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Article

Revisiting the Logical Empiricist Criticisms of Vitalism

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Abstract:

Vitalism claims that biological organisms are governed by nonmaterial agents like entelechies. The received view today rejects vitalism by presupposing metaphysical materialism (or physicalism). Metaphysical materialism maintains that the world is ultimately material (or physical), and it, therefore, repudiates the existence of nonmaterial entelechies. However, this marks a shift compared with the arguments against vitalism developed by logical empiricists, who were indifferent to metaphysical issues and were only concerned with logical and empirical matters in the sciences. Logical empiricists rejected the concept of the entelechy (vitalism), because vital laws confirmed by biological phenomena were unavailable; in contrast, they accepted the concept of the atom (materialism), since it constituted physical laws and was therefore associated with verifiable results in modern physics.

Keywords: Vitalism; Materialism (or Physicalism); Logical Empiricism; Entelechy; Atom

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Introduction: The Metaphysical Refutation of Vitalism

Today most biologists and philosophers understand vitalism as a heretical doctrine in the history of biology, originally proposed by Hans Driesch in the early twentieth century.[2] According to Driesch's doctrine of vitalism, biological organisms are governed by nonmaterial vital agents termed entelechies (Driesch 1929; Churchill 1969; Allen 2008). Now the received view consents to an almost universal rejection of vitalism. For current biologists and philosophers, vitalism is no longer a viable option because it violates their materialist belief. For instance, to defend organicism Scott Gilbert and Sahotra Sarkar first characterize materialism as the default ontological option for the philosophy of biology. Then for these two authors, vitalism is heretical because it advances a "non-materialist claim" confirming

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[2] But this by no means suggests that Driesch's doctrine was the only doctrine of vitalism in the history of biology. Since the late eighteenth century, a great many doctrines have been labelled as doctrines of vitalism (Hein 1968; Benton 1974; Normandin and Wolfe (eds.) 2013; Wolfe 2011, 2014, 2017).

the existence of some specific "life force," thereby going against the "ontologically materialistic philosophy", which "provides the basis for contemporary natural Science" (Gilbert and Sarkar 2000, 1).

Next Gilbert and Sarkar term their own organicist position material holism, which consents to metaphysical materialism, or in their own words, "ontological materialism." Today the two terms, "metaphysics" and "ontology," are often used interchangeably, and in those cases, both are concerned with the basic, fundamental, ultimate or essential categories of the metaphysical Reality.[3] For Gilbert and Sarkar, the default materialist position endorses a belief in the constitutional priority of microphysical entities over biological objects. As a matter of fact, most biologists and philosophers, following Gilbert and Sarkar, take it for granted that from a metaphysical point of view a biological object is *nothing but,* and therefore *ontologically reducible to*, a set of fundamental physical entities and their interactions. For instance, the evolutionary biologist Ernest Mayr claims that modern biologists do not oppose "constitutive reduction", which suggests that "all organic processes can ultimately be reduced to or explained by physico-chemical processes" (Mayr 1988, 10-11). This position is termed "ontological reduction" by Ingo Brigandt and Alan Love (2017), in the entry "Reductionism in biology" from *the Stanford Encyclopedia of Philosophy*. For them, ontological reductionism claims that "each particular biological system (e.g. an organism) is constituted by nothing but molecules and their interactions" (2). Moreover, they affirm that ontological reductionism is "a default stance nowadays among philosophers and biologists…" (3)

Yet to be more accurate, currently, a similar but more popular stance among philosophers is physicalism (Stoljar 2010, 2015). Various formulations of physicalism exist in either a priori or a posteriori forms (Banks 2014). But for most philosophers of biology, physicalism is still a metaphysical position incompatible with vitalism. For instance, according to Alex Rosenberg, physicalism suggests that "there are no nonphysical events, states, or processes, and so biological events, states, and processes are 'nothing but' physical ones" (2006, 25). Peter Godfrey-Smith makes the physicalism-vitalism dichotomy more explicit. In his *Philosophy of Biology* textbook, Godfrey-Smith claims that vitalism is at odds with the physicalist interpretation of life (Godfrey-Smith 2014, 10). More recently Brigandt and Love also ascertain us that vitalism has been denied by physicalism (Brigandt and Love 2017, 3).

Ontological materialism, constitutive or ontological reductionism, physicalism and various other metaphysical positions, although their contents differ in detail, all tend to impose a priori restraints onto the ultimate constituents of the metaphysical Reality. In consequence, most of them appear to legitimize a metaphysical rejection of vitalism. The controversy over materialism (or physicalism) and vitalism seems closed today, attested by Brigandt and Love, who write that "vitalism (...) is largely of historical interest" (Brigandt and Love 2017, 3). In the history of science, indeed, one significant moment for vitalism was the early twentieth century, when logical empiricists attacked the vitalism of Hans Driesch and contributed to its final overthrow. Along with some biologists, logical empiricists argued that the concept of the entelechy had no place in scientific biology.

Yet logical empiricists were also famous for their rejection of metaphysics, so it seems unlikely that logical empiricists refuted Driesch's vitalism out of metaphysical concerns. Indeed, a closer examination shows that the logical empiricist criticisms of vitalism were at odds with the received view held by current biologists and philosophers. In this article, my aim is to give an interpretation of the criticisms of vitalism offered by logical empiricists. First,

[3] This is not to deny that these two terms are also used in different senses. For instance, some philosophers, under the name of "ontology," deal with questions about categories developed in empirical sciences (e.g., Wimsatt 1994). These questions have more scientific relevance and are irrelevant to metaphysical concerns over "the basic, fundamental, ultimate or essential categories". See Hook (1953) for a fine distinction.

I show that materialism formulated in metaphysical terms was not within the concern of logical empiricists in dealing with vitalism, and logical empiricists dismissed metaphysical materialism as raising meaningless pseudo-questions about a questionable metaphysical Reality. Second, from the logical empiricist point of view, even though vitalism advanced nonmaterial agents like entelechies, it could not be refuted simply for its going against metaphysical materialism. Instead, logical empiricists rejected vitalism for its lack of precise law formulations and its inability to generate determinate experimental results. In order to better articulate the logical empiricist standpoint, I give an analytic comparison between a representative materialistic concept, that is, the atom, and the vitalistic concept of the entelechy, on the basis of some writings from logical empiricists. In the end, I clarify the doctrine of physicalism developed by logical empiricists. I claim that the physicalism of logical empiricists was hypothetical and empirical in character. Unlike the physicalism understood in the philosophy of biology today, the physicalism of logical empiricists was no metaphysical position, and it could not enforce a refutation of vitalism.

Logical Empiricism against Metaphysical Materialism

The received view today issues a metaphysical rejection of vitalism. Now vitalism is no longer a viable option, since biologists and philosophers conceive of several materialist metaphysical positions, from ontological reductionism to a priori physicalism, as already having captured the ultimate constituents of the metaphysical Reality. This evaluation of vitalism, however, goes sharply against the non-metaphysical ethos of logical empiricism. My focus in this section is then to characterize the logical empiricist attitude towards metaphysics, especially metaphysical versions of materialism.

It is well known that logical empiricists were hostile to every form of metaphysics. Thus, there is no doubt that logical empiricists would reject vitalism if it made statements about the so-called Essences of the biological reality. However, very importantly, the anti-metaphysical attitude of logical empiricists will be misunderstood, if we neglect their equally forceful opposition to metaphysical doctrines of materialism. Commenting on the philosophy of science in the early twentieth century, Rosenberg sees this point clearly:

> In the heyday of empiricism, mechanism or materialism was treated as a metaphysical doctrine no less otiose than vitalism and organicism. No empiricist who embraced the thesis of the unity of science took the claim as one about the metaphysical assimilation of biological to the physical, for this thesis was treated as just as empty of empirical content as its vitalistic denial. (Rosenberg 1985, 22)

Rudolf Carnap, perhaps the most well-known logical empiricist in mainstream analytic philosophy, later in his intellectual autobiography suggested that throughout his career he was indifferent to metaphysical materialism. In Carnap's own words, "the ontological theses of the traditional doctrines of (…) materialism remained for me entirely out of consideration" (Carnap 1963, 18), and in fact he treated "the theses of phenomenalism, materialism, realism and so son in their traditional forms as pseudo theses" (Carnap 1963, 50). For Carnap, materialism was chiefly of two variants in the nineteenth century, the dialectic materialism held by Marxist philosophers and the mechanism which assumed that phenomena and laws in nature are reducible to those in mechanics. Of the former, Carnap commented that "the dialectic in its Marxist form" should be rejected "no less than the Hegelian dialectic" (Carnap 1963, 24).[4]

[4] The logical empiricist reading of German idealist philosophers might not be entirely fair. Even though it was not inadequate to brand philosophers like Hegel and Schelling as metaphysicians, logical empiricists failed to note that both Hegel and Schelling were quite learned men and built their

Other logical empiricists paid greater attention to the doctrine of mechanism. For instance, Herbert Feigl, a central participant in the logical empiricist movement, expressed his discontent with this misconception commonly held by humanists against science: "science is still identified with an absurd mechanistic reductionism" (Feigl 1953, 8). Frank, another major logical empiricist, traced one important historical background for the rise of logical empiricism as "the failure of mechanistic science" (Frank 1949b, 4). For Frank, "two characteristic beliefs of nineteenth-century science broke down during its last decades; these were the belief that all phenomena in nature can be reduced to the laws of mechanics (...)" (Frank 1949b, 4) Frank repeated this story throughout his life (Frank 1949a, 1987). Further, in his interpretation of the great physicist Ernst Mach, Frank endorsed Mach's attitude against metaphysical materialism of the mechanistic form. According to Frank, Mach essentially "separated the conception of scientific explanation from mechanical explanation" and through this separation he "saved the scientific world picture from going down along with the mechanistic picture" (Frank 1949b, 6). In Mach's mind, mechanistic reductionism was a "pure illusion", because mechanical phenomena "chosen as the basis of explanation are by themselves no more understandable than the phenomena that are to be explained" (Frank 1949b, 6).

The American logical empiricist Ernest Nagel offered another case against materialist metaphysics, in a debate with the physicist Arthur Eddington. In his 1929 *the Nature of the Physical World*, Eddington contributed a philosophical reflection on modern physics and provided his famous (or infamous) tale of two tables. For Eddington, there was "an ordinary table" as "a commonplace object" in everyday human experience, and there was also "a scientific table" which was "mostly emptiness" but with "numerous electric charges rushing about with great speed" (Eddington 1929, x). Further, according to Edington, modern physics assured that the "scientific table is the only one which is really there" and the ordinary table was merely a "strange compound of external nature, mental imagery and inherited prejudice." (Eddington 1929, xii) In Eddington's viewpoint, modern physics identified the metaphysical Reality as consisting of small physical particles and "mostly emptiness", as a result, science could dismiss commonsense experience as a sheer illusion. However, Nagel sneered at Eddington's formulation and treated it as a typical misreading of modern physics, for its misuse of concepts and categories from the different context of commonsense experience. For Nagel, the concepts used by Eddington, such as "mostly emptiness" were "defined or specified in just those contexts in which it is appropriate to predicate" the ordinary table, and they had "no assigned meanings" in modern physics and were thus meaningless when used to characterize the so-called scientific table (Nagel 1941, 313). Above all, Eddington's metaphysical tale of two tables annihilated the reality of commonsense experience, and, according to Nagel, would not be taken seriously in the logical empiricist conception of knowledge (1940, 438). For logical empiricists, in the words of Frank, "matter and atom" were merely auxiliary concepts of natural sciences (or even only modern physics), the metaphysical move to read them into "everything in the world" was a grave mistake to be avoided in an adequate philosophy of science (Frank 1949b, 74).

The Logical Empiricist Conception of the Atom

A current example in modern physics, already mentioned above by Frank and Nagel, will help better illuminate the logical empiricist attitude toward materialism. Though philosophers today seem to have disagreements on the most adequate formulation of materialism and physicalism (Stoljar 2015; Ellenzweig and Zammito (eds.) 2017), the dominant version shared by scientists is still atomism. In current science education offered to laymen and science

philosophical systems upon contemporary scientific knowledge. For this, see Friedman (2010).

students, atomism is generally conveyed as a body of indisputable truths about the basic constituents of the metaphysical Reality. In this way, the scientific concept of the atom, consolidated in the nineteenth century through the great achievements in statistical mechanics and atomic physics, receives an interpretation intuitively intelligible to commonsense experience. According to most scientists, even though at the super atomic levels nature has many different layers, from the ontological point of view entities at these layers are nothing but numerous atoms in certain spatial configurations. For biologists, in particular, biological organisms are mere aggregates of invisibly small atoms of different chemical elements.

Now regarding vitalism, the exclusive right to serve as the basic units of the Reality, claimed by the atoms, rules out possibility of the existence of vital agents peculiar to biology. This metaphysical opposition between atomism and vitalism is vividly demonstrated by the philosopher of biology David Hull, "both scientists and philosophers take ontological reductionism for granted. Vitalism is dead. Organisms are 'nothing but' atoms, and that is that" (Hull 1981, 282). Seen from the case of Hull, I suggest, the atomistic version of metaphysical materialism is implicitly presupposed in general science education. Sometimes even branded as the scientific worldview, metaphysical materialism asserts that all objects at the super atomic levels are "composed" of invisibly small atoms.[5]

It is certainly comfortable to treat an atom as an *invisibly* small entity, and further a biological object as composed of large amounts of atoms. This well accommodates commonsense experience wherein a string of beads is composed of *visibly* small beads. However, nothing was more alien to logical empiricists than digesting atomism through analogies in commonsense experience. Moritz Schlick depicted the everyday version of atomism as stemming from the pictorial worldview of the microcosm. Under the pictorial worldview, the microcosm was invisible because entities within it were spatially too small. But for Schlick, "…a pictorial model of electrical and magnetic processes…[has] long since been finally abandoned", and "the inadequacy [of the pictorial model of the atom] is even more clearly brought home to us by the modern quantum theory which shows that even in respect of spatio-temporal conditions, the model must fail" (Schlick 1949, 16).

The pictorial worldview was implicitly associated with the belief that the Complex (e.g., macro objects) must be constituted out of the Simples (e.g. atoms). But for Nagel, this belief is "either a tautology or a sheer dogma; and the dogma appears to me to have been generated by viewing as 'ultimate constituents' of a subject-matter phases of it which have isolated through the use of a particular method relevant in a particular context of inquiry" (Nagel 1936, 15). So according to Nagel, the concept of the atom must be understood in modern physics and its associated mode of inquiry. It became questionable or even meaningless when taken out of its proper context.

To better illustrate the logical empiricist conception of the atom, it is useful to go back to their intellectual predecessor, Mach. Mach was famous (or infamous) for his distrust of atomism. For Mach, the atom was no more than a "constructed mental symbol" to represent "a complex of sensuous elements" (Mach 1897, 152). In other words, the atom "must remain a tool for representing phenomena" (Mach 1898, 207), and it "would be a mere empty word for one in whom it did not awaken a large group of well-ordered sense-impressions" (Mach

[5] Some very helpful comments on previous drafts of this article have pointed out that scientists in their everyday practice may not care about these metaphysical claims of materialism and atomism, and even if they do, they give a false interpretation of their sciences. I agree with these comments, but they do not contradict the fact that most scientists hold the belief that atoms exclusively constitute the metaphysical Reality. My point is rather that although this belief is irrelevant to scientific practice and is even very unsound upon a critical analysis (which will be done in a future article from the standpoint of transcendental philosophy, starting from the Kantian category of community or wholes-parts relation), it does underpin many bold formulations of materialism and physicalism.

1898, 202-3). To those who were inclined to take atoms as the ultimate blocks of the metaphysical Reality, Mach raised a question from psychology, "(…) how is it possible to explain feeling by the motions of the atoms of the brain?" (Mach 1898, 208).

Mach appeared to hold an instrumentalist view of atomism (but this is dubious, see Brush 1968; Banks 2014), and based on Mach's doctrine Frank made essential improvements. Yet to start, Frank understood Mach's concern, and he agreed with Mach that the concept of the atom was useless in psychology and cognitive science (Frank 1949b, 70). But Frank quickly moved beyond Mach by insisting that "the usefulness of the atomic theories in this limited realm (physics) is certainly indisputable" (Frank 1949b, 70). According to Frank, Mach underestimated the role of mathematics in consolidating the concept of the atom. As Frank pointed out, the atom concept was valid in modern physics since it participated in "a structural system having exact logical coherence with the world of facts" (Frank 1949b, 44). But like Mach, Frank did not give a metaphysical reading of atomism. For Frank, the validity of the atom concept partly lied in its "form" which involved a set of mathematical equations, and this was quite unlike the claim from materialist metaphysics, in which the atom stands as crude "matter" in the metaphysical Reality.

More importantly, according to logical empiricists, the atom concept could only be understood within scientific development. Following Frank, Nagel gave this point a subtler illustration from the historical perspective (for a history of atomism, see Chalmers 2009). For Nagel, the "forms" associated with the atom concept accumulated after Dalton revived the atomic theory of matter in chemistry. However, this accumulation of knowledge could not be used to support the view that physicists were making progress "in our knowledge concerning a fixed set of submicroscopic objects" (Nagel 1979a, 370). Quite similar to Thomas Kuhn (Kuhn 1962), Nagel suggested that this was because:

> Each [atomic] theory in a certain series of theoretical constructions having a number of broad assumptions in common-postulated (or "defined") distinctive kinds of submicroscopic components for macroscopic objects, with distinctive "natures" for the components in each case. (Nagel 1979a, 370)[6]

Accordingly, Nagel concluded that the atoms of Democritus, the atoms of Dalton, and the atoms of modern physics were quite different physical particles, and it was illegitimate to regard these theories as unfolding the truths about a metaphysical Reality of atoms.

Logical empiricists were generally more concerned with contemporary scientific theories. Then when it came to the early twentieth century, for them the atom was certainly no longer Democritus' invisible entity, the theory of which was rather speculative; nor was it Dalton's chemical unit, which only had limited use in chemistry. According to Schlick, the atom in modern physics could be the elastic spherical entity employed in the kinetic theory of gases (Schlick 1949, 98), the point center in the dynamic theory of matter (Schlick 1949, 102), and the electro-dynamic system in the electrical theory (Schlick 1949, 113-9).[7] In each

[6] Nagel's remark clearly reminds us of Kuhn's idea of incommensurability. Friedman articulates this idea in terms of the relativized Kantian conception of constitutive a priori (Friedman 2010, 712). So, concerning the history of atomic theory, we might suggest that different conceptions of the atom are incommensurable with each other because each constitutes its own a priori laws about the physical structures of matter.

[7] Because of these statements, the majority of logical empiricists such as Schlick, Carnap and Frank, along with Mach, have long been treated as instrumentalists (Chakravartty 2015), in contrast to a minority of realists including Feigl (1936, 1950) and Hans Reichenbach (1938). But recent discussions on this point suggests that the traditional interpretation is problematic and misses the real force of logical empiricism (Parrini 1994; Salmon 1994; Psillos 2011; Friedman 2011, 2012; Neuber 2014). I endorse the view that logical empiricists took the realist-instrumentalist controversy to be, at best a problem of "modes of speech" (Nagel 1979a, 152), at worst a metaphysical "pseudo-problem" (Feigl 1979,

theory, the atom concept was associated with respective physical laws affirmed by experimental phenomena.

The essential difference between the logical empiricist conception of the atom and that of metaphysical materialism might be better shown in Frank's radical interpretation of Heisenberg's uncertainty principle in quantum mechanics. According to metaphysical materialists, atoms stand out there as basic blocks of matter, each with its own exact position and velocity. Then on the basis of the uncertainty principle, materialists suggest that we are unable to decide simultaneously on the position and the velocity of an atom. But in sharp contrast, Frank suggested that "concepts like position and velocity of a particle can be used only under certain experimental conditions, while the formulas of physics only give directions for bringing such observations into relation with one another" (Frank 1949b, 178). For Frank, quantum mechanics did not postulate any "new mysterious objects like 'particles without a definite position'" (Frank 1949b, 179):

> Quantum physics says only that with certain experimental arrangements concepts like "particles with a definite position" or "particles with a definite velocity" can be defined. In other words, the physical processes that occur with these experimental arrangements can be predicted through statements in which one refers to "a particle with a definite position" or "a particle with a definite velocity," but there is no arrangement for which one can predict processes through statements involving "a particle with a definite position and velocity." This, however, does not mean that there are particles of which, because of the defectiveness of our apparatus or because of malicious natural laws, we cannot measure all the characteristics (position and velocity); it means rather that such combinations of words as "a particle with coordinates x, y, z, and velocity components v_x, v_y, v_z" must not be introduced into the language of physics. If we were to say that the things corresponding to such combinations of words nevertheless exist as absolute, but unknowable, things, we should be going over into pure metaphysics and destroying every bond with experience (…). (Frank 1949b, 182)

According to Frank, in quantum mechanics an atom could not be reified into an extended but invisible entity standing out there, waiting for any complete description. Instead, its empirical existence rested on the validity of physical laws and observational results in a certain experimental context.[8]

The last sentence captures the essence of the logical empiricist criterion of a valid scientific concept. For logical empiricists, on the one hand, the concept invoked law formulations; on the other hand, verifiable experimental results should be derivable from the laws and theories in which the concept participated. The atom was associated with both and therefore it was beyond any doubt a warranted concept in modern physics.

I have made the effort to articulate the logical empiricist conception of the atom. Indeed, the way in which logical empiricists treated the concept of the atom already implied their attitude toward vitalism. Again in the words of Rosenberg who has seen this issue clearly: "The justification for eliminating or embracing such notions as Driesch's entelechy is

xxviii). Take atomism as an example. For logical empiricists, the atom was empirically (rather than metaphysically) as real as the table, but the table was as instrumental as the atom. Moreover, to understand atomism in modern physics, according to logical empiricists, the genuine task was to clarify the logical structure of statements about atomism, rather than to contend whether atoms were real or not (Friedman 2006).

[8] But admittedly Frank's radical suggestion about the uncertainty principle was not universally accepted among logical empiricists. For instance, Carnap remarked that "such a radical change is inadvisable" (Carnap 1966, 289). Yet this disagreement on the specific point in quantum mechanics did not affect their universal agreement on the nature of the atom in modern physics.

no different in kind (than) that employed to assess claims about the existence of electrons, magnets, or virions" (Rosenberg 1985, 8). Suppose that a logical empiricist in the early twentieth century were invited to assess the validity of the two concepts, the atom in physics and the entelechy in biology. Then if he started from commonsense experience, the invisible atom and the imperceptible entelechy were equally unavailable to direct observations. One could therefore not claim based on sense experience, either that a physical object was composed of invisible atoms, or that a biological organism was under the control of an entelechy. Yet at that time both concepts were integrated into, or at least appeared in contemporary scientific theories, which made statements far beyond commonsense experience. Then in order to give an adequate assessment of the atom and the entelechy, the logical empiricist must examine their respective roles in scientific theories. As is shown above, the atom concept proved sound since it could be associated with physical laws and some experimental results in modern physics. Thus, like the concept of the atom, the validity of the entelechy was to be evaluated against the background of contemporary biology, and to be assessed in terms of its ability to explain biological phenomena.

This was exactly the attitude of logical empiricists. They never rejected Driesch's vitalism on the grounds that it was a metaphysical heresy, and they agreed with Driesch that the concept should be judged on scientific grounds alone. Consequently, the logical empiricist rejection of vitalism is based on subtler concerns.[9]

The Logical Empiricist Critique of Vitalism

It is a historical fact that logical empiricists criticized Driesch's doctrine of the entelechy and various other theories of vitalism. According to the previous interpretation, the criticisms of vitalism from logical empiricists were not, however, based on a commitment to metaphysical materialism. For logical empiricists, Driesch was not a metaphysician advancing heretical doctrines. Carnap later in his life praised Driesch and commented that "he was quite different from most philosophers in Germany in that he really wanted to develop a scientific philosophy" (Carnap 1966, 14).

The most systematic critique of Driesch's neo-vitalism within the logical empiricist context was developed by Frank. But overall Frank understood well that Driesch's vitalism was based on empirical arguments. He claimed: "The introduction of the magnitude E, in accord with Driesch, certainly means going beyond the frame of physical laws, but in no way an abandonment of the ground of empirical science, nor an introduction of anthropomorphic, soul-like elements" (Frank 1998, 111). In this claim, Frank correctly pointed out that Driesch's introduction of the entelechy (the vital factor E), resulted from his concerns over the difficulties of mechanistic explanations in embryology. Indeed, Driesch began his biologist career as a disciple of the school of developmental mechanics exemplified by Wilhelm Roux. Roux's research program endorsed mechanistic explanations and remained suspicious of vitalistic doctrines. Yet in 1891, Driesch succeeded in separating the first two blastomeres of sea urchin eggs and showed that each half was capable of developing into an adult organism. Driesch's experimental results contradicted those of Roux, who had advanced the mosaic theory of development suggesting that each half of the blastomere represented a determinate part of the adult organism. Greatly puzzled by these results, Driesch later concluded that a few embryological phenomena could not be fully explained in mechanistic concepts (Churchill 1969; Allen 2008).

In 1907, Driesch was invited to give the Gifford Lectures in Aberdeen, Scotland. Based

[9] The biologist C.H. Waddington shared this concern. Facing another distinguished biologist Francis Crick's attack on vitalism (Crick 1966, 99), he questioned: "is a quark included? And if biologists should find it necessary to postulate an entity as odd as a quark, would that be vitalistic or not?" (Waddington 1967, 203).

on these lectures he published *Science and Philosophy of the Organism* (1929), a comprehensive illustration of his doctrine of vitalism. In Driesch's deepened proofs for vitalism, he contended that mechanistic explanations failed to adequately deal with the complexity of embryological processes. For Driesch, the morphogenetic system was a harmonious-equipotential unit and a number of developmental phenomena were unintelligible if biologists only took mechanical variables (the sizes of the embryo, internal and external conditions, formative and directive stimuli, chemical compounds, etc.) into consideration. Disappointed at mechanistic explanations, Driesch concluded that a vital factor E, namely, entelechy, must be responsible for the generation of these peculiar phenomena.

For logical empiricists, Driesch was correct, and it was a truism, that mechanistic explanations were largely unavailable in most areas of biology. Though it was certainly necessary to further pursue such explanations, Frank detected a danger that materialism and mechanism in some cases were degenerating into empty words. For this he even felt the need to issue a limited defense of vitalism:

> To be sure, Driesch shows that we can assume for the living processes a specific state variable, not that we must. For it is not possible to foresee every trick that one might invent in *the fiction of hidden combinations of inorganic state variables*. In favor of vitalism, I should like to remark that, just as I cannot force someone who regards heat as a specific state variable to consider it as a motion of particles, so I cannot force the adherents of entelechy to replace it by fictitious state variables. (Frank 1941, 26-27)

For Frank, the introduction of fictitious inorganic state variables was not acceptable. Indeed, it was just these similar concerns that pushed Frank to reject vitalism.

Frank developed thorough criticisms of Driesch's doctrine of the entelechy in his 1932 *Das Kausalgesetz und seine Grenzen* (Frank 1998, 95-136; also see Frank 1970). In this book, after raising criticisms of various details, Frank concluded that Driesch failed to justify his conclusion. To start, despite his early sympathy with Driesch's approach, Frank argued that the introduction of the entelechy was far from necessary. For Frank, although numerous phenomena in biology remained unexplained in terms of some contemporary physico-chemical theories, Driesch in his reasoning had not considered every possibility; moreover, Driesch also failed to show that for these biological phenomena mechanistic explanations would always remain unavailable in future.

After that Frank contributed a more general critique of vitalism and its related concepts, which in my view better reflected the ethos of logical empiricism. Importantly, Frank saw no essential difference between biological explanations through finalism, purpose, plan, and entelechy, and they were rejected for exactly the same reason. The essential defect of these explanations was never related to any metaphysical commitments, but to their poor scientific merits. For instance, Frank claimed that "the mere assumption of the 'existence of a plan' is meaningless" (Frank 1998, 98), and "in the case of living organisms (…) the mere claim of 'aiming at a purpose' is meaningless" (Frank 1998, 102). In brief, the introduction of concepts like purpose, plan and entelechy, "does not help us toward any deeper understanding" (Frank 1998, 97).

If these concepts were to have any real scientific merits, according to Frank, biologists must give laws that indicated determinate consequences associated with these concepts. For instance, Driesch must further explicate the concept of the entelechy, through identifying "a detailed rule from which it could be deduced how much can be taken away from an ovum in the process of cell division without destroying the growth of a whole organism" (Frank 1998, 98). Further, "a general connection between the stages of division and the possibility of a regeneration of the whole" must be found (Frank 1998, 98). For vitalists who assumed "the existence of a plan", Frank wrote, "if somebody could clearly

explain the plan that nature pursues with respect to the evolution of organisms, the claim that the history of evolution is purposeful would be of a scientific character; for then the future could be predicted from it" (Frank 1998, 99). Unfortunately, "nobody can foresee future development from the hypothesis of compliance with a plan, since nobody knows the plan" (Frank 1998, 99).

The conceptual defect was better shown through a comparison between finalism (the use of "purpose") in physics and biology. Frank suggested that in some sense physics also used finalist explanations:

> For example if we say about heavy bodies only that they strive towards the center of the earth, or that nature pursues a purpose of assembling all heavy bodies at the center of the earth, that there is a tendency to produce an arrangement in which all heavy bodies group themselves around the center as a big ball and it happens that bodies are stopped in their path only by external causes, then with all this we say something about the processes of motion of heavy bodies that is not directly incorrect. (Frank 1998, 98)

Why was the finalist language accepted by physics? This was because, according to Frank, physicists were able to answer the following questions: "Under what circumstances a heavy body is stopped on its way to the center, how such an obstacle can deflect it, and how its motion takes place in detail. However, such rules of balance and the motion of bodies can be found in the science of mechanics" (Frank 1998, 98). For Frank, physics did not reject finalist language, but the superiority of finalism in physics over that in biology lied in its much stronger explanatory power. This was achieved through the formulations of physical laws such as the laws of gravitation. As Frank pointed out, "we need only glance at the history of physics and chemistry to see that progress always goes hand in hand with the replacement of teleological, anthropomorphic notions by mathematical laws" (Frank 1998, 84). Indeed, finalism in physics had long been purged of its anthropomorphic-animistic meaning, while finalism in biology by and large retained it. To put it more explicitly, the end, the plan, and the purpose of the heavy bodies striving towards the center of the earth were accurately known to physicists through laws in physics, but the end, the plan, and the purpose of the embryological development was only asserted, but never really articulated by vitalistic biologists.

Frank compared biology with not only physics but also with theology. Surprising to many philosophers and scientists today, Frank did not dismiss as nonsense the hypothesis that some natural phenomena were created through God's miraculous power, and sometimes he even ironically suggested that its formulation as superior to that of biological vitalism (Frank 1998, 94). But for Frank, the use of miracles in explanation could make sense only if one could demonstrate how God carried out the miracles. One must give laws governing the production of miracles and thus illuminated how God did His work. Further, as Frank consistently maintained, one could not negatively justify the use of miracle or the entelechy by appealing to the gaps left by mechanistic explanations (as Driesch and many theologians had done). Instead, these concepts were only justifiable by giving positive law statements (Frank 1998, 82).

Through the comparisons above, the defects of biological vitalism and Driesch's entelechy should be fully exposed. The entelechy failed to have its own laws giving determinate and testable results. A similar line of argument was developed by two other logical empiricists, Carl Hempel and Carnap. In Hempel's case, he agreed with Frank that Driesch was not advancing any mysterious metaphysics. Driesch's theory of vitalism should be rejected, not because it assumed the existence of mysterious agents. The concept of the field in physics was equally unavailable to sense experience (Hempel and Oppenheim 1948). However, the crucial difference was that the concept of the field was associated with general laws governing its effects on physical bodies and was, therefore, able to generate testable

hypotheses. In contrast, the concept of the entelechy in biology could do neither, and the entelechy was simply "inaccessible to empirical test and thus devoid of empirical meaning" (Hempel and Oppenheim 1948, 330).

Carnap once conducted a debate with Driesch. Driesch justified his use of the entelechy by claiming that physicists employed the concept of magnetism. Nonetheless, Carnap quickly pointed out that Driesch's entelechy seemed to "lack something" (Carnap 1966, 14). As Carnap emphasized, the crucial difference was that physicists after introducing magnetism had further offered laws of magnetism. The laws might be formulated in quantitative terms, like "Maxwell equations that describe magnetic fields" (Carnap 1966, 15). The laws also could remain at the qualitative level, and "if you magnetize a needle and suspend it by the middle so that it swings freely, one end will point north" (Carnap 1966, 15). By contrast, the entelechy did not constitute any natural laws and thus failed to offer any determinate and testable empirical consequences.

In sum, Frank, Hempel and Carnap reached a logical empiricist consensus consisting of two claims concerning vitalism. The first is that Driesch's vitalism was not guilty of any heretical metaphysical claims. The second is that the concept of the entelechy had few scientific merits, since it failed to give precise vital laws explaining biological phenomena and therefore had no clear empirical reference.

The Physicalism of Logical Empiricists

"Physicalism" is a term popularized by logical empiricists in the 1930s. Now sometimes branded as an updated form of materialism, physicalism in philosophy of biology offers the new ground for rejecting vitalism. For some philosophers (Godfrey-Smith 2014, 10; Brigandt and Love 2017), physicalism and vitalism contradict each other and only one choice is possible. However, as I have shown above, logical empiricists would not endorse such a refutation of vitalism conducted at the metaphysical level. The physicalism of logical empiricists, as a matter of fact, had a meaning different from that understood in the current philosophy of biology. In the following, I show that the physicalism of logical empiricists was only a working hypothesis, and this hypothesis could not by itself exclude other hypotheses about vitalism.[10] Indeed, the physicalism of logical empiricists was close in spirit to a posterior physicalism, a position that has become increasingly popular in recent years (Banks 2014).

The physicalism understood in the philosophy of biology today still ensures a metaphysical rejection of vitalism. By sharp contrast, the physicalism of logical empiricists was hypothetical and empirical in character, although sometimes blurred by too polemic tones. For instance, first, Hempel explicitly claimed that the physicalism of logical empiricism was only a working maxim, and it remained detached from traditional materialist metaphysics. For Hempel, "the reducibility of the laws of the non-physical sciences to those of physics is an open question…the issue cannot be settled on a priori grounds or with philosophical methods alone; it calls for further scientific research" (Hempel 1951, 321). Physicalism was proposed as a "heuristic maxim" for scientific research (Hempel 1951, 321). Clearly, in Hempel's eyes, physicalism only suggested a research direction in close relationship with empirical sciences, and it was devoid of metaphysical meanings (also see Hempel 1969).

Second, the physicalism of logical empiricists was also empirical in character. This in general means that unlike physicalists defending physicalism as a set of metaphysical truths, logical empiricists were clear about the limitation of their physicalist project. They never claimed that physics had already unified other non-physical sciences. For example, Feigl in his

[10] Logical empiricists would not be surprised that their physicalism is misunderstood today. For instance, Feigl noted that "it was easy again for metaphysically-minded opponents to misconstrue this position [physicalism] as a variant of ontological materialism" (Feigl 1981a, 289).

treatise on physicalism and the unity of science claimed that physicalism was "by no means as sufficiently established by the progress of research to date" (Feigl 1981b, 302). Even Carnap's more passionate *the Unity of Science* admitted that "biological research in its present form is not adequate to answer the question" whether "the natural laws which suffice to explain all inorganic phenomena can also be a sufficient explanation in the region of the organic" (Carnap 1934, 68), and it could only be answered "in the course of the future development of empirical research" (Carnap 1934, 68).

Yet admittedly, it is also true that some logical empiricists often indicated a strong dogmatic tendency, which blurred the hypothetical and empirical character of their physicalist project. For instance, in some rather polemic essays for physicalism, Otto Neurath did not show any interest in logical analysis, instead, he was more inclined to condemn non-materialistic concepts, from Driesch's entelechy to Hegel's Spirit, as meaningless metaphysics. For instance, against vitalism, Neurath wrote, "In the field of biology, the physicalists reject 'vitalism' insofar as it maintains that non space-time entities become 'effective.'" (Neurath 1931, 621). Unlike Frank, Hempel and Carnap, Neurath never gave a close analysis of the concept of the entelechy. But even so, overall Neurath was still clear of the empirical nature of his project. Though today Neurath's physicalism is branded as "empiricism without empirical research" (Cat 2014), like other logical empiricists he emphasized that his physicalism went "without metaphysics" (Neurath 1983, 58), and it was a task to be accomplished.

On how to be a genuine empiricist Nagel might be a good example. Nagel not only pointed out the contemporary limitation of physicalism but even remained suspicious of its future. In his philosophical reflections about biology, Nagel understood the scientific situation as that "it is no less evident that the techniques of observation and experimentation in biology are in general different from those current in the physical sciences" (Nagel 1979, 399-400). Evidence also shows that Nagel was suspicious of the possibility of reducing biology to physics in the future, even though he did not deny this possibility. For Nagel, "the task facing such a proposed reduction is admittedly a most difficult one; and it undoubtedly impresses many students as one which, if not utterly hopeless, is at present not worth pursuing" (Nagel 1979, 435). More importantly, Nagel developed an open mind toward alternative approaches. Commenting perhaps on the philosopher of biology Joseph Woodger's anti-physicalist approach to clarifying concepts and laws in biology, Nagel wrote, "(…) there is a genuine alternative in biology to both vitalism and mechanism-namely, the development of systems of explanation that employ concepts and assert relations neither defined in nor derived from the physical sciences" (Nagel 1979, 431).

Finally, the physicalism of logical empiricists could be better understood by referring again to the concept of the atom. Recall Hull's claim, "Organisms are 'nothing but' atoms… and that is that" (Hull 1981, 282). In contrast, Frank depicted the contemporary status of biological research as follows: "The exact physical observation of the atoms of a living body is [still] compatible with the known empirical laws for the behavior of living bodies and with the physical hypothesis about their atomic structures" (Frank 1949b, 169-70). Frank avoided being dogmatic. He acknowledged that once empirical evidence demonstrating the incompatibility between the vital laws of a living body and the physical laws of its atomic structures had been submitted, it would be scientific to claim that the living body had vital laws of its own.[11] As Frank summarized, the *possibility* of such "a vitalist presentation of natural phenomena… should not be denied" (Frank 1998, 117).

[11] In Feigl's words, "[Alfred] Whitehead's suggestion that the behavior of electrons within living organisms may be fundamentally different from that in inorganic compounds can of course not be refuted a priori" (Feigl 1981b, 317).

Conclusion

Logical empiricists rejected the concept of the entelechy because vital laws were not available in biology. For logical empiricists, moreover, it was meaningless to reject vitalism by presupposing materialist metaphysics, and the possibility of future vital laws could not be denied, at least in principle. On the contrary, they accepted the concept of the atom, because it could be associated with physical laws and verifiable experimental results. But logical empiricists declined to view the validity of the concept of the atom as supporting metaphysical materialism (or physicalism).

Further, I believe that an adequate understanding of the logical empiricist criticism of vitalism has deeper implications for the contemporary philosophy of biology. Consider, for instance, organicism, which claims to offer a promising middle road between (reductive) materialism and vitalism (Gilbert and Sarkar 2000). Yet if we accept the logical empiricist criticism of vitalism, organicism turns out to be dubious as well. First, the judgment that organicism as material holism is superior to vitalism loses its ground because it is no longer legitimate to refute vitalism by presupposing materialist metaphysics. Second, organicism in its current form stresses the importance of treating biological organisms as holistic organizations, but this is nothing more than a truism. This organicist concern equally applies to complex physico-chemical organizations, and in present biology, there is no contradiction in treating biological organisms as merely complex physico-chemical organizations. As a result, unlike vitalism which has advanced the entelechy as a bio-specific concept, current organicism fails to capture the genuine specificity of biological organisms. Third, if follows that, in order to be bio-specific, organicism must be able to show how biological organization is different from the merely complex physico-chemical organization. One way here is to offer laws specific to biological organization (x is a biological organization if and only if these laws apply to x). Yet if these laws were available, it would then be difficult to distinguish them from vital laws vitalists are supposed to provide.

Even more interestingly, the rationale of the logical empiricist criticism of vitalism also applies to some concepts popular in reductive materialism as to concepts like genetic program and genetic information, it is often the case that biologists use them as if physiological, developmental and even evolutionary mechanisms have already been laid out in the physical structures of genes. Admittedly, these concepts appear to have certain material bases in genes and are thus materialism-friendly. However, a logical empiricist evaluation of these concepts cares little about whether they are materialism-friendly or not. Regarding concepts like program and information, further, the result of such an evaluation is not optimal. As Frank already alluded above – in the comparison between "fictitious [inorganic] state variable" and the entelechy, (Frank 1941, 26-7; also see Mainx 1970, 629) –, these concepts are currently just as defective as the entelechy, if they are used as causative agents which only nominally "unify" various biological mechanisms. These concepts are defective, since, unfortunately, in most cases, the determinate relations between these concepts and respective mechanisms are merely asserted, rather than precisely established as laws with experimental support.

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