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Is There a Possible World in which Imagining Zombies Can Shed Light on Our Understanding of Consciousness?

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ABSTRACT

In this article I criticize the explanatory reductionism underlying the zombie argument from the point of view of the philosophy of science. I argue that it is a thesis that finds no support in the available models of reduction, a thesis that is based on an unfounded idealization of the natural sciences and that depends on an uncertain appeal to the possibility in principle of a future unified physics. I conclude that the uncertain character of these assumptions calls for a reassessment, not only of the implications of this type of argument for methodological naturalism but also of the role such arguments play in the study of consciousness.

KEYWORDS: *Consciousness, Zombies, Physicalism, Reductionism, Modal Arguments.*

RESUMEN

En este artículo critico el reduccionismo explicativo que subyace al argumento zombi desde el punto de vista de la filosofía de la ciencia. Defiendo que se trata de una tesis que no encuentra sustento en los modelos disponibles de reducción, una tesis que está basada en una idealización infundada de las ciencias naturales y que depende de una incierta apelación a la posibilidad en principio de una futura física unificada. Concluyo que el carácter incierto de estos supuestos invita a una reconsideración no sólo de las implicaciones de este tipo de argumentos para el naturalismo metodológico, sino también del papel que los mismos desempeñan en el estudio de la conciencia.

PALABRAS CLAVE: *conciencia, zombis, fisicalismo, reduccionismo, argumentos modales*

I. INTRODUCTION

No doubt there is an epistemological chasm between fundamental physics and psychology. Attempts to establish some kind of explanatory connection between theories of the former and phenomena in the do-

main of the latter belong rather to science fiction than to scientific research. However, there is also an identical chasm between fundamental physics and the different areas of biology, chemistry, and even physics itself — as "we should think about physics not as giving a single description of the world, but as giving a plethora of descriptions, of different systems, at different scales" [Wallace (2021), p. 75; cf. *infra* § III].

The first type of chasm has prompted a great deal of discussion in the past decades, resulting in the development of the modal strategy in the philosophy of mind. The modal strategy revolves around a set of arguments based on the premise of the non-existence of the second type of chasm. In the pages ahead I will examine this premise addressing one of the most widely discussed modal devices: the zombie argument. Considering the wide array of assertions concerning scientific knowledge and practice underpinning this argument, I will approach the task at hand through the lens of the philosophy of science, departing from the conventional reliance on semantics and metaphysics.

A partial exception to this norm in addressing the zombie argument from a metaphysical perspective has been Block & Stalnaker (1999), whose focus is on conceptual analysis, specifically on the feasibility of translating concepts from everyday language into scientific terms. Their argument shows that we cannot derive facts expressed in natural language from fundamental physics — or determine whether there are sufficient "microphysical conditions" for their application. In this paper, I argue that neither can facts from higher-order disciplines — even when expressed in scientific language — be derived from that basis. My argument does not rely on any assumptions regarding the conditions or feasibility of any type of analysis of everyday vocabulary into scientific terms, nor does it require committing to any particular interpretation of the meaning of natural kinds. The main point is that there are no scientific explanations of the kind required by the zombie argument — at least not in the sense and to the extent implied by that argument.

The conventional literature on the zombie argument, from its inception to the present [e.g. VandenHombergh (2020); Marton (2023)], has been heavily reliant on uncertain modal assumptions. By contrast, my argument maintains neutrality, avoiding specific commitments within the inherently slippery modal terrain. Like all other modal arguments, the zombie argument seeks to draw conclusions about the nature of the world and/or our capacity for scientific understanding, based on hypothetical scenarios deemed conceivable despite involving seemingly inconceivable things, such as individuals who know everything about the

physical world. The idea that such scenarios are genuinely conceivable is contentious, yet even more so is the idea that they are possible *because* they are conceivable. After Newton, we have had to come to terms with the fact that our intuitions are anything but a reliable guide for our rational attempts to understand the world [e.g. Lange (1865/1875), p. 315; Koyré (1957), p. 272]. Today, the profound schism between our intuitions — or any label we may devise for our "access" to "modal knowledge" — and our best theories about the natural world is more than conspicuous. In the light of that schism, what becomes of the connection between conceivability and possibility? Does it operate bidirectionally? This is the choice of the modal theorist, who places the inconceivable yet effectively possible on equal footing with the supposedly possible by virtue of our supposed capacity to conceive it. Even if we were to attempt to address objections of this nature from a particular modal epistemology, the lack of agreement and the wide range of proposals regarding the nature and justification of our "modal knowledge" advise caution against excessive reliance on such an uncertain foundation.

It is often claimed that consciousness poses a unique "metaphysical problem." This assumes that metaphysical issues can be distinguished from what scientific theories provide, a premise that demands justification. Approaching the zombie argument from the standpoint of contemporary analysis of actual scientific practice and knowledge should be the default option for those unsure about that justification.

My argument can be extended to address the intended metaphysical implications of the zombie argument; however, that is not my focus here. Instead, I am concerned with the alleged threat the zombie argument poses to methodological naturalism, understood as the thesis that the methods of rational inquiry, as applied to the study of the natural world, retain their validity when investigating mental phenomena [Chomsky (2000); (2002); (2016), p. 30]. Accordingly, my central message is epistemic in nature[1]: I contend that the zombie argument rests on a flawed philosophy of science; thus, it cannot provide a valid basis for advocating a radical shift of the natural sciences in their efforts to explain consciousness [e.g. Chalmers (1995), §6; (1996); (2010), chap. 5].[2]

In the following sections, I will examine the aforementioned flawed philosophy of science, focusing on a key assumption of the zombie argument, namely explanatory reductionism. I will begin in the next section by introducing the discussion on reduction in the philosophy of science at the most general level, and subsequently address it in the fol-

lowing two sections from the perspective of increasingly specific debates in the philosophy of physics.

II. The Gap Between Reduction and Reductionism

Let's call the reductionist assumption pivotal to the zombie argument "zombie reductionism" (ZR). According to ZR, "the remarkable progress of science over the last few centuries has given us good reason to believe that [...] for every natural phenomenon above the level of microscopic physics there seems in principle to exist a *reductive explanation* […]. In these cases, when we give an appropriate account of lower-level processes, an explanation of the higher-level phenomenon falls out" [Chalmers (1996), p. 42].[3]

What are those "good reasons"? Chalmers does not expound them, and they remain unknown to most scientists and philosophers of science who have delved into these issues. In every branch of the natural sciences, ZR is typically considered utopian and unattainable: today, even paradigm cases of reduction — such as that of thermodynamics to statistical mechanics [Batterman (2011); Chibbaro et al. (2014)] or Mendelian genetics to molecular genetics [Kitcher (1984)] — are generally seen through the lens of the practical failure of the reductionist program [Dupré (1993), chap. 6; (2000)], even within "microscopic physics."[4]

Reductionist proposals in contemporary philosophy of science are ontological in substance and call into question the fundamental assumptions of ZR, recognizing the unworkable nature and lack of alignment with actual scientific knowledge and practice of explanatory reductionism, which postulates the feasibility of deducing all truths regarding higher-level phenomena from those regarding their lower-level components [Gillett (2016); Sachse (2007); Tahko (2021)]. This combination of ontological reductionism and explanatory antireductionism is indeed referred to as the "received view" [Polger (2012)].

It is worth noting that not even in the program of the Unified Science put forth by the logical positivists can we find a reductionist proposal as ambitious as ZR—Otto Neurath, founder of the Institute for the Unity of Science, advocated for a model of unification without reductionism [Neurath (1936); (1937); Cat, Chang & Cartwright (1996); cf. Chibbaro et al. (2014), chap. 7].

In both the neopositivist context and subsequent philosophy of science, the discussion concerning reduction revolved around theoretical

reduction. The pioneering and most influential model of reduction in this debate was that of Nagel, which characterized reduction as a form of explanation [Nagel (1961)]. Nagel conceives of reduction as an explanatory relation between two theories, where one of the theories is derivable or deductible from the other: thus, the relation of reduction reflects the pattern of deductive arguments. This model of scientific reduction is based on the Hempelian covering law model of scientific explanation, which implicitly underlies the zombie argument [e.g. Chalmers (1996), chap. 2; cf. Van Orman (2014), chap. 3].[5] In line with the intersection between the Hempelian covering law model and the Nagelian reduction model, the zombie theorist posits that all higher-level scientific explanations ultimately collapse into those of fundamental physics. The zombie theorist faces several issues at this point, as the covering law model of explanation may be considered ruled out; it was precisely the deficiencies of the — arguably weaker than ZR [cf. Chalmers (2012), p. 304] — reduction model based on this model of scientific explanation what forced philosophy of science to abandon the neopositivist program; and none of the subsequent models of reduction can serve the zombie theorist's purposes.

The main alternative to Nagel's model in later philosophy of science was developed within the structuralist program, stemming from the work of Wolfgang Stegmüller in the late 1970s to that of Erhard Scheibe in the late 1990s. However, while the zombie theorist depends on a global and maximalist conception of reduction, this alternative focuses on reconstructing specific historical episodes of theoretical change. Moreover, in contrast to zombie maximalism, this alternative recognizes that strict forms of reduction do not exist. As a result, the reduction relation in this alternative is much weaker and flexible, taking the form of a similar relation between theories, understood as an approximation of one theory to another under ideal conditions.

It might be suggested that the New Wave account of reduction developed by Paul Churchland and Clifford Hooker in the 1980s provide an interpretation of reduction that aligns better with the goals of the zombie theorist. However, this alternative is still weaker than the zombie theorist requirements, as it also focuses on reconstructing specific episodes of theoretical change or, at best, optimistically attempts to draw analogies between theories and place those analogies on a strong-to-weak, smooth-to-bumpy spectrum [Bickle (1998)].

Finally, while the New Mechanism account of scientific explanation in biology can be seen as an alternative to Nagel's model, there is no rea-

son to conceive of this approach as a reductionist interpretation of scientific explanation [Craver (2007)]; the main proponents of this account depict it as non-reductive [e.g. Bechtel (1994)].

After decades of debate, it is generally acknowledged in contemporary philosophy of science that, even within physics, any talk of reduction must be qualified as partial, as even the most compelling examples of reduction are incomplete and approximate [Schaffner (2012)] — there are, indeed, strong arguments in contemporary philosophy of physics for a weak, localized, and *a posteriori* interpretation of reduction [Rosaler (2015); (2019)]. Asserting that ZR represents the current orthodox position [Chalmers (2010), p. 110; (2012), p. 293] is, at the very least, problematic.

III. The Gap Between Physics and Physicalism

According to modal theorists, "a positive conception of the physical" is not a prerequisite for their work [Levine & Trogdon (2009), p. 361; Chalmers & Jackson (2001), p. 316], and so, in the zombie literature, the term "physical" behaves like an honorific term applied to everything, excluding phenomenal consciousness. To understand this usage of the term "physical," we need to take a closer look at ZR.

According to ZR, all natural phenomena — excluding phenomenal consciousness — can be reductively explained, i.e., they can be deduced *a priori* from "a microscopic description of the world in the language of physics" [Chalmers & Jackson (2001), pp. 330-1], as they are "entailed" by the microphysical facts [Chalmers (1996), p. 71]: "the conjunction of all microphysical truths about the universe" necessarily entail all truths [Chalmers (2010), p. 107].[6]

An initial insight into the effective absence of inter-level deducibility in actual science can be found in the literature examining the prospects of reducing different areas of chemistry to physics. In this context, even authors more inclined towards reductionism remain distant from ZR, outlining instead local, partial, idealized, approximate, and non-continuous inter-level links [Hettema (2012); (2017); cf. Chibbaro et al. (2014), chap. 6]. This literature offers an illustration of a much more general phenomenon: beyond a highly restricted domain of phenomena, there is nothing that can be deduced from "a microscopic description of the world in the language of fundamental physics". The primary reason for this lies in the fact that the interrelations between physical theories at different levels involve limits as certain parameters approach zero, and

the limits involved are typically "singular," with the relevant terms diverging to infinity, thereby precluding deductibility across levels. This has nothing to do with "technical difficulties, which may be practically insurmountable but conceptually obvious" [Chibbaro et al. (2014), p. 15], but rather with situations where a regular asymptotic limit cannot be taken, rendering inter-level deduction impossible. In these situations, "the basic theory is not sufficient to cover higher-level phenomena" [Ibid. p. 38] and new properties *emerge* [Ibid. p. 34].

The zombie theorist acknowledges that "the language of a completed fundamental physics is not known" [Chalmers (2012), p. 110], but contends nonetheless that "the truths in the languages of all correct theories are epistemologically deducible from the truths of fundamental physics" [Ibid. p. 302]. To the best of our current knowledge, fundamental physical theories, though highly successful in certain contexts, continue to fall short in explaining even the most ordinary physical phenomena. The Standard Model of particle physics is widely considered to be the most fundamental theory in contemporary physics: we can derive good theories of electrons and light from it, and while efforts persist in the pursuit of a deeper theory that might eventually deduce the Standard Model, if one were to designate something as fundamental, it would be this theory. Despite its success, the Standard Model features nineteen free parameters, physical values that can be determined experimentally, but not derived theoretically.[7] As we progress from particle physics to atomic physics and then to chemistry, etc., the natural sciences provide us with mathematical expressions embodying regularities that can be experimentally detected, but not deduced from some "description in terms of fundamental microphysical properties" [Chalmers (2002), p. 176].

According to ZR, once the "fundamental microphysical" facts are established, all other facts are also fixed and can be reduced to and deduced from these "fundamental microphysical" facts. Asserting that science is in a position to provide such strong explanatory connections between the microscopic and the macroscopic, allowing for transparent epistemic deductions of truths regarding chemistry or biology from fundamental physics [e.g. Chalmers & Jackson (2001), p. 354], is something that can only be done when there is no intention to delve into the specifics of the micro-macro explanatory relations that have been explored in the literature.

In the zombie literature, the term "physics" denotes something fundamentally dissimilar to the discipline conventionally labeled with that term. Specifically, that term refers to a complete and consistent de-

ductive system containing as axioms those of a complete fundamental physics, and as theorems, all true statements of the natural sciences. Maybe someday we may have something significant to say about that ideal physics and that complete system of the sciences. However, if we take real physics as our foundation, the duality between the physical and the phenomenal that the zombie argument aims to unveil cannot but be extended to a duality between physics and physics itself. The vast majority of physics, along with all other natural sciences, fall outside the concept of the "physical" as employed in the zombie literature, and likewise outside the concept of "reductive explanation" as used in that literature.[8]

In the zombie literature, physics is, by definition, the aforementioned deductive system, and the physical is the domain of that system. As a result, we are confronted with technical terms: in zombie literature, physics and the physical are what the zombie literature informs us they are. The problem is that stipulating the meaning of a technical term makes sense only when that term is integrated within the framework of some explanatory theory [Chomsky (1995), pp. 25-6]. In the case of the zombie literature, the place of such a theory is occupied by a series of variations on the same argument against a theory that does not exist outside of that literature — a theory known as "physicalism," which revolves around the idea that the meaning of the word "science" coincides with that assigned by stipulation to the word "physics" in the zombie literature.

The hiatus between the zombie theorist interpretation of "physics" and physics itself is likely wider than the one the zombie literature endeavors to locate between the physical and the phenomenal. Those who maintain the belief that phenomenal consciousness can be accounted for within the framework of the natural sciences share equivalent reasons for embracing the zombie interpretation of "physics" as those who maintain that superconductivity in inhomogeneous materials, kin selection, or gravitational lensing can be elucidated within that framework.

IV. The Gap Between Principle and Practice

While it is true that the debate surrounding reductionism remains ongoing in the philosophy of science, finding an advocate of ZR poses a genuine challenge [cf. Gillett (2007; 2016); Sachse (2007); Tahko (2021); Wallace (2021), chap. 4]: "virtually no one has really supported it and even fewer have practiced it" [Chibbaro et al. (2014), p. xiv]. Proponents of the zombie argument may argue that debates in the philosophy of sci-

ence hold little to no significance for them, as what is being discussed there pertains to actual science, whereas the zombie theorist is interested in a possible ideal system of the sciences: the aforementioned complete and consistent deductive system [Chalmers & Jackson (2001), p. 316]. According to this response, even though current science cannot provide reductive explanations in the desired sense, and even when contemporary philosophy of science generally deems such explanations an unattainable goal, the zombie theorist knows a) that they are possible in principle, and b) what consequences follow from that possibility.

This response encapsulates the core of the zombie argument, as it relies on the existence of a potential unified physics to which all sciences could eventually be reduced. In the recent debate in physics and philosophy of physics, several proposals have been considered for this hypothetical future physics. The most debated proposal in this regard is the so-called Theory of Everything, a set of equations with universal explanatory power. While it is easy to find principled objections to the feasibility of such a theory [Laughlin & Pines (2000)], it proves challenging to find an explicit defense of this idea: when similar proposals have been advocated, they have typically been nuanced and weaker versions [cf. Barrow (1991); (2008)]. There are other approaches, the primary example being Effective Field Theories. Despite interpretations that align this approach with strong variants of reductionism, its dependence on empirical data for inter-theoretical construction poses significant challenges in interpreting this approach in the deductive manner required by the zombie theorist. Furthermore, there are no compelling reasons for any particular philosophical interpretation of this framework [Rivat & Grinbaum (2020)].

Although these debates are ongoing, they by no means provide a basis for asserting that ZR represents the current orthodoxy [Chalmers (2010), p. 110; (2012), p. 293]. There is little in these debates that enables the zombie theorists to believe they can talk to Laplace's demon or Broad's archangel, i.e., to claim they can somehow know that someone possessing complete knowledge of all "microphysical truths" would thereby know all "macrophysical truths" — except for the phenomenal ones. No one can conceive of such an omniscient mind, let alone claim to know which aspects of nature it would find deducible from a complete microphysical description of the world and which ones it would not. It is, therefore, not surprising that many scholars "do not value reduction *in principle*, if nobody can carry it out in practice" [Chibbaro et al. (2014), p. 9].

V. Conclusion

It is not uncommon to find good synthesis works where the only philosophical question regarding consciousness is the modal question and most of the modal question revolves around the zombie argument [Sebastián (2022)]. If my assessment of the shortcomings of ZR is on the right track, a substantial portion of contemporary philosophical literature on consciousness rests on precarious grounds. If my assessment is on the right track, the proliferation of this vast body of literature may be attributed to the confluence of our natural interest in consciousness and some sort of neglect of actual science and philosophy of science.

The absence of an explanation for consciousness "in terms of fundamental microphysical properties" captivates our imagination more than the lack of such an explanation for language acquisition, the evolutionary emergence of sexual reproduction or the inheritance of instinctive behaviors. This fascination is understandable, as consciousness lies at the core of our self-understanding. However, there are many phenomena that we cannot explain in "fundamental microphysical" terms, and there is no argument in the zombie literature to grant consciousness a differential status. The intuition that consciousness poses a unique and profound problem, different from those related to any other aspect of reality that cannot be "reductively explained" — the idea that "the bare intuition of distinctness [...] arises here and nowhere else" [Levine (2020), p. 403; cf. Horst (2007)] —, is the fundamental drive behind the modal strategy, but it is entirely dependent on a selective blindness to these other problems.

The zombie theorist believes that, someday, reductive explanations will encompass all natural phenomena. That day, all truths within each branch of the natural sciences will be deductible from a future completed fundamental physics, and hence, perhaps, that day we may have some grounds to consider consciousness science as somehow different from each and every other branch of the natural sciences. For the time being, there are few indications leading in that direction, and philosophy may indeed play a constructive role in addressing the problem of consciousness — beyond the uncertain domain of modal speculation. The problem with modal speculation is not merely that it is based on numerous questionable assumptions; it also diverts time and effort away from the constructive task of advancing the science of consciousness. Numerous philosophers are actively engaged in this endeavor, grounded in the

largely unchallenged premise that, at times, when we pose good questions, nature provides interesting answers.

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NOTES

[1] Levine's explanatory gap argument seeks to establish an epistemological impasse more explicitly than the zombie argument, though in a very similar manner. Virtually nothing needs to be altered from the argument I develop here to apply the conclusions reached to Levine's argument.

[2] Despite efforts to present it as standard scientific practice, introducing "fundamental properties" when research programs have barely begun to elucidate a phenomenon is uncommon in science, especially when all indications suggest that this "fundamental property" pertains to a domain characterized by highly complex systems, such as brains — quite far from the electroweak interaction, to put it succinctly. I will not pursue this line of reasoning here, but if the argument I develop in the following sections is on the right track, it is readily arguable that the "zombie" interpretation of the natural sciences would require the introduction of new "fundamental" properties across all areas of the natural sciences.

[3] Emphasis in the original.

[4] In the words Robert Laughlin, "despite all the evidence that the reductionist paradigm in physics is in trouble, subnuclear experiments are still generally described in reductionist terms […]. In situations that matter, mythologies are immensely powerful things, and sometimes we humans go to enormous lengths to see the world as we think it should be, even when the evidence says we are mistaken" [Laughlin (2005), pp. 113-4].

[5] It is quite contentious whether the emphasis on deduction required by ZR can be found within models of explanation such as Bas van Fraassen's pragmatist conception, Wesley Salmon's ontic view or its subsequent mechanistic developments.

[6] The so-called *a priori* entailment thesis is not a peculiarity exclusive to Chalmers [e.g. Levine (1983); (1993); Jackson (1993); (1994)]. An important issue with the broad, standard formulation of this thesis lies in the assumption that the terms of natural languages "refer" in the same way as the technical terms of the natural sciences [cf. Block & Stalnaker (1999)]. In fact, the modal strategy has relied on this assumption since its inception [Kripke (1980)]. This assumption presupposes the existence of a reference relation connecting natural

language expressions with extra-mental objects [Chomsky (1993)]. While it may be contended that a reference relation exists in both instances, the lack of clear counterparts between the common-sense concepts used in natural language and the technical concepts of the natural sciences [Chomsky (2000), p. 138] poses a significant barrier to the modal strategy from the outset: to claim that it is metaphysically necessary that water is H_2O is to conflate concepts of fundamentally different nature in a single identity statement. Even if we were to agree that the identity statement has a clear meaning, that statement constitutes more than just an oversimplification [cf. VandeWall (2007)]. In any case, it's worth asking why identity statements involving the common-sense concept "water" are so prevalent in this literature, whereas such statements for other common-sense concepts like "earth," "air" or "fire" are nonexistent. The answer is straightforward: H_2O has an extremely vague correspondence to "water", but it is impossible to find similar correspondences for the vast majority of ordinary concepts [Chomsky (1992)]. The radical divergence of perspectives, aims, and interests of ordinary and technical usages is the root of a fundamental departure that precludes any branch of the natural sciences from incorporating the broad, ambiguous, and intuitive semantic repository of natural language terms. The natural sciences require the creation of artificial terms with semantic properties that radically differ from those of natural language terms: when exploring the laws of nature, the perspectives offered by common-sense concepts are insufficient, and as such, the objects under examination are not approached from this standpoint [Chomsky (1993); (1995); (2000)]. The entities referred to in natural language, which form the foundation of our common-sense understanding of the world, do not exist within the domain of the natural sciences. As for the entities, properties, and relations postulated by the natural sciences, they are not individuated by their relation to common-sense entities, but rather by their position within "a matrix of principles" [Chomsky (1992), p. 209].

[7] Going back to the fundamental basis of the Standard Model does not improve the situation. "Quantum mechanics is the most fundamental theory we have, [but] nobody understands quantum mechanics [...] and our best attempts to understand fundamental physics have reached something of an impasse" [Carroll (2019)]. Worse still, quantum mechanics can be characterized as a mathematical formalism rather than a physical theory. Within quantum mechanics, a multitude of different theories coexist alongside the same formalism: it lacks an ontology and so it "does not specify what physically exists and how it behaves" [Maudlin (2019), p. 5] — the idea of explaining everything "in terms of simpler entities" [Chalmers (1996), p. 42] simply collapses at this point. Moreover, fundamental phenomena such as quantum entanglement or symmetry breaking do not fit ZR's deductive, hierarchical framework [e.g. Anderson (1972); Horodecki et al. (2009)] — here, "hierarchical" means that it "ought to be possible in principle" for biological phenomena to be explained in terms of cellular phenomena, which in turn can be explained in terms of biochemical phenomena, which are

explainable in terms of chemical phenomena, and ultimately in terms of physical phenomena [Chalmers (1996), p. 51].

[8] Maybe a hindrance to grasping these facts lies in the prevalent heroic tenor in popular science. In this regard, a well-known theoretical physicist and science communicator highlights that "the whole history of science until now has been a success story of reductionism: biology can be reduced to chemistry, chemistry can be reduced to atomic physics, and atoms are made of elementary particles; this is why we have computers today" [Hossenfelder (2020); (2021)]. The most credible of these assertions is the one stating that atoms are made of elementary particles, so designated due to a straightforward reason: "We say they are 'fundamental' […], but that's just a way to say to students, 'Don't ask! I don't know the answer'" [Wolchover (2020)]. These standards of scientific communication cannot be attributed to the concision imposed by the journalistic format: even when afforded the space of an entire book, science communicators often fail to critically assess some of their most far-fetched ideas — such as the suggestion that reductionism is not simply a philosophical stance, but rather an empirically confirmed scientific hypothesis [Hossenfelder (2022), p. 88]: a viable idea only as long as one subscribes to the discarded logical positivist model of empirical confirmation.

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