A Historico-Logical Re-assessment of Hans Driesch's Vitalism

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Abstract Today vitalism is widely dismissed as a metaphysical heresy. For instance, Brigandt and Love (Reductionism in biology. In: Zalta EN (ed) The stanford encyclopedia of philosophy, 2017) claimed that "the denial of physicalism by vitalism, the doctrine that biological systems are governed by forces that are not physico-chemical, is largely of historical interest" (p. 3). Perhaps the most "infamous" vitalist is the German biologist Hans Driesch. However, Driesch (In Rádl E (ed) Actes du Huitième Congrès International de Philosophie a Prague 2–7 septembre 1934. Comité d'Organisation du Congrès, Prague, pp 10–30, 1936) himself very explicitly stated that his vitalism is "neither 'mysticism'[…]nor 'metaphysics'" (p. 27). So, in order to address the mismatch between the present conception of vitalism and his own, I seek to offer a historico-logical re-assessment of Driesch's vitalism. From the historical point of view, I show that Driesch had provided long ignored theoretical reflections on the nature of entelechy (the central concept in his vitalism), especially those in relation to evolution and physics. From the logical point of view, following logical empiricists (Phillipp Frank and Rudolf Carnap), I indicate that Driesch's vitalism should be rejected due to its lack of vital laws, at least with respect to current biology; it is an unestablished theory rather than a metaphysical heresy. Ironically, some current theoretical biologists have proposed similar theories (or principles and laws) of life, even though they (incoherently) reject Driesch's vitalism. In the end, I briefly conclude that the failure of vitalism actually alludes to the fact that even today we understand very little about the nature of life (I mean, the pure concept/phenomenon of life!) (While I cannot elaborate here, it is of extremely importance not to conflate knowledge about the pure concept/phenom-

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enon of life and knowledge about objects predicatable of life (Ben-Naim, manuscript, p. 281). For instance, it is common among philosophers of biology today to cite elementary knowledge in a particular biological discipline as offering a better understanding of life. Yet their promise fails to be delivered. At best, they are merely relying on knowledge about objects predicatable of life (in most cases, merely knowledge about complex organizations of matter: about heredity, reproduction, development, metabolism, etc); but such knowledge has not been shown of any relevance to the pure concept/phenomenon of life).

1 Driesch's Vitalism: Introduction

The general attitude towards vitalism today is dismissive. While there is no need for the majority of working biologists to care about vitalism, it seems quite expedient for philosophers of biology to dismiss rival stances as vitalistic heresies. This phenomenon was summarized by Susan Oyama: "one need not be a scholar of vitalism to know that it can be a potent instrument of abuse, albeit one that often contaminates by association and innuendo rather than outright accusation" (2010, p. 401). Oyama offered a good example. As an anti-reductionist in philosophy of biology, Oyama has been classified as a vitalist by her reductionist opponents, especially for her enthusiasm for concepts like complexity and organization. But Oyama also shot back. For her, some reductionists are genuinely hard-core vitalists, because they reply on mysterious concepts such as information (Oyama 2010).

Vitalism is rejected by biologists and philosophers today because they treat physicalism (or materialism) as the default stance of modern science. In the entry "Reductionism in biology" of the *Stanford Encyclopedia of Philosophy*, Brigandt and Love gave an exhaustive summary of metaphysical or ontological issues relevant to the rejection of vitalism:

> Ontological reduction is the idea that each particular biological system (e.g., an organism) is constituted by nothing but molecules and their interactions. In metaphysics this idea is often called physicalism (or materialism), which assumes in a biological context that (a) biological properties supervene on physical properties (i.e., no difference in a biological property without a difference in some underlying physical property), and (b) each particular biological process (or token) is metaphysically identical to some particular physico-chemical process... Ontological reduction in this weaker sense is a default stance nowadays among philosophers and biologists...The denial of physicalism by vitalism, the doctrine that biological systems are governed by forces that are not physico-chemical, is largely of historical interest. (2017, p. 3)

This summary was written in 2017. In my view, it provides one of the most forceful illustrations of how vitalism is rejected today by presupposing metaphysical/ontological positions such as materialism or physicalism (also see Haraway 1976; Mayr 1982).

Despite the dismissive attitude towards vitalism, there has recently developed a new trend of reconsidering vitalism in its historical context, and the leading scholar

is Charles Wolfe. Wolfe started with the French Montpellier school of medicine in the eighteenth century. Deepening the points made by Peter H. Reill (2005), Wolfe emphasized that at least some forms of vitalism in the eighteenth century went "without metaphysics" (Wolfe and Terada 2008; Wolfe 2008, 2017a). In addition, Wolfe identified what we might call the doctrine of Newtonian vitalism, inspired by Newton's conceptual innovations in classical mechanics. Importantly, Newtonian vitalism, according to Wolfe (2014), was also without metaphysical baggage. Moreover, Wolfe in another article cast doubts on the traditional dichotomy between vitalism and materialism. He identified a few vital materialists in the eighteenth century who attributed inherent vital forces to matter (Wolfe 2013). In the end, Wolfe also aimed to show that themes of vitalism were deeply embedded in the eighteenth-century Enlightenment context; vitalism was associated with issues like the continuation of the Scientific Revolution and anti-mathematicism (Wolfe 2011a, 2017b; Normandin and Wolfe 2013; for positive evaluations of vitalism, also see Lenoir 1982; Richards 2002; Zammito 2018; Steigerwald 2019).

Thanks to Wolfe's and others' efforts, now it has been confirmed that the term "vitalism" was used in many different meanings. So, it might not be incorrect to claim that there are a variety of vitalist doctrines in the history of science. Given all of these, a categorization of these different meanings and doctrines should be highly desirable. Based on his extensive works on the history of biology, Wolfe (2011b) proposed that there are three kinds of vitalism, substantival, functional and attitudinal. For the purpose of this article, only the first two will be discussed. According to Wolfe, substantival vitalism presupposes the existence of "a (substantive) vital force" (p. 212); functional vitalism indicates "an attempt to 'model' or 'describe' organic life without reducing it to fully mechanical models or processes" (p. 213). Regarding this distinction itself, my view is that it is valid, with respect to biologists' thoughts and attitudes in the history of science;[1] but here for our interest, it seems that Wolfe's attempt to distinguish between different meanings attributed to the term "vitalism" has also an implicit purpose of legislating vitalism. For Wolfe, the reputation of vitalism might be saved, if it can be shown that not every doctrine of vitalism in the history of biology was a metaphysical heresy.

The purpose of legislating the term "vitalism" becomes clearer when it comes to judging Driesch's vitalism. Since Driesch appealed apparently to entelechy as the living principle, Wolfe took Driesch's doctrine of entelechy to be a representative of (the bad) substantival vitalism, in contrast to (the good) functional vitalism. Yet, if Wolfe tried to save vitalism by disassociating this term from Driesch's doctrine of

[1] But to emphasize, this distinction might not be valid, with respect to biological knowledge itself. In that case, biologists (arguably most in the history of biology) who made the distinction would themselves be hopelessly confused. Such confusions are already detected in Wolfe (2011b). On the one hand, as Wolfe admitted, substantival vitalism was also "scientifically studied" (p. 212). Then, does this, even in the slightest sense, indicate that substantival vitalism can be used as a heuristic tool and therefore become functionalized? On the other hand, when functional vitalism claims to capture "the uniqueness of living bodies" (p. 218), does it succeed in doing that? Maybe in order to do that, it has to advance quasi-substantival claims as well?

entelechy, a few other scholars wanted to do more justice to Driesch and turn to his empirical achievements in biology (Freyhofer 1979; Innes 1987). For them, Driesch's achievements are underestimated. Indeed, Driesch's numerous experiments addressed relational and structural aspects of embryological processes (Driesch 1929; for an updated summary, see Bolduc's Chapter "On the Heuristic Value of Hans Driesch's Vitalism", in this volume), and in this respect there seems little difference between Driesch and Wolfe's functional vitalists. Further, as these scholars requested, Driesch's empirical achievements should be separate from his vitalism or his doctrine of entelechy. The historian Reinhard Mocek, for instance, even suggested that Driesch was almost an organicist or systems theorist, despite his unfortunate vitalist heresy (Mocek 1998; Nyhart 2000). In sum, even though the term "vitalism" can receive different interpretations compatible with modern biology, once it is presented as Driesch's doctrine of entelechy, it will be quickly dismissed as a metaphysical heresy. By terming Driesch's vitalism "substantival vitalism" or separating Driesch's empirical achievements from his doctrine of entelechy, Wolfe and other scholars have appeared to re-affirm the mainstream view. For all of them, it seems legitimate to refute Driesch's vitalism as a metaphysical heresy.

However, I would like to recall that this conception of Driesch's vitalism, unfortunately, goes sharply against his own evaluation of the doctrine of entelechy. In his lecture given in 1934 at the Eighth International Congress of Philosophy in Prague, Driesch emphasized that, in response to common misunderstandings, the choice of entelechy was "a matter of pure logic" and entelechy was "neither 'mysticism'[…]nor 'metaphysics"' (Driesch 1936, p. 27). Seen from this response, it seems that scholars often revoke Driesch's vitalism for their own purposes, despite Driesch's explicit denial. While it is of course inadequate to trust blindly everything he said, it seems more desirable to judge Driesch's doctrine of entelechy after checking its details. This clarifies the intent of this chapter, namely, a historico-logical re-assessment of Driesch's vitalism. In what follows, Sects. 2 and 3 elaborate Driesch's doctrine of entelechy from the historical perspective, with a focus on his theoretical speculations in relation to evolution and physics. Sects. 4 and 5 address the nature of entelechy from the logical point of view. Section 6 concludes by briefly comparing entelechy and life.

2 History I: Driesch on Entelechy and Evolution

It is well known that Driesch intended his doctrine of entelechy to explain some peculiar embryological phenomena about sea urchins. However, it is little known today that Driesch, in his doctrine of entelechy, also dealt with evolutionary phenomena. In Driesch's words, vitalism must concern "the relation of transformism in general to our concept of entelechy" (1908a, p. 293). For this, Driesch introduced a new phrase to study the relation between vitalism and evolution, that is, "systematics of entelechies" (p. 293). It is not difficult to appreciate Driesch's theoretical concern. As a biologist living more than half a century after Darwin popularized the

thesis of descent, Driesch took facts of evolution for granted. Further, since Driesch also proposed the doctrine of entelechy, naturally he would have to face the following question: "we know that entelechy...uses material means in each individual morphogenesis...what then undergoes change in phylogeny, the means or entelechy?" (p. 295). Thus, according to Driesch, in a concrete case of organic transformation, either the same entelechy used a different mean to "construct" a new organism, or a different entelechy emerged in evolution to "give rise to" the new organism.

On this question Driesch opted for the latter, in favor of "entelechy, rather than "the means". Let us quote him in full:

> We know that entelechy, though not material in itself, uses material means in each individual morphogenesis, handed down by the material continuity in heritance. When then undergoes change in phylogeny, the means or entelechy? And what would be the logical aspect of systematics in either case?
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> Of course there would be a law in systematics in any case; and therefore systematics in any case would be rational in principle. But if the transformistic factor were connected with the means of morphogenesis, one could hardly say that specific form as such was a primary essence. Entelechy would be that essence, but entelechy its generality and always remaining the same in its most intimate character, as the specific diversities would only be due to a something, which is not form, but simply means to form. But the harmony revealed to us in every typical morphogenesis, be it normal or be it regulatory, seems to forbid us to connect transformism with the means of morphogenesis. And therefore we shall close this discussion about the most problematic phenomena of biology with the declaration, that we regard it as more congruent to the general aspect of life to correlate the unknown principle concerned in descent with entelechy itself, and not with its means. Systematics of organisms therefore would be in fact systematics of entelechies, and therefore organic forms would be *formae essentiales*, entelechy being the very essence of form in its specificity. (p. 295)

For Driesch, in evolutionary history it is less probably the case that a single entelechy "gave rise to" the whole variety of organisms through different means; rather, it is more probable that in each concrete case of evolution, a new entelechy emerged to "construct" a new organism.[2]

However, as Driesch alluded, with facts of evolution he had a different concern with systematics. In particular, he asked for "a law in systematics" which would make a truly "rational" science. Then what did Driesch mean here? For this let us look at his discussion of vitalism and evolution in detail. To start, there is little doubt that Driesch accepted Darwin's "theory of descent" (p. 250) or "the idea of transformism" (p. 251), namely, "the hypothetical statement that the organisms are really allied by blood among each other, in spite of their diversities" (p. 251). Like us today, he agreed with Darwin that "there certainly is a great amount of probability" in "the idea of transformism" (p. 251). In particular, he classified "two different

[2]Yet later in 1927, Driesch frankly acknowledged the other possibility that there might be a "super-entelechy which possesses a fixed essence and does nothing but copy its essence once more into matter, and realize phylogeny in this way" (1927, p. 6). To emphasize, no matter which possibility Driesch choose, he strictly followed the logical rules. Indeed, regarding these two possibilities, Driesch concluded that with "empirical phylogeny as it is…we possess no means whatever to decide" (p. 7).

groups of facts" as supportive evidence, "the geographical distribution of animals and plants and to paleontology" (p. 251) and "similarities and diversities" observed "in the system of animals and plants" (p. 253).

While Driesch approved of the thesis of descent, he could not consent to the claim that the descent thesis explains "the diversities of the organism" (p. 255). On this point, Driesch raised strong criticisms of Darwinism and Lamarckism in his time. Driesch took Darwinism held by his contemporaries to be "dogmatism in one of purest forms" and very far removed from "the opinion of Charles Darwin" (p. 260). And he maintained that he was "speaking against Darwinism of the most dogmatic form only, not against Darwin himself" (p. 269). Dogmatic Darwinism, according to Driesch, consisted of two theoretical parts, natural selection and "fluctuating variation" (p. 264). First on natural selection. For Driesch, it was self-evident that natural selection "always acts negatively only, never positively" (p. 262). So, Driesch continued, it could be correct to state that natural selection explained "why certain types of organic specifications, imaginable a priori, do not actually exist" (p. 262). But Driesch stressed that it was misleading to assert that natural selection explained "the existence of the specifications of animal and vegetable forms that are actually found" (p. 262). For this, Driesch turned to "fluctuating variation the alleged cause of organic diversity" (p. 264). But he remained deeply unsatisfied. In response to contemporary Darwinians in the biometric tradition, Driesch agreed with them that the concept of fluctuating variation might be useful to explain "new quantitative differences" (p. 266); yet he insisted that it was illegitimate to merely use fluctuating variation to explain "organic diversities" (p. 269, for reasons see below).

Driesch also criticized the doctrine of Lamarckism or Neo-Lamarckism. Again, Driesch emphasized that he was not against the opinion of Lamarck himself; instead he only attacked Lamarckism "in its dogmatic modern form" (p. 271). For Driesch, Neo-Lamarckism had two basic parts, the idea of the "inheritance of acquired characters" (p. 275), and "the hypothesis of storing and handing down contingent variations" (p. 282). On the first Driesch said little as he viewed it as basically an empirical question. He concluded that "not one case is known which really proves the inheritance of acquired characters", yet it is not advisable to "deny the possibility...in an absolute and dogmatic manner" (p. 278). Driesch focused on the second part, which was open to similar objections made against the Darwinian concept of fluctuating variation. For Driesch, "the whole anti-Darwinistic criticism...may also be applied to Lamarckism with only a few changes of words" (p. 288).

Indeed, Driesch took issues with the Darwinian concept of "fluctuating variation" and the Lamarckian assumption of "storing and handing down contingent variations" *for exactly the same reason*. According to Driesch, Darwinism and Lamarckism in his time were similarly problematic in that they "shake hands on the common ground of the contingency of organic forms" (p. 288): Darwinism tended to explain the diversity of organic forms through fluctuating variation and natural selection, Lamarckism tried to do it by referring to contingent needs of organisms in their living environment. But for Driesch, the appeal to contingency was unacceptable in science, and "other principles (were) wanted" (p. 281). Here Driesch

requested "law(s) of systematics" (p. 295), even though he knew well that these laws might only be available "at some future date" (p. 295).

According to Driesch, laws of systematics were concerned with "the totality of possible forms" (p. 296). Ideally, with such laws all possible organic forms and species could be placed into a unified system, and knowledge about then could accordingly be deduced from laws of systematics. Then, what would such laws of systematics be like? On this Driesch wrote, with an illuminating reference to physics and chemistry (and Kant!):

> In physics and chemistry no perfect rational systems have been established hitherto, but there are many systems approaching the ideal type in different departments of these sciences. The chemical type of the monohydric saturated alcohols, for instance, is given by the formula CnH2n+1OH, and in this formula we not only have an expression of the law of composition which all possible alcohols are to follow, but, since we know empirically the law of quantitative relation between n and various physical properties, we also possess in our formula a general statement with respect to the totality of the properties of any primary alcohol that may be discovered or prepared in the future. But chemistry has still higher aims with regard to its systematics : all of you know that the so-called "periodic law of the elements" was the first step towards a principle that may some day give account of the relation of all the physical and chemical properties of any so-called element with its most important constant, the atomic weight, and it seems to be reserved for the present time to form a real fundamental system of the "elements" on the basis of the periodic law by the aid of the theory of electrons. Such a fundamental system of the elements would teach us that there can only be so many elements and no more, and only of such a kind…we are dealing here with some of the most remarkable properties of the so-called synthetic judgments a priori in the sense of Kant…(p. 244)[3]

Further, Driesch compared phylogeny (as the study of the evolutionary history) and rational systematics. For Driesch, in contrast to the pursuance of rational laws, the study of the evolutionary history only attended to "actual diversities" (p. 264) of organic forms, both existent and extinct, found in the history of nature. But importantly, according to Driesch, the study of the history did not contradict rational systematics. Driesch wrote:

> Is there no contradiction between historical development and a true and rational system...by no means. A totality of diversities is regarded from quite different points of view if taken as the material of a system, and if considered as realized in time. We have said that chemistry has come very near to proper rational systematics, at least in some of its special fields; but the compounds it deals with at the same time maybe said to have originated historically also, though not, of course, by a process of propagation. It is evident at once that the geological conditions of very early times prohibited the existence of certain chemical compounds, both organic and inorganic, which are known at present. Non the less these compounds occupy their proper place in the system. And there may be many substances theoretically known to chemical systematics which have never yet been produced, on

[3] It might be helpful to show what Driesch (and Kant) meant here by "a priori" here. Important theories in science, like Newton's thee laws in classical mechanics and the periodic table of elements in physico-chemistry, are of course a posteriori, as empirical achievements in science; yet they are also a priori, in relation to more concrete works in classical mechanics and physico-chemistry. In sum, these are both a posteriori and a priori, but only at different levels. I thank my friend Ghyslain Bolduc for raising this issue.

> account of the impossibility of arranging for their proper conditions of appearance, and nevertheless they must be said to "exist". "Existence", as understood in systematics, is independent of special space and of special time, as is the existence of laws of nature: we may speak of a Platonic kind of existence here. Of course it does not contradict this sort of ideal existence if reality is added to it. (pp. 257–8)

Driesch's reference to the laws of systematics in chemistry (e.g., the periodic table of elements) is illuminating. For Driesch, similar to those in chemistry, laws of biological systematics in relation to evolution, if they were available, would only determine "possible forms", from which the evolutionary history would pick up "actual forms". In other words, the evolutionary history should proceed partly in accordance with a pre-determined system of possible species governed by laws of systematics.

To connect evolution with his vitalism, recall that Driesch came up with the concept of "systematics of entelechies" (p. 293). Indeed, it is clear that, in Driesch's doctrine of entelechy, the system of entelechies must be correlated with the system of all possible organic forms. To put it more explicitly, it is not incorrect to say that evolution is partly governed by the system of entelechies. Hence in Driesch's doctrine of entelechy the relation between vitalism and evolution becomes clear. He summarized this as follows:

> Thus the problem of systematics remains, no matter whether the thesis of descent be right or wrong. There always remains the question about the totality of diversities in life: whether it may be understood by a general principle, and of what kind that principle would be. As, in fact, it is most probably by history, by descent, that organic systematics is brought about, it of course most probably will happen some day that the analysis of the causal factors concerned in the history will serve to discover the principle of systematics also. (p. 258)

For Driesch, if Darwin's doctrine or even Darwinism was understood merely as the thesis of descent, then it was the most plausible answer to the question of actuality: how "organic systematics is brought about". However, the question of possibility, that is, the question of "the totality of diversities", remained entirely untouched, and here laws yielded by the systematics of entelechies must be requested.

Finally, to emphasize, it should be kept in mind that the systematics of entelechies or the systematics of all possible species or organic forms, even till today, have not been given in any rational form, i.e., as a system of rational laws. Indeed, Driesch was not the first, nor the last to envisage such rational systematics for evolution. Rather, Driesch's request of laws of systematics represents the central concern of theorists of evolution in more than two hundred years, both before and after Darwin. Before Darwin we have the great name of Kant and other German philosophers of nature such as Schelling (for more, see Chen 2019). After Darwin, as we will see later (Sect. 5), the theoretical biologist Brian Goodwin has also come up with similar research projects. Therefore, it should be clear now that the relation between vitalism and evolution envisaged by Driesch is not the product of some boundless speculations offered by a discredited biologist.

3 History II: Driesch on Entelechy and Physics

As in Sect. 2, I begin with Driesch's *The Science and Philosophy of the Organism* (1908a, b). We have seen that in the first volume (1908a) Driesch with much rigor discussed the relation between vitalism and evolution in detail. In the second volume, in like manner, he went on to dealing with issues in relation to vitalism and physics. In his own words, he was going to show "how our concept of entelechy as an elemental natural factor is related to those concepts of general ontology which play any part in the science of inorganic nature" (1908b, p. 153). Here Driesch demonstrated his non-trivial learning in physics, admittedly rare among biologists at any time.

Driesch first touched on the principle of the "conservation of energy" (p. 158), which is now termed the first law of thermodynamics. In relation to his doctrine of entelechy, Driesch raised the following question, "how stands entelechy to the concept of energy itself?" (p. 164). According to Driesch, some contemporary physicists such as the distinguished Wilhelm Ostwald conjectured that "in cases of morphogenesis...some unknown potential forms of energy may be at work" (p. 167) and entelechy was just vital energy peculiar to life. But Driesch endorsed an unequivocal rejection of this supposition. Two reasons were advanced by Driesch to support his rejection. First, "at least in all [functional and developmental] cases where the economic equation [the principle of the conservation of energy] is fulfilled there would seem to be no place for a 'new' energy" (p. 168). Second, "all energies, actually known to exist or invented to complete the general energetical scheme, are quantities" (p. 168), but "entelechy lacks all the characteristics of quantity" and it is "order of relation and absolutely nothing else" (p. 168). Clearly, Driesch, in his own words, "decline(d) any kind of 'energetical' vitalism" (p. 170).

Driesch next dealt with the principle of the "augmentation of entropy" (p. 158) or the principle of "dissipation" (p. 174), which is now termed the second law of thermodynamics. Unlike many physicists and philosophers who have always been producing mysterious interpretations of the second law, Driesch took it to be "a mere fact that is encountered in almost all fields of physics" (p. 174). Since this principle was merely empirical, according to Driesch, "it of course offers no special ontological problem with regard to entelechy" (p. 176). Then regarding possible functions of entelechy in relation to physico-chemical factors, Driesch came up with some rather imaginative and entertaining suggestions. According to Driesch, entelechy might be able to "suspend possible becoming" (p. 179) in physico-chemical systems. More concretely speaking, suppose a chemical reaction, with all its necessary chemical compounds ready, was about to take place; yet at this time entelechy was able to suspend the chemical reaction. On this Driesch wrote:

> ...Entelechy is able, so far as we know from the facts concerned in restitution and adaptation, to suspend for as long a period as it wants any one of all the reactions which are possible with such compounds as are present, and which would happen without entelechy. And entelechy may regulate this suspending of reactions now in one direction and now in the other, suspending and permitting possible becoming whenever required for its purposes. (p. 180)

Driesch took "this faculty of a temporary suspension of inorganic becoming" (p. 180) to be "the most essential ontological characteristic of entelechy" (p. 180). In other words, entelechy was able to interfere the principle of the augmentation of entropy in physico-chemical systems, as "the non-physico-chemical agent" (p. 180). After this, Driesch moved to speculating about the function of entelechy in organic systems. Driesch started with his famous concept of the "harmonious-equipotential system", which he considered to be a "system of equally distributed potentialities" (p. 192). Then in the embryological process, according to Driesch, "entelechy transforms a 'homogeneous' distribution of given different elements and given possible reactions into a 'heterogeneous' distribution of effect" (p. 193). In other words, "entelechy...is capable of augmenting its diversity of distribution in a regulatory manner" (p. 192), as "an intensive manifoldness, embracing a real system of pre-existing diversities in itself" (p. 197).

According to the principle of the augmentation of entropy, the increase of entropy signifies a decrease of diversity. Given this principle, did Driesch ever consider the role of entelechy to be contradicting the entropy principle? Not at all. For Driesch, the entropy principle only held in physico-chemical systems, empirically. Then regarding a biological system, Driesch suggested, even though the entropy principle still tends to eliminate its inner diversity, entelechy, on the contrary, elevates the diversity of the system as a biological agent. As a result, being biological, "organic systems may acquire a higher degree of diversity of distribution" (p. 197), due to the presence of entelechy. In a positive formulation, Driesch could say, entelechy and the entropy principle operate simultaneously, although in opposite directions, to give rise to relevant effects in relation to the biological system. So, for Driesch, "there is no opposition between inorganic and vital phenomena" (p. 196). To summarize, in Driesch's doctrine of entelechy, it is perfectly fine to conclude that a biological system, thanks to the presence of entelechy, might be able to overcome the principle of the augmentation of entropy only ascertained in physico-chemical systems.

More generally speaking, for Driesch, in biology entelechy gave rise to diversities not found in physico-chemistry, just like gravity did with respect to Cartesian mechanics (p. 193) and human mind did in creating artifacts from chaos in nature (p. 194). Entelechy is just a new concept, which introduces a new type of causal factors. Since the presence of entelechy was assumed by Driesch to be unique in biology, it could then justify the autonomy of biology and revive the organic-inorganic distinction "forgotten by physics and chemistry" (p. 196). With entelechy, Driesch reminded us that:

> There also was a great contrast between vital phenomena and the complete "science of inorganic or spatial becoming" that is to be written in the future. Entelechy, as endowed with the faculty of enlarging the amount of diversity in the distribution of given elements, was in opposition to that future science. (p. 225)

By the way, given Driesch's clear formulation, no one will fail to recognize the similarity between entelechy and the famous Maxwell's Demon. Indeed, Driesch commented twice on Maxwell's Demon. First, regarding mere physico-chemical

systems, "of course, the empirical law of the dissipation of energy would be contradicted by Maxwell' fiction" (pp. 199-200). Second, In the case of entelechy, "the work of the 'demons' of Maxwell is here regarded as actually accomplished" (p. 225).

Driesch's discussion on entelechy and thermodynamics, or more generally, "vital and physical principles" (p. 198), alludes to many interesting, but long-ignored historical details about vitalism. Although these details cannot be presented here due to the lack of space, there is an important lesson to learn from the logic of science. As I have shown, according to Driesch, even though the effects of entelechy run against the second law of thermodynamics, it does not necessarily follow that the existence of entelechy should be forbidden in science. Further, in no way it follows that vitalism should be banned as a metaphysical heresy. Then, why is vitalism still not a scientifically valid theory? To answer this question, we must now execute a logical analysis of Driesch's doctrine of entelechy.

4 Logic I: The Logical (in Contrast to the Metaphysical) Refutation

As I have shown in the Introduction, vitalism is now almost universally refuted as a metaphysical heresy by presupposing materialism and physicalism. Sometimes it is even used as "a potent instrument of abuse, albeit one that often contaminates by association and innuendo rather than outright accusation" (Oyama 2010, p. 401). In this section I first make the structure of the metaphysical refutation clear. To do this, let us first quickly review a few negative remarks on vitalism, from contemporary biologists and philosophers:

> To those of you who may be vitalists I would make this prophecy: what everyone believed yesterday, and you believe today, only cranks will believe tomorrow. (Crick 1966, p. 99)
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> Both scientists and philosophers take ontological reductionism for granted. Vitalism is dead. organisms are nothing but atoms, and that is that. (Hull 1981, p. 282)
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> [Vitalism] virtually leaves the realm of science by falling back on an unknown and presumably unknowable factor… (Mayr 1982, p. 52)
>
> No "vital forces" exist, and all living phenomena consist only of chemical and physical processes. Such an ontologic position (i.e., a stance as to what exists in the universe) is called materialism, and it provides the basis for contemporary natural science. (Gilbert and Sarkar 2000, p.1)
>
> [Vitalism] faded as the mechanistic side of biology advanced. (Godfrey-Smith 2014, p. 10)
>
> The denial of physicalism by vitalism, the view that biological systems are governed by forces that are not physico-chemical…is largely of historical interest... (Brigandt and Love 2017, p. 3).

These passages contain both "innuendos" and "outright accusations". In sum, especially in Gilbert and Sarkar (2000), vitalism is rejected with forceful statements asserting that vitalism violates an overarching worldview legitimized by modern science. Hull termed this worldview "ontological reduction", Gilbert and Sarkar

termed it "materialism", and most recently Brigandt and Love went for "physicalism". In spite of this terminological diversity, it is clear that vitalism today is refuted by presupposing materialism and physicalism, and it is a metaphysical refutation.

A few more remarks on the metaphysical refutation. In the first place, my impression is that scientists are more used to the term "materialism", and they are very inclined to accept Hull's ontological statement, "organisms are nothing but atoms, and that is that" (I have encountered no exception!). In contrast, philosophers prefer "physicalism" with the intent of being more precise. From "materialism" to "physicalism", on the one hand, philosophers take apparently non-materialistic concepts (gravity, electro-magnetism, field, energy, etc.) in modern physics into account; on the other hand, they can claim that physicalism relies on ongoing physical sciences, rather than knowledge in physics in a particular time.

In the second place, I anticipate that some will raise objections to my characterization of materialism and physicalism, since today there are diverse "philosophical" doctrines of materialism and physicalism (Stoljar 2021). I cannot clarify all relevant issues here, but I do think that such a diversity is more or less a result of terminological confusions. Further, the essential point I want to make is that materialism and physicalism, whatever they mean, are used in this context to issue dismissals of vitalism. In sum, the existence of life forces, entelechies and other similar vital entities are judged as violating the metaphysical tendency of current scientists and philosophers, and they all receive a metaphysical refutation.

However, there is a different way of rejecting vitalism, and I call it a logical refutation. This refutation was endorsed in the early twentieth century by a few biologists and philosophers (for details see Chen 2018). In this logical refutation, first of all, vitalism is not treated as a metaphysical heresy; rather, it is received as a promising (or at least not-too-bad) scientific theory. According to the Russian biologist Alexander Gurwitsch, "practical vitalism claims the right to be restricted in formulating hypotheses only by postulates of logic and of the general theory of knowledge, and by nothing else" (1915, p. 765). It is also important to notice that logical empiricists essentially agreed with Gurwitsch. For instance, Philipp Frank wrote in his early years:

> 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 1941/1908, pp. 26–7)

Frank did not refute vitalism by presupposing any metaphysical materialism or physicalism, as present biologists and philosophers do.

According to the logical refutation, second, vitalism is defective for a different reason. On this Carnap wrote:

> Driesch did not give laws. He did not specify how entelechy of an oak tree differs from entelechy of a goat or giraffe. He did classify his entelechies. He merely classified organisms and said that each organism had its own entelechy. He did not formulate laws that state under what conditions an entelechy is strengthened or weakened… the notion of an entel-

> echy does not give us new laws, it does not explain more than the general laws already available. It does not help us in the least in making new predictions. (Carnap 1966, pp. 15–16)

According to Carnap, the central defect of vitalism was that Driesch failed to give new laws after he advanced the concept of entelechy.[4] Without such laws, even today, we simply have no idea about what the nature of entelechy is.

In this section I have contrasted the metaphysical refutation of vitalism with its logical refutation. I also want to endorse the view that the logical refutation is to be preferred. While there is no space to elaborate here (but see Chen 2019), the main defect of the metaphysical refutation, in my opinion, is that it relies on a rather problematic conception of matter, in which matter is treated as a Kantian thing in itself, rather than ever-changing physico-chemical principles. As a result, it has not, even in the slightest, captured the historical development of science. Indeed, in the history of science metaphysical versions of materialism and physicalism were often obstacles to scientific progress.

5 Logic II: Theoretical Biologists and Their Envisaged Vital Laws

In this section, I show one, arguably the most important, implication of the logical refutation of vitalism. In current biology as well as the history of biology, there have been theoretical biologists who take the metaphysical refutation of vitalism for granted and propose speculative research projects to search for principles of life. For instance, Ludwig von Bertalanffy, once influential for his general systems theory, took biological organisms to be far-from-equilibrium open systems; based on his knowledge in thermodynamics, Bertalanffy was eager to have "a thermodynamic criterion that would define the steady state in open systems in a similar way as maximum entropy defines equilibrium in closed systems" (1968, p. 151). Bertalanffy himself was not so hostile to vitalism (1933, p. 30), but he still complained that vitalism "refers…to a metaphysical or psychical factor and consequently renounces the possibility of a natural scientific explanation" (1933, p. 46). More recently, similar to Bertalanffy, the well-known theoretical biologist Stuart Kauffman envisaged "the fourth law of thermodynamics" (2000, p. xi) for life. Kauffman did not think highly of vitalism, either. Obsessed with holism and emergentism, he further claimed that "no vital force or extra substance is present in the emergent, self-reproducing whole" (1995, p. 24).

Yet is Driesch's vitalism really different from Bertalanffy's and Kauffman's research projects to find either a new thermodynamic criterion for open systems or even the fourth law of thermodynamics? My view is that, there is little difference,

[4] This refutation can also be found in other contemporary authors, such as Morris Cohen (1931, pp. 253–4). I thank Christopher Donohue for this reference.

from the logical point of view. Recall Driesch's discussion on how entelechy might function in the physico-chemical world; in its very least, the search for either a new thermodynamic criterion or the fourth law of thermodynamics can be read as an attempt to give laws to capture the effects of entelechy. In other words, these are just vital laws envisaged by Driesch. Therefore, despite a shared but actually unfounded metaphysical superiority, their research projects, from the logical point of view, can be received as disguised forms of vitalism. Meanwhile, needless to say, like Driesch's search for vital laws, so far Bertalanffy's and Kauffman's ambitious proposals have not found anything even close to a new thermodynamic criterion or the fourth law of thermodynamics.[5]

In addition to Bertalanffy and Kauffman, another theoretical biologist with interest in a general or universal theory of life is Brian Goodwin. Goodwin stood out among theoretical biologists as a rare admirer of Driesch (Webster and Goodwin 1981, pp. 5–6). In his research project, Goodwin not only proposed "biological field theory" (1982), he also made essential use of the analogy between the system of possible biological forms and the periodic table of elements: "(we need) a theory of organismic form analogous to the theory of atomic structure" that is, "the universal laws or constraints which define what is possible" (1982, p. 45). Like Driesch, Goodwin wrote:

> The rational taxonomy which could emerge from a logical classification of these forms would be quite independent of the actual historical sequence of appearance of species, genera and phyla, just as the periodic table of the elements is independent of their historical appearance, and is compatible with a great variety of possible sequences. (1982, p. 51).

In Goodwin's rational morphology, every possible biological organization is a dynamic whole governed by its own unique (morphogenetic) field equations. Then, all these unique field equations are further unified into a common scheme. For all these, Goodwin's project cannot fail to remind us of Driesch's "systematics of entelechies". In addition, it is clear that Goodwin's proposed "biological field theory" correspond to Driesch's envisaged vital laws.

Finally, to emphasize, vital laws envisaged by Driesch, like Goodwin's biological field theory and Bertalanffy's and Kauffman's new thermodynamic principles, have never been obtained till today. Indeed, Driesch's claim that his concept of entelechy must be invoked to explain embryological phenomena is untenable. On this point Carnap's criticism of vitalism is temporarily adequate. However, Driesch would not be wrong, if he merely proposed to look for vital laws. As a matter of fact, if vitalists could offer such vital laws, Carnap's criticism of vitalism would fail (and he would acknowledge this, for sure) and vitalism would consequently be as valid as any respectable theory in science. While it might not be very promising to attain such vital laws even in future biology, but the possibility of such vital laws can never

[5] To emphasize, this is not to dismiss other important but more concrete contributions made by theoretical biologists. Yet, it is also important to understand that those more concrete contributions so far have not given any genuine theory of life. Driesch also had genuine contributions in theoretical biology; however, those did not help his doctrine of entelechy, which in its essence tends to be a theory of life (see below).

be denied decisively. The validity of vitalism relies on vital laws, and this is a logical point. As we have seen, a lack of clarity on this point misleads some theoretical biologists (e.g., Bertalanffy and Kauffman) to envisage theories and principles with fancy names, which, from the logical point of view, turn out to be scarcely different from Driesch's vital laws.

6 Conclusion: Entelechy and Life

The logical refutation shows that at least in current biology vitalism is invalid. In other words, the statement that "the organism is governed by its entelechy" should be viewed with suspicion. Due to the lack of vital laws, this statement cannot be treated as a serious piece of biological knowledge. But now consider a different statement, "the organism is alive". Indeed, even though this statement is treated as trivially true, its logical status is similar to that of the previous statement about entelechy. Unfortunately, due to a lack of principles or laws of life (in Bertalanffy's and Kauffman's words), the statement that "the organism is alive", although presupposed, is of little real use in biology. It stands very isolated from all other well established biological statements. As a matter of fact, it seems possible to treat the two previous statements as synonymous (but note that vitalism is still invalid, since to explain life by appealing to entelechy amounts to nothing but a tautology), and the invention of entelechy can be read as a desperate and failed attempt to explain life (I mean, the pure concept/phenomenon of life). Nevertheless, such a failure should also remind us of the gloomy fact: even in current biology our knowledge about life does not go beyond our knowledge about entelechy, because both amount to almost nothing (for an elaboration of this point, see Chen 2019).

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