of dealing with those cases, is also perfectly compatible with the hylomorphist (or generally anti-reductionist) claim that higher-level structures are causally efficacious and an irreducible part of physical reality.

Keywords Hylomorphism · Causal closure of the physical · Philosophy of science · Constraints · Structure · Microphysicalism

1 Introduction

Howard Robinson (2014, 2021) has criticized the contemporary revival of hylomorphism for, on the one hand, accepting the causal closure of the physical while, on the other, ascribing a real and irreducible causal role to form or structure. The basic incompatibility between these positions, Robinson argues, should be obvious: if one accepts that the world is causally closed under physics, thereby consigning all genuine causal efficacy to the domain of fundamental physical interactions, it makes no sense to postulate a higher-level form or structure that actively affects the "distribution of matter and its motion" (Robinson 2021: 284). This line of reasoning is reminiscent of Kim's (1998) causal exclusion argument, according to which, since there can be no difference in higher-level phenomena without a difference in the base physical phenomena, the former are fully determined by the latter, rendering emergent phenomena causally impotent. And just as Kim (1999: 33) distinguished between genuine causation and mere "conceptual" explanation (which can invoke higher-level structures as useful descriptions), Robinson (2014: 209–212) too proposes a purely conceptual treatment of structure, recognizing that it may figure in our explanations but only as a competent description that does not ultimately track any real causal activity in the world.

Robinson's general reasoning may seem rather question-begging. Surely, if causality is delimited ab initio to the spatiotemporal and causal relations between basic physical entities, the conclusion that form or structure plays no causal role will follow but not be substantive[1]. The hylomorphist

✉ João Pinheiro da Silva
jpds1@st-andrews.ac.uk

[1] Department of Philosophy, University of St Andrews, Scotland, UK

[1] Lowe (2000) argues that similar uses of the causal closure of the physical principle, especially in its stronger formulations, are question-begging. Morris (2010) makes a similar point.

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may thus reasonably question why he should even accept a principle such as the causal closure of the physical in the first place, since it seems to effectively rule out the hylomorphic position from the outset. This, in fact, is the avenue taken by some hylomorphists who explicitly reject closure. Robinson, however, has a stern response: abandoning closure means abandoning modern science; one may salvage hylomorphism by doing so, but the resulting outcome "will not fit nature as we now understand it" (Robinson 2021: 284).

In this article, I will argue that hylomorphists should not respond to Robinson's challenge by simply rejecting the causal closure of the physical. Firstly, because while I reject Robinson's hasty connection between causal closure (as he understands it) and modern science[2], I believe that there are good historical and empirical reasons to subscribe to at least some form of the causal closure principle – reasons that, as I shall argue, should be especially appealing to hylomorphists. Secondly, hylomorphists shouldn't discard closure altogether because they are not obliged to accept Robinson's overly strict understanding of the causal closure of the physical, whose stringent requirements render it unable to accommodate important cases in contemporary science. I will demonstrate this by examining two such cases: one from physics (the Fractional Quantum Hall Effect), the other from microbiology (information control in microorganisms). In each of them, Robinson's microphysical closure fails, yet a more modest – and more scientifically defensible – version of closure remains intact. This reformulated understanding of closure is perfectly compatible with the hylomorphist claim that higher-level structures are causally efficacious and an irreducible part of physical reality.

The argument will proceed as follows: firstly, I reconstruct Robinson's *causal closure argument against hylomorphism*; secondly, I challenge the strict microphysical closure principle presupposed throughout the argument by examining one case from physics and another from microbiology; thirdly, I propose an alternative understanding of causal closure compatible with hylomorphism; fourthly, I assess how other contemporary hylomorphists (Jaworski 2016a; Simpson 2023; Yates 2026) have engaged with causal closure.

2 The Causal Closure Argument Against Hylomorphism

Despite the different argumentative strategies in each of Robinson's (2014, 2021) articles tackling hylomorphism, there is a similar line of thought running through both, comprising what I shall call the *causal closure argument against hylomorphism*. In formulating the argument, I have tried to stay as close to Robinson's own formulations as possible. Thus, for instance, my continuous mention of "structure" instead of "form", as Robinson is mainly interested in tackling what he calls "modern hylomorphism", that is, the structural hylomorphism as defended in its various versions by Kathrin Koslicki (2008) and William Jaworski (2016a). That is also the reason why my rendering of the *causal closure argument against hylomorphism* never defines the causal closure of the physical: Robinson himself, despite how central and ubiquitous causal closure is to his general argument, never does so. This is particularly problematic because causal closure can be formulated in various ways[3], and the strength of Robinson's argument depends crucially on which formulation is operative. We must therefore infer Robinson's understanding of closure from the various passages where he describes what follows from a commitment to the principle. The three most important ones are:

1. bottom-level force operation ("under such closure, all the forces operate at the bottom level" (Robinson 2014: 213);
2. bottom-up explanatory completeness (there exists a complete bottom-up explanation of "where the physical parts end up located", given the interactions of fundamental constituents following basic physical laws (Ibid.: 204)); and
3. universal applicability of basic physics ("physical closure requires that basic physics applies to the basic constituents within complex structures as much as to them when more isolated" (Ibid.: 213)).

The conjunction of these three commitments generates a *very strong* causal closure principle. The requirement that all forces operate at the bottom-level goes beyond the standard formulations of closure (such as "every physical effect has a sufficient physical cause") which don't necessarily exclude higher-level physical properties from being those sufficient causes. Moreover, it demands not merely physical processes to be causally complete, i.e., not supplemented by *non-physical* forces, but for them to be *complete at the most fundamental level*. Robinson's version of causal closure is thus not a mere "causal closure of the broadly physical"

[2] Many have pointed out good reasons to question whether the causal closure of the physical (as formulated by Robinson) straightforwardly follows from (or is required by) contemporary scientific practice. See, for example, Crane and Mellor (1990), Drossel (2021), Garcia (2014), Montero (2006), Morris (2010), Simpson (2023: 30–41) and Vicente (2006).

[3] For a survey of the various versions of the causal closure of the physical, see Gibb (2015).

(Yates 2016: 833−34), but a strict *causal closure of the microphysical*, wherein every physical effect is completely determined by, and has a complete explanation in terms of, bottom-level microphysical entities and their interactions (governed by fundamental physical laws). It is this conception of causal closure that permeates and animates the entire edifice of the *causal closure argument against hylomorphism*. The argument can be formalized as follows:

P1: Causal closure under physics implies that all forces operate at the fundamental physical level.

P2: Fundamental physical forces provide a complete causal explanation of matter's distribution.

P3: Therefore, under physical closure, there are no additional (structural) forces at higher levels that contribute to determining matter's distribution and motion. [from P1, P2]

P4: For structures to be causally efficacious, they must exert forces that make a difference to matter's distribution beyond what fundamental forces alone determine.

P5: Therefore, under closure, higher-level structures are not causally efficacious, for they exert no forces beyond fundamental forces. [from P3, P4]

P6: Something is part of concrete physical reality (not merely conceptual) only if it is causally efficacious (Eleatic Principle).

P7: Therefore, under closure, higher-level structures are not part of concrete physical reality – they are at most explanatorily useful conceptual categories. [from P5, P6]

P8: Realist hylomorphism requires structures to be part of concrete physical reality, not merely conceptual.

P9: Modern hylomorphists affirm both realist hylomorphism AND closure under physics.

C: Therefore, modern hylomorphism is incoherent. [from P7, P8, P9]

3 Against Microphysical Closure

Robinson claims that because of its failure to be reconciled with closure, hylomorphism is inherently at odds with contemporary science, and so does "not fit nature as we now understand it" (2021: 284). After all, modern science was in great part erected in deliberate repudiation of Aristotelian science and philosophy, attaining its extraordinary successes by ditching formal and final causes in favour of a purely "bottom-up" approach to the natural world, investigating phenomena in terms of their smallest constituents and operations.

The methodological triumph of the reductive approach to nature provides *prima facie* good reasons for believing that closure is not a baseless metaphysical postulate but rather a genuine and judicious outcome of modern scientific discoveries. As Gillet (2025) has recently argued, the first round of debate between emergentists and reductionists, in the late nineteenth and early twentieth centuries, was decisively won by the latter party. Emergentists centred their case on the, at the time, persistent failures to analyse higher-level phenomena in terms of lower-level constituents: from the incapacity to explain the properties of salt by appealing to the properties of sodium and chlorine, to the inability to explain higher-level biological processes (such as digestion) in terms of its cellular or molecular components (*Ibid*.: 4). This explanatory lacuna led vitalists such as Hans Driesch to posit "uncomposed and fundamental biological forces and/or energies" (*Ibid*.: 32), which should somehow supplement the forces of physics, thereby solving the apparent gap between both realms of inquiry.

Against this emergentist program, the reductionists advanced a thesis which Gillett (2025: 33) terms "Everyday Reductionism", according to which "all working individuals, and also all of their activities and working properties, are fully composed by lower-level working individuals and their activities and properties". This research program proved overwhelmingly successful, and by the mid-20th century, compositional explanations to all the previously polemical cases had been furnished. The jewel crowning the reductionist victory was the progressive discoveries regarding DNA and RNA and the molecular basis of heredity and organismal development, which allowed reductionists to finally conquer what had been, for at least two centuries then, the last bastion of emergentist resistance: biology. These triumphs refuted decisively all previous appeals to vital or otherwise non-physical forces.

Nowadays, scientists accept and operate within the postulates of "Everyday Reductionism" as a kind of unreflective background assumption. It is this comprehensive empirical victory, I submit, that established the intuitive plausibility of the causal closure principle that Robinson invokes. The successful provision of compositional explanations across the sciences showed that there are no causal-explanatory gaps requiring supplementation by non-physical forces. That is the great motivator behind Papineau's (2001) inductive arguments for the completeness of physics: the *argument* *from fundamental forces* and *the argument from physiology*, both relying on a similar empirical pattern according to which apparently special forces are consistently reduced to a "small stock of fundamental forces", leaving no place for anomalous or uncomposed higher-level forces. All of this makes Robinson's argument against hylomorphism appear compelling: how can higher-level structured wholes possess irreducible causal powers beyond what is determined by fundamental physical forces? Wouldn't this reintroduce precisely the kind of "spooky" or crypto-vitalist non-physical forces that twentieth-century science so decisively eliminated?

Before tackling those questions directly, it should be noted that we are currently in the midst of a second round of reduction-emergence debates (Gillett 2025). The catalyst for the reemergence of this century-old discussion comes from "challenging compositional cases" (*Ibid.*: 50–64), wherein we possess successful compositional explanations of wholes, yet our precise empirical measurements reveal that parts behave differently in complex wholes than they do in simpler systems. While no contemporary emergentist seeks to dispute or revoke Everyday Reductionism and its achievements, they question whether additional determinative phenomena and relations exist alongside compositional structure. The *crux* of the contemporary debate, then, is whether the behaviour of parts in complex wholes is *exhaustively determined* by the laws and principles that govern them in simpler systems. This is highly consequential for assessing Robinson's argument. For instance, if we find that determinative relations exist at higher levels, we have good reasons to reject Robinson's causal closure requirement 3).

As such, I turn now to a pair of cases that prove hard to square with Robinson's argumentative strictures. In each, we find examples wherein the operating microphysical forces are identical across different configurations, but the physical or functional outcomes differ systematically – and in a way that can't be accounted for solely by appealing to microphysical forces and interactions.

3.1 Fractional Quantum Hall Effect

If the microphysical version of causal closure is correct, then one would expect that specifying the fundamental forces and initial microstates of a physical system should exhaustively determine its behaviour. Yet, the Fractional Quantum Hall Effect (from now on, FQHE) (Laughlin 1999) provides a case where (i) the microscopic Hamiltonian is completely specified, (ii) the fundamental forces are identical across different configurations, but (iii) the physical outcomes differ systematically due to higher-level constraints irreducible to those forces.

There are two types of Quantum Hall Effect. When electrons are confined in a 2D surface at extremely low temperatures and in a strong perpendicular magnetic field, they exhibit quantized Hall conductivity:

$$\sigma_{xy} = \nu \frac{e^2}{h}$$

In the case of the Integer Quantum Hall Effect, ν is an integer, whereas in the FQHE, ν is a fraction. Whereas the former is essentially a single-particle effect multiplied by many particles (and thus not as challenging to microphysical closure), the latter is "*not* adiabatically deformable to any noninteracting electron state", meaning that it "is something unprecedented – a new state of matter" (Laughlin 1999: 869).

To understand why this occurs, we must first consider how this state is formed. In the absence of a magnetic field B, electrons occupy a dense spectrum of closely spaced energy states. When B is strong, however, the energy spectrum quantizes into discrete Landau levels; and when B is strong enough, the energy gap between the lowest Landau level (LLL) and the next level exceeds both the thermal energy and the interaction energy, which effectively confines the electrons into the LLL. Because of this quenching of kinetic energy, every electron possesses the exact same, constant energy eigenvalue (while still occupying a distinct quantum state, satisfying the Pauli exclusion principle), and the kinetic energy operator, which is usually the driver of dynamical behaviour, becomes a mere constant scalar in the Hamiltonian, whereupon it drops out of the dynamics altogether. The system is left with massive degeneracy. For N electrons at filling factor (the ratio of the number of electrons to the number of available quantum states in the lowest Landau level) $\mathrm{v} = 1/\mathrm{k}$, there are k times as many quantum states available in the LLL as there are electrons to fill them. Given this exponentially large degeneracy, the problem of finding the ground state becomes analytically intractable. The option space is too vast.

It would be reasonable to expect that the remaining microscopic force (the Coulomb interaction between electron pairs) would be enough to resolve this degeneracy and determine the ground state. However, the microscopic Hamiltonian leaves the question of which state is selected underdetermined. The local interaction law cannot, by itself, select among the multiple distinct phases of matter that are compatible with it. It is, for instance, perfectly compatible with a Wigner crystal (Laughlin 1999: 870) – and the classical expectation would be crystallization so as to minimize Coulomb repulsion. However, the FQHE is a liquid, not a crystal. Why does this happen? The answer lies in the quantum correlations that lower the energy of the liquid state slightly below that of the crystal at specific filling factors (v). These constitute a global, holistic constraint which cannot be reduced to any local force law between electron pairs or derived from the local pairwise Coulomb interactions alone. What this means, in effect, is that two systems with identical local interaction Hamiltonians (same pairwise Coulomb forces) but different filling factors will occupy entirely different physical phases, i.e., that ν restricts the accessible configuration space in a way that no local force law can accomplish on its own.

This already poses a significant challenge to the microphysical version of closure: the filling factor ν, which must be specified independently of the local pairwise interactions, is a global parameter that is not derivable from microscopic forces which nevertheless acts as a genuine difference-maker in determining which phase emerges. But the challenge goes deeper still. The universal low-energy properties of FQHE states are described by Chern-Simons gauge theory. As a topological field theory, it admits no local propagating degrees of freedom, and its physical observables are determined by global topological constraints rather than local energy minimization. The fundamental equation governing FQHE physics is flux attachment condition,

$$b(r) = \frac{2\pi}{k}\rho\ (r)$$

where $\mathrm{b}(\mathrm{r})$ is an emergent statistical gauge field at position r, and $\rho\ (\mathrm{r})$ is the local electron density[4]. This equation expresses not the transfer of energy or momentum (as usual dynamical force laws do) but instead a topological constraint which binds magnetic flux quanta to each electron, thereby (effectively) transforming the strongly interacting electrons into weakly interacting composite fermions, which Ellis and Gabriel (2021: 17) describe as "fractionally charged quasi-particles". This topological reorganization creates the FQHE ground state and gives rise to emergent elementary excitations wholly absent from the underlying microscopic theory. Most remarkably, the system supports the aforementioned quasi-particles which carry fractional charge $\mathrm{Q} = \pm\, \mathrm{e}/\mathrm{k}$ (impossible for individual electrons) and obey anyonic statistics – meaning that when these quasi-particles are braided around one another, the resulting quantum phase shifts depend exclusively upon the topological braiding pattern itself. Ellis and Gabriel (2021: 17) take this to be a striking instance of "top-down alteration of lower levels", wherein higher-level topological organization creates and defines the properties of lower-level entities.

The causal relevance of the topological structure becomes even more evident when we consider that the ground state structure of the system depends on it, not on local interactions. For example, when an FQHE system is placed on a surface with non-trivial topology, the number of ground states depends on the genus g (number of holes) of the manifold. For a sphere, g = 0, and for a torus, g = 1. The number of degenerate ground states scales as

$$D = k^g.$$

where k characterizes the filling fraction $\nu = 1/k$. For a $\nu = 1/3$ state, a sphere ($D = 1$) has a unique ground state, but a torus ($D = 3$) has three degenerate states.

This cannot be explained by local forces and interactions alone[5]. The microscopic Hamiltonian describes pairwise Coulomb repulsion between electrons, a force which depends only on the distance between particles. Local distance measurements, however, are identical on a sphere and a torus: an electron situated 5 nanometres from its neighbour experiences the same electrostatic force regardless of whether that neighbour occupies a position on a spherical or toroidal surface. Therefore, the microscopic Hamiltonian is topologically invariant: it is the same operator acting on electrons whether they are in a sphere or a torus. But the physical ground state structure is extremely different (one unique state versus three degenerate states). If the local microphysical interactions are identical but the physical effects are different, then the microphysical interactions cannot constitute the complete explanation. The difference-maker is the genus g, a global topological property of the manifold. Contra microphysical completeness, the FQHE shows us that topological structure can be a genuine causal, determinative factor[6]: a higher-level structure that constrains the system's quantum state without being reducible to local interactions. As Bishop (2019: 4–21) puts it, "however the situation is described, ontologically, there is a transformation to a whole object that behaves accordingly with a new endogenous context provided by the aggregate environment of interactions—the FQH liquid", where "neither the

[4] Adapted from Tong's (2016) Eq. (5.25), in natural units where $\hbar = e = 1$.

[5] Of course, various other quantum correlations are generally non-local. The FQHE is not "special" in that sense. Still, it is a particularly apt case study for the purposes of this article because (1) the topological constraints are mathematically well-defined and empirically measurable, (2) we can experimentally vary the topological parameter and observe systematic differences in ground state degeneracy, and (3) the local Hamiltonian is completely specified yet insufficient.

[6] Since attributing causal efficacy to quantum systems can be quite philosophically contentious, my claim here can also be read more modestly as an assertion that the topological structure is a *difference-maker*. Systems with identical local Hamiltonians but different topologies produce systematically different physical outcomes. Whether this constitutes "causation" in any metaphysically robust sense depends on one's theory of causation, but with regards to the *causal closure argument against hylomorphism*, it is enough to show that local microphysical forces alone do not determine all physical outcomes.

internal nor external constraints of the stability condition is given by the QM domain alone".

3.2 Higher-Level Informational Control in Microbiology

As previously mentioned, the remarkable success of molecular biology established the viability of compositional explanations within the life sciences. Yet precisely within this compositional framework, empirical evidence increasingly reveals that higher-level organizational structures constrain and control lower-level molecular operations in ways that cannot be captured by considering exclusively those lower-level operations. One such example can be found in the work of Jaeger and Calkins (2011), who have argued from recent research in synthetic biology that living systems are fundamentally characterized by "top-down causation (TDC) by information control", wherein higher-level functional requirements *select* and *constrain* which molecular configurations are viable at lower levels. Just as in the FQHE case, their examples involve systems wherein (i) compositional completeness is not in question, as every biological process has a fully describable molecular basis, (ii) the operating forces are identical across different configurations, yet (iii) the functional outcomes are determined by higher-level (informational and organizational) constraints.

Jaeger and Calkins consider the various integrated processes (DNA replication, RNA transcription, protein translation, and regulatory mechanisms) that make up what they call the "Cellular Operating System" (COS). All of them are characterized by multiple information feedback loops, which, as Jaeger and Calkins demonstrate through extensive complementation experiments (wherein one molecular system is replaced by a functionally equivalent but structurally unrelated alternative), exhibit functional equivalence classes, that is, different modes of molecular operation that produce the same functional outcome, providing compelling evidence that it is the higher-level functional requirement, not the specific molecular mechanism, that determines what configurations are viable.

The paper documents a plethora of examples of functional equivalence classes wherein structurally unrelated molecular systems are interchangeable, from Lysyl-tRNA Synthetases to tRNA aminoacylation and maturation pathways. For present purposes, however, it suffices to consider "the best example of all" (*Ibid*.: 31), the case of RNase P, an enzyme responsible for cleaving the 5' leader sequences from precursor tRNAs to produce mature tRNAs. In bacteria, this function is performed by a catalytic RNA molecule (a ribozyme of ~ 400 nucleotides) with a small protein cofactor. In plant organelles (mitochondria and chloroplasts), however, the same function is performed by PRORP1, a purely protein-based enzyme (~ 75 kDa) with no RNA component whatsoever, belonging to the PPR (pentatricopeptide repeat) protein family and employing a completely different catalytic mechanism.

The interesting fact is that PRORP1 can completely replace the RNA-based RNase P in E. coli. When the bacterial RNase P RNA is knocked out and replaced with the plant PRORP1 gene, the bacteria survive and reproduce normally. This result is remarkable precisely because it swaps RNA catalysis for protein catalysis – with different chemical scaffolds and different catalytic mechanisms – yet the cell functions normally. It follows that different molecular implementations can result from identical initial conditions (same bacterial cell, same genomic context minus the swapped component) and identical lower-level constraints (same substrates, same cellular environment), depending simply on whether they satisfy the functional requirement and allow cellular replication to proceed.

Those of a more microphysicalist inclination could point out here that both molecular systems simply happen to perform the same chemical reaction through their respective causes at the molecular level, and since all relevant forces remain at the level, functional talk is a mere byproduct of our conceptualization of what the molecules happen to do. One might even object further that this demonstrates nothing more than multiple realizability, which is perfectly compatible with microphysical closure and complete bottom-up supervenience.

These objections misunderstand the challenge to microphysical closure. The issue is not whether functional outcomes supervene on molecular states – they clearly do. Of course, at the immediate mechanistic level, molecular forces perform the cutting. Every biological process will have a complete molecular basis. The challenge concerns whether that basis alone can provide the complete causal explanation of why only some molecular configurations persist. As we have seen, explaining why RNA-catalysis (bacterial RNase P) and protein-catalysis (plant PRORP1) are both viable – while other chemical reactions that could in principle cleave phosphodiester bonds are not biologically instantiated – requires reference to the COS, that is, to the higher-level functional architecture within which these molecular mechanisms operate. The functional requirement imposed by the COS genuinely constrains molecular configurations by, as García-Valdecasas and Sánchez-Cañizares (2025) put it, acting as "selection rule" which prevents molecular configurations that fail to produce mature tRNAs at adequate rates from persisting, thus creating "the functional constraints and boundaries within which the lower functions can evolve, diversify and eventually become more complex" (Jaeger and Calkins 2011: 30). Specifying all local molecular or microphysical details without accounting for the COS will leave underdetermined which of the many chemically distinct structures will be selected for and maintained across evolutionary and developmental timescales. While the viability of any specific molecular configuration may emerge from microphysical patterns and correlations, molecular properties alone do not determine what counts as functionally equivalent.

4 Hylomorphism and the Causal Closure of the Physical

4.1 Against Microphysical Closure

While many other examples could have been provided – from Cooper pairs and superconductivity (Ellis and Gabriel 2021), to the Rayleigh-Bénard convection (Bishop 2019), to heart rhythm requiring membrane voltage constraints (Noble 2012)[7] – the cases just examined provide us with good enough reasons to reject the *causal closure argument against hylomorphism*. In both examples, we find systems wherein the higher-level constrains the lower-level in ways that cannot be reduced to simple microphysical force operation. As we saw in the FQHE example, two systems with identical microscopic Hamiltonians can produce systematically different physical outcomes depending on higher-level topological constraints[8]. Similarly, distinct molecular implementations (RNA-catalysis vs. protein-catalysis) will produce the same functional outcome based on whether they satisfy the same higher-level requirements. In both cases, the relationship between microphysical specifications and outcomes is mediated by irreducibly higher-level factors which cannot be derived from or determined by local microphysical specifications alone. This denotes that compositional completeness (in the FQHE case, the microscopic Hamiltonian is completely specified, describing all electron-electron Coulomb interactions; in the RNase P case, complete molecular descriptions exist for both the RNA-based bacterial enzyme and the protein-based plant enzyme) may be insufficient to determine outcomes. The successful provision of compositional explanations does not entail that all causally relevant factors are located at the compositional base.

What does this mean, then, for Robinson's tripartite causal closure requirements?

Requirement 1), bottom-level force operation, remains defensible if properly understood. Robinson equivocates the plausible claim that "all the forces operate at the bottom level" (with no additional non-physical forces supplementing the inventory of fundamental physics) with the more polemical claim that *only* such forces operating at the bottom level are causally relevant or efficacious[9]. The FQHE case, to mention just one of the examples, counters this: all forces operate at the bottom level, but it is global topological constraints that make the determinative difference (without being forces themselves). My proposal, following Bishop (2021), García-Valdecasas and Sánchez-Cañizares (2025), Juarrero (2023) and Yates (2016, 2026), is that while all forces may indeed operate at the basal physical level, there is more to causation than mere force exertion. This requires rejecting the exclusive identification of causation with "efficient causation" and force-transfer, recognizing that though higher-level constraints may not be "directly involved in energy transfer" (Juarrero 2025: 25), they are nevertheless causally consequential, ineliminable, and irreducible.

Following García-Valdecasas and Sánchez-Cañizares (2025), I take constraints to perform "causal selection" by restricting the space of physical possibilities. Selection, in this account, is a genuine form of causal influence, since "what gets selected is not arbitrary: it is the result of a limit in the range of possible configurations" (*Ibid*.: 9). This form of higher-level selection is also irreducible because "the fundamental laws of physics show no preference for potential configurations", and so the "process of selection cannot be explained through microphysical states alone" (*Ibid*.: 12). The fundamental laws of physics are neutral with respect to which among their compatible configurations is realized. Without system-level constraints to restrict the possibility space, there is no mechanism by which microphysical interactions alone could systematically favour certain configurations over others. Both cases examined in this paper exemplify such higher-level "causal selection": in the FQHE case, the topological constraint (genus g) functions as a "selection rule" determining the ground state degeneracy; similarly, in the RNase P case, the functional requirement imposed by the COS is a "selection rule" determining which molecular configurations are instantiated. In line with

[7] See Ellis, Noble and O'Connor (2012) and Ellis and Gabriel (2021) for more examples.

[8] Of course, it is debatable whether such properties or constraints count as genuinely "higher-level" in any robust sense. The main reason why I call these topological properties and constraints "higher-level" is that they are properties of the system as a whole rather than of local regions. Other than that, they are invariant under continuous local deformations and so cannot be specified by pointing to any particular local configuration. And they also constrain the system's behavior in ways that local interaction laws alone do not determine. Even if this does not constitute a "higher-level" in other discussions (and discussions about levels are often murky), it certainly does when it comes to Robinson's argument and understanding of closure, which requires utter microphysical specification.

[9] An anonymous reviewer has helpfully pointed out that Robinson's assumption of a "fundamental" or "bottom" physical level is in tension with recent work in Quantum Field Theory, where theories are only deemed "effective" within finite limits (see Cao and Schweber (1993) and Castellani (2002)).

García-Valdecasas and Sánchez-Cañizares (2025) characterization, these constraints arise from system-level organization, they remain stable across multiple microphysical realizations, and they restrict the range of possible system behaviours without having to produce specific outcomes through force transfer, thus being compatible with the plausible reading of 1).

Requirement 2) states that there should be a complete bottom-up explanation of "where the physical parts end up located" (Robinson 2014: 204), given the interactions of fundamental constituents following basic physical laws. This fails in both cases considered. In the RNase P case, RNA-based and protein-based catalytic mechanisms are both viably instantiated despite their differences. Specifying the molecular apparatus per se cannot explain why these particular mechanisms persist while other chemically viable reactions do not. This can only be explained by the COS constraint operating as a selection rule. It thus seems to be the case that "determination doesn't flow simply from bottom up" (Bishop 2019: 5−2). In at least some cases, appealing to microphysical forces and initial conditions alone will lead to systematically underdetermined outcomes. This implies that specifying all local microphysical facts plus fundamental laws is *insufficient* to determine which state emerges without *also* specifying the constraints which sculpt the space of physical possibility.

Unlike 2), requirement 3), the universal applicability of basic physics, may initially seem uncontroversial. Of course, basic physics applies to constituents within complex structures just as it does when they are more isolated is initially plausible. After all, an electron in an FQHE system still obeys quantum mechanics and an ion channel protein in a cell membrane still follows the same biophysical laws it would in an artificial membrane. Robinson is correct if he simply means that we cannot somehow exempt certain domains natural reality from the laws of fundamental physics. But there is a weak and a strong reading of 3). On the weak reading, the same fundamental laws govern the behaviour of basic constituents in all contexts. On the strong reading, the same fundamental laws operating on the same basic constituents produce the same physical outcomes regardless of context, meaning that the behaviour of parts in complex wholes is exhaustively determined by the laws and principles governing them in simpler, isolated systems. While the two cases examined in this article support the weak reading (for instance, nothing suggests, as previously mentioned, that electrons in FQHE systems violate quantum mechanics), they do not support the strong interpretation: the same fundamental laws operating on identically constituted systems produce different phases, different ground state degeneracies, and quasiparticles depending on higher-level constraints that are not themselves specified by, or derivable from, the fundamental laws.

4.2 Reassessing the Causal Closure Argument Against Hylomorphism

We are now in a good position to reassess the causal closure argument against hylomorphism.

P1, like requirement (1), is defensible if properly interpreted: all fundamental forces do operate at the physical level. P2, that fundamental physical forces provide a complete causal explanation of matter's distribution, corresponds directly to requirement (2), and is thereby refuted by the scientific cases we analysed. Since P2 fails, P3 does not follow.

Moreover, even if we were to grant P3, it would not support Robinson's conclusion. P3 states that "there are no additional (structural) forces at higher levels". If this signifies merely that there are no additional *fundamental* forces beyond the forces of physics, then P3 is true – but it remains compatible with the view I advance. If instead P3 means that nothing at higher levels plays any causal role whatsoever, then it simply reasserts what needs to be proven and stands empirically refuted given the cases we have examined.

P4 rests upon the equivocation identified in requirement (1): the conflation of "all the forces operate at the bottom level" with "*only* fundamental forces are causally efficacious". Since the higher-level can be causally efficacious without having to exert force, P4 is false. Consequently, P5 does not follow.

Having demonstrated that higher-level structures can be efficacious despite not exerting fundamental forces, one can accept P6 (the Eleatic Principle), P8 (that higher-level structures are part of concrete physical reality), and P9 (affirm both hylomorphism and (a version of) the causal closure of the physical), without any incoherence.

4.3 Causal Closure for Hylomorphists

One of the main motivators for closure principles is the conviction that they insulate the physical domain from the intrusions of anti-scientific appeals to mysterious forces that would somehow violate the laws and principles of physics. Robinson's worry, it seems, is that acknowledging genuinely efficacious higher-level structures would open the door to precisely that surreptitious return of discredited vitalist or dualist theories. This concern is, of course, honourable, but it is also misguided, inasmuch as it is possible for the higher-level to be causally relevant while remaining in perfect consonance with the fundamental laws of physics.

Properly understood, the causal closure of the physical is a principle concerning the bottom (or most fundamental) level. It requires only acknowledging that, when examining the causal history of any physical interaction at that fundamental level, we should not expect to find any causal gaps. Every physical effect will have a physical cause, and no non-physical forces will supplement or violate the basic inventory of fundamental physics. Yet, ensuring that every physical effect has a physical cause at the fundamental level does not entail that physical effects are *determined* at the fundamental level alone. Consider again the FQHE case. At any given instant, there is a complete local microphysical description. The local microscopic Hamiltonian describes all pairwise Coulomb interactions. As we have seen, however, this local specification is compatible with different quantum phases depending on the global topological structure. The topology is surely physical in the broad sense that it is physically realized, but it is not determined at the local microphysical level. Similarly, in the RNase P case, every catalytic event has a complete physical and chemical explanation at the molecular level, but the molecular level alone cannot explain why two radically different molecular mechanisms are both viable while countless other chemical reactions are not – that requires making referencing the higher-level functional constraint imposed by the COS.

Robinson's causal closure principle states that every physical effect is completely determined by, and has a complete explanation in terms of, bottom-level microphysical entities and their interactions (governed by fundamental physical laws). My proposed version of the causal closure principle, on the other hand, states that every physical effect at the fundamental level has a sufficient physical cause at the fundamental level, and no non-physical forces supplement or violate the inventory of fundamental physics. So understood, causal closure is perfectly compatible with higher-level constraints playing a determinative causal role. It is not necessarily the case that "causal relations at (or between) higher levels (or between higher levels and the fundamental level) threaten to disrupt the physical order at the fundamental level" (Ben-Menahem 2018: 159). The fundamental level may be causally continuous without being causally exhaustive. This account preserves the fundamental scientific and metaphysical insights behind the usual formulations of closure, it is consistent with the postulates of "Everyday Reductionism" and even compatible with Papineau's (2001) inductive argument from fundamental forces.

But why should any form of the causal closure principle be attractive to hylomorphists? It is common for hylomorphists to present their theories as a "third way" (Koons 2014) between reductive materialism and Cartesian dualism, a position able to secure the reality of macroscopic substances their causal powers without resorting to "vitalistic dualism" (Simpson 2023: 30). Oderberg (2007: 183) mentions explicitly that the vitalist's "repudiation of the idea that a living organism's vivacity – its state of being alive – can be explained satisfactorily in terms of its form and composition", requiring the addition of "some immaterial vital principle", should be abhorrent to the hylomorphist, given that forms are "wholly materially dependent". I submit that this common hylomorphic desideratum[10] already presupposes the form of the causal closure principle I am defending. That is, when hylomorphists reject vitalism, they are thereby committing themselves to the view that biological phenomena require no supplementation by non-physical forces beyond those recognized by fundamental physics. And that is the core commitment of a defensible account of the causal closure of the physical. Robinson's strict microphysical version of causal closure illegitimately extends this insight into the claim that only fundamental forces matter causally. But one does not need to accept that. In fact, a reformulated version of closure preserves which preserves what is scientifically and metaphysically essential – the rejection of non-physical forces – will still allow that causally efficacious organizational structures emerge at higher levels without violating or supplementing the fundamental physical laws.

Such an account of closure could, moreover, be understood in terms resembling the Aristotelian act-potency distinction: the fundamental physical laws provide the full space of physical possibility, while higher-level organizational structures play a role in determining which of these possibilities is realized (or actualized). As a result, higher-level structure does not need to "add to or subtract from the physical totality of the universe" to secure its efficacy, since, as Hart (2024: 45) puts it, "physical causes can be directed along different paths within a distribution of possibilities by a kind of causality that isn't a physical force"[11]. My proposed version of closure is certainly weaker than Robinson's, but it remains substantive (it excludes vitalism and some forms of substance dualism, for instance) without having to exclude higher-level features that are demonstrably operative in actual scientific practice.

5 Hylomorphists and the Causal Closure of the Physical

Before concluding, I shall briefly assess some previous hylomorphic engagements with the causal closure of the physical, namely: Jaworski (2016a, b), whom Robinson tackles directly in his critique and accepts closure; Simpson

[10] This attitude can also be found, to give a few more examples, in Charles (2021); Feser (2014); Jaworski 2016a); Oderberg (2005); Stump (1995).

[11] See also García-Valdecasas and Sánchez-Cañizares (2025).

(2022 (with Horsley), 2023, 2026), whose arguments tackle microphysical closure while at times suggesting a more sweeping rejection of causal closure as such; and Yates (2026), who recently expounded a new theory of hylomorphism that purports to be compatible with the causal closure of the physical.

5.1 William Jaworski

Jaworski (2016a) is the main target of Robinson's (2014) arguments. As I see it, his main problem is the attempt to uphold three unreconcilable theses (at least as he understands them): a strict version of the causal closure of the physical (Jaworski 2016a: 292); which leads to a rejection of top-down causation (*Ibid*.: 280–285); while still positing that higher level structures (such as living organisms) possess irreducible causal powers (*Ibid*.: 7; Jaworski 2016b). The tension here is precisely identified by Robinson (2014): if the motion and distribution of matter are exhaustively determined by microphysical laws, as Jaworski suggests, then structure is causally impotent.

Jaworski (2016a: 18) attempts to resolve this by arguing that structure "makes a difference" since "it operates as an irreducible explanatory principle". However, as Robinson argues, the fact that we need structural vocabulary to explain a phenomenon does not grant that structure real causal power. It may just be the case that our micro-physical knowledge is limited or that macro-descriptions are somehow useful in scientific practice[12].

What Jaworski needs, then, is an account of how higher-level structure can be causally efficacious without being a physical force – which surely goes beyond mere explanatory indispensability. He needs, in sum, to reject the strict version of causal closure.

5.2 William M. R. Simpson

Simpson has written extensively on the relation between hylomorphism and physics and tackled the issue of causal closure at least a couple of times. While his arguments usually target *microphysical* closure specifically, his rhetorical framing sometimes suggests a more general dismissiveness toward the causal closure of the physical, treating it as "metaphysical dogma" (Simpson 2023: 41), not only incompatible with hylomorphism but more importantly fundamental physics. Yet, Simpson's actual position is at least consistent with the reformulated closure principle I defend in this article.

Simpson and Horsley (2022: 42) consider concerns regarding "the violation of the causal closure of the microphysical world" given that contemporary physics lists only "four physical 'forces' in nature: gravitation, electromagnetism, the weak interaction, and the strong interaction" and it is difficult to square how higher-level properties are supposed to be causally efficient without "introducing 'spooky' forces into nature". This worry is then dismissed by pointing out that it does not follow from a denial of lower-level closure that there are more than four basic forces in nature. Their line of reasoning is similar to the one developed in this article, and they cite ' remark that the higher-level can be efficient by setting "the context and boundary conditions for the lower-level actions" (in *Ibid*.: 43). A similar argument appears in Simpson (2023) as an attack on the assumption that microphysical laws (like the Schrödinger equation) are sufficient to determine physical outcomes. Simpson argues from the Contextual Wavefunction Collapse interpretation (Drossel and 2018) that standard quantum mechanics is incomplete without reference to a macroscopic context[13].

It must be noted that Simpson's arguments target *microphysical* closure, not closure principles as such. However, without explicit disambiguation between microphysical and broader formulations of closure, such rhetoric can suggest a more sweeping rejection than his arguments warrant. As I have shown, there are various possible formulations of causal closure, some of which are compatible with hylomorphism, and a minimal form of closure should be appealing to hylomorphists who, like Simpson (2023: 30), reject "vitalistic dualism". A complete rejection of closure would place hylomorphism in an unnecessarily dialectically weaker position. Accepting a principled version of closure strengthens rather than weakens the hylomorphist position. It demonstrates that hylomorphism is not a mere ad hoc metaphysics, but a position grounded in careful attention to scientific practice. It may also allow hylomorphists (and other non-reductionists) to dissolve the apparent tension between causal closure and strong emergence that Simpson and Horsley (2022) describe[14]. Indeed, if, as Simpson seems to indicate at various points, hylomorphism allows us to expand "the physical" to include matter and form together, then our positions fundamentally converge. In fact, Simpson's (2026) contribution to this issue moves in that direction, providing a description of form in terms of higher-level constraints that resolves some of the concerns raised here. In his proposal of a Contextual Bohmian Mechanics (CBM), Simpson develops the idea of a context

[12] For a detailed hylomorphic critique of Jaworski's "explanatory pluralism", see Simpson (2023: 32–41).

[13] There has been a recent attempt to demonstrate that, when properly framed, quantum mechanics is compatible with hylomorphic metaphysics. For an overview of this "quantum hylomorphism" project, see Koons (2022, 2024), Miller (2023) and Simpson (2021, 2025).

[14] Koons' (2017, 2022) proposal of "hylomorphic [or ontological] escalation" may be a way to do just that – and it seems compatible with the form of causal closure outlined in this article.

field which serves as a "rigorous surrogate for local form" (*Ibid*.: 3). The context field constrains which macro-contexts are dynamically accessible (via admissibility conditions on local micro-features) and modulates local particle dynamics through context-dependent Hamiltonian terms, all without adding fundamental forces beyond those of standard quantum mechanics. Simpson's CBM is thus compatible with the version of the causal closure principle defended in this article.

5.3 David Yates

Yates (2026) has recently proposed a new brand of "geometric hylomorphism" that purports to be compatible with a "very strong causal closure" principle. The reason why Yates is able to build an account of hylomorphism – which he deems to be, in Koons's (2014) sense, "staunch" enough – that is compatible with closure, is because of a distinction (similar to the one we drew regarding Robinson's requirement 1) between causal power bestowal from basic physical properties, and the causal role of geometric structure. This renders, I believe, Yates' "very strong causal closure principle" functionally equivalent to the weaker reading of closure that I advocate in this article, given that both seek to permit higher-level efficacy without violating the physical monopoly on force. The great difference in our conceptions of closure is that while Yates saves the concept of a "sufficient physical cause" by expanding what "physical" means so as to include structure, I would prefer to maintain closure as a thesis about the bottom-level.

This renders Yates well equipped when it comes to dealing with Robinson's argument. Building on a previous proposal (Yates 2017) and clothing it in new hylomorphic language, Yates is able to argue that "there is more causal work involved in the basic physical dynamics than just the generation of forces—in addition, there is the role played by the spatiotemporal *patterns* such forces make in relation to each other" (2026: 23).

There are various affinities between my view and Yates'. Still, while I regard his framework as coherent and fruitful for further hylomorphic investigation, I believe his example of geometric structure is too limiting. That is, by focusing solely on "geometrical hylomorphism", Yates may miss some hylomorphically interesting aspects of higher-level constraints and structures. For instance, in Yates's vector composition case, once all basic physical facts are specified, the geometric structure is mathematically necessitated. Different basic physical arrangements can realize the same structure, but any complete determination of the basic physical facts also determines the higher-level structure. Geometric structure is thus explanatorily ineliminable but still determinatively supervenient on basic physics. In the FQHE case, by contrast, the microscopic Hamiltonian completely specifies all local pairwise Coulomb interactions without determining which phase the system occupies. The same local interaction Hamiltonian is compatible, as we have seen, with different phases and ground state degeneracies. One must, then, specify additional system-level parameters that are not determined by, and not reducible to, local microphysical forces. These are genuinely higher-level organizational features that make a causal difference beyond what local microphysical interactions can determine. The higher-level is determinatively irreducible to the lower-level specification. The RNase P case exhibits a similar pattern. The explanation of why two different molecular substrates are functionally interchangeable requires referencing the system-level constraint by the COS.

So, while Yates demonstrates that force laws alone don't suffice, for one always needs to appeal to composition principles involving structure, the FQHE and RNase P cases demonstrate that not even complete local specification suffices. In Yates's geometrical case, underdetermination exists only at the level of local intrinsic properties: complete basic physical description (that is, accounting for all spatial relations) determines the geometric structure. In FQHE case, on the other hand, underdetermination persists even with complete local specification. Constraints play an even greater determinative role than Yates' recognizes.

6 Conclusion

The consequences of Robinson's *causal closure argument against hylomorphism* extend far beyond a mere attack on hylomorphism. If successful, the argument would eliminate from the causal structure of reality whatever lies beyond the fundamental physical level: from topological properties to chemical structure, to biological functions, to mental states. In fact, the strict microphysical form of causal closure adopted by Robinson would threaten the very scientific endeavour itself. After all, is science possible if the instruments and investigators upon which it depends lack genuine causal relevance?

Rejecting the *causal closure argument against hylomorphism* and showing how the higher-level can be causally operative without appealing to mysterious additional fundamental forces should thus be of interest not just to hylomorphists, but to anyone with broadly non-reductive sympathies. The argument I have developed in this article, while focused on microscopic cases, bears direct implications for the causal status of middle-sized things. If even at the microscopic level, even in domains where fundamental physics exercises great explanatory power, complete local microphysical specification may leave outcomes underdetermined, then the causal relevance of the mesoscopic becomes more plausible. Whenever systems exhibit organizational structure that constrain lower-level dynamics in ways not fully determined by local interactions, that structure is causally efficacious. This applies whether the "higher-level" in question is the topological structure of a quantum system relative to local electron interactions, the functional requirements of cellular metabolism relative to individual chemical reactions, the homeostatic regulatory architecture of an organism relative to local biochemical processes, or even, I would argue, the informational content of a mental state relative to the firing patterns of individual neurons.

The great virtue of Robinson's argument is the way it obliges those of non-reductive inclinations to explain precisely how higher-level structures are supposed to be causally relevant to the world. My aim in this article has thus not been to provide a vindication of hylomorphism per se, but rather to secure the foundations upon which such a hylomorphic theory that is compatible with causal closure might stand. Much work remains to be done in order to bridge the gap between the specific "structural constraints" of modern science and the metaphysical forms or structures that hylomorphists appeal to. While none of the higher-level features considered in this article may constitute a form or structure per se, they at least exhibit characteristics *associated with* or *reminiscent of* form and structure – such as irreducible holism, top-down constraint, functional organization, dynamic stability – providing a plausible starting point for hylomorphic interpretation. The time is ripe for such interpretations, as growing literature from the sciences converges on the conclusion that higher-level factors play irreducible determinative roles in the natural world. I thus submit that hylomorphists should try – as far as possible – to position themselves in the "second round" of the emergence-reduction debate described by Gillett (2025) by engaging with the sciences, extracting from them the conceptual resources necessary for articulating a more scientifically-informed metaphysics of form/structure. To this end, it is essential that the central idea of the first round of such debate be appropriately acknowledged – and that requires acknowledging a form of the causal closure of the physical.

Robinson's dilemma – accept microphysical closure and abandon hylomorphism or reject closure and abandon modern science – presents a false choice. A properly formulated closure principle can accommodate both the causal efficacy of higher-level structures and the fundamental insights that motivated closure principles in the first place. It appears that, after all, it is the strict version of microphysical causal closure that does not quite "fit nature as we now understand it" (Robinson 2021: 284).

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