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# CONSTRAINING THE COMPRESSION: THERMODYNAMIC DEPTH AND COMPOSITION

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*This paper examines Bird's account of restricted compositionality in terms of compression of information. Additionally, this paper proposes an alternative perspective (to Bird's) that links compositionality to the Free Energy Principle and the minimisation of collective entropy. Emphasising functional integration, this criterion provides a more focused and relatively more objective (patternist) account of composition.*

**Keywords:** composition, information compression, thermodynamic depth, Free Energy Principle, objects.

## I. INTRODUCTION

At times, diverse entities constitute authentic composite objects, while at other times, they do not. Discerning the authenticity of composed objects can be straightforward in some cases, such as the human body. However, placing a candle in one's hand may not create a true composite object. Yet, in cases like the Hand of Glory, the hand and the candle form an authentic (though perhaps fictional) composite object with distinct (magical) properties.[1] Determining when joined entities yield genuine composite objects remains challenging. On this topic, Alexander Bird (2023) has recently explored the restricted composition view, which differs from both mereological nihilism (the stance that in no case is there a composite object) and mereological universalism (the stance that in every case there is a composite object). Furthermore, in support of this view, Bird has introduced a scientifically informed measure rooted in patternism, where patterns are defined as the compression of information. Nevertheless, this paper argues that further elaboration is necessary to establish a robust constraint on information-carrying links, ensuring a more

[1] See https://sites.pitt.edu/~dash/hand.html#baring-gould

objective account of the restricted composition of material objects. To advance beyond mere criticism, this paper also aims to expand upon Bird's perspective on the connection between composite organic objects and their functionality. Building upon recent advancements in computational neuroscience (Friston 2010; Friston *et al.* 2015; Ramstead, Badcock and Friston 2017), and specifying the notion of compression of information in terms of thermodynamic depth (Collier 1999; Ladyman and Ross 2007), the paper offers its alternative to Bird's take on the relation between compression of information and compositionality. This leads to an account of compositionality that, although not universally applicable to all material objects, accounts for the compositionality of self-organising entities with a viable degree of objectivity (in the patternist sense). This proposal aligns with van Inwagen's (1995) perspective that entities form an object only when they come together to create a living system.

The paper comprises two main sections. First, it offers a critical overview of Bird's account, highlighting its shortcomings and addressing key issues. Subsequently, it introduces constraints on informational patterns that have the potential to bind parts into composite objects.

## II. BIRD'S VIEW

Bird (2023) aims to defend the concept of fastening against critics who claim that being fastened alone is inadequate for establishing objecthood. While acknowledging that fastening is not an essential prerequisite for objecthood, he concedes that the correlation between the locations and motions of two parts that are bound together plays a significant role in determining their status as an object. Fastening is the view that 'the Xs compose an object Y when the Xs are physically fastened or bonded together'(Bird 2023: 679). Bird's defence of fastening is inspired by Dennett's (1991) 'Real Patterns' as well as Petersen's (2019) application of patternism to compositionality, which holds that when things form a real pattern, they compose a whole. By incorporating concepts such as information compression and patternism, Bird demonstrates a promising approach to accounts of objecthood and compositionality.

It is also worth noting that works inspired by Dennett's ideas usually extensively explore the intricacies of information compression, employing technical concepts such as computational depth and Kolmogorov complexity (Ladyman and Ross 2007, 2013; Millhouse 2019, 2021). Ofcourse, in some cases, a non-technical language can effectively convey the same points without sacrificing clarity, and generally, it is even preferable in philosophy journals (such as *The Philosophical Quarterly*) not to delve into too much technicality.[2]

[2] I'm not suggesting suitability for publication in a reputable philosophy journal serves as a truth criterion. What I mean is, while it may not always be advisable in general philosophy

However, the case of Bird's proposal is complicated. Be that as it may, early in his paper, Bird states his view thus:

> When two parts are fastened or bound together, the locations and motions of those parts are, to some degree, correlated. The significance of this correlation is that one part will carry information about the other. I will build on this and conclude that some parts, the Xs, constitute some entity Y of which they are the parts when information about Y is able to compress information about the Xs. (Bird 2023: 678)

To start with, consider the case of an entity Y that may compress information about Xs without Xs being inherent parts of Y. A prime example of this is a map, which compresses information about various regions of the actual world without those regions being component parts of the map. No composition. It may be argued that to avoid such cases, emphasis should be placed on the correlation between motions and locations. That is to say, the motions and location of Xs, as integral components of Y, are correlated with the location and movement of Y itself, which in turn compresses information about the Xs. However, the correlation between motions and locations does not imply composition either. For example, when a map is placed inside a country or a model of a train is positioned within an actual train, a correlation exists between the location and motion of both the map/model and the encompassing country/train. However, this correlation does not necessarily indicate a relationship of composition. In the same vein, consider the case of a fleet of ships seeking to synchronise their directions with one another. To achieve this, the sailors rely on information about the configuration of stars in Little Dipper. *For the sailors*, the arrangement of stars in the Little Dipper provides compressed information regarding the configuration of the fleet and its course of navigation, despite the ships themselves not being component parts of the stellar constellation. No composition still (we will return to the case of navigation soon). To fortify the criterion of restricted composition against such eventualities, Bird introduces the Information Compression Proposal (ICP):

> (ICP) The Xs compose an object Y when the Xs are a non-divisible maximal collection of objects such that relevant information about Y compresses corresponding information about the Xs in an efficient albeit possibly lossy way.

In contemplating the ICP alongside the navigation example, two crucial points come to light. The first point concerns why we should not regard the stars and ships as constituting a genuine composite object in the context of the navigation example. ICP might be *construed* to suggest that the combination of ships and stars forms a non-divisible maximal collection of objects. To render this construal accessible, one might even coin a new term for the composite,

journals, incorporating an excess of technical details can be crucial in specific discussion (such as this one).

such as 'shipstars', and posit that restricted composition is indeed genuine in their case. The challenge here lies in providing a precise interpretation of the concept of a 'non-divisible maximal collection'. The shipstars construal would presuppose that a 'shipstar' is a 'non-divisible maximal collection', a characterisation that can hardly be justified based on either everyday intuitions or scientific criteria. This paper's perspective, on the other hand, aligns with the bound state proposal (Waechter and Ladyman 2019), asserting that the objectivity of restricted composition typically arises from some form of binding, potentially involving a physical force (which is notably absent in the 'shipstar' example). There are various approaches to elaborating on this alternative. For instance, one might argue that physical objects should only be considered composite when they exist in a bound state characterised by negative total energy (McKenzie and Muller 2017), or when conditions such as thermal contact are prerequisites for physical composition (te Vrugt 2021). Bird's proposal, on the other hand, does not focus on specifying such a physical force. Instead, it posits that, according to ICP, Xs would compose an object Y if they formed a *non-divisible maximal collection of objects*, where information compression can assume a pivotal role in establishing a demarcation criterion for non-divisible maximal collections of objects. Nonetheless, the mere reliance on information compression does not automatically affirm the superiority of Bird's proposal over the bound state proposal. Nor does it guarantee the objectivity of composition relations. This leads us to the second critical point of my discussion.

Bird's proposal aims to bring objectivity to the account of restricted composition, given that 'Whether information is compressed or not is an objective matter, not a matter of perspective, interest, or salience' (Bird 2023: 697). My second critical point, as emphasised in my focus on '*for the sailors*' in the last example, pertains to the role of the *observer*. This point has been a subject of extensive discussion, with technical attempts made to introduce constraints aiming to enhance the objectivity of real patterns (Floridi 2005; Ladyman and Ross 2007; Millhouse 2022). Regrettably, Bird dismisses these technical intricacies and takes for granted that the notion of information at issue in his discussion of information compression corresponds to an objective commodity, thereby infusing a sense of objectivity into his account of composition. This poses a problem because when Bird assumes that the objectivity of information guarantees the objectivity of his account of information (without clarifying what objectivity means in this context), the Patternist view on information presumes an intentional (observer-based) perspective on information that is associated with a moderate pragmatic sense of objectivity.

The crux of the debate here revolves around the objectivity of information. Bird (2023: 699) remarks that 'Whether information is compressed or not is an objective matter, not a matter of perspective, interest, or salience. As Petersen's closely related view, patternism, says, composite objects are real patterns in Dennett's sense'. However, this is not precisely what Dennett says.

According to Dennett, rival theories may not 'even agree on which parts of the world were pattern and which were noise' (1991: 49), as he also asserts that the determination of patterns becomes observer-dependent and contingent upon idiosyncratic pragmatic considerations (ibid). In short, while Bird attributes an objective nature to the identification of patterns through information compression, Dennett's perspective indicates that pattern selection is inherently influenced by the observer's perspectives and pragmatic grounds. Interestingly, Bird's parallel between explanatory relevance and information compression suggests an understanding that compression is contingent upon the context and perspective of the observer. However, the implications of this observation are not adequately explored in Bird's analysis. Below, I shall unpack this point.

In an attempt to narrow down the type of information relevant to the identification of genuine composite objects, Bird turns to the concept of explanatory relevance, submitting that explanatory information constitutes 'relevant information'. This assumption raises a significant point that is articulated in Bird's (2023: 689) conjecture:

> I conjecture that the objects identified by science in virtue of their explanatory salience will coincide with those identified by the information compression criterion. It is notable that the good-making qualities of explanations—above all, unification and simplicity—are precisely those that make for efficient compression.

This conjecture is problematic for several reasons. It can be (and indeed has been) argued that while scientific explanation holds philosophical significance, it does not necessarily dictate the primary aims of science or play a central role in the identification of objects within scientific inquiry (van Fraassen 1977, 1989). Additionally, the proposal assumes that criteria of explanation, such as unification and simplicity, possess clear and universally agreed-upon meanings. However, the extensive discussions surrounding these notions suggest otherwise. The fact that there is a persistent need for ongoing debates on how to clarify or refine the concepts of simplicity and unification highlights their inherent complexity and the absence of universal consensus on their significance (Myrvold 2003; Gijsbers 2015; Pocheville, Griffiths and Stotz 2017; Millhouse 2019). Moreover, if there does indeed exist a viable account of explanatory salience and the virtues of unification and simplicity, why invoke information compression at all to address the issue of restricted composition? Why not simply rely on explanatory virtues to precisely define objecthood at its core?

In short, further elucidation is required regarding the objective basis for demarcating between patterns of compressed information that constitute genuine composite objects and patterns simpliciter. I appreciate how Bird's account of natural kinds could be enhanced by incorporating the notion of restricted composition in terms of compressed information. However, his approach does not establish the objectivity of restricted compositions. Perhaps this is the price to pay for introducing an abstract, universal criterion of compositionality.

## III. A POSITIVE PROPOSAL

To move beyond mere critique, I illustrate how a more detailed exploration of the connection between information compression and genuine pattern formation can help address the issue of the objectivity of composite objects. My proposal is congenial with the reliance on physical bonding (McKenzie and Muller 2017; Husmann and Näger 2018) and thermodynamics (te Vrugt 2021) in addressing the issue of restricted composition. However, it particularly draws from the physics of life, as articulated in terms of biological thermodynamics and the Free Energy Principle (FEP).

As Ladyman and Ross (2007: 217–8) argue, with a reference to the works of John Collier (1999; Collier and Hooker 1999), the individuation of objects could take place based on different articulations of the criterion of compression of information. One such articulation comes in terms of the concept of logical depth, which measures computational complexity and can serve as a basis for individuating objects in the realm of physical depth.[3] On the other hand, the notion of thermodynamic depth, which refers to the minimum amount of entropy generated during a state's evolution, can be employed to individuate biological objects. This technical elaboration goes beyond Bird's proposal—he simply suggests that information about physical objects pertains solely to their location and movement, whereas the notion of information can be broadened to encompass not only the spatial structure but also information about the *functional integration* of a living entity. In the same vein, but with a focus on details, I refine the role of information, specifically concerning the functional integration of a living entity. This refinement places a notable emphasis on biological thermodynamics, aiming to provide a technical alternative to Bird's proposal.

Biological thermodynamics is the application of thermodynamic principles to study energy flow in the animate domain, encompassing how living organisms acquire, store, and utilise energy while considering the organisation and functioning of biological systems. Within this framework, the FEP serves as a theoretical framework that applies the principles of biological thermodynamics to self-organising systems (Friston and Stephan 2007; Friston 2010). FEP

[3] Also, expansive discussions on the compression of information, specifically concerning the criteria of logical depth and Kolmogorov complexity, can be found in the works of Dennett and Petersen, and whether or not their elaborations produce a viable measure for objecthood can be subject to further discussion.

proposes that self-organising systems strive to minimise free energy, which is a measure of the discrepancy between an organism's internal model of the world and the sensory input it receives. Free energy is an upper bound on surprise or its time-average entropy and minimising free energy implicitly reduces the organism's surprise or prediction errors, ensuring the adaptability and survival of the organism. This principle applies *biological thermodynamics* to explain the cognitive processes and adaptive behaviour of living systems (Friston 2012; Ramstead, Badcock and Friston 2017).

It is also worth mentioning that FEP is intricately connected to the compression of information and Kolmogorov complexity. By minimising free energy, which captures the discrepancy between an organism's internal model and sensory input, FEP is in the business of constructing (and updating) generative models that embed accurate predictions by compressing the underlying regularities and patterns in the environment. This compression reduces the complexity of the sensory input, as the generative models distil the essential information necessary for successful prediction. The overarching goal of the system under FEP is to obtain information that is sufficiently detailed to provide a precise representation of the environment, while also ensuring it remains simple enough to be effectively utilised (Kuchling *et al.* 2020). The minimisation of free energy, takes place in a hierarchical structure, with generative models at the top level and sensory inputs entering the hierarchy from below. Interactions occur at each level between the downward-going predictions made in the generative model at the top level and the upcoming actual input, facilitating the refinement and adjustment of the representations of the environmental causes. By minimising their free energy, organisms implicitly minimize their internal entropy, enabling the retention of their structural and functional integrity.

Given the limited space in this paper, there is not enough room to delve into further details about FEP. The main question to ponder is whether FEP or more generally, thermodynamic depth, provides a criterion for the compositionality of objects. The answer to this question is affirmative. The FEP indeed provides an objective enough criterion for the individuation of composite objects. From protozoa to pontiffs, all entities strive to maximise their chances of survival by minimising their free energy. The minimisation of free energy occurs across various scales (Friston *et al.* 2015; Kirchhoff *et al.* 2018), and it has been suggested that the emergence of life and intelligence at each scale might be related to the collective minimisation of free energy (Watson and Levin 2023). In this context, genuine (organic) composite objects, such as different orders of individual biotic self-organising systems, can be characterised by the efficient collaboration of their parts in minimising their collective entropy. In other words, genuine composite objects exhibit a high degree of functional integration and coordination, leading to the collective reduction of collective entropy of the system and the maintenance of their structural and functional integrity. This criterion of restricted composition is *non-arbitrary*, as the minimisation of collective entropy is deeply connected to the existential imperative of FEP, whereby organisms strive to maximise their chances of survival and adaptation by reducing their free energy. Moreover, in the context of explanatory considerations, the coordinated actions of constituent elements within the framework of FEP offer a viable explanation for the functioning of the organism (Beni 2022a,b). In this context, retaining one's structural and functional integration aligns with the concept of compression of information, as genuine composite objects can be seen as effectively compressing and encoding essential information about their organisation and interactions.

The current proposal frames restricted composition within the framework of the FEP, rather than the traditional thermodynamic concept. This may appear to deviate from previous approaches, such as (te Vrugt 2021), which revolve around physics. However, it is crucial to be clear about the relationship between thermodynamics and the FEP's notion of variational free energy.[4] The central tenet of the FEP lies in its explanation of how biological systems efficiently regulate their energy (or internal information entropy) while operating in non-equilibrium conditions.[5] Thereby, the FEP explains how living systems efficiently regulate their internal systems in optimal alignment with the second law of thermodynamics to operate in an adaptive and efficient manner.[6] Thus, there is no real incompatibility between the application of the FEP to the issue of compositionality and more traditional thermodynamic approaches.

## IV. A GENUINELY REALIST PROPOSAL?

The primary objective of this paper was not to challenge Bird's proposal but rather to reinforce it while simultaneously circumscribing its scope. This reinforcement was achieved by delving into a more objective conception of information compression in the biological domain. This notion of objectivity

[4] On a technical note, Gibbs free energy, a fundamental concept in thermodynamics, represents balance between the system's internal energy (enthalpy) and its tendency to spread out or become more disorderly (entropy). Variational free energy, on the other hand, quantifies the average surprise or uncertainty associated with a system's sensory inputs.

[5] This non-equilibrium behaviour is a defining characteristic of living systems, setting them apart from passive physical systems (Friston *et al.* 2023).

[6] The crucial explanation is this: While the FEP is a departure from traditional thermodynamic approaches, it is not incompatible with the second law of thermodynamics. The second law states that the total entropy of an isolated system always increases over time. However, biological systems are not isolated systems; they are constantly exchanging information with their environment. This allows them to harness the second law to their advantage. By minimising surprise and maintaining a low variational free energy state, biological systems can effectively regulate their entropy and maintain a state of order.

does not subscribe to an unwavering adherence to scientific realism and it is not incompatible with the assertion that we must adopt a limited form of scientific anti-realism in relation to those aspects of scientific theories that refer to composition relations (Brenner 2018). The general insight here is that we can endeavour to objectively delineate the structure of our environment (from an intentional stance) to the extent that dependence on cutting-edge science incorporates a sense of objectivity. There is no need, or indeed ability, to step outside our intentional stance to verify if our sense of objectivity is *really* objective. Far from being incompatible with Bird's proposal, acknowledging such limitations is a cornerstone of patternism which is also embraced by Bird (see Dennett 1991).[7] From this perspective, the boundaries of composite objects, or organisms, are not rigid. Under the rubric of FEP, self-organising objects engage in constant dynamical ecological interactions with their environment. Consequently, the criterion of composition aims to delineate the boundaries of objecthood in a flexible manner that can easily accommodate the absence of sharp borders for complex systems such as the subterranean fungus *Armillaria ostoyae* or various forms of selfhood with fluid boundaries. The coordinated functioning of their constituent parts allows for the compression and efficient representation of relevant information, contributing to the overall reduction of entropy within the system. Interestingly, this view aligns with van Inwagen's (1995) perspective, as it suggests that restricted composition occurs in the animate domain, where entities form a genuine composite object only when they come together to create a living system. Despite not embracing a robust form of scientific realism (or perhaps precisely due to this absence), this perspective remains compatible with patternsim (Levin and Dennett 2020).

## V. CONCLUDING REMARKS

This paper built upon Bird's valuable contribution to restricted composition to illuminate a critical aspect of the trade-off between universality and objectivity in defining criteria for restricted composition. On the one hand, Bird's reliance on information compression offers a universally applicable framework, transcending specific physical or biological mechanisms. However, this universality comes at the expense of objectivity in determining which correlated structures constitute legitimate restricted compositions. In contrast, an alternative approach grounded in biological thermodynamics presents a more objective criterion for defining restricted compositions. This criterion, nonetheless, is confined to the realm of complex self-organising entities, where biological processes and energy flows play a pivotal role in shaping the stability

[7] 'Now, once again, is the view I am defending here a sort of instrumentalism or a sort of realism? I think that the view itself is clearer than either of the labels…' (Dennett 1991: 51).

and functionality of these structures. However, this also means that in enhancing the objectivity of compositions, some of the generality of Bird's proposal must be sacrificed.[8]

## REFERENCES


Beni, M. D. (2022a) 'Dosis Sola Facit Venenum: Reconceptualising Biological Realism', *Biology & Philosophy*, 37: 1–18.

———. (2022) 'A Tale of Two Architectures Free Energy, Its Models, and Modularity', *Consciousness and Cognition*, 98: 103257. https://doi.org/10.1016/j.concog.2021.103257

Bird, A. (2023) 'Restricted Composition Is Information Compression', *Philosophical Quarterly*, 73: 677–700. https://doi.org/10.1093/pq/pqad034

Brenner, A. (2018) 'Science and the Special Composition Question', *Synthese*, 195: 657–78. https://doi.org/10.1007/s11229-016-1234-6

Collier, J. (1999) 'Causation Is the Transfer of Information', In H Sankey (ed.) *Causation and Laws of Nature*. Dordrecht: Springer Netherlands, 215–45.

and, J. and Hooker, C. (1999) 'Complexly Organised Dynamical Systems', *Open Systems and Information Dynamics*, 6: 241–302. https://doi.org/10.1023/A:1009662321079

Dennett, D. C. (1991) 'Real Patterns', *The Journal of Philosophy*, 88: 27–51. https://doi.org/10.2307/2027085

Floridi, L. (2005) 'Informational Realism', *Conferences in Research and Practice in Information Technology*, 37: 1–7.

Friston, K. J. (2010) 'The Free-Energy Principle: A Unified Brain Theory?' *Nature Reviews Neuroscience*, 11: 127–38. https://doi.org/10.1038/nrn2787

———. (2012) 'A Free Energy Principle for Biological Systems', *Entropy (Basel)*, 14: 2100–21.

Friston, K. J. *et al.* (2023) 'Path Integrals, Particular Kinds, and Strange Things', *Physics of Life Reviews*, 47: 35–62. https://doi.org/10.1016/j.plrev.2023.08.016

——— *et al.* (2015) 'Knowing One's Place: A Free-energy Approach to Pattern Regulation', *Journal of the Royal Society Interface*, 12: 20141383. https://doi.org/10.1098/rsif.2014.1383

Friston, K. J. and Stephan, K. E. (2007) 'Free-Energy and the Brain', *Synthese*, 159: 417–58. https://doi.org/10.1007/s11229-007-9237-y

Gijsbers, V. (2015) 'Why Unification Is Neither Necessary Nor Sufficient for Explanation', 74: 481–500.

Husmann, J. and Näger, P. M. (2018) 'Physical Composition by Bonding', In: L. Jansen, and P. Näger, (eds) *Peter van Inwagen. Münster Lectures in Philosophy*, vol 4. Springer, Cham. https://doi.org/10.1007/978-3-319-70052-6_4.

Kirchhoff, M. D. *et al.* (2018) 'The Markov Blankets of Life: Autonomy, Active Inference and the Free Energy Principle', *Journal of the Royal Society Interface*, 15: 20170792. https://doi.org/10.1098/rsif.2017.0792

Kuchling, F. *et al.* (2020) 'Morphogenesis as Bayesian Inference: A Variational Approach to Pattern Formation and Control in Complex Biological Systems', *Physics of Life Reviews*, 33: 88–108. https://doi.org/10.1016/j.plrev.2019.06.001

Ladyman, J. and Ross, D. (2007) *Every Thing Must Go*. Oxford: OUP.

———. (2013) 'The World in the Data', In: D. Ross, J. Ladyman and H. Kincaid (eds) *Scientific Metaphysics*, 108–50. Oxford: OUP.

Levin, M. and Dennett, D. C (2020) 'Cognition all the Way Down', *Aeon Essays*. https://aeon.co/essays/how-to-understand-cells-tissues-and-organisms-as-agents-with-agendas

McKenzie, K. and Muller, F. A (2017) 'Bound States and the Special Composition Question', *European Studies in Philosophy of Science*, 5: 233–41. https://doi.org/10.1007/978-3-319-53730-6_19


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Millhouse, T. (2019) 'A Simplicity Criterion for Physical Computation', *The British Journal for the Philosophy of Science*, 70: 153–78. https://doi.org/10.1093/bjps/axx046
———. (2021) 'Compressibility and the Reality of Patterns', *Philosophy of Science*, 88: 22–43. https://doi.org/10.1086/710027
———. (2022) 'Really Real Patterns', *Australasian Journal of Philosophy*, 100: 664–78.
Myrvold, W. C. (2003) 'A Bayesian Account of the Virtue of Unification', *Philosophy of Science*, 70: 399–423. https://doi.org/10.1086/375475
Petersen, S. (2019) 'Composition as Pattern', *Philosophical Studies*, 176: 1119–39. https://doi.org/10.1007/s11098-018-1050-6
Pocheville, A., Griffiths, P. E., and Stotz, K. (2017) 'Comparing Causes—An Information-Theoretic Approach to Specificity, Proportionality and Stability', *Proceedings of the 15th Congress of Logic, Methodology and Philosophy of Science*. London: College Publications, 93–102.
Ramstead, M. J. D., Badcock, P. B., and Friston, K. J. (2018) 'Answering Schrödinger's Question: A Free-Energy Formulation', *Physics of Life Reviews*, 24: 1–16. https://doi.org/10.1016/j.plrev.2017.09.001
te Vrugt, M. (2021) 'The Mereology of Thermodynamic Equilibrium', *Synthese*, 199: 12891–921. https://doi.org/10.1007/s11229-021-03359-2
van Fraassen, B. C. (1977) 'The Pragmatics of Explanation', *American Philosophical Quarterly*, 14: 143–50.
———. (1989) *Laws and Symmetry*. New York: Oxford University Press.
van Inwagen, P. (1995) *Material Beings*. Ithaca: Cornell University Press.
Waechter, J. M. and Ladyman, J. A. C (2019) 'In Defence of Ordinary Objects and a Naturalistic Answer to the Special Composition Question', In: J. Cumpa, and B. Brewer, *The Nature of Ordinary Objects*, 82–188. Cambridge: Cambridge University Press.
Watson, R. and Levin, M (2023) 'The Collective Intelligence of Evolution and Development', *Collective Intelligence*, 2: 26339137231168. https://doi.org/10.1177/26339137231168355

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