

Claude Bernard and his concept of physiological function

Claude Bernard e seu conceito de função fisiológica

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Resumo: A maneira pela qual Claude Bernard entendia as atribuições funcionais próprias da Fisiologia pode ser melhor compreendida considerando isso que, na atual Filosofia da Biologia, é caracterizado como a concepção das funções como papéis causais. Ademais, a maneira pela qual Bernard explicava a noção de função serve para mostrar a suficiência dessa concepção do conceito de função na Fisiologia, e também para mostrar que a concepção etiológica do conceito de função não considera os pressupostos sob os quais são aceitas as imputações funcionais que ocorrem na Fisiologia. A abordagem de Bernard, elucidada neste trabalho, afirma que a noção de função não é uma noção histórica e que as análises funcionais são apenas uma forma particular de análise causal.

Palavras-chave: Bernard, C.; Fisiologia Experimental; Função Biológica; Papel causal; Teleologia intra- orgânica.

Abstract: The way in which Claude Bernard understood the functional attributions proper to Physiology can be better understood considering what, in the current Philosophy of Biology, is characterized as the conception of functions as causal roles. Moreover, the way in which Bernard explains the notion of function serves to show the su-

fficiency of this conception of the concept of function in Physiology, and to show that the etiological conception of the concept of function does not consider the assumptions under which, the functional imputations that are given in Physiology, are admitted. Bernard's approach states that the notion of function is not a historical notion and that functional analyzes are only a particular form of causal analysis.

Keywords: Bernard, C.; Biological Function; Causal Role; Experimental Physiology; Intra-organic Teleology.

Claude Bernard was not the founder of Experimental Physiology. In the seventeenth and eighteenth centuries, an experimental science of living beings had begun to develop and, there, the primordial of an Experimental Physiology were already sprouting (cf. Grmek, 1990; Salomon-Bayet, 2008). Moreover, even without considering pioneers like William Harvey, and Antoine Lavoisier himself, it can be said that there is already an Experimental Physiology in François Magendie (Morange, 2017, p.147): teacher and mentor of Claude Bernard (cf. Canguilhem, 2015[1957], p.758). As there was also an Experimental Physiology in Johannes Müller: initiator of that tradition of German Physiology, which development was parallel to the growth of French Physiology; and that gave rise to figures as relevant as Justus Von Liebig, Carl Ludwig, Emil Du Bois- Reymond or Hermann Helmholtz (Holmes, 1999). Physiologists, all of them, whose experimental results were no less relevant, although perhaps less paradigmatic, than those attained by Bernard (cf. Canguilhem, 2015[1957], p.758-9). In other words, Claude Bernard did not meant for Physiology what Darwin meant for Evolutionary Biology.

Before the release of *On the Origin of Species* (Darwin, 1859), there were, of course, many naturalists who enunciated evolutionary theses. However, before that moment, there was no disciplinary domain, a field of Baconian cooperation, we could say, that were articulated by the goal of reconstructing and explaining evolutionary processes (cf. Bowler, 1996; Caponi, 2011). There was, however, and as I just said, an Experimen-

tal Physiology before the works of Bernard. These latter were contributions, indisputably crucial, to an already existing science. Nobody like him, nevertheless, understood so early, and so clearly, what were the most basic theoretical assumptions, the specific cognitive targets, the most important methodological rules, and the most general and central articulating concepts, of that disciplinary field. Bernard did not found Experimental Physiology, but there is no doubt that besides contributing divisively to the progress of that discipline, he also allowed us to understand its foundations and guiding principles with a precision and perspicacity that was unprecedented and that, even until now, has not had many emulators of its same excellence. Claude Bernard was not the founder of Experimental Physiology, but he was the forerunner of that not always well-attended chapter of Philosophy of Biology that, following Mayr (1961), we could label 'Philosophy of Functional Biology'.

I use that expression because the epistemological sagacity of Claude Bernard surpasses Physiology itself. He not only demarcated the first pathways of Experimental Physiology; but he even indicated the direction that would lead to the development of all that field of Biology that Mayr (1961) distinguished from 'Evolutionary Biology'. This can be seen in relation to various issues. Consider, for example, not only the way in which Bernard understood the relationship between the physical-chemical sciences and the biological sciences; but also the way he understood the structure of those causal explanations that could occur in the domain of Experimental Physiology. Here, however, I will only deal with the way in which Claude Bernard understood and justified the concept of biological function and the nature of functional attributions. For that, I will give particular attention to the idea of intra-organic teleology, which can be characterized as the organizing key, and as the *raison d'être*, of those functional attributions made in Physiology.

Intra-organic teleology

One of the clearest starting points of Claude Bernard's epistemological reflections, was the assumption that "all the

phenomena of a living body are in a reciprocal harmony such that it seems impossible to separate a part of the organism without immediately generating a flaw in the whole” (Bernard, 1984[1865], p.99). However, it is very important to stress that Claude Bernard’s commitment to organicism went far beyond the mere acceptance of a difficulty. Bernard assumed that this way of understanding living beings was a central postulate of Experimental Physiology (Reiss, 2009, p.116): a supposition that could never be disregarded, and that should guide all physiological inquiry. This is very well settled in Introduction to Experimental Medicine, where Claude Bernard (1984 [1865], p.137) says:

The physiologist and the physician must never forget that the living being forms an organism and an individuality. The physicist and the chemist, unable to place themselves outside the universe, study bodies and phenomena in isolation, in themselves, without being forced to refer them necessarily to the whole of nature. Nevertheless, the physiologist, finding himself, on the contrary, located outside the animal organism of which he sees the whole, must take into account the harmony of that set at the same time as he tries to penetrate inside it for understanding the mechanism of each one of its parts. Hence, the physicist and the chemist can put aside all idea of final causes in the facts they observe; while the physiologist must admit a harmonious and pre-established purpose in the organized bodies, all of whose partial actions are interdependent and mutually generative.

That is, quite clearly, the same idea expressed by Cuvier (1992[1812], p.97) in his Principle of the Correlation of Forms in Organized Beings. As this principle establishes: “all organized being make up a whole, a single and closed system, whose parts are all mutually connected, and converge to the same definitive action by a reciprocal reaction” (cf. Caponi, 2008, p.46, Reiss, 2009, p.98). This principle, as explained by Pierre Flourens (1838, p.xxx-xxxi) in his “Éloge de Cuvier”, stated that: “In a machine so complicated, and so essentially one, as that constituted by the body animal, all the parts must necessarily be mutually arranged, in order to connect, to adjust among themselves, for making together a being, an unique system”. This makes it clear that there, in the ‘law of Cuvier’, reverbera-

tes, as Paul Janet (1882, p.64) highlighted, the concept of organized product of nature that Kant introduced in his Critique of Judgment. “An organized product of nature,” says Kant (KU §66) there - an organism, we can understand -, “is that being in which everything is goal, and reciprocally, also mean”. In an organized product of nature, “each part, as it exists only as results of all the others, is also exists for the others and for the whole” (KU §65)¹⁷; and it is the same idea of organism that we find in Bernard’s Introduction.

That is to say: both Cuvier’s project (1805, p.46) and Bernard’s project (1878, p.340) were focused, as indeed all possible Physiology should do, on this adequacy of structure and function that Kant had considered inherent to the definition of organism (Quarfood, 2006; Huneman, 2014). Kant had glimpsed that, without the notion of organized product of nature, our understanding could never move from the domain of mere physics to the domain of what we, now, call ‘biology’. Bernard, no less than Cuvier, accepted and ratified that presumption. Thus, in the Lessons on the phenomena of life common to animals and plants (Bernard, 1878, p.340), he said “every act of a living organism has its aim within that organism” (cf. Grmek, 1965, p.230; Mazliak, 2002, p.303). Therefore, the physiological inquiry should be guided by the assumption that each element, and each organic reaction, have a role to play in the constitution and persistence of the organism in which these elements and reactions are set; and that is what Bernard (1878, p.340) described as “a kind of particular finality”, or “intra-organic teleology”.

Thus, “if the living organism is decomposed by isolating its different parts, it is only to facilitate the experimental analysis and not to conceive those parts separately” (Bernard, 1984[1865], p.137). Because, “when one wants to give to a physiological property its value and its true meaning, it is always necessary to refer it to the whole and not draw any definite conclusion if it is not in relation to its effects in relation to that whole” (Bernard, 1984[1865], p.137). Moreover, as we read in his latest lessons, “the grouping of vital phenomena into functions,” is the

¹⁷ Concerning this point of Kant’s philosophy, see: Huneman (2006), Steigerwald (2006), and Rosas (2008).

“expression of that thought” according to which: “every act of a living organism has its aim in that organism” (Bernard, 1878, p.340). It is the expression of that teleological perspective that today, no less than in the second half of the nineteenth century, continues to guide the work of the physiologist (cf. Duchesneau, 1997, p.147; Weber, 2004, p.38). A function, said Claude Bernard (1878, p.370), is nothing but “a series of acts or phenomena grouped, harmonized, in view of a given result”. Nevertheless, although the concurring of “the activities of many anatomical elements” is necessary for its accomplishment, a function cannot be reduced to the “mere sum of the elementary activities of juxtaposed cells” (Bernard, 1878, p.370). On the contrary, to individualize a function, so that a set of organic activities can be described as fulfilling a function, we must consider them as “harmonized, concerted, in order to concur in a common result” (Bernard, 1878, p.370). A common result that is just the constitution and preservation of the vital order.

There, with his well-known clarity, Bernard shows how the causal and the functional perspectives should be closely integrated in the work of the physiologist. This latter should study the causal mechanism that govern the operation of the different components and subsystems of the organism. Thus, in some cases, the best procedure can be the isolated reproduction, *in vitro*, of that reaction which, *in vivo*, always occurs entangled and functionally integrated with the other organic phenomena (Bernard, 1984[1865], p.218-9). That is the basis of an interminable movement, back and forth, between the test tube and the organism itself; and there, the scientist should manage an inextricable connection between causal explanation and functional analysis (Bernard: 1984[1865], p.138; 1947, p.197). Thus, to suppose that by pointing out that dialectic, Bernard shown an epistemological indecision (Pichot, 1993, p.996-7), is to ignore a trait inherent to physiological inquiry. There, the functional perspective is not only based in the causal explanation, but it also boosts the expansion of the causal perspective. The functional perspective can help to reveal causal circuits that would be indiscernible through a purely causal analysis; and the causal analysis gives to the functional analysis

its indispensable foundations. For ratifying a functional attribution, it is always necessary to identify the causal circuit by which the supposed function is performed.

Two ways of thing about functions

If we consider the contemporary literature on the concept of function¹⁸, we can say that Claude Bernard thought the functional attributions of Physiology in a way that has been contemplated by the so-called 'concept of function as a causal role'³¹⁹. This way of understanding the notion of function (cf. Lewens, 2007, p.531) is frequently opposed to the so-called 'etiological concept of function' (cf. Garson, 2006, p.537; Longy, 2007, p.90; Lewens, 2007, p.531; Gayon 2010, p.129). According this latter point of view, the function of an element within a system is the effect whose production caused, or motivated, the incorporation of that element into that system (Gayon, 2007, p.69; Longy, 2007, p.89)²⁰. Meanwhile, according to the first conception, usually attributed to Robert Cummins (1975), a function is just the causal role that a sub-process plays within a larger, and more complex, causal process. And it can also be said that, under Cummins conception, a function is the causal role that is played by the operation of a particular subsystem within the operation of a larger system (Gayon, 2007, p.68; Longy, 2007, p.90).

From the etiological perspective, the top tube of the bike would have the unique and specific function of reinforce the general structure of that vehicle. To carry an extra passenger would never be a function of that component of classical bicycles. Despite the occasional use that can be given to that part

¹⁸ Good reviews of that literature can be found in papers of Allen et al (1998), Gayon (2006), Lewens (2007), and Garson (2008).

¹⁹ In fact, this way of referring to the systemic conception of function was proposed by Karen Neander (1998, p.327): one of its critics. I think, however, that, far from being pejorative, this terminological option is fully adequate.

²⁰ The etiological conception was initially enunciated by Larry Wright (1972; 1973); and later was adopted in Philosophy of Biology by Ruth Millikan (1989, 2002) and Karen Neander (1998; 1999). Although it was also supported by many other authors (cf. Buller, 1999).

of the bike, its function, in the strict sense, its ‘proper function’, would be that effectively intended in the design process of this object. That is to say, that tube is there because it has the effect of strengthening the structure of the bike. Meanwhile, in the case of any biological structure, which replaces the reference to an intentional design process, is the reference to that unintentional process of design that is natural selection. Therefore, we will decide if a coloration has an aposematic or cryptic function considering what was the selective pressure that rewarded it. If it was its cryptic effect, so, we will say that this effect is its function; but if what was rewarded were the aposematic effect, we will consider this latter effect as the (proper or selected) function of that coloration.

Thus, both in this case and in the case of an artifact constructed by an intentional agent, the etiological perspective leads to think that a functional attribution always obeys this scheme that Wright (1972, p.211; 1973, p.161) highlighted:

To say “the function of x (in the system or process z) is y” presupposes that:

1. X produces or causes y.
2. X is there (in z) because it produces or causes y.

When z is a system, or process, conceived and built by an intentional agent, the clause ‘[2]’ means that this designer placed x, in z, in the way she did, because she expected or desired the occurrence of the effect y. Therefore, carry an extra passenger would not be a function of bike’s top tube; it is just a possible accidental use not considered by the warranty if resulting in any damage of the bike. Meanwhile, in the case of biological systems, the clause ‘[2]’ refers to the natural selection process that configured z and x rewarding the production of y. Thus, in the context of life sciences, functional attributions, according to the defenders of the etiological perspective, have to obey to this particular variant, or specification, of Wright’s scheme:

To say “the function of x (in the system or process z) is y” presupposes that:

1. X produces or causes y.
2. X is there (in z) because natural selection rewarded the occurrence of y in the ancestral forms of z.

It is, in fact, a very restrictive way of understanding functional attributions. If we adopt it, many functional attributions that we accept in contexts where there are not at stake neither living beings nor artifacts, should be considered illegitimate. We should treat them as abuses of language; or as metaphors that it would be better to avoid. Such is the case of what happens when someone says that ‘the phases of the moon have a function in the movement of the tides’. However, I will refer to this point a little later. Now I just want to point out that the etiological conception of functional attributions is incompatible with many biological uses of the term ‘function’. Such is the case, for instance, of the biologically convenient, but not selected, effects of those structures that Gould and Vrba (1982) called ‘exaptations’. The followers of the etiological conception of functions would tell that to characterize these not selected effects as being functions, would be an improper way of speaking. Moreover, if based on that same way of understanding functions, we examine the functional imputations that proliferate in the discourse of Physiology, we would have to say that most of them lack justification. The physiologists formulate them without waiting for any possible justification based on explanations by natural selection (cf. Davies, 2001, p.112; Weber, 2003, p.37).

In fact, the Theory of Natural Selection had no role in the justification and acceptance of William Harvey’s theory on the function of cardiac movement in blood circulation. Obviously, he did not have any role initially; but neither was the case, after 1859, of anyone considered that this Darwinian justification were necessary. Worth the same for the function of the pancreatic fluid in the emulsion of fats, which had been established by Claude Bernard. This function was established, and accepted, regardless of any consideration concerning the evolution of the pancreas. In both cases, the relevant thing was to confirm that the processes alluded by Harvey and Bernard did

indeed happen in the way they described them; and, above all, that the items to which they had assigned the functions under consideration, effectively performed, in those processes, the causal roles that those functional imputations indicated. There, it is implied a way of understanding the functional attributions that seem convergent to the conception of function as a causal role. According to it:

To say “the function of x (in the system or process z) isy” presupposes that:

1. X produces or causes y.
2. X has a causal role in the occurrence, or in the operation, of z.

Thus, given any causal process (such as the operation of a machine, a physiological reaction, the explosion of an airplane when taking off or the movement of the tides), it can be said that an element has a function within that causal process, if the operation or presence of that element has a causal role in its occurrence or fulfillment. If the movement of the pedals is transmitted, through the chain, from the bigger front gear to the back gear, driving the bicycle, therefore, we will say that the function of the pedals is to impulse the bike. If the cardiac movement circulates the blood inside the organism, we will say that this is its function in the circulatory system. Likewise, if a metal plate inadvertently left on the runway of an airport, is sucked by the turbine of an airplane that is taking off, making it to explode, then, we will say that the metal plate had a function in the accident. Finally, if we determine that, because the gravitational attraction that moon can exert on the large masses of liquid, this celestial body affects the ebb and flow of tides; we will also say that it has a function, a causal role, in these processes.

It is not being said, however, that the plat was deliberately placed there, on the runway, for generating an accident intentionally planed by a terrorist group lacking financial support. Neither is it said, of course, that the *raison d'être* of the moon is producing the tides; and that it was created, or placed there, for it. The concept of function should not be confused with the concept of *raison d'être*. Contrary to what the proponents of

the etiological conception assume, the function of something is not always its *raison d'être*. In fact, we are just saying that the moon intervenes in such process analogously to how the metal plate could have had a causal role in the explosion of the plane; and it is only by reference to those particular processes that we attribute a function to these elements. Given a greater process, a particular sub-process acquires a functional relevance within the former, without implying that the latter was there because of that participation. From this perspective, the functional attribution does not suppose any hypothesis about the origin or construction of the functional system; nor about the origin or construction of the item to which the function is imputed.

In addition, it is also important to emphasize that making a functional attribution does not imply denying that the imputed item may be the object of another different functional attribution. Mr. Di Pietro can be a manager of a banking agency; and, at the same time, he can be member of a gang that is planning the theft of that same agency. What really matters is that the processes that serves as references for those functional attributions could be clearly identified. Causal roles must be attributed within well-defined and clearly individualized processes. Functional relationships are triadic predicates: an item *x* has a function *y* inside a process *z*; and it can happen that that same item *x* had a function *y'* inside a process *z'*. Not recognizing that necessarily triadic character of all functional attributions had generated most of the confusions about the concept of function, giving fuel to the etiological conception.

To understand functions as causal roles implies that functional attributions can be made, not only in relation to organic processes or artifacts constructed by intentional agents, but also in relation to any causal process. That is what has motivated the objection that this concept of function is too tolerant or promiscuous. Assuming it, one can speak, as in fact it is usually done, about the function of the clouds in the water cycle or about the function of the movement of the geological plates in the tectonic system. Nevertheless, for the defenders of the notion of function as a causal role, that tolerance is not a difficulty. On the contrary, this apparent promiscuity shows that this way of understanding

the concept of function contemplates all the varied contexts in which we can perform, and in fact we perform, functional imputations (Davies, 2001, p.85). The functional attributions, the imputations of causal roles, are ubiquitous because the world is a network of causal processes that can be functionally analyzed. They may be analyzed by distinguishing the causal roles played in them by their moments or components.

Concerning this point, the apparently radical attitude of Margarita Ponce (1987, p.106) still seems to be the most correct and coherent. According her, in a functional analysis the functional entity is a phenomenon, or fact, that we understand by virtue of its consequences; and “the function is the effect of the functional thing that contributes to the attainment of the state of things, or of the phenomenon, whose causes we are searching”. I, however, would prefer to express that idea by saying that, in a functional analysis, the functional entity is the phenomenon or element whose contribution or intervention in the occurrence of a particular process we want to understand or highlight. At the same time, the function is the contribution or intervention of that entity in the process that is being considered. Whenever there are causal explanations and attributions, we could say, it will be always possible to make functional analysis and functional attributions. That is so because those analyzes and those imputations, as Margarita Ponce (1987, p.103) also said, are only the reverse of those causal explanations and attributions.

Physiological function

Nevertheless, to understand the notion of physiological function that we find in the texts of Claude Bernard, we have to insist on what I described as the triadic character of the functional imputations. Remembering, also, that the same element can be object of different functional imputations by virtue of being considered by reference to different processes or causal systems. If the noise produced by a heart beating does not seem to be a function of that movement, it is because we are assuming that the process of reference is blood circulation or the functioning of the organism as a whole. However, if the reference process

were the functioning of the polygraph, the lie detector, we may consider that the heart's noise has, indeed, a function in that process. However, this process is not a physiological process. This is a fact that Margarita Ponce (1987, p.106) also emphasized: in some way, functional attributions depend on the interest of the researcher. They depend on the process that the researcher is interested in reconstructing and analyzing.

In the case of Claude Bernard, as in the case of all Physiology, this process is the generation and preservation of a vital order relatively independent of the environmental contingencies. That is the guiding principle of all the functional imputations formulated in Physiology (Goldstein, 1951, p.340; Polanyi, 1962, p.360). The preservation of the vital order, the persistence of the organism, is the “result glimpsed by the spirit” from which the physiologist “establishes the nexus and unity of these phenomena” that she analyzes (Bernard, 1878, p.370). It can be said, therefore, that it is the observer that “makes the function” (Bernard, 1878, p.370). However, it could be better to say that Physiology itself establishes what should be the target of all its functional analysis. So, if it the physiologist obeys to this guide, there won't be any risk of ‘promiscuity’. ‘To have a function’ is always ‘to have a function within a certain process or system’. Therefore, whenever the process of reference is the constitution and preservation of the vital order, we arrive to the physiological concept of function that is subtended in the works of Bernard: the physiological function of an organic component, or process, is its causal role in the constitution and preservation of the vital order. Considering that, it may be said that the functional attributions that are typical of physiology, obey to this schema:

To say that the ‘physiological function of x, in the organism z, is y’ implies accepting that:

1. X produces or facilitates y.
2. Y has a causal role in the constitution or preservation of the vital order of z.
3. X is part of z.

It should be mentioned, however, that in this schema we find two new elements that deserve to be clearly highlighted. As we have seen above, when functional attributions are considered under the scope of the conception of functions as causal roles, such attributions are supposed to presume two clauses, which I called [1] and [2]. Regarding [1], the scheme that I am introducing now, does not show any distinctive note. There is, nevertheless, a first peculiarity in [2]: there, it is specified that the process of reference is the constitution, or the preservation, of the vital order. Nevertheless, besides that, in this scheme there is a third clause, [3], which merits a particular justification.

That the functional item is a part of the organism means that the functional performance of such item, its way of operating, is constrained and made possible by its integration in that organism. That this is a kind of consent that should be made to the 'organizational conception' of functions (Moreno & Mossio, 2015, p.73). Starting from the general conception of functions as causal roles, but integrating that restriction that is added to the one already incorporated in [2] on the process of reference of the functional imputations proper of Physiology, one can define the physiological concept of function without appeal to other specifications. Accepting [3], what fulfills a function, in the sense of contributing to the life cycle of an organism, but without may be considered as a part of that living being, or moment of its life cycle, would be considered a resource of that organism or that life cycle. It is worth noting that in order to attribute a biological function to a resource, it is necessary to suppose a conception of the functions that is less restrictive not only than the etiological but also than the organizational one. The conception of

functions as causal roles complies that requirement without preventing us from making further specifications.

It is true, however, that Claude Bernard himself never pointed out that element of functional imputations. Nevertheless, as what I am proposing here is a reconstructive elucidation of the way in which Bernard thought about functional attributions, I allowed myself to emphasize that the conception of

function that he supposed was not refractory to that specification that I introduced in [3]. On the other hand, what he really did, was to indicate rather clearly that point of convergence of every physiological functional analysis is the preservation of the vital order. The idea of intra-organic teleology, to which I referred above, is the expression of that way of thinking. According to that, the organism is “a microcosm, a small world, where things are made for each other” (Bernard, 1878, p.340); and Bernard assumed that it was by virtue of the preservation of that microcosm that physiological functions should be individualized. The constancy of the internal environment was the notion that operationalized this presupposition: contributing to the vital order materialized in contributing to the preservation of that constancy; and the physiologist had to individualize that contribution in each structure and process that he studied. As Françoise Gaill explained (1987, p.247):

According to Claude Bernard, the organs exist for regulating the conditions of cellular life, both qualitatively and quantitatively. This conception recognizes the autonomy of the constituent elements; and it is through the mediation of an internal environment that all these elements, the parties, remain solidary. Mechanism and finalism coexist in the organism; but in a redefined way. The purpose exists, indeed, but in an inverted way. Because, in that conception, the organism is built in view of the elemental life.

A last remark

According to what I have been saying, the generation and preservation of the vital order would be the guiding principle that rules those functional imputations that are inherent to physiological discourse. However, saying just that can be a bit vague; because, in fact, the whole discourse of Physiology has a functional character and everything in it is organized in order to explain the generation and preservation of that vital order (cf. Gayon, 2010, p.125). Thus, each organic process is considered by virtue of its possible contribution to the vital order; or, when the inquiry focuses on pathological processes, by virtue of their possible contributions to the unbalance or disruption

of that order. The generation and preservation of the vital order, to put it another way, is not only the target of functional imputations: it is the main objective, the central concern, of all Physiology. That is why the functional perspective rules, almost integrally, the language of this science; and this tells us something about what we can characterize as the ideal of natural order of modern Physiology. I allude, of course, to the notion coined by Stephen Toulmin (1961, p.44).

In *Foresight and Understanding*, Toulmin(1961, p.57) featured the ideals of natural order as principles that (for a given theory or for a specific domain of inquiry) define the horizon of constancy or regularity in relation to which it is necessary to situate the facts that such theory, or such domain of inquiry, assumes as needing and capable of explanation. Supposing those principles such facts should be assumed as deviations from that ideal order. A fact, we might say, is the unexpected that breaks into a horizon of permanence that the theory, or the domain of inquiry that we are considering, accepts as something obvious and self-explained; and, to say this, is the same as to affirm that a fact is that which, given an ideal of natural order, appears as needing explanation. Thus, as paradigmatic example of those ideals, Toulmin (1961, p.56) proposes the Principle of Inertia: An object will remain at rest, or in uniform motion in a straight line, unless acted upon by an external force.

This first law of Newton, says Toulmin (1961, p.62-3), indicates that, for Newtonian mechanics, the permanence of a body in any of these two states is what is expected, normal, or natural: something that does not require any explanation. What must be explained, what must be the object of interrogation, is, therefore, the deviation from the rest or of from the uniform and rectilinear movement; and Newtonian mechanics offers the explanatory resources to answer those questions, allowing us to explain and calculate the deviations from that ideal state by appealing to additional laws such as the Law of Gravitation. Nevertheless, like other aspects of scientific grammar, ideals of a natural order are regional: different scientific theories or, more generally, different disciplinary domains, may obey to dif-

ferent ideals; and it is on the horizon of those different ideals of a natural order that the explanatory objectives of each theory, or of each specific research domain, must be understood. What in each case is considered as obvious, as natural, in itself explicable, is different; and that also makes different what, in each case, will be considered as a detour from that natural state that should be explained.

Different Ideals of Natural Order, by establishing the most diverse discriminations between what needs and does not need explanation, generate and commit us to different explanatory endeavors; each one with its perplexities and its fundamental questions. Thus, if we consider that the central problem of Physiology is the explanation of the constitution and preservation of the vital order, we can then say that, for Physiology, the absence of that order is what does not need any explanation. The basic question of Physiology, to put it another way, seems to be always Why life rather than death? The latter, death, defines what, for Physiology, would be the natural and most probable state of things: a state that, at first glance, it is not necessary to explain; because what happens in it is something from which Physics and Chemistry already give us an explanation. What is necessary to explain is the fact that, notwithstanding the greater probability of death, the order of life, despite its fragility, lasts. The life, understood as that autonomy that the living one preserves against the contingencies of the environment, appears as the improbable, and problematic, deviation of a state of things that is considered already explained by Physics and by Chemistry.

This, however, is not typical of all Physiology. That ideal of natural order to which I am referring is the one that was established by imposing the perspective proper to Experimental Physiology that Bernard advocated. The Experimental Physiology, as Bernard (1878, p.56-7) remarked, supposes the negation of the vital forces (cf. Bognon- Küss, 2012, p.413); and from its perspective, life can only be a result of certain forms of organization of matter. Unlike Buffon (2007[1756], p.722), for whom life was a primitive and irreducible property of a spe-

cial kind of matter, and unlike Bichat (1994[1800], p.57), for whom life was an unexplained force whose existence had to be assumed for explain the vital phenomena, Bernard's program clearly put life on the side of the effects to be explained. For his Experimental Physiology life was not the cause that explained the effects to be studied (Bernard: 1984[1865], p.109; 1878, p.56-7). There, life appears as a fragile order: a labile order whose existence, so improbable, asks for explanation. Therefore, this improbable result that is life becomes the axis of all the causal circuits that the Physiologist should analyze; and it is in this the *raison d'être* of that functional perspective that guide all the development of Physiology.

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