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Biological pathology from an organizational perspective

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Abstract In contrast to the "normativist" view, "naturalist" theorists claim that the concept of health refers to natural or normal states and propose different characterizations of healthy and diseased conditions that are meant to be objectivist and biologically grounded. In this article, we examine the core concept of these naturalist accounts of disease, i.e., the concept of *biological malfunction,* and develop a new formulation of the notion of malfunction following the recent organizational approach to functions in the philosophy of biology. We focus on the notions of *adaptive regulation* and *functional presupposition* to develop a new conceptual framework that justifies the ascription of malfunctional behaviors to biological systems according to the embodied normativity of biological organizations.

Keywords Function · Disease · Naturalism · Biological organization

Introduction: in search of naturalist normativity

Emphasizing the impossibility of a strictly biological characterization of disease, Marc Ereshefsky has recently proposed a distinction between state descriptions and normative claims. State descriptions are "descriptions of physiological or psychological states" and normative claims correspond to "explicit value judgments concerning whether we value or disvalue a physiological or psychological state"

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that is beyond the realm of biological science [1, p. 225]. Ereshefsky holds that a naturalistic characterization of the notions of health and disease is not possible because these concepts necessarily involve value judgments from an external observer. Significantly, Ereshefsky considers that external value judgments are present even in the ascription of biological malfunctions: "state descriptions make no claims about whether a physiological or psychological state is functional or dysfunctional" [1, p. 225]. Our proposal in this article affirms that it is possible to ground the ascription of malfunctions in naturalistic terms, i.e., it is possible to identify when a biological organization is dysfunctioning. We justify this claim by arguing that biological organizations instantiate an intrinsic normativity, which is grounded not in external value judgments imposed by an observer, but rather, in the living organism's capacity to respond to the changing demands of the environment. Organismic processes are normative because the preservation of life presupposes the organism's ability to establish and follow stable and flexible norms. In Georges Canguilhem's words,

> "Life is in fact a normative activity." The normative, in philosophy, includes 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. The normative, in the fullest sense of the word, is that which establishes norms. And it is in that sense that we plan to talk about biological normativity [2, pp. 126–127].[1]

In a similar vein, James G. Lennox claims that the notion of health is an "objective value." Health, in the sense of "absence of dysfunctionality," is a *biological value concept*, and

> *biological value concepts* apply in the context of action, as tools for referring to the contributions activities make to continued living—some make positive, and some negative, contributions. This is, if anything, an empirical fact…. The concepts of health and disease are in place to characterize that connection, and in so far as continued life is, as a matter of fact, conditional on successful biological function, such concepts are both evaluative *and* biologically grounded. [4, p. 503]

Health is thus an evaluative concept, but it does not depend on subjective considerations external to the very organization of organisms. As Justin Garson argues, the current theory and practice of biomedical sciences shows that a biofunctional and normative interpretation of organismic mechanisms is ubiquitous and useful [5, pp. 325–329].

[1] According to Canguilhem, organisms are healthy insofar as they are normative with respect to environmental fluctuations. Therefore, health implies the organismic capacity to tolerate variations within what is typical for a given organism, as well as the living system's ability to adapt and establish new behavioral patterns in order to meet changing demands [2, p. 132]. Canguilhem's approach provides an eco-organismic strategy to contextualize a naturalistic account of health and disease (see [3]). The formulation of organizational malfunction we develop in this article can be seen as a contribution to this naturalistic project.

In this article, we share with Lennox the interpretation of health as an evaluative and biologically grounded value, which is related to Canguilhem's conception of life as a normative activity. The very fact of life implies the presence of norms that instantiate objective values. As we will explain, the concept of *organizational malfunctionality* that we introduce here should be understood as a "state description" of biological processes that refers to this embodied normative dimension of living beings, which is of paramount importance for the debate about the concepts of health and disease.

We do not, of course, deny that subjective values related to social, cultural, and personal phenomena play a fundamental role in the conception of health and disease of patients and professionals of healthcare systems. In fact, a fair analysis of how people interpret and use the conceptual distinction between human health and disease needs to be made from a pluralistic perspective that accounts for the great diversity of non-biological factors that also intervene. But this analysis should account primarily for health and disease as biologically grounded. The notion of malfunction that we develop here serves, at the very least, to characterize an important dimension of the medical notion of *disease*, understood as "a negative bodily occurrence as conceived of by the medical profession" [6, p. 670].

As Lennox has argued, "Biomedicine is partly in the business of determining, for each aspect of human anatomy and physiology, what the proper range of operation for each system and sub-system is, and designing diagnostic means of monitoring systems to determine whether or not they are so operating" [4, pp. 502–503]. We will try to show how the notion of function could provide a crucial theoretical tool for the task of determining the "proper range of operation" of biological systems. Accordingly, the normative dimension of biological functionality[2] will turn out to be crucial for the philosophy of medicine.

However, a complete characterization of the normative dimension of biological functions relevant to the theoretical definitions of health and disease is still to be formulated. In contemporary philosophy of medicine, discussions on the theoretical definition of the terms "health" and "disease" are usually presented as a debate between *normativist* and *naturalist* approaches [13, 14]. On the one hand, normativists [15–18] consider that our conceptions of "health" and "disease" are primarily based on human value judgments. Thus, healthy states are those states we desire to be in, and diseased states are those states we want to avoid. On the other hand, naturalists [19–21] try to give definitions of "health" and "disease" that attempt to highlight what is biologically natural and normal for humans. The

[2] Although there are some exceptions (see, for instance, [7, 8]), there is a general assumption that the notion of function is a normative one, since it refers to some effect that is supposed to take place [9, pp. 12–15; 10, p. 144]. As Peter McLaughlin [11, 12] points out, functions show a particular type of relation between certain means and goals in a system, namely, one that goes beyond the standard concept of causality and has a normative flavor: in order for some systemic goals to happen, some effects need to occur, effects to which we refer as "functions." The attribution of functions consequently implies the postulation of a specific type of effect with respect to the functional traits. This type-token relation is what allows us to evaluate a system's activity in normative terms. For example, saying that the heart's function is to pump blood is equivalent to affirming that tokens of the type "heart" *should* pump blood. In the event it fails to do so, the heart would not be working properly, i.e., it would be functioning "wrongly" according to a norm ascribed to tokens of the type "heart."

naturalist project in philosophy of medicine searches for an "objectivist" definition of disease; a definition based on scientific theory that does not include personal or social values.[3]

In a recent paper, Peter H. Schwartz [25] labeled naturalist theories of health and disease as "dysfunction-requiring accounts" because they refer to biological dysfunctioning in their definitions of disease. According to naturalist theories, for a pathological condition to be so, it is necessary that a part of the organism fail to perform one of its biological functions. Therefore, by appealing to biological dysfunctions, naturalist formulations attempt to avoid observer-dependent external values in their definition of "health" and "disease." In the influential Bio-Statistical Theory (BST), championed by Christopher Boorse, "disease" is defined in terms of statistically abnormal functioning of a specific trait in comparison with the average functioning of traits of the same type in individuals of a concrete "reference class" (members of the same species, gender, and age), and health is simply the absence of disease, i.e., statistical normality. Accordingly, Boorse defines a diseased state as "a type of internal state which impairs health, i.e., reduces one or more functional abilities below typical efficiency" [19, p. 62]. This position is supposed to be an objective and value-free approach and, in fact, has been the mainstream naturalist position in philosophy of medicine for the last four decades.[4]

However, many criticisms have been raised against the alleged objectivist character of the notion of "malfunction" in BST. For reasons of space, we cannot develop all those criticisms here, and we shall focus only on one of the most significant: the "line-drawing problem" described by Schwartz. According to Schwartz, the notion of malfunctionality in BST, insofar as it corresponds to the idea of statistical abnormality, leads, necessarily, to the inability to establish a clear frontier between healthy (normal) and unhealthy (abnormal) levels of functioning without adducing subjective and arbitrary considerations. Since the characterization of function that BST endorses (a variant of the dispositional notion of function (see [27, 28])) is based fundamentally on a statistical criterion, the distinction between healthy and diseased individuals is a comparative and vague issue that intimately depends more on contextual and external variables than on the actual consequences that a biological state of an individual has for her welfare.[5] As Ereshefsky has recently argued, the "line drawing problem" ultimately shows that BST cannot be considered a truly "naturalist" approach because it lacks a basis in biological theory [1, p. 227].

[3] There are also some "hybrid" approaches that combine different aspects of these two perspectives [22–24]. These approaches claim that both biological and value-laden factors play important roles in the conceptualization of health and disease. In this article, we shall explore the scope and limitations of the naturalist-objectivist project, and since these hybrid approaches defend the necessity of including external values, we shall consider them as "non-naturalist" views, and therefore, we will not focus our analysis on them. The philosophical debate between normativist and naturalist approaches is described in [1, 13, 20].

[4] For a review on BST, its virtues and weak points, see [13, 17, 26]. Boorse himself has offered revisions of his theory and responses to many criticisms in [20, 27].

[5] More recently, Hausman [29], Schroeder [30], and Garson and Piccinini [31] have defended new versions of the BST that emphasize the comparative aspect of this approach. These new theories are presented as improvements of Boorse's account, and although they can solve some of the problems of his theory, they do not provide a satisfactory solution for the "line-drawing problem," insofar as they are still based on a bio-statistical characterization of "normal function."

In this article, we develop a bio-functionalist approach that can solve the "line-drawing problem" from a valid naturalist perspective. This approach is built upon a different concept of malfunction, namely, one based on the organizational properties of living beings as complex self-maintaining systems. To do so, we focus on the recent Organizational Approach to functions. Within this framework, the organizational approach to biological functionality is connected with a non-observer-dependent normativity with relevant implications for a theoretical view of pathology. Our notion of malfunction can be interpreted as a characterization of an important dimension of the professional sense of *disease* in the frame of a pluralistic conceptual analysis (see [6]). Additionally, this organizational concept of malfunctions underlines an important aim of medical practice. Indeed, one of the principal goals of medical treatments is to help the natural adaptive capacities of living systems to counterbalance those biological states that threaten the preservation of organizationally closed processes of self-maintenance. By helping to avoid malfunctionality, medicine contributes to the preservation of that state of successful performance of biological functions we call "health."

Biological organizations and functional normativity

The Organizational Approach

The Organizational Approach (OA) is a new perspective that has been developed within the philosophical discussion of the notion of biological function.[6] The different formulations, recently proposed, among others, by Gerhard Schlosser [32], John Collier [33], Peter McLaughlin [11], Wayne Christensen and Mark Bickhard [34–36], and Matteo Mossio, Cristian Saborido, and Alvaro Moreno [37–39], ground functional attributions in the fact that biological systems realize a specific kind of causal regime in which the actions of a set of parts are a necessary condition for the persistence of the whole organization through time. Biological systems are (complex) self-maintaining organizations, and within such organizations, functions are interpreted as specific causal effects of a part or trait that contributes to a complex web of mutual interactions, which, in turn, maintain the organization and, consequently, the part itself. Thus, organizational theories argue that there is a causal loop, based on processes of self-maintenance, such that a trait has (or serves) a specific function, to the extent that the trait contributes to the maintenance of the biological organization to which it belongs.

The organizational approach claims that this view of functions as a trait's effect that contributes to the self-maintenance of the organization can also ground its normativity. For instance, Christensen and Bickhard affirm that a function is normative because it "can succeed or fail in supporting the system, and this makes a distinct difference to the system, and to the world" [36, p. 16]. Normativity thus ultimately lies in the

[6] This new approach has been introduced as an improvement and an integration of the well-known "etiological" and "systemic-dispositional" approaches [37, pp. 816–821]. For a critical survey of these two mainstream perspectives and a review of the current state of the debate on functions in the philosophy of biology, see [39].

precarious far-from-equilibrium existence of biological organizations—"the conditions of existence of the system are here interpreted as the norms of its own activity: a functional trait must behave in a specific way, otherwise it would cease to exist" [38, p. 584]. Consequently, these norms are not external "observer-dependent" values because they appeal to the *conditions of existence* of a living organization.

In order to analyze this organizational strategy in more detail, we focus on the organizational formulation proposed in [37] and [38]:[7] Trait T has a function if and only if:

C1. T contributes to the maintenance of the organization O of S;
C2. T is produced and maintained under some constraints exerted by O;
C3. S realizes organizational closure. [38, p. 595]

The "organizational closure" of C3 is realized when inter-connected material structures are able to exert mutual constraining actions on their boundary conditions, such that the whole web is collectively self-maintaining (see [40]). Whereas each constraint is not *per se* able to achieve self-maintenance, the whole web of constraints (insofar as it is subject to organizational closure) can make up for its own decay, due to its far-from-equilibrium nature, by constraining its own surroundings in such a way as to recursively assure the replacement of the different components. Thus, the intimate association between complexity and integration accomplished by organizational closure is a mark of biological self-maintenance. Biological self-maintenance implies integration among the different processes and structures of an organism's traits. If one considers, for instance, the classical example of the function of the heart, this definition would imply that the heart has the function of pumping blood, since pumping blood contributes to the maintenance of the organism by allowing blood to circulate, which in turn enables the transport of nutrients to and waste away from cells, the stabilization of body temperature and pH, and so on. At the same time, the heart is produced and maintained by the organism, whose overall integrity is required for the ongoing existence of the heart itself. Lastly, the organism realizes organizational closure, i.e., it produces numerous other structures that contribute in different ways to the maintenance of the organizational closure of the system [37, p. 828]. Therefore, this formulation defines functions as a trait's contribution to the biological self-maintenance of the systemic organization.

Regimes of self-maintenance

From what has been said, a breakdown in a specific form of organizational closure does not necessarily imply the death of the organism. A trait is functional not because it is indispensable for the organism's life, but because it contributes to the organizational closure of what we call "a concrete regime of self-maintenance." By this term, we mean:

> each possible specific organization that an individual member of a class can adopt without ceasing to exist or losing its membership of that class. Each

[7] The reader can find a complete description of this definition in [37, 38]. For a comparison between that formulation and other organizational accounts, see [38, pp. 587–599].

> class may thus include several regimes of self-maintenance. In organizational terms, if a trait is subject to closure (and thus has a function), then *the specific regime of self-maintenance* that the system has adopted requires the said trait as an indispensable component. Nevertheless, not every functional trait contributes to all possible regimes of self-maintenance of a given class, which means that an individual system can sometimes compensate for the breakdown of a component by shifting to a different regime of self-maintenance, in which the defective trait is no longer required. In contrast, some functional traits are indispensable, in that they are required for all regimes of self-maintenance that a member of a class could possibly adopt. [37, pp. 829–830]

To illustrate the way an organism can "compensate for the breakdown of a component by shifting to a different regime of self-maintenance," one can think in many cases of (non-fatal) injuries. We compared two different cases of biological functions: the heart's pumping of blood and the eyes' transduction of light. A failure that prevents the first function necessarily implies the death of the system, but in the case of the function of eyes, the system can typically instantiate a new organization in which the malfunction does not threaten global self-maintenance and the risk of collapse of the causal closure is avoided. This shows that there is an important difference between "being subject to the organizational closure" and "being indispensable for the self-maintenance of a system" [37, p. 830].

In this article, we argue that this distinction is the key to defining the concept of malfunction from an organizational perspective. A biological trait can malfunction without necessarily causing the collapse of the circular process of self-maintenance because biological systems show plasticity in their organizations. And this plasticity is possible because living beings are paradigmatic examples of self-*regulated* systems.

Regulation

Regulated systems are those entities that are able to modulate their constitutive functional regime according to either internal or external perturbations, in order to preserve their organizational self-maintenance. Interestingly, regulation implies the existence in the system of a specific subsystem with the capacity to modify the regime of self-maintenance according to the circumstances. This capacity is expressed as "adaptivity."

Here, we claim that adaptive regulation implies normativity. Adaptive regulated systems show specific behaviors that can be interpreted as attempts to avoid the loss of a function, that is, as reactions devoted to anticipating the loss of a function (more exactly, the degree of risk of losing a function). As Ezequiel Di Paolo has explained,

> [Adaptivity is] a system's capacity to regulate, according to the circumstances, its states and its relation to the environment with the result that, if the states are sufficiently close to the boundary of viability, (1) tendencies are distinguished and acted upon depending on whether the states will approach or recede from the boundary and, as a consequence, (2) tendencies of the first kind are moved closer to or transformed into tendencies of the second and so

future states are prevented from reaching the boundary with an outward velocity. [41, p. 438]

Adaptive regulation is, therefore, a central feature of living organisms. If one analyzes living organisms from the perspective of their adaptive capacities, one must consider functional traits/organs to have a range of activity submitted to adaptive modulation, and that there is a (sub)system specifying their particular range of activity. When environmental conditions change, the adaptive system triggers actions in order to adequately modulate the functioning of the organs, namely, to set them in specific regimes of functioning: those that satisfy the adaptive norms. This is precisely an *adaptive reaction*. If biological systems did not actively regulate their interactions with their changing environment, they would perish, and that is why the specific regime of contribution of each function matters. For example, in a situation of danger, the heart's beating accelerates, blood pressure rises, blood vessels in muscles dilate, increasing the flow of oxygen and energy. At the same time, blood flow is reduced in the gastrointestinal tract, thus making more blood available to be shunted to skeletal muscle. In the eyes, pupils dilate, improving vision. Digestive processes are slowed down, but release of glucose from the liver is accelerated. In sum, a whole set of modifications of the functional processes of the body are triggered so as to increase readiness to fight or to flee [42, pp. 913–914].[8]

The idea of adaptive regulation implies that some selective and meta-functional operation modulates an underlying range of functional operations in the structure of each trait.[9] The specific way that this regulation works depends on the regulatory system, *but each trait should be able to operate within a specific range*. If, in a given situation, a particular trait cannot attain the range that the regulatory subsystem requires—i.e., if it can only operate in a more limited range—the structure is deleterious. In other words, if, in the process of adaptive modulation, the functional trait is unable to adopt the specific range of functioning required (say, because of a difference in its structure), this trait's behavior will not fit within the functional regime adopted by the remaining organs. For example, a human heart can pump blood within a certain range of flows, and the same applies to the lungs, the kidneys, and other organs. The specific rate of functioning of each organ is specified by the regulatory system according to environmental (and also, internal) conditions.

[8] Regulation, therefore, requires a fundamental distinction within the system of two different operational levels, such that a subsystem (the regulatory subsystem) functionally modulates the low-level (i.e., basic or constitutive) functions, which, in turn, constrain the underlying processes constituting the system. All these adaptive changes are themselves ultimately functional, in the sense that these changes are biological traits' effects that satisfy the organizational definition of function. In their work, Alvaro Moreno and Matteo Mossio [43] have argued that the specificity of regulatory functions is that they are *second-order functions*. In this article, we do not focus on this specificity.

[9] Though it is reasonable to think that prebiotic systems could have maintained stability against perturbations (to a certain degree) through mere feedback mechanisms, when these systems increased their functional complexity, only an operationally differentiated subsystem (i.e., adaptive regulation) could ensure stability against perturbations.

However, in some cases, the adaptive reactions of the regulatory subsystem are able to compensate for the effects of a deleterious structure. To illustrate this, we examine the case of aortic stenosis. In patients with aortic stenosis, adaptive mechanisms can overcome structural and morphofunctional alterations for years, and the systemic functioning of the body appears normal. However, with time, the disruption of the functional integration within this regime of self-maintenance becomes clear, as symptoms belonging to a specific morbid entity appear. Thus, malfunction (instantiated by these symptoms) may be avoided for a long period of time, even if the adaptive reactions will ultimately not be fully able to make up for the alteration in the aortic valve. We now consider this alteration in more detail.

In some cases, patients are born with normal tricuspid aortic valves, but thickening and calcification can lead to stenosis when these patients are in their 60s or 80s. Why this occurs in some patients with normal valves and not in others (predisposition to disease) is unknown. The normal aortic valve area is 3–4 cm^2 and virtually no hemodynamic disturbance (i.e., malfunction) occurs until the orifice is reduced to less than 33% of its normal size. At this point, a systolic gradient between the aorta and the left ventricle is apparent. Normally, the pressure in both the left ventricle and the aorta are similar at the time of systole. However, in aortic stenosis, left ventricular intracavitary pressure increases with respect to aortic pressure in order to overcome the resistance to blood flow from the stenosis. A geometric progression thus arises: as the valve surface area diminishes, the magnitude of the gradient increases. The gradient may increase to 10–15 mmHg with valve areas between 1.3 and 1.5 cm^2, and even 70 mmHg in the case of stenoses of 0.6 cm^2.[10]

The progress of stenosis is highly variable from individual to individual: one patient may remain stable for many years with a steady gradient and another may show a gradient increase at a rate of 15 mmHg per year. Despite the anomalous structure of the valve, normal function of the left ventricle is maintained by a compensatory mechanism: concentric myocardial hypertrophy of that ventricle. This hypertrophy helps to maintain ejection fraction and cardiac output in spite of the aortic transvalvular pressure overload. This is a clear example of regulatory compensation that aims to meet the blood flow needs of the body.

From an organizational perspective, one can tell that a valve is a malfunctional trait only when its functioning does not fit with what many or all the other functional parts of the system do (following the regulatory rules of the adaptive (sub)system). In other words, a trait becomes malfunctional when—due to the fact that its particular structure limits its range of modulation—it is unable to do what the regulatory (sub)system "tells" it to do within the framework of a specific regime of self-maintenance.

Functional presupposition

As we have argued, due to its structure and organization, the set of functional traits requires a specific regime of self-maintenance: this means that the structure of a

[10] Cf. [44].

given trait is such that it "presupposes" that it will enter in a regime of interactions not only allowing a generic viability, but also the appropriate regime of interactions. In turn, the regime of functioning of the regulatory (sub)system should fit the structure and organization of the organs of the whole system. More specifically, each trait in a system, by its structure, allows a range of forms of contribution, which depend on the specific regime of self-maintenance of a given system. For example, a heart can pump blood within a certain range of flows, and the same applies to the lungs, the kidneys, and other organs. The specific rate of functioning of each organ is specified by the regulatory system according to environmental (and also, internal) conditions. Because malfunctional traits are structurally different from normal traits, and because this structural difference is the cause of their more limited range of ways of functioning, a system with malfunctions, when approaching the boundary of the range of essential variables (even in conditions that the adaptive mechanism should control) cannot recede from these limits.

According to all these considerations, the organizational approach "F is a function of T" means "the organization O of a biological system S, which produces and maintains the trait T, presupposes T performing the effect F." Biological systems are characterized by a complex functional integration of its components. There is a precise tuning among all the functional elements and the demands enforced by the environment. Thus, there are interdependent causal relationships between the systemic organizational properties and the specific traits' effects that ground what we call *functional presupposition* [36, p. 17].[11]

However, not every breakdown of a specific regime of self-maintenance will inevitably lead to the collapse of the system, and some biological traits may make a contribution to the maintenance of a self-maintaining organization, even when these effects do not fulfill the functional presuppositions of the rest of the components. For instance, a heart with aortic stenosis may still pump blood and, consequently, contribute to the self-maintenance of the organism—what happens is that this contribution is not *adjusted to a certain norm* related to the preservation of a specific regime of self-maintenance, and this is why we say that it is a bad or poor contribution. Said norm is expressed in the behavior of the regulation subsystem. Leriche's famous *dictum* "health is life lived in the silence of the organs" is recovered under a different light with our account. A malfunction is the biological behavior of an organ that triggers a response from the remaining organs, when this response modifies the functioning norms of the organism in accordance to each situation. The effects of a functional trait are deemed "good" or "bad" with respect to an *embodied norm* that lies in the action of the regulatory subsystem that the whole organism presupposes.

[11] It is worth noting that there are important similarities between our conception of "functional presupposition" and the conception of this idea proposed in [34] and [36]. According to these authors, functional presupposition is a structural property that allows us to conclude the existence of a concrete system's part or trait and its function by considering the whole set of the rest of parts or traits. Our interpretation of functional presupposition, by considering the functional behavior of the whole system and its parts, allows us to postulate a *range* of functioning of a trait that is determined by the regulatory system. Thus, by considering the structure and dynamics of a system's component, it is possible to postulate the "necessary" existence of a functional trait, the range in which the function of that trait has to be performed, and accordingly, certain aspects of its structure.

Conclusions: an organizational definition of biological malfunction

We are now in a position to propose a definition of biological malfunction. From the organizational perspective, a malfunctional trait is a structure unable to display the range of functional processes that other functional traits of the system presuppose, and, as a result, the system acts within a range of viability that is narrower than the range of viability that the system's organization presupposes. Accordingly, *a malfunction happens when the effects of a biological trait fail to fulfill their functional presupposition in a way that is not fully balanced by the adaptive regulations of the organism.*

This definition implies four conditions for the ascription of organizational malfunctions to biological traits:

C_1: A biological trait T has the function F, i.e., the organization O of an organism S "presupposes" T performing the specific effect F (in a range of activity).
C_2: In a given circumstance, some internal or external conditions disrupt the functional integration of T in O, i.e., T cannot perform F in the range of activity presupposed by the organism as a whole.
C_3: As a consequence of this failure, an adaptive reaction is triggered by the regulatory (sub)system of S.
C_4: However, this failure is not fully compensated for by the adaptive reaction.

A malfunctional trait is, by its own structure, unable to display *the range* of functional processes that other functional traits of the system presuppose, and as a result, the system acts within a range of viability that is narrower than the range of viability that the system's organization presupposes. Accordingly, for instance, a heart failure is an organizational malfunction because of the following. (1) The heart (according to the organizational definition described above) has the function of pumping blood, which, in turn, is required for the functioning of the remaining parts of the organization of the body and, consequently, for the self-maintenance of the organism. (2) The heart in question is unable to provide blood at the rate that the living organization presupposes. (3) This failure is detected by the organism, and, consequently, the organism regulates its internal states and its interactions with the environment in a way that aims to compensate for it: a body with a very arrhythmic heart entails many reactions from other traits aimed at adapting themselves to the functioning of the heart by, for instance, limiting mobility. (4) These adaptive reactions do not completely fix the situation caused by the heart failure, and the living system has a more limited range of viability. An organism with heart failure cannot perform some of the activities (for instance, running or hunting) that it could perform with a normal heart. If, due to its adaptive capacity, an organism is able to make up for the failure in such a way that additional adaptive reactions are not required to preserve the current regime of self-maintenance, the malfunction disappears.

To summarize, we conclude that the essential feature of the pathological (according to the organizational account we have developed here) stems from the incapability of a functional trait to fulfill the norm that the adaptive subsystem prescribes. Since this incapability is linked to certain objective aspect of functional traits, the organizational view of the pathological corresponds to the objectivist conception of health and disease found in medical practice. This view sharply differs from the interpretation of the pathological in terms of biostatistical normality or in terms of social, cultural, or any other human values, because it can be assessed in an individual biological system, just by analyzing its current organization.[12] As we stated in the introduction above, we do not affirm that non-biological factors do not play a crucial role in our use of the health and disease distinction, but we argue that by aligning "healthy" and "unhealthy" with those physiological processes that are "correct" or "incorrect" according to an organizational notion of biological malfunctionality, our account establishes the basis for a non-observer dependent approach to biological normativity, with relevant implications for a theoretical definition of health and disease. For these reasons, we claim that the organizational account of malfunction is a key tool for the construction of a promising naturalist approach to the philosophy of medicine.

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[12] Significantly, it would be interesting to explore, in future developments of the organizational approach, the extent to which this "human value free" normative perspective can be adopted in fields other than medicine. For instance, this account could be useful for a theoretical account of the notions of health and disease in plants and (non-human) animals, and even to deal with key notions in the study of ecological and social systems, such as "sustainability," "resilience," or even "norm."

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