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## Dossier Georges Canguilhem

### Canguilhem and the Logic of Life

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#### Abstract:

In this paper we examine aspects of Canguilhem's philosophy of biology, concerning the knowledge of life and its consequences on science and vitalism. His concept of life stems from the idea of a living individual, endowed with creative subjectivity and norms, a Kantian view which "disconcerts logic". In contrast, two different approaches ground naturalistic perspectives to explore the logic of life (Jacob) and the logic of the living individual (Maturana and Varela) in the 1970s. Although Canguilhem is closer to the second, there are divergences; for example, unlike them, he does not dismiss vitalism, often referring to it in his work and even at times describing himself as a vitalist. The reason may lie in their different views of science.

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#### Keywords:

Canguilhem; Vitalism; Biology; Logic of life; Autopoietic/Heteropoietic; Analysis/Synthesis; Living individual

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*La vie déconcerte la logique*  
(Canguilhem 1977, 1)

*To do biology, even with the aid of intelligence,  
we sometimes need to feel like beasts ourselves*  
(Canguilhem 2008a, xx)

## Introduction

In Canguilhem's philosophy, life disconcerts logic by its intrinsically self-produced or "autopoietic" nature in contrast with mechanical devices. This is logic in the sense of the method of scientific discovery, even that which Claude Bernard theorized for experimenting

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with organisms in vivo (Bernard 1865, Coleman 1985), but also logic understood as a model or scheme of the internal organization or functional integration that underlies the living state. Therefore, the knowledge of life, the method, is challenging for biology. Experimental biology tends to consider living beings as machines, and the knowledge operation required for that leaves part of life aside; it cannot grasp life in full. In fact, although Canguilhem as a historian and philosopher of science has a high regard for biology,<sup>3</sup> he nevertheless thinks that there is something missing in scientific knowledge trying to understand life via analysis, although this is the only way knowledge can probably proceed. The analysis/synthesis dichotomy is important for Canguilhem's view on life and especially for his understanding of medicine, and the pathological more generally. Life is not analyzable, he contends, i.e., life defies scientific methods because of its inherent plasticity and variability, and also in its interactive or relational capacity, especially because of his conceptualization of the milieu as an intermediary between two entities. Canguilhem's philosophy develops from a given understanding of life. It has to do with its capabilities to establish its multiple own norms according to its environment or milieu, and change them to establish a new physiological order when required.<sup>4</sup>

This is the main distinctive feature of Canguilhem's vitalism. Not that he posits the matter of life as an ontological or metaphysical entity different from that of physicochemical systems. Canguilhem denies that vitalism is a metaphysics, and then adds immediately afterwards that it is "the recognition of the originality of the fact of life [*le fait vital*]" (Canguilhem 1965, 156). But what is this originality, then? It is not an ontological specificity (like a Drieschian entelechy), yet is a feature which resists any 'logic of life'. Although he warns that there are intellectual dangers inherent in positing that living beings are like an empire within an empire – *imperium in imperio* – (Canguilhem 1965, 95), he asserts that *Life itself* determines living beings to act in interpretive, purposive, normative, vital ways. Life "disconcerts logic" (Canguilhem 1977, 1). He does not reject biology's kind of knowledge as science either. It is mainly the idea that life is something that is beyond the knowledge capabilities of a logic or method as these are devised for inert systems, those that can be manipulated from the outside. The something beyond is related to the fact that one has to be alive to be able to grasp it. And being alive is the same as being synthetic, as opposed to analytic, and synthetic, like autopoietic, means that it is a system in continuous creativity.

Here we examine Canguilhem's ideas concerning the knowledge of life and its consequences on science and vitalism. First, his concept of life, which stems from the idea of the living individual, as endowed with creative subjectivity and norms; we will consider it as a Kantian view which shares Kant's challenge to a science for living beings (as we discuss in the next section). Second, why life disconcerts logic. In order to explicate this, we examine two different perspectives, the evolutionary genetically based logic of life of works such as Jacob's, and the organizational dynamic logic of the individual of the autopoietic school. Although Canguilhem is closer to the second, both in its conclusions and in the kind of materials used to depict the image, there are divergences. For example, unlike them, he does

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<sup>3</sup> The relation of Canguilhem with science and its knowledge has been questioned (for example Gabel 2015 mentions Jacob's comment in the *Web Stories* video, that Canguilhem told him that he would not have written much of what he did, had he read Jacob earlier. Although Jacob seems to have understood Canguilhem's remark at face value, we could always think he was just being polite and appreciative of the work of the scientist). In any case we will argue that Canguilhem's thesis is not empirical and therefore not vulnerable in principle to such criticisms.

<sup>4</sup> "Man is only truly healthy when he is capable of multiple norms, when he is more than normal. The measure of health is a certain capacity to overcome organic crises in order to establish a new physiological order, different from the initial order. In all seriousness, health is the ability [*le luxe*] to fall ill and then get over it. On the contrary, illness is the reduction of the power to overcome other illnesses" (Canguilhem 1965, 167). See also (Canguilhem 1972, 77, 155). (All translations are ours unless otherwise indicated).

not dismiss vitalism. Third, we explore his claim for vitalism connected with views about the role of analysis in the scientific knowledge of life and his characterization of life as synthesis (in the second and third sections, respectively).

## Canguilhem and the Life of an Individual

Since the second half of the 19<sup>th</sup> century there have been two distinctive styles in the study of biology. Physiology is centered in the living individual, in the organism, and its main topic is the organization of parts or organs to produce the organized whole. The other style is that of evolutionary biology, concerned by the changes in lineages of individual forms through – mainly – genealogical processes.

The philosophical topic of physiology is biological individuality, its delimitation and its cohesion. Physiology's problem is how a living individual maintains its integrity and organization through the causal interactions of its parts and the regulation of those interactions (Bernard 1878-1879; Pradeu 2016). This was the approach pursued experimentally by Claude Bernard's physiology, as it aimed to reach scientific status; some considered him as the Newton of medicine (see note 5 below). Physiology thus understood parted ways with the more observational approach of natural history. Canguilhem's philosophy of life is embedded in this kind of thinking and operates within this framework. The antagonism between mechanist and vitalist views about the special status of living beings and in what sense they constitute a challenge for the scientific knowledge of life are ingrained here.

This subject matter is reminiscent of Kant's view of organized beings and scientific knowledge. Kant promoted the view of living beings as purposeful and self-organized, in his 1790 *Critique of Judgment* (§ 65, AA 5, 374). There he established the grounds for understanding organized beings whose components are mutually dependent on each other and on the whole they generate. Being teleological and self-organized they are very different from a watch, organised according to a designer's plan. But this understanding set a limit for science. Difficulties appear in the project of reconciling it with the conceptual framework Kant developed for natural sciences in his *Critique of Pure Reason* (1781), founded in natural laws without purposiveness, in external causes, and in mechanical principles (Nuño de la Rosa and Etxeberria 2010). Kant did not think there can be a naturalist scientific explanation for living beings, such as there is one for physical systems. His declaration that there will not be a "Newton of the blade of grass"<sup>5</sup> is well known: "Indeed, so certain is it, that we may confidently assert that it is absurd for human beings even to entertain any thought of so doing or to hope that maybe another Newton may some day arise, to make intelligible to us even the genesis of but a blade of grass from natural laws that no design has ordered." (Kant, *Critique of Judgment*, § 75, AA 5, 400).<sup>6</sup>

Kant's view of the organism as a self-organized system constitutes a challenge for science. There have been attempts to reconcile teleology and mechanism, such as Lenoir

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<sup>5</sup> Since then, there was a long controversy about who could be the scientific figure that would contradict Kant. According to Cassirer, for biologists like Haeckel, Darwin was the "Newton of the blade of grass," yet Roux rejected this (Cassirer 1950, 163). Others have mentioned Claude Bernard (Prochiantz 1990), and still others thoroughly agree with Kant (Nuño de la Rosa and Etxeberria 2010). We return to this topic in the final section.

<sup>6</sup> This statement of Kant's is often quoted approvingly, a rare exception being Zammito (2006), who notes that Kant is neatly placing himself in the rearguard of scientific thought of his time concerning living entities. Our point here is simply to note the existence of this influential position according to which 'Life' is not reducible to a certain set of empirical (measurable, quantifiable) features. In that sense Canguilhem can be said to be a Kantian. See Brillman (2017) for an interesting development of this connection.

(1982)'s who understood the Kantian tradition as a way to integrate self-organization and teleology within scientific biology. But naturalizing efforts or scientific explanations of material self-organizing appear to be reductionistic<sup>7</sup> (Moss and Newman 2016). In sum, the Kantian challenge is basically the problem of whether our knowledge of life or of living systems can be naturalized. Canguilhem's approach to this, asks how we can know about living beings with the kind of knowledge developed to investigate inanimate realms such the production of technical devices.

Canguilhem's view of living systems as actively self-produced or autopoietic establishes the difference with technological objects. He referred to living beings as "autopoétique" or "autopo(i)etic"<sup>8</sup> in "L'expérimentation en biologie animale", an essay on the experimental tradition started by Claude Bernard, originally delivered as a talk in 1951 and included in *La connaissance de la vie*. There he distinguishes the "heteropoietic" character of human technical activity in the interaction with the environment: "Man first experiences and experiments with biological activity in his relations of technical adaptation to the milieu. Such technique is heteropoetic, adjusted to the outside, and it takes from the outside its means, or the means to its means" (Canguilhem 2008a, 9). However, he contends that when in interaction with other living beings, experimenters become aware of the "autopoetic character of organic activity". The realization of this has been an achievement: "Only after a long series of obstacles surmounted and errors acknowledged did man come to suspect and recognize the autopoetic character of organic activity and to rectify progressively, in contact with biological phenomena, the guiding concepts of experimentation." Human action producing technology "presupposes a *minima* logic – for the representation of the exterior real, which human technique modifies, determines the discursive, reasoned facet of the artisan's activity, and all the more so the engineer's." This does not work in the case of living entities because humans cannot produce them externally, therefore: "we must abandon this logic of human action if we are to understand living functions" (Canguilhem 2008a, 9).

Canguilhem's attention is focused on the kind of knowledge of or attitude towards living entities, in epistemological terms. The "autopoetic" character of living beings, in contrast with artefacts, refers to the kind of object of knowledge. Later Maturana and Varela (1973, 1980) will use a similar term (autopoiesis) to characterise the constitutive organization of living beings. The work of Rheinberger (2015) further pursues this reflection on the nature of the different knowledge objects produced by science to explain life. This topic appears also in the analysis/synthesis opposition: Canguilhem insists that knowledge of living systems proceeds by analysis, to know living individuals science or biology has to analyze them, while they are ontologically synthetic, as they dynamically make themselves in an active and creative way. As he remarks in "Le tout et la partie dans la pensée biologique":

The physiology of regulation (or homeostasis, as it has been called since Walter Bradford Cannon), together with cytologic morphology, enabled Bernard to treat the organism as a whole and to develop an analytic science of organic functions without

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<sup>7</sup> To be precise, there is a 'material difficulty' of the sort just outlined, and a 'conceptual difficulty' in the sense that such programs strongly invoke the Kantian pedigree, while somehow overlooking the fact that a core element of the Kantian concept of the living (of organism) is that it cannot be the object of a causal-naturalist science.

<sup>8</sup> Canguilhem wrote "autopoétique" and "heteropoétique" without the "i", translated into English as "autopoetic" and "heteropoetic" in Canguilhem (2008a). As the term has stabilized in usage as "autopoiesis" (reflecting the Greek *ποίησις*), we use the term in this way throughout the paper. When we quote Canguilhem we write in the same way he wrote it, i.e., without the "i"; "autopoetic" ("autopoétique") and "heteropoetic" ("heteropoétique").

brushing aside the fact that a living thing is, in the true sense of the word, a *synthesis*. (Canguilhem 1994, 298).

To argue that living bodies are special, Canguilhem takes over Kurt Goldstein's chief holistic or organismic idea presented in his influential work *The Organism* (1934/1939) – it is the organism as a totality, not a cluster of functions or organs, which acts and reacts as a unified approach to its environment and its challenges (Canguilhem 1972, 49) – and strips it of some of its more overtly metaphysical trappings. Yet the holistic dimension, the emphasis on the 'whole person', reappears now and then with surprisingly existentialist and humanist overtones, when Canguilhem opposes Life to technology and the various forms of the "mechanization of life."

In sum, in Canguilhem's unique way of engaging with 'organisms' and the question of their uniqueness we find one of the curious features of Goldstein's account: the way in which he wavers or moves back and forth between a cautious, epistemological position (reminiscent of the Kantian regulative ideal in the third *Critique*) in which organisms are real and special *because of the way we cognitively constitute them*, and a bold, ontological position in which organisms are real because of basic, intrinsic features which are just there. However, this convenient distinction between the epistemological (projective, constitutive) vision of biological entities and the ontological vision (strong vitalist, 'rational metaphysics' as Kant might have said) is somewhat muddled when Canguilhem introduces a further vitalist twist, in "Aspects du vitalisme": that it might be an objective ('ontological') feature of living beings that they are interpretive beings, and especially that they need to consider *other* entities as themselves organismic, purposive, vital. We interpret Canguilhem as alluding to this need of being interactively immersed with other organisms to know what they are, when he writes in *La connaissance de la vie* that "We suspect that, to do mathematics, it would suffice that we be angels. But to do biology, even with the aid of intelligence, we sometimes need to feel like beasts ourselves" (Canguilhem 2008a, xx). There may also be an existentialist *parfum* in Canguilhem's reflections, as when he describes this interpretive stance as essentially a kind of fundamental existential attitude. In any case what is distinctive of his position, especially when we consider the core arguments of *The Normal and the Pathological*, is the presupposition that normativity is a power or capacity proper to *living* beings:

We, on the other hand, think that the fact that a living man reacts to a lesion, infection, functional anarchy by means of a disease, expresses the fundamental fact that life is not indifferent to the conditions in which it is possible, that life is polarity and thereby even an unconscious position of value; in short, life is in fact a normative activity. Normative, in philosophy, means every judgment which evaluates or qualifies a fact in relation to a norm, but this mode of judgment is essentially subordinate to that which establishes norms. Normative, in the fullest sense of the word, is that which establishes norms. And it is in this sense that we plan to talk about biological normativity. (Canguilhem 1972, 126-127)

We find here an insistence that there is something unique about living entities that makes them creators of a certain world which they inhabit. Upon closer examination, this idea seems to contain some Nietzschean overtones (Foucault also pointed to this aspect in his mentor's work: Foucault 1991, 21), namely, the idea that values, norms and other higher-level constructs are in fact products of our vital instincts, so that life integrates rationality to itself through its normative activity. In a lecture in the problem of regulations in the organism and society, Canguilhem also insists that

An organism is an entirely exceptional mode of being, because there is no real difference, properly speaking, between its existence and the rule or norm of its existence. From the time an organism exists, is alive, that organism is 'possible', i.e., it

fulfils the ideal of an organism; the norm or rule of its being [existence] is given by its existence itself. (Canguilhem 2002, 106-107)

Yet he does not appeal to a disembodied, foundational subjectivity, like more anti-naturalistic trends in phenomenology; there is no pure ego contemplating the reality of the flesh like a sailor in a ship, for him. As regards the relevance of experience, it would seem that – despite their shared affinity for Goldstein – it is more than unlikely that Canguilhem would go as far as Merleau-Ponty, as we see when he reflects on the limitations of a conceptualization of the living body as “inaccessible to others, accessible only to its titular holder” (Canguilhem 2008b, 476).

Canguilhem’s position on organic uniqueness and what he somewhat cryptically calls ‘experience’ is subtly yet significantly different:

the classical vitalist grants that living beings belong to a physical environment, yet asserts that they are an exception to physical laws. This is the inexcusable philosophical mistake, in my view. *There can be no kingdom within a kingdom [empire dans un empire]*, or else there is no kingdom at all. There can only be one philosophy of empire, that which rejects division and imperialism. [...] One cannot defend the originality of biological phenomena and by extension, of biology, by delimiting a zone of indeterminacy, dissidence or heresy within an overall physicochemical environment of motion and inertia. *If we are to affirm the originality of the biological, it must be as a reign over the totality of experience, not over little islands of experience.* Ultimately, classical vitalism is (paradoxically) too modest, in its reluctance to universalize its conception of experience. (Canguilhem 1965, 95; emphasis added)

‘Classical’ vitalism as described here is what one of us has termed substantial vitalism elsewhere (Wolfe 2011, 2015a). And Canguilhem’s diagnosis of an “inexcusable philosophical mistake” is clear enough. But what should we make then of his defense of the “originality of the biology,” i.e. the autonomy of biology, as a “reign over the totality of experience”? What looks at first glance like metaphysical holism might instead be an ‘attitudinal’ conception, that is, a *point of view* on experience.

Canguilhem was aware and acceptant of the biology of his times,<sup>9</sup> and paid attention both to the physiological perspective and to the evolutionary/molecular biology perspective. Yet he does not appear to be keen to develop what we could call a logic of life or the living, why? Taking into account Canguilhem’s views, we examine some aspects of the nature of life and organisms as discussed in the biology of the 1970s, such as F. Jacob’s and Maturana and Varela’s, each proposing a particular proposal for a logic in biology. Canguilhem’s ideas contrast with those of biologists of the time: we will specifically take into account François Jacob’s evolutionary perspective in *La logique du vivant* and Humberto Maturana and Francisco Varela’s organizational one in *Autopoiesis and cognition*. Both books were originally written in the early 1970s (in languages different from English) and elaborate very different research programs to explore living organization.

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<sup>9</sup> Yet some authors appear dismissive of the understanding of genetics and evolutionary biology of authors of the French philosophical tradition. For example, Gabel writes: “In France, institutional biology largely rejected both Darwinian natural selection and Mendelian genetics. Biologists do not believe that evolution could be explained by natural selection” (Gabel 2016, 71). This is an often repeated cliché but unlikely. In the case of Canguilhem’s work, we should consider it more a case of philosophical disagreement than of bad scientific perception. Similarly, if Bernard ignored evolutionary biology it was because it was hardly relevant for the experimental approach he pursued (see note 10).

## The Logic of Life at Large

In the philosophy of biology of the 19<sup>th</sup> and 20<sup>th</sup> centuries two different intuitions about life, related either to the evolution of life at large, or to the organization of particular living individuals, have run parallel courses.<sup>10</sup> The former was mainly concerned with the fact that all life is connected, and requires that connection, so that the study of isolated individuals, as it is usual in physiology, is very limited and insufficient. The latter aimed to explain the physiological organization of living entities as organisms or agents, both constitutively and interactively.

In the early 1970s, related to the above-mentioned distinction of two styles of biology, different and opposed views were held on the primacy of organization and reproduction / evolution for biology. The former would imply a principle grounding the mechanisms of living individuality; the latter, a connection among somewhat ephemeral living forms. These differences implied separate research programs for biology. François Jacob's logic of life represents the mainstream view that the most important feature of life is reproduction and evolution (although very aware of the historical concerns for organization, Jacob considered them to be overcome with the new findings in molecular biology).

Jacob's *La logique du vivant* was a very important book in the 1970s in which the author, already a Nobel Prize winner and a widely recognized molecular biologist, made a remarkable attempt at reconstructing the history and philosophy of biology around the notion of biological organization and the "logic of life". Jacob attempted to reconcile classical views in European continental thought on biology with views stemming from contemporary ideas on genetics and evolution. It is full of enthusiasm towards the notion of biological information and the logic of genetics of the 1960s and 1970s, which he understands to be the corollary of biological struggles to understand biological organization. (This he shares with Canguilhem to a certain point, as is visible in the latter's 1966 additions to *Le normal et le pathologique*, displaying a real openness to genetics as a "nouvelle connaissance de la vie".) This book was very important and had a deep influence on biologists of the time and defends a model of life sympathetic to informational formalisms for genetic regulation.

For Jacob, the special features of life appear in the evolutionary genetic image, linked not to the properties of living beings studied by classical philosophy (e.g. Thomism) but by the new image made possible by the evolutionary science of the time. Some of its features are that it enhances the view of life as a genealogically connected succession, rather than mechanistically explainable in the living being:

An organism is merely a transition, a stage between what was and what will be (Jacob 1973, 2).

Everything in a living being is centred on reproduction (4).

Let us imagine an uninhabited world. We can conceive the establishment of systems possessing certain properties of life, such as the ability to react to certain stimuli, to assimilate, to breathe, or even to grow - but not to reproduce. Can they be called living systems? Each represents the fruit of long and laborious elaboration. Each birth is a unique event, without a morrow. Each occasion is an eternal recommencement. Always at the mercy of some local cataclysm, such organizations can have only an ephemeral existence. Moreover, their structure is rigidly fixed at the outset, incapable

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<sup>10</sup> As several authors have noted, Claude Bernard's physiological tradition had little interest in evolutionary or developmental biology, which it did not view as proper sciences. See (Normandin 2007).

of change. If, on the contrary, there emerges a system capable of reproduction, even if only badly, slowly, and at great cost, that is a living system without any doubt. (4-5)

Jacob distinguishes explicitly the two views of biology. According to his preferred perspective, evolutionary accounts consider the genealogical connection among living beings so that from this perspective it is very evident that living beings are not systems that arise and disappear due to their physicochemical properties, or at least not only because of them, as many of their capacities have been inherited from their ancestors. These systems, or part of them, have been *informed* by others:

Much of the controversy and misunderstanding, particularly with regard to the finality of living beings, is caused by a confusion between these two attitudes. Each tries to establish a system of order in the living world. For one, it is the order which links beings to one another, sets up relationships and defines speciations. For the other, it is the order between the structures by which functions are determined, activities coordinated and the organism integrated. One considers living beings as the elements of a vast system embracing the whole earth. The other considers the system formed by each living being. One seeks to establish order between organisms; the other within each organism. The two kinds of order meet at the level of heredity, which constitutes the order of biological order, so to speak. (Jacob 1973, 7-8)

Darwinian evolution implies two main ideas: one is that of the genealogical connection among all forms of life, which is often represented as the tree of life, the second is that of natural selection as a main cause of evolution, implying that any trait or important feature of living beings has evolved by natural selection. The *received view* of the Modern Synthesis answered the two questions, proposing genes as the main ontology. However, critics of this view affirm, as expected, that evolution does not contribute to our knowledge of living organization. Very soon, and especially after the 2000s, new approaches in systemic and synthetic biology made clear the need to take into account more organismic approaches both for molecular and evolutionary biology. Jacob made a great effort to integrate the new biology based on genetics and molecular biology with the organizational tradition. But he appears to consider that the new understanding overcomes philosophical efforts to understand living organization. In fact, Jacob identifies the genetic program, and the determinism it embodies, as the fundamental element of its theory of the living. However he also admits the importance of different levels of integration in the domain of life, called *integrations*, each of them being characterized by some independence with respect to lower ones.

Current systemic approaches consider the need of the two perspectives. On the one hand, the study of evolution needs to include the mechanical causal processes taking place in development – in addition to population dynamics at various levels and contingent events- and processes responsible for organizations and entities that emerge in interactions such as symbionts, ecosystems, etc. The *extended evolutionary synthesis* (Pigliucci and Müller, eds., 2010) has vindicated a perspective that would be encompassing and inclusive. On the other hand, the search of living organization cannot rely on the analysis of logical and mathematical aspects only; organizations need to be studied in the material domain, which includes evolutionary processes. Jacob underlines biology as an exploration of a logic of life that is beyond any logic of the living individual. This knowledge is not concerned with individuality, finality or causal mechanisms because it is a science of living forms that appear and are transmitted in a contingent way.

In his review of François Jacob's evolutionary perspective, Canguilhem (1971) addresses the view of life taking place at the level of cells and the logic of reproduction, as

disclosed by the genetics of the time. He now maintains that “in order to understand what we are as living beings, we must look to the chromosome, the gene, the DNA molecule. The biochemical study of the bacteria is the beginning of self-knowledge of oneself as a living being” (Canguilhem 1971, 23). This obliges one to reject finalism, and the centrality of individuality. In addition, he seems to accept the new playground of biological science, namely the informational perspective. Gabel quotes Jacob saying that only in the fifties Canguilhem began reading contemporary biological research, and contends that after that he gave up his vitalism. “Though he did not renounce his old positions – in fact he seems to have felt his philosophy to be consistent with the discoveries of genetics and molecular biology – he in fact moved away from both humanism and vitalism” (Gabel 2015, 82). We disagree, as in that paper Canguilhem remains sceptical about informational logic of life. Also philosophical positions may be modulated, but are not dictated by scientific facts, and this is evident in Canguilhem’s case, who writes: “The execution of a program that is identified with its realization is a blunt fact, without cause or responsibility. The logic of life does not refer to any logician” (Canguilhem 1971, 23). In that sense, blind evolution is change without history, as “evolution through natural selection is only history in its incidents, errors and rare events” (24). And at the end of the review, Canguilhem reflects on Jacob’s much-quoted pronouncement that biological research no longer “inquires into Life” (“On n’interroge plus la vie aujourd’hui dans les laboratoires”), i.e., that the concept of Life (and by extension any ontologically foundational clauses attached to work in the life sciences) no longer serves any purpose in such work (Jacob 1970, 320).<sup>11</sup> With a curious kind of pathos that is however not ‘Romantically anti-scientific’, he observes that living beings “think they live” a life “outside of laboratories”, not realizing (Canguilhem literally writes “not knowing”) that in laboratories, “Life has lost its life with its secret” (Canguilhem 1971, 25).<sup>12</sup>

## The Logic of the Living

Very soon after the 1970s, and especially at the turn of the century, both in the philosophy of biology and in most biological disciplines there was a big movement in search of systemic and organizational principles, as is made evident by advances in systems biology, synthetic biology and the extended evolutionary synthesis. Historically there are (at least) two organizational traditions: the physiological one starting in Claude Bernard, to which autopoiesis (and most of the work on biological autonomy) belongs, and the developmental one which has led to structuralism and Evo-Devo (Etxeberria and Bich 2017; Etxeberria 2004). Both are connected to Kant’s *Critique of Judgment*, although they have kept quite apart during the twentieth century.

To Jacob’s plea for a logic of life, Varela and Maturana respond with a new vindication of the centrality of the living individual as a foundation of biology, this time looking for a “logic” of the living. Maturana and Varela’s notion of autopoiesis can be considered as an answer to Jacob’s picture reject the informational perspective in biology, a view shared by the Developmental Systems Theory in philosophy of biology, especially after Susan Oyama (1985). Their narrative on the logic of the living, clearly influenced by Jacob’s book, deliberately disputes many of his positions about the logic of life and the centrality of

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<sup>11</sup> At the conceptual level, this corresponds to Edouard Machery’s deliberately deflationary suggestion (Machery 2012) that we should give up seeking to provide definitions of life, as these are either folk concepts, or unresolvable with other competing definitions: namely, evolutionists, theoretical biologists, self-organization theorists, molecular biochemists and artificial life researchers cannot agree on a definition.

<sup>12</sup> He adds that “it is outside laboratories that love, birth and death continue to present living beings – the children of order and chance – the immemorial figures of these questions that life science no longer asks of life”.

reproduction and evolution. In contrast, for the positive part, it often draws Canguilhem's views to contrast Jacob's informational stance. But their main claim goes far beyond Canguilhem's position and points to developments in biology that Canguilhem did not foresee, probably because he was not aware of work in cybernetics and complex artificial systems that was aiming to explore living phenomena through synthetic and systemic models and simulations.

The autopoietic approach to the living belongs to the above-mentioned physiological systemic tradition focused on the problem of the relational unity of the living, associated to Kant's understanding of organisms in the *Critique of Judgment*, Claude Bernard's concept of *milieu intérieur*, and the organicist tradition that considers life as organization – a tradition including Hans Jonas and Jean Piaget among others.<sup>13</sup> Other clear associations are with the cybernetic movement, especially with second-order cybernetics (Etxeberria and Bich 2017).

The notion of autopoiesis was proposed by Maturana and Varela<sup>14</sup> (Varela 1979; Maturana and Varela 1973, 1980) to refer to the biological self-organization of individual living beings, in contrast with other properties of life that the biology of their time considered as primary (genes as DNA or informational properties). The basic idea of autopoiesis is self-production, as a relational dynamic of components that generates or brings forth a membrane or boundary. This constitutes the individual living being's identity as separated from the surroundings (Varela 1981).

The autopoietic approach to life is different from that of evolutionary and molecular biology in that the theory focuses on autonomy and identity to naturalize them as marks of life, and not in reproduction or evolution. They claim that living organization has primacy with respect to those other phenomena associated to life (Etxeberria 2004). In contrast with Jacob's view, it is not life at large, but individual organisms and their autopoietic organization, what is central for biology. All system components have the same status to explain the self-referent dynamics by which they produce a unity; that is to say, living phenomenology is not explained in terms of some components being information carriers, but in terms of relations. Autopoietic systems, also initially called *autopoietic machines*, explore the general relational scheme common to all living systems as the configuration of transformative processes whose result is the configuration itself, so that identity and activity, producer and product coincide (Bich and Etxeberria 2013). The individual identity constituted by the system itself and not by anything external (heteropoietic) is a central idea of this approach. As said, some of the distinctions they stress, for example the one between autopoiesis and heteropoiesis, already appear in Canguilhem's *La connaissance de la vie*, as we have noted before. The relations of the autopoietic unity and its surroundings cannot be understood in terms of input/output fixed interactions. Instead, non-specific perturbations are coupled with plastic behaviors of the system within the range of internal coherence.

In their initial writings the authors embrace mechanism and criticize vitalism. This is important because, according to them, vitalism focuses on entities bearing properties, in contrast with the relational approach they vindicate in which properties appear in the relations among components (see Bich and Arnellos 2012, 79). Maturana writes that

in a vitalistic explanation, the observer explicitly or implicitly assumes that the properties of the system, or the characteristics of the phenomenon to be explained, are to be found among the properties or among the characteristics of at least one of

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<sup>13</sup> Canguilhem sits somewhat unsteadily here, given that he is less of a 'naïve (ontological) organicist' than the rest.

<sup>14</sup> Both Francisco Varela and Humberto Maturana have separately claimed to have coined the term, referring to different sources for the invention. In this paper we maintain that they probably conceived the notion from those passages of Canguilhem's *La connaissance de la vie* in which he says that living systems are autopoietic.

the components or processes that constitute the system or phenomenon. In a mechanistic explanation the relations between components are necessary; in a vitalistic explanation they are superfluous. (Maturana 1978, 30)

For interactionist or ecological perspectives living beings cannot be fully accounted for in terms of *intrinsic* properties, but need to take into account *relational* properties arising from interactions between living constituents.

There is a tension in naturalism, regarding whether the organization of living beings is spontaneous or pre-existent. In fact, to the question: can life be understood in terms of pure/actual/synchronic organization?, both creationists and evolutionists answer no! For creationists the organization of life is pre-existent as life was created by a designer (God), for evolutionists it is obtained from ancestors that transmit it in various ways. The notions of tree of life and common ancestor suggest that the living state must come from another living being, that living organization cannot be produced spontaneously. This would entail that a naturalistic evolutionary theory with commitments to understand the organization of life – and living beings – needs to give up the intention to explain the evolutionary process in an algorithmic way (Dennett, genetic algorithms, ultra-Darwinist arguments...) and attend to other factors that can give clues about how the elements of living organization come to be.

One difference between Canguilhem's usage of the term 'autopoietic' and Maturana and Varela's account of autopoiesis may be that the latter intend to explore ways in which the autopoiesis of living systems can be explored in artificial models. This is not exactly like Canguilhem, who thinks that the autopoietic character of living beings is equivalent to their not being susceptible to be grasped by knowledge. Canguilhem starts his book *La connaissance de la vie* with the sentence: "Connaître c'est analyser" ("To know is to analyse") only to remind us quickly of the difficulties of grasping a true knowledge of what it means to be alive through knowledge, through analysis. Today not everyone would accept that biology as a science proceeds merely by analysis. On the contrary, many fields including Synthetic Biology and, earlier, Artificial Life, have attempted to build synthetic models, systems or simulations by integrating knowledge from many biological fields and exploring their emergent and creative properties.

To try and understand Canguilhem in relation to recent theoretical biology (including the 'organizational' theories, see Moreno and Mossio 2015, Bechtel 2007) results in a curious situation. The concept of scientific knowledge associated with many of current fields is far from the idea that the aim of models is to represent reality. In fact many systems can be in some ways creative or autopoietic as well. Then to ask 'are organisms unique in the physical world? If so, why?' as an orienting question does not only affect issues of an ontological kind (what is life?), or an epistemological kind (how can we know life?), but also brings about issues that start having a new relational or interactive character. If Canguilhem's problem was how the knower relates to a known that is autopoietic, similar situations appear with respect to some scientific and technological products.

## Canguilhem's Claim for Vitalism

A main feature of vitalism in scientific research is to consider that living beings are in some sense different from inorganic or inert beings;<sup>15</sup> this does not always have further ontological

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<sup>15</sup> "The difference between what is life and what is not has changed with the advance of science. For a long time, especially in antiquity, when life had total primacy, the opposite of the living was 'dead'. Later, it changed to simply 'inorganic', reflecting the fact that during the twentieth century the question of what is life mostly concerned physicists, who sought to understand the peculiarities of living matter, as opposed to the inorganic. Today, the opposite of life is generally 'inert', which is a category that includes organic materials. The difference between the inorganic and the inert reflects

and methodological implications. Canguilhem's work appears to be among those believing the first. Canguilhem appears more cautious than Jacob or other prominent figures who try to dissolve the problem of what life is into an evolutionary logic. This deflationary view underlies usual attempts to substitute the definition of life by a list of living properties, such as those appearing in many biology textbooks. In contrast Canguilhem is suspicious of the rejection of vitalism in this way because many of the features that are associated with life, in contrast with those of inanimate systems do surreptitiously appear in normative concepts such as evolutionary advantage (1971, 24).

Canguilhem often refers to vitalism in his work, going as far as describing himself – playfully – as a vitalist.<sup>16</sup> He acknowledges that vitalism is a position that is difficult to maintain. As Dominique Lecourt comments, “Canguilhem, a hero of the Resistance, clearly expresses the difficulty of presenting himself as a ‘vitalist’ in 1946-1947” (Lecourt 2011, 8), and he thus quotes this passage from “Aspects of Vitalism”:

Today, above all, the usage of vitalist biology by Nazi ideology, the mystification that consisted in using theories of *Ganzheit* to advocate against individualist, atomist, and mechanist liberalism and in favor of totalitarian forces and social forms, and the rather easy conversion of vitalist biologists to Nazism have served to confirm the accusation formulated by positivist philosophers like Philipp Frank, as well as by Marxists (Marcel Prenant) that it is a “reactionary biology”. (Canguilhem 1965, 97; Canguilhem 2008a, 72)

In the same essay, Canguilhem asserts from the outset that when the philosopher inquires into biological life, she has little to expect or gain from “a biology fascinated by the prestige of the physicochemical sciences, reduced to the role of a satellite of these sciences” (Canguilhem 1965, 83; Canguilhem 2008a, 59). What this entails for vitalism is that it has a specifically *philosophical* place, whether it is scientifically ‘validated’ or ‘refuted’, and apart from its status as a scientific ‘construction’. In this sense, as Canguilhem suggests in “Aspects du vitalisme”, *vitalism is not like geocentrism or phlogiston: it is not refutable in quite the same way.*<sup>17</sup>

To summarize these two dimensions of Canguilhem's thought, one could say that on the one hand his vitalism is *heuristic*, a claim that living phenomena need to be approached in a certain way in order to be understood; but on the other hand, it possesses a more *ontological*, Aristotelian dimension. Consider the example Canguilhem had given in “Aspects du vitalisme”: vitalism is not like (the theory of) phlogiston or geocentrism. Now, faced with this ‘fact’ that vitalism is not like phlogiston, there are two possible responses: it's not like phlogiston because it's *true* and thus one's ontology needs to include it or it's not like phlogiston because it has this *heuristic value*, or explanatory power.

For Canguilhem vitalism is a way to understand Life in a certain way in order not to miss its essential spontaneity; historically, thinkers known as vitalists have had what he calls “this

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an increasing awareness that life is so complex that the scientific study of transients cannot attempt to start from raw inorganic materials, but rather needs to begin with organic compounds and processes to study how these, or similar alternatives, are produced in living systems and the laboratory” (Etxeberria and Ruiz-Mirazo 2009, S33-4).

<sup>16</sup> For example, in the Foreword to his book on the development of the notion of reflex: “Il nous importe peu d'être ou tenu pour vitaliste...” (It does not matter to us to be or to be considered a vitalist ...) and he presents the book itself as a “defense of vitalist biology” (Canguilhem 1955, 1). But some years earlier, he had devoted one article exclusively to the topic, “Aspects du vitalisme” (originally a series of lectures given at the Collège Philosophique in Paris in 1946-1947), in Canguilhem 1965.

<sup>17</sup> (Canguilhem 1965, 84; Canguilhem 2008a, 60). The Medawars note that it is hard to devise an experiment to ‘refute’ vitalism. (Medawar and Medawar 1983)

vitalist confidence in the spontaneity of life” (Canguilhem 1965, 89). In other words, the philosopher in this position is almost inexorably led to a vitalist *positionnement*. The type of questions she will have for biological science entails that the latter not be conceived of in reductionist terms, although Canguilhem doesn’t explicitly say if a purely physicochemical perspective on biological entities is flawed ontologically, or just methodologically. Nevertheless, this is a loaded, rather a prioristic conception of biological science, actually quite reminiscent of the holism of Goldstein, who Canguilhem openly credits as a major influence.<sup>18</sup>

But what sort of claim is the insistence on the originality of vital facts? Just because it is not naïve ontological vitalism does not mean it is vitalism without any ontology. As this is not an analysis of vitalism in general but of certain issues in the thought of Canguilhem, it may be worth rapidly clarifying this terminology. It seems that, in addition to a kind of ‘de facto’ vitalism of some life scientists who insist on the specificity of the systems they study, including in relation to the objects of other sciences such as chemistry and physics, there is a non-ontological vitalism, articulated in thinkers like Claude Bernard and at times in Xavier Bichat, distinct from an *ontological* vitalism in that the latter will consider the difference between living and non-living beings, organisms and mechanisms, ‘whole-person’ analyses in medicine and molecular analyses, etc., as having ontological significance and/or as being ontologically grounded.

This sense of privacy, of inaccessible interiority, is a crucial feature of many defences of what organisms are and how they are different from machines. This raises the issue of the relation between Canguilhem and phenomenology.<sup>19</sup> That is, while mainstream biologists thought the problem with vitalism was its appeal to immaterial vital forces, or ‘entelechies’ that could not themselves be located anywhere in the spatiotemporal world, there may be a different, more philosophical problem with vitalism, in that it can become an appeal to a kind of foundationalist subjectivity, a Self, a Centre. Interestingly – and idiosyncratically – Canguilhem’s way of renewing vitalism is neither that of the “classical” vitalist, in his terms (which matches the standard critical portrayal of the vitalist), nor that of the subjectivist.

Kurt Goldstein and Canguilhem were, we suggest, onto something when they insisted that rather than say what is unique about the biological, we look to the *observer*: to be an organism is to have a *point of view* on organisms; one which produces intelligibility, which reveals organisms as meaning-producing beings. Goldstein stressed a kind of ‘standpoint’ dimension in ‘the organism’ (in fact, typically the human patient), namely, the idea that we necessarily have ‘points of view’ on our environment and that such points of view enter into the basic definition of what it is to be such an organism. Canguilhem gave further inflection to this idea by speaking of how vitalism is not a mere scientific theory (true or false, refutable, experimental, etc.) but, crucially, something existential, what he calls an *exigence*:

Vitalism expresses a permanent requirement or demand [*exigence*] of life in living beings, the self-identity of life which is immanent in living beings. This explains why mechanistic biologists and rationalist philosophers criticize vitalism for being nebulous

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<sup>18</sup> On Canguilhem and Goldstein, Gayon (1998, 309-310) and Métraux (2005) make some useful observations (Métraux also reproduces a letter from Canguilhem to Goldstein); see also Wolfe (2015b). Gayon notes several further references to Goldstein in (Canguilhem 1965, 11-13, 24, 146); (Canguilhem 2002, 347); (Canguilhem 1977, 138). Canguilhem (along with Merleau-Ponty) played a key role in the introduction of Goldstein into France, through the translation of the *Organism* book, which Canguilhem initiated (the co-translator, Jean Kuntz was his student) and also by translating Goldstein’s article on the “problème épistémologique de la biologie” together with his wife Simone.

<sup>19</sup> For a nice discussion which makes Canguilhem a phenomenologist, see (Gérard 2010); for an equally convincing reading which seeks to draw Canguilhem away from phenomenology, see (Sholl 2012).

and vague. It is normal, if vitalism is primarily a ‘demand’, that it is difficult to formulate it in a series of determinations. (Canguilhem 1965, 86).

Other prominent recent figures like Varela also underline the uniqueness of the biological by rejecting that life can be characterized by providing some empirical criteria and vindicate the need for a concept of life that takes into account the self-producing activities of living systems. Yet he explicitly rejects vitalism and embraces naturalism. In this respect Weber and Varela differ from Kant, who believed that living organization cannot be explained scientifically: “Our immodest conclusion is that Kant, although foreseeing the impossibility of a purely mechanical, Newtonian account of life, nonetheless was wrong in denying the possibility of a coherent explanation of the organism. But this ‘Newton of the Grassblade’ was surely not Darwin.” Instead, they maintain that it is the “convergence of philosophical and biological thinking” which offered “an objective account of biological individuality that joins in circle with the constitution of a subject” (Weber and Varela 2002, 120-121). Thus, they think that the times are ripe for a naturalistic understanding of the living individual. However both authors would probably agree with Canguilhem that there is a difference between knowing life and interacting with it.

## Summary/Conclusions

Does life have a logic that can be scientifically studied? Kant answered no; later biologists have tried to find affirmative answers based either in evolution by natural selection or in self-organization.

In this paper we have tried to show the main problems Canguilhem faced in challenging the existence of a logic of life, namely embodiment, relations of the living with other living organisms, and sympathy to some phenomenological ideas about the nature of life and living bodies, notably their ‘existential’ and ‘attitudinal’ dimensions (even though this definitely does not make him a phenomenologist), although he does not go all the way into literal appeals to the “truth of my body” (Canguilhem 2008b, 475); his residual existentialism (with occasional overtones of anthropocentrism) may hold some lessons for present-day thinking about life.

Perhaps the difference between vitalism and organicism, given the Kantian difficulties for a science of the living, lies in the difference between a complete scepticism (towards some vitalist positions, although most of them are caricatures) and the hope that science can advance, however partially or perspectively, in understanding at least some aspects of biological organization. Although it is clear that most vitalists were in agreement with this position, criticisms (like for example those of logical empiricists like Frank, although closer reading reveals important nuances<sup>20</sup>) have built a straw-man of vitalism as a position that wholly rejects scientific understanding of life and embraces mysticism instead. Canguilhem is not a vitalist according to this excessively partial picture, yet he also does not believe that life has a logic that can be grasped in fixed norms or regulations. And this not only because the norms are internal or internally produced and managed (like in autopoiesis), but also and more importantly because they are variable and their very organization may be contingent in some respects. The recognition that some scientific models may have properties of the kind Canguilhem attributes to living beings – that is to say, they are also emergent, creative, and synthetic, and oblige scientists to interact with their products instead of just analyse or represent them – may be a landmark separating different views of science. Organicism tends to value these models as scientific whereas vitalism as understood by and in Canguilhem, takes a step back from scientific models.

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<sup>20</sup> On such nuances see (Chen, ms. a and b)

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