Canguilhem and the Logic of Life

Arantza Etxeberria and Charles T. Wolfe

[L]a vie déconcerte la logique.
(Canguilhem 1977a, 1)
[T]o do biology, even with the aid of intelligence, we sometimes need to feel like beasts ourselves.

(Canguilhem 2008a, xx)

Abstract 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, we examine two naturalistic perspectives in the 1970s exploring the logic of life (Jacob) and the logic of the living individual (Maturana and Varela). Canguilhem can be considered to be a precursor of the second view, but 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.

Keywords Canguilhem · Vitalism · Biology · Logic of life · Autopoetic/heteropoetic · Analysis/synthesis · Living individual

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1 Introduction

In Canguilhem's philosophy, life disconcerts logic because of its intrinsically self-produced or "autopoetic"[1] 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 with organisms in vivo,[2] but also, 'logic' understood as a concept or scheme of the internal organization and functional integration that underlies the living state. 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,[3] he finds that something goes missing when scientific knowledge aims to understand life by means of an analysis of wholes in(to) parts, even if this may be the only way to proceed. The analysis/synthesis dichotomy is important in Canguilhem's view on life and vitality, as well as for his understanding of medicine, and of the pathological more generally. Life is not analyzable, he contends, i.e., life defies scientific methods because of its inherent plasticity and variability, which are evident in its interactive or relational capacity. The latter is particularly emphasized in his conceptualization of the milieu as forming a constitutive relation with the organism,[4] notably close to, and inspired by, von Uexküll's idea of *Umwelt*.

Canguilhem's understanding of life sets a high value on its capacity to establish its own multiple norms according to its relationship with the milieu, and change them within a range of potentialities to establish a new physiological order when required.[5] This entanglement of organism and milieu in a normative relation 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*

[1] As we discuss below, Canguilhem writes "autopoetic", rather than "autopoietic".

[2] Bernard 1865, Coleman 1985.

[3] Canguilhem's relation to science itself and the knowledge of science 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.

[4] In "The Living and its Milieu," he writes that "the relationship between the organism and the environment is the same as that between the parts and the whole of an organism" (Canguilhem 2008a, 111).

[5] "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" ("Le normal et le pathologique," in Canguilhem 1965, 167). See also Canguilhem 1972, 77, 155.

vital]."[6] What is this originality, then? It is not an ontological specificity (like a Drieschian entelechy), yet it 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 livings beings to act in interpretive, purposive, normative, vital ways. Life "disconcerts logic" (Canguilhem 1977a, 1). He does not reject biology's kind of knowledge as science either, but contends that being alive is the same as being synthetic, as opposed to analytic; and synthetic, like autopoetic, means that it is a system in a state of continuous creativity.

In this essay we examine Canguilhem's ideas concerning the knowledge of life and its consequences for 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 in that it shares Kant's challenge to a science of living beings (Sect. 2). Second, why life disconcerts logic. In order to explicate this, we examine two different perspectives. One is the evolutionary and genetically based logic of life of works such as Jacob's (1973) (Sect. 3). The other is the organizational dynamic logic of the individual of the autopoietic school (Maturana and Varela 1973). Although Canguilhem seems to have preceded and influenced the latter, there are divergences. For example, unlike them, he does not dismiss vitalism (Sect. 4). 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 (Sect. 5).

2 Canguilhem and the Life of an Organism

Since the second half of the nineteenth century there have been two distinctive styles in the study of biology. One of them, physiology, focuses on the living organism, and takes as its main topic the arrangement of parts or organs into an organized whole. The other style, that of evolutionary biology, is concerned with differential changes of traits in populations and lineages through – mainly – genealogical processes. The main exponents of each of these styles or traditions were, respectively, Claude Bernard (1865) and Charles Darwin (1859).[7]

A main philosophical topic of physiology is biological individuality, its delimitation and its cohesion: 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

[6] Canguilhem, "Le normal et le pathologique," in Canguilhem 1965, 156.

[7] 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).

parted ways with the more observational approach of natural history and intended to be scientific. Canguilhem's philosophy of life operates within this physiological framework permeated by the antagonism between mechanist and vitalist views concerning the special status of living beings and the challenge thus posed for the scientific knowledge of life.

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 self-organized, they are very different from artifacts such as a watch, organised according to a designer's plan. But this understanding set a limit for science. Difficulties appear in the project of reconciling this with the conceptual framework Kant developed for natural sciences in his *Critique of Pure Reason* (1781/1787), 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"[8] 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 1790/1987 § 75, AA 5, 400).[9]

Kant's view of the organism as a self-organized system constitutes a challenge for the scientific analytic method. There have been attempts to reconcile teleology and mechanism, such as Lenoir (1982)'s who understood the Kantian tradition as a way to integrate self-organization and teleology within scientific biology. But those naturalizing efforts or scientific explanations of material self-organizing appear to be reductionistic (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. Kant seems to hold that it cannot (and some praise him for this, while others

[8] 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 Sect. 4.

[9] 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 Brilman 2018 for an interesting development of this connection).

reproach him for just the same claim).[10] Canguilhem's approach to this, in some respects similar to Kant's (Brilman 2018), asks how we can know about living beings with the kind of knowledge developed to investigate inanimate beings and the production of technical devices.

Canguilhem's view of living systems as actively self-produced or autopoetic establishes the difference with respect to technological objects. He referred to living beings as "autopoétique" or "autopoetic" in "L'expérimentation dans la 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 "heteropoetic" character of human technical activity in its 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 *minimal* logic – for the representation of the external 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 from the exterior, 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. 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 ontologically they are synthetic, as they dynamically produce themselves in an active and creative way. "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 brushing aside the fact that a living

[10] Respectively, Chen 2019 and Zammito 2006 and 2018. The extent to which Kant 'refuses' naturalization or perhaps just the integration of the life sciences in a mechanistic scientific project (on Kant's 'Newtonian' understanding of science), given that naturalization itself is a debated and non-transparent category, is somewhat controversial: for a different view from ours see Duchesneau 2018 (thanks to G. Bolduc for pointing this out), and the review of this book by one of us (Wolfe 2020).

thing is, in the true sense of the word, a *synthesis*" ("Le tout et la partie dans la pensée biologique," translated in 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) – 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. 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, externally constitutive) vision of biological entities and the ontological vision (strong vitalist, 'rational metaphysics' as Kant might have said) is somewhat muddied 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 regard *other* entities as being, like 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, Introduction 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 – not a 'fact' but a way of life, indeed a contemplative way of life. 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).

Organisms have agency. Yet Canguilhem does not appeal to a disembodied, foundational subjectivity, as we might find in 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.[11]

'Classical' vitalism as described here is what one of us has termed substantival vitalism elsewhere (Wolfe 2011, 2015a). That is, a form of vitalism claiming that living beings are ontologically special, different from the rest of the physical world, and perhaps even unexplainably so. And Canguilhem's diagnosis of an "inexcusable philosophical mistake" is clear enough (whether we explicate this in Spinozist terms – no kingdom within a kingdom – or in physicalist terms – no gaps in the law-like physical world; neither of these are to be confused with a more 'Gaian' sense of 'one world' in which life is coeval with this world). But what should we make, then, of his defence 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.

[11] Canguilhem, "Aspects du vitalisme," in Canguilhem 1965, 95, emphasis ours. To our knowledge, this unusually 'phenomenological'-sounding appeal to 'lived experience' rather than 'life' has not been pointed out in Canguilhem, with the exception perhaps of Paul Rabinow's comments on Canguilhem's "not-so-latent existentialism," in his introduction to the Canguilhem anthology *A Vital Rationalist* (Rabinow 1994, 18).

Canguilhem was aware and acceptant of the biology of his times, 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 on living individuals, we can now consider the reason why life disconcerts logic according to him. For this, we examine some views on the nature of life and organisms in the biology of the 1970s, such as François Jacob's and Humberto Maturana and Francisco 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 Jacob's evolutionary perspective in *La logique du vivant* and Maturana and Varela's organizational perspective 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.

3 The Logic of "Life at Large"

As mentioned earlier, two major traditions of biological thought emerged in the nineteenth century, which articulate and convey distinctively different intuitions concerning life. The evolutionary approach conceives of life as a whole and unique phenomenon, whereas the physiological approach is concerned with the organization of particular living individuals underlying the living state.

In the early 1970s, the two styles of biology generated different and opposed views on whether the organization of living organisms or the phenomena of reproduction and evolution of living entities was primary in biology. A previous clash between the two styles can be also found earlier in the twentieth century, when scientists and philosophers of the Theoretical Biology Club (such as Needham, Woodger, and Waddington, among others) developed a distinctive organicist framework in contrast to the then-emerging framework of molecular biology and the Modern Synthesis in evolutionary biology (Etxeberria and Umerez 2006; Peterson 2017).

François 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. His "logic of life" stands for the then-prevailing genetic and evolutionary consensus that the most important feature of life is reproduction (and evolution), visible in the recent findings in molecular biology. Jacob attempted to reconcile the received tradition of continental European biological thought 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, through a model of life sympathetic to informational formalisms for genetic action.

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." (see Morange 2000; Loison 2018).

For Jacob, the special features of life appear in the evolutionary genetic framework, linked not to the properties of living beings such as studied by classical philosophy (e.g. Thomism) but to the new image made possible by the evolutionary science of the time. It enhances a collective view of life connected as a genealogical succession, rather than mechanistically explainable at the level of the individual 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 (ibid, 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 1ong 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 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. (ibid, 4–5)

Jacob distinguishes explicitly the two views of biology. According to his preferred perspective, evolutionary accounts consider the genealogical connection among living beings in the sense 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: that of the common ancestor, which entails that there is a genealogical connection among forms of life, often represented as the tree of life, and secondly, a claim about the causes of evolutionary processes, such as natural selection (thus understood as explanatory of key features of living beings). The *received view* of the Modern Synthesis reinterpreted both aspects, and by the 1970s many proposed genes as the main ontology, but critics of this view affirm, and Jacob was among them, that evolution by natural selection does not contribute to our knowledge of living organization if it is not by studying development and regulation. After the 2000s, new approaches in systemic and synthetic biology made clear the need to take into account 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 (Jacob 1977). In fact, Jacob and Monod's distinction between structural and regulative genes has been identified by some as a source for the field of evo-devo (Morange 2017, 278). Jacob identifies the genetic program, and the determinism it embodies, as the fundamental element of the emerging new theory of the living. However, he also admits the importance of different levels of integration in the domain of life, called *integrons*, each of them being characterized by some independence with respect to lower ones.

Current systemic approaches search for a complementarity 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* attempts to advance a perspective that would be encompassing and inclusive (Pigliucci and Müller 2010). On the other hand, research on the nature of living organization cannot rely only on formal, mathematical aspects; organizations need to be studied in the material domain, including historical evolutionary events. Jacob emphasizes how biology is an exploration of a logic of life beyond any logic of the living organism. From this perspective, biological knowledge is not concerned with individuality, finality or causal mechanisms; 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 there confronts the view 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 view seems to oblige one to reject finalism, and the centrality of individuality (see Brilman 2018 for a reading of Canguilhem that emphasizes how, in contrast, his philosophy of norms is or can accommodate a philosophy of individuality). In addition, Canguilhem treats the new playground of biological science, namely the informational perspective, as a new logic for understanding life and getting rid of vitalism in order to achieve full continuity of the vital and the inanimate. Canguilhem's review of Jacob's book praises his effort but does not give in, to the contrary.

Gabel quotes Jacob saying that only in the fifties did Canguilhem begin to take account of 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 his review Canguilhem remains sceptical about the informational logic of life. Indeed, as Morange has maintained, molecular biology does bear out the continued relevance of some of Canguilhem's ideas (even if Canguilhem did not analyse developments in biology adequately). Also, philosophical positions may be modulated, but are not dictated by scientific facts, and this is

evident in Canguilhem's case, as when he 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 a 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.[12] 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."[13]

4 The Logic of the Living Individual

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 significant movement in search of systemic and organizational principles, as is made evident by current advances in systems biology, synthetic biology and the extended evolutionary synthesis. Historically there are (at least) two organizational traditions: the physiological one starting with 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 have connections to Kant's view of organisms in his *Critique of Judgment* in their ways of arguing holistically and/or mereologically, 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 individual. Maturana and Varela's notion of autopoiesis can be considered to be an answer to Jacob's picture that especially rejects the informational perspective in biology, a view shared by the Developmental Systems Theory in philosophy of biology, especially after Susan Oyama (1985).

[12] Jacob 1970, 320 (all translations are ours unless otherwise indicated). 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.

[13] Canguilhem 1971, 25. 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.

Their narrative on the logic of the living individual, clearly influenced by Jacob's book, deliberately disputes many of his positions about the logic of life and the centrality of 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, in particular in work in cybernetics and artificial systems that aimed to explore living phenomena through synthetic and systemic models and simulations. (see however Canguilhem's remarks on cybernetics in his essay on the emergence of the concept of biological regulation, in Canguilhem 1977b, 82). It is within this research field that Maturana and Varela's contributions flourished.

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, additionally associated with Kant's understanding of organisms, 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.[14] Other clear associations are with the cybernetic movement, especially with second-order cybernetics (on this relation see Bich and Etxeberria 2013).

The notion of autopoiesis was proposed by Maturana and Varela[15] (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, which constitutes the individual living being's identity as separated from the surroundings (Varela 1981). The autopoietic approach to life criticises evolutionary and molecular biology, and focuses in contrast on, autonomy and identity, aiming to naturalize them as marks of life, prior to reproduction or evolution. The autopoietic theorists claim that living organization has primacy with respect to the other phenomena associated with life (Etxeberria 2004). The status of individual identity, constituted by the system itself, and not by anything external (heteropoietic), is a central idea of this approach. As we noted, some of the distinctions they stress, for example that between autopoiesis and heteropoiesis, already appear in Canguilhem's *La connaissance de la vie*. 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, in the name of their logic of self-production. This is important because, according to

[14] Canguilhem sits somewhat unsteadily here, given that he is less of a "naïve (ontological) organicist" than the rest.

[15] Both Francisco Varela and Humberto Maturana have separately claimed to have coined the term, referring to different sources for the invention. Here we suggest that they probably conceived the notion based on those passages of Canguilhem's *La connaissance de la vie* in which he describes living systems as autopoetic.

them, vitalism focuses on entities bearing properties, in contrast with the relational approach they defend in which properties appear as a result of 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 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.[16]

One difference between Canguilhem's usage of the term 'autopoetic' 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 autopoetic 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 analysis.

Although Maturana and Varela also recognise the difficulty of knowing life, "regarded as rationality's blind spot" (Brilman 2018, 40), they rely more confidently on the possibility of exploring the autopoietic organization through the construction of networks and other artificial systems that will allow for the exploration of important aspects of self-production. 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 different sources and exploring their emergent and creative properties. As a result, the concept of scientific knowledge associated with many fields is far from the idea that the aim of models is to represent reality. Rheinberger (2015) has reflected on the nature of the different epistemological objects produced by science to explain life, and 'organizational' theories in the philosophy of biology (see Moreno and Mossio 2015; Bechtel 2007) have contributed to understand their epistemological and ontological properties.

Many of those systems can in some ways be creative or autopoetic as well, at least in that the complexity of their organization and their operation is opaque to

[16] We do not discuss Canguilhem's relation to ecology here for want of space but in his rather little-known essay "Qu'est-ce que l'écologie?" (1974) he expresses a rather cautious, at times deflationary attitude towards what one might term the more Romantic and/or political determinations of ecology, without thereby dismissing it out of hand. It is tempting, however, to see his reflections on organism and environment as lending themselves to an almost 'Gaian' type of understanding, according to which nothing that we know on Earth as natural can be understood as such without the intervention of life: biological phenomena permeate and intervene in the physics and chemistry of all the natural world, so that biology is fundamental.

rationality. 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 highlights the presence of a specifically *relational* dimension.

In considering these matters, Hacking (1998, 202) highlights the relational character of Canguilhem's anti-Cartesian thinking about machines: "He takes all tools and machines to be extensions of the body, and part of life itself" (Hacking 1998, 202). In this sense, Canguilhem's approach stresses that there may be an aspect of life which cannot be grasped only by considering the system's properties (as when we question whether machines and living beings are or not similar). On the contrary, what is considered is a certain relation to the milieu (Gayon 1998; Etxeberria 2020). Something that is still opaque to logic.

5 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; this does not always have further ontological and methodological implications. Canguilhem's work appears to be among those defending that view, although he is critical of … uncritical ontological vitalism. At the same time, 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 replace the definition of life with 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, yet not just playfully, given the circumstances – as a vitalist.[17] 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, 13) 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

[17] 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…" and when he presents the book itself as a "defense of vitalist biology" (Canguilhem 1977a, Avant-Propos, 1). 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.

> by positivist philosophers like Philipp Frank, as well as by Marxists (Marcel Prenant) that it is a "reactionary biology" (Canguilhem 1965, 97, 2008a, 72)

At the same time, Canguilhem was comfortable identifying himself with the equally problematic figure of Nietzsche, and his reference to Marxist criticisms of vitalism should not be taken to mean outright agreement. In the same essay, Canguilhem asserts from the outset that when the philosopher inquiries 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, 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, *vitalism is not like geocentrism or phlogiston: it is not refutable in quite the same way*.[18]

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 vitalist confidence in the spontaneity of life."[19] 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.[20]

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[18] Canguilhem, "Aspects du vitalisme," in Canguilhem 1965, 84; Canguilhem 2008a, 60. The Medawars note that it is hard to devise an experiment to 'refute' vitalism (Medawar and Medawar 1983).

[19] "Aspects du vitalisme," in Canguilhem 1965, 89.

[20] 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: Canguilhem 1965, 11–13, 24, 146; Canguilhem 2002, 347; Canguilhem 1977b, 138. Canguilhem (along with Merleau-Ponty) played a key role in the introduction of Goldstein into France, through the translation of the Organism book (Goldstein 1934/1939), 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.

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 (Wolfe 2019), 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, but as we mentioned earlier, one should rather think in relational terms. This raises the issue of the relation between Canguilhem and phenomenology.[21] 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, whether this is equated with life itself (as in the old Aristotelian motif that 'the soul is life') or is seen as a precondition thereof. Interesting – 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 and vague. It is normal, if vitalism is primarily a 'demand', that it is difficult to formulate it in a series of determinations ("Aspects du vitalisme," in Canguilhem 1965, 86).

[21] 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.

An *exigence* is not a vital 'fact' in a static sense but rather something processual and indeed agential. 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 as autopoietic.

6 Conclusions

In this paper we have shown some of the problems Canguilhem faced in challenging the existence of a logic of life that can be known by science, in contrast to Jacob and Maturana and Varela, who are more confident than him, but with very different arguments. Some of Canguilhem's difficulties derive from embodiment, relations of the living with the milieu and with other living organisms, and his apparent sympathy for certain phenomenological approaches to 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 doesn't go all the way and literally appeal to the "truth of my body", as Merleau-Ponty did (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,[22] lies in the difference between a complete skepticism (towards some vitalist positions, although most of them are caricatures) and the hope that science can advance, however partially or perspectivally, 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

[22] Aside from some of the difficulties mentioned earlier, the specific 'conceptual difficulty' lies in the way some non-reductionist programs like Varela's strongly invoke the Kantian pedigree, while somehow overlooking the fact that a core element of the Kantian concept of organism is that it cannot be the object of a causal-naturalist science.

nuances)[23] 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. We suggest that 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 analysing or representing them – may be a landmark separating different views of science. Organicism tends to value these models as naturalistic, whereas vitalism as understood by and in Canguilhem, takes a step back, and stresses their relational nature.

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[23] On such nuances see Chen 2018, 2019.

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