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**Mind in Life: Biology, Phenomenology, and the Sciences of Mind.** Evan Thompson. Cambridge, Massachusetts: Harvard University Press, 2007, 568 pages, $49.95 hardcover.

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In *Mind in Life: Biology, Phenomenology, and the Sciences of Mind*, Evan Thompson defends the thesis of a "deep continuity of life and mind" according to which "life and mind share a set of basic organizational properties . . . . Mind is life-like and life is mind-like" (p. 128, also p. ix). On the one hand, Thompson *uncovers mind in life*, by considering *life* and explaining how living organisms are organized in a way that involves the biological implementation of properties that are usually attributed to mental states. On the other hand, he *roots mind in life* by considering the *mind* and explaining how mental states are anchored to (neuro)biological processes. Following the lead of Merleau–Ponty and his notion of "*comportment*" (1963, p. 4; see *Mind in Life*, p. 67), Thompson argues that the notion of *autonomous dynamic system* can integrate the orders of life and mind, and account for the originality of each order, allowing the understanding that "on the one hand, nature is not pure exteriority, but rather in the case of life has its own interiority and thus resembles mind. On the other hand, mind is not pure interiority, but rather a form of structure of engagement with the world and thus resembles life" (p. 78).

## Biology, Phenomenology, and the Sciences of the Mind

The subtitle of the book should act as a warning: *Mind in Life* is not easy to swallow. Along the way, diverse disciplines will be chewed and the reader will have to digest a lot of technicalities from *biology, phenomenology, and the sciences of the mind.* Such interdisciplinary scope is necessary for anyone interested in "contributing to the work of a new generation of phenomenologists who strive to 'naturalize' phenomenology" (p. 14), as *Mind in Life* does.

This approach is doomed to failure notably according to both Kant (p. 136) and Husserl (p. 356). According to Thompson, however, these negative appraisals are defeated by empirical and theoretical scientific progress. Importantly, to benefit from such progress, interdisciplinary integration should not be taken as the mere pil-

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ing up of data imported from exotic horizons. Rather, advances from any relevant disciplines should participate to the development of, and be integrated to, a single framework. According to *Mind in Life*, as far as the investigation of mind and life are concerned, this unifying framework is defined by *autonomous dynamic systems* approaches where biological, neurophysiological, and phenomenological evidence can be adequately articulated. Technical details related in *Mind in Life* thus serve a triple purpose: (1) they are obviously relevant for their own sake, in their "home discipline," but also (2) for setting the relevant scene, where (3) other disciplines at stake can in turn be displayed.

In this sense, this "triple-braided" (Varela, 1997; *Mind in Life*, p. 357) approach is genuinely non-reductive and conceives of phenomenology and empirical sciences as partners in a reciprocal relationship. This relationship, however, is asymmetrical. Indeed, the notions relevant to the scientific investigation of life and mind (e.g., the notion of "form" as conceived of by Merleau–Ponty) are described as "irreducibly phenomenal" (p. 81). Thompson insists, however, that this view should not be mistaken with any "argument for metaphysical idealism — that physical forms are constructions out of a preexistent consciousness" (p. 82). The non-reductionist framework he displays acknowledges a "transcendental" perspective which questions how objects are disclosed to us, and conceives of consciousness as a "condition of possibility for there being any appearances at all" (p. 240). This transcendental perspective "in no way denies the existence of a real physical world" (p. 82) and is completed (rather than denied, p. 239) by an empirical perspective which acknowledges that "mind emerges from matter and life" (p. 86). It is the task of *Mind in Life* to defend and put to work this non-reductionist naturalism.

## Outline

*Mind in Life* first presents minimal forms of life/selfhood, and then investigates more sophisticated forms of mind/selfhood. This organization makes obvious sense: to efficiently argue that mind is rooted in life, one needs to present one's conception of life at length, in turn justifying the anchoring of mind down to this order. Here, however, I will reverse this order. Indeed, I will assume that a hypothetical reader coming from cognitive sciences and/or philosophy of mind is not already convinced that biology matters for the investigation of the mind. My starting point will thus be the description of relevant properties of the mind. On this basis, I intend to show (or rather recall Thompson's arguments which intend to show) that equivalent properties are implemented at the biological level. Such equivalence should both uncover and root *mind in life*. More in detail, I will inspect three levels: the *mental*, the *neuronal*, and the *living* systems, underscoring how each of these systems can be adequately understood as *autonomous* and *dynamic*. Before turning to this task, however, more needs to be said about these latter notions.

## Autonomous Dynamic Systems

A system can be defined as a "collection of related entities or processes that stands out from a background as a single whole, as the observer sees and conceptualizes things" (p. 39). A system is said to be autonomous when it is "a self-determining system, as distinguished from a system determined from the outside, or a heteronomous system" (p. 37).

> Autonomy and heteronomy literally mean, respectively, self-governed and other-governed. A heteronomous system is one whose organization is defined by input–output information flow and external mechanism of control . . . . An autonomous system, however, is defined by its endogenous, self-organizing and self-controlling dynamics. (p. 43)

Such a system is, by definition, "a whole that cannot be dislocated from its components but cannot be reduced to them either" (p. 66). Thompson exploits this idea by underlining the *dynamic* co-emergence of a constituted entity and its constituents (pp. 68–69). A dynamic system is, basically, "one that changes over time" (pp. 38–39). By contrast with linear systems (pp. 68–69) describable in terms of a sequence of discrete states which are ordered serially and determined by an input–output flow, dynamic systems are better described in terms of a structure unfolding in real time according to ongoing processes running in parallel (p. 42). *Mind in Life* describes mind, brain, and life in these terms. In the present discussion, I will first report these elements as described in Thompson's work and then subject them to potential criticisms.

## Cognition

As a starter, one may characterize the mind as a cognitive apparatus. In turn, cognition is "sense-making" (p. 159) and can be conceived of as based on the manipulation of symbols (cognitivism, p. 4), the emergence of patterns of activity in a (neuronal) network (connectionism, p. 8), or self-organized compensations triggered by perturbations issued from the immersion of the system into its environment (embodied dynamicism, p. 10). *Mind in Life* grants its sympathy to the latter view, and goes one step further by integrating it with phenomenological investigations of human subjectivity: this is the so-called "enactive approach" (p. 13).

Like embodied dynamicism, the enactive approach argues that cognition is a skillful know-how which is irreducible to prespecified problem solving "because the cognitive system both poses the problems and specifies what actions need to be taken for their solution" (p. 11). Think of the cognitive subject as a climber who needs to "read" the rock, entertaining a sort of "dialogue" with it: the rock determines the background of the problem to be solved, but it is tailored to the climber's ability to exploit its details according to his agility. Contrast this with indoor climbing which requires a different technique: as the holds colorfully pop out of the plane surface of the wall, problems and solutions are (much more) prespecified, constraining the climber to accommodate to the wall, while in addition, the complexity of natural cliffs can also be assimilated to the climber's own needs. In this sense, according to the enactive approach, "a cognitive being's world is . . . a relational domain enacted and brought forth by that being's autonomous agency and mode of coupling with the environment" (p. 13; see also p. 71).

## Prereflectivity

It is in this framework that enactive approaches insist on the additional idea that "experience is not an epiphenomenal side issue, but is central to any understanding of the mind" (p. 13). As Husserl argued at length (p. 232), the experience of oneself as a bodily subject is constitutive of perception: it is not a mere varnish covering perceptual states with a subsidiary "what it feels like." Let us consider an obvious criti-

cism to this view. Intuitively, it does not seem that we experience ourselves constantly, as a requirement to experience any perceptual object. When observing the stars, we are paying attention to *them*, not to ourselves. Self-oblivion may be even more pronounced in skillful coping where our abilities unfold themselves without our conscious assistance: when driving along a non-bumpy road, we are usually not paying attention to our performance, even less to our gestures (*Mind in Life*, p. 316; Dreyfus, 2000).

This self-forgetfulness, however, is *not* a form of self-*un*consciousness. Rather, it involves a form of tacit, intransitive, prereflective self-consciousness: while we are not transitively aware of our awareness, we are aware of it intransitively (p. 286). At this level, experience is transparent (p. 284) as it is not (or cannot be) taken as an *explicit* object of *intentional* acts of consciousness. Due to its transparency, prereflective self-consciousness is notoriously difficult to describe. Thompson does not provide a description which is entirely satisfying here, because he articulates under the single notion of prereflective self-consciousness (at least) three disparate dimensions of subjectivity. Compare the following statements:

> Prereflective bodily self-consciousness is evident in touch . . . we feel ourselves touching them and touched by them . . . . Such bodily experience offers . . . the experience of sensorial events that relate one's subjectively lived body to itself. Usually these sensorial events are those in which one's body does not sense itself explicitly. (p. 250)

> In seeing an object, I prereflectively experience my seeing (p. 283). [T]he experience of seeing . . . [is] phenomenally manifest as mine. (p. 262)

> We are aware of our experiences and mental activities as arising, enduring, and ceasing . . . . Time consciousness thus comprises . . . awareness of the experience itself as temporal and as unified across time (p. 318); Thanks to [its] lengthwise intentionality, consciousness is internally related to itself and self-affecting (p. 322); Time-consciousness entails prereflective self-awareness. (p. 328)

These descriptions of "prereflective self-consciousness" involve, respectively, bodily feelings disclosing non-bodily objects, a spatial perspective together with a sense of "owning" one's experience, and the backward and forward self-unfolding characterizing the temporal structure of consciousness. Interestingly, these three seemingly disparate characterizations can be reconciled. Stated negatively, their common point is that they are not reflective, not transitive, not explicit forms of consciousness. Stated positively, and more interestingly, these descriptions all characterize a pervasive form of self-consciousness which can be adequately named "sentience." "Being sentient means being able to feel the presence of one's body and the world" (p. 221, see also p. 161) and it involves being "present" to the "standing–streaming" ever-present flow of experience (pp. 326–328). Thus, to be prereflectively self-aware involves being aware of one's experience as lived by oneself as subject, a subject who is bodily, spatially and temporally situated. These three aspects surely deserve separate considerations, and in this respect, the use of a common notion to characterize them might be detrimental. Nonetheless, it also points to the fact that prereflective self-consciousness is not only minimal and pervasive, but also multifaceted.

## Intentionality

Another problematic aspect of the descriptions of prereflective self-consciousness ordinarily found in the relevant literature is that they proceed by contrast and characterize prereflective self-consciousness as a *non*-intentional form of self-consciousness. Though not incorrect, this characterization fails to articulate a crucial point: the prereflective subjectivity of experience (self-involving) and its intentionality (object-directed) are two inseparable facets co-constituting a *single* act of consciousness. Prereflective self-consciousness is not self-standing, apart from world-consciousness. The prereflective subject does not have an intransitive eye turned inward to ensure prereflective self-consciousness and a transitive eye turned outward to ensure intentional consciousness of the outer world. Rather, it is intrinsically to his intentional object-directed "gaze" that he experiences himself as a subject "gazing" to the world. This implies that the traditional subject–object dichotomy does not capture adequately the specificity of prereflective self-consciousness which is better characterized as the experience of *being-in-the-world* (p. 247; following Heidegger): "for a bodily subject it is not possible to specify what the subject is in abstraction from the world, nor is it possible to specify what the world is in abstraction from the subject" (p. 247; see also Merleau–Ponty, 1962, p. 430).

In psychology, this idea is best conveyed by the notions of *umwelt* (von Uexküll, 1957; *Mind in Life*, p. 59;) and *affordance* (Gibson, 1979; *Mind in Life*, p. 247;). In this context, it is worth underscoring that the subject's openness to the world encompasses but is not limited to, neutral sensorimotor interactions with the physical environment. Rather, our primordial openness to the world is provided by our "affectively 'saturated intentionality'" (p. 30; Steinbock, 1999). Moreover, the relevant environment is not only physical but also social: "human subjectivity is from the outset intersubjectivity, and no mind is an island" (p. 383).

In a nutshell, enactive approaches underline that the mind is characterized by its *inner organization*, i.e., its prereflective self-consciousness, and its *openness*, i.e., its intentionality. How can these two fundamental characteristics be "naturalized," i.e., understood in the framework of natural sciences? A first place to look at is the brain: How are such mental states rooted in brain states?

## Brain–Body–World

### *Neuro or Hetero?*

The investigation of how the mind is rooted in the brain involves the integration of phenomenology and empirical neurosciences, and this can be done in (at least) two contrastive ways: *neurophenomenology* and *heterophenomenology* (Dennett, 1982, 1991). Thompson advocates a *neurophenomenological* approach whose working hypothesis has been described as follows by its founding father, Francisco Varela: "phenomenological accounts of the structure of experience and their counterparts in cognitive science relate to each other through reciprocal constraints" (Varela, 1996, p. 343; quoted in *Mind in Life*, p. 329; see also p. x, 273, 358).

Like neurophenomenology, heterophenomenology also intends to exploit first-person data in a scientific framework. However, these two approaches depart from each other on at least the two following points.

1. Heterophenomenology aims at taking a third-person point of view on the beliefs that the subject explicitly expresses (pp. 303–304). The status of the mental states reported by a subject is evaluated according to objective criteria, most notably brain activations. This attitude is common in mainstream cognitive neuroscience and states that "if how things seem to us subjectively at the personal level does not match or correspond to the internal representations at the subpersonal level, then our subjective experience is a kind of illusion — it is not what it subjectively seems to be" (p. 275). This strategy relies on the "matching content hypothesis" according to which the content of experience matches the content of neuronal representation (p. 349). By contrast, neurophenomenology argues that experiential content at the personal level cannot be conflated with, nor evaluated on the basis of representational format at the subpersonal level (p. 305).
2. Heterophenomenology limits its scope to explicit reports of contents of subjective experience and neglects the possibility to access structural aspects of subjective experiences. Neurophenomenology, by contrast, underlines that the focus on contents "runs the risk of missing the biologically and phenomenologically more fundamental phenomenon of sentience [which] underlie and pervade all sensory experience" (p. 355). Moreover, experiences cannot be limited to what their subject expresses overtly, notably due to the *transparency* of experiences by which the subject is (usually) not aware of their intrinsic mental features (p. 284). Neurophenomenology insists on the idea that this transparency can be partly overcome with training (p. 306). It thus advocates a pragmatic approach (p. 20) involving Buddhist philosophy and contemplative mental training (see also p. 338 for an application of this idea in experimental neurophenomenology).

### Information and Enaction

To better understand neurophenomenology, it is important to emphasize that it refuses to reify information "into something that preexists 'out there,' is 'picked up' and 'processed' by representational systems in the brain" (p. 186). The dynamic approach to the brain rather insists on the idea that "autonomous systems do not operate on the basis of internal representations in the subjectivist/objectivist sense . . . they enact an environment inseparable from their own structure and actions" (p. 59). This approach has notably led to innovating empirical investigations of time-consciousness which suggest that the temporal structure of consciousness is "structurally mirrored at the biological level by the self-organizing dynamics of large-scale neural activity" (p. 329). To cut short a story detailed in *Mind in Life*, "patterns of synchronous oscillations between different populations of neurons . . . define a temporal frame of momentary and transient neural integration that corresponds to the duration of the present moment of experience" (p. 330). In this view, the conscious experience of time, and the temporal structure of experience are based on neither an external nor an internal ticking clock "but rather arises from an endogenous and self-organizing neurodynamics" (p. 335).

Interestingly, this view presupposes two things: (1) an endogenous activity animating the autonomous system; (2) an openness and adaptability of the system to the perturbations issuing from the environment. Now, if you remember the characterization of the mind proposed above, you must start to see some organizational similarities: both the mind and the brain can be adequately characterized by their inner

organization and their openness. This "equivalence" should not be confused with any "analytic isomorphism" which advocates a one-to-one mapping between contents represented at the mental and neuronal levels (p. 272; contrast with structural isomorphism, pp. 357–358). Quite the contrary, the point here is to emphasize that both mind and brain are dynamic autonomous systems which are equivalently structured in a way that constitutively involves inner organization and openness. Let us now consider the third order investigated in *Mind in Life*: Life.

## Life

### *Autopoiesis*

> In an autonomous system, the constituent processes (i) recursively depend on each other for their generation and their realization as a network, (ii) constitute the system as a unity in whatever domain they exist, and (iii) determine a domain of possible interactions with the environment. The paradigm is a living cell." (p. 44)

These sentences clearly summarize that, like mind and brain, life too is adequately characterized as a dynamic autonomous system, i.e., its structure, functioning, maintenance constitutively involve inner organization and openness. This claim now needs to be unpacked.

The most important notion at play here is the notion of autopoiesis (chap 5) according to which "the cell embodies a circular process of self-generation: thanks to its metabolic network, it continually replaces the components that are being destroyed, including the membrane, and thus continually re-creates the difference between itself and everything else" (p. 99). In simple terms, autopoietic processes allow the "self-production of an inside" (p. 79).

### *Self*

The crucial point for the investigation of how the mind is rooted in life is that, according to Thompson, "an autopoietic system is . . . an individual in a sense that begins to be worthy of the term *self*" (p. 75, see also p. 48). The "self-identity" involved here is conceived of as "an invariant dynamic pattern that is produced, maintained, and realized by the system itself, while the system undergoes incessant material transformation and regulates its external boundary conditions accordingly" (p. 75). By advocating this definition of an "organic self," Thompson follows the lead of Jonas for who "the introduction of the term 'self,' unavoidable in any description of the most elementary instance of life, indicates the emergence, with life as such, of internal identity — and so, as one with that emergence, its self-isolation too from all the rest of reality" (Jonas, 1966, quote in *Mind in Life* p. 149).

### *Openness*

The definition of an organic self involves an unconventional view of selfhood and it may be all the more difficult to understand it that in *Mind in Life*, the very notion of self is not defined for its own sake. To better understand how the self is conceived in the present framework, it must be emphasized that (despite a rather important terminological ambiguity quite visible in the aforementioned quotes, if taken in isola-

tion) the self defined here is not self-enclosed. Rather, otherness is correlative of selfhood (p. 49). The "self-isolation" defined by Jonas thus "cannot mean outright independence from the world" (p. 150). Varela's terminology used by Thompson in *Mind in Life* is equally ambiguous: the term "operational closure" (p. 48) "does not mean that the system is materially and energetically closed to the outside world . . . an autonomous system is always structurally coupled to its environment . . . the state changes of an autonomous system result from its operational closure and structural coupling" (p. 45: see also note 4, p. 448). In the terms used above to describe both mind and brain, this means that living systems are characterized *both* by their inner organization *and* their openness.

*Sense Making*

Organic openness should not be conceived of as the mere ingestion of nutriments which are ready to be consumed in the environment surrounding the living organism. Rather, in line with the notion of information defined at the level of human cognition, here again, the "informational stimulus is not equivalent to the physical stimulus. The latter is definable independently of the organism; the former is not. The informational stimulus is the stimulus as informed by (the form or structure of) the organism" (p. 69; see also p. 173, 182). A piece of information is thus defined by the organism processing it, according to the "vital significance" of the stimulus for the organism in question. It is for this reason that the living organism's openness is interpreted in terms of "sense making" (p. 158) and that life can be equated with autopoiesis and *cognition*. Here, a cognitive system is defined as

> a system whose organization defines a domain of interactions in which it can act with relevance to the maintenance of itself . . . . Living systems are cognitive systems, and living as a process is a process of cognition. This statement is valid for all organisms, with and without a nervous system. (Maturana 1970/1980, quoted in *Mind in Life*, p. 124; see also p. 125 and p. 126)

Again, the claim is strong, and *Mind in Life* provides a word of caution: the usage of "cognition" to characterize the openness of the organic self "is admittedly a broad one" and Thompson states that he certainly does not intend "to obscure the distinctive characteristics of animal and human cognition. Nonetheless, this usage is not merely a way of speaking because it rests on an explicit hypothesis about the natural roots of intentionality: intentionality arises from the operational closure and interactive dynamics of autopoiesis" (p. 159). However, this justification is problematic in Thompson's own framework. Indeed, he himself argues that attributing experiential states all the way down to biological cells would prevent the naturalization of consciousness, i.e., the understanding of how consciousness is anchored to non-conscious matter (p. 161). The same applies here: the attribution of cognitive states all the way down to biological cells would not favor but prevent the naturalization of cognition and intentionality by erasing the distinction between cognitive and non-cognitive states. Beyond this general point, the (ir)relevance of the notion of cognition to describe "organic selves" has in fact opened an important debate, and will introduce the next and last section.

## Criticisms

In what precedes, I intended to report what I take to be the main arguments which Thompson provides in *Mind in Life*, and according to which organic, neuronal, and mental systems are autonomous and dynamic systems, all characterized both by their inner organization and their openness. In what follows, I intend to raise a number of questions in order to consider whether there are more significant similarities or differences between mind and life. I will content myself with justifying these questions in the framework of *Mind in Life*, and will leave the answers to the reader's appreciation.

### *Openness*

The first point I wish to explore concerns the notion of cognition and its relevance to characterize life. Thompson, following the lead of Maturana and Varela, argues that life entails autopoiesis which entails cognition (p. 124). In *Mind in Life*, he discusses a number of objections which maintain that "all living systems are both autopoietic systems and cognitive systems, but an autopoietic system is not necessarily a cognitive system" (p. 124; see Bitbol and Luisi, 2005; Bourgine and Stewart, 2004). Here, I would like to question the very conception of cognition that is implicated both by Thompson and these critics.

Intentionality is classically defined both as the object-directedness of consciousness and/or its world-involvement (p. 23). Accordingly, the experiential field is structured by a horizon, which functions as a precondition for anything to appear (p. 35). If this structure applies to cognition as well as to experience, then one may relevantly ask in which sense an organic self (e.g., a bacteria) can be said to have a horizon or a world, which would provide the background against which this organic self would "make sense" of an object (e.g., sugar). Bacteria do not seem to be able to isolate an object of vital significance over an irrelevant background left unexplored. In this sense at least, the organic self seems to lack any field of appearance. In this case, in which sense can there be a "cognitive object"?

Moreover, an "object" is defined at the phenomenological level as "something that remains invariant through perspectival variation" (p. 76). Is this description relevant only for "experiential object" or for any "cognitive object"? Can there be any cognitive act without an object defined in this sense? If a negative answer is given to the latter question, then in which sense can an organic self be said to be a cognitive system, since it would lack access to such objects?

Thompson also affirms that "there is no good reason . . . for thinking that autopoietic selfhood of the minimal cellular sort involves any kind of intentional access on the part of the organism to its sense-making" (p. 162). In other terms, organic selves "do not know the problem they are trying to solve" (Damasio, 2003; quoted in *Mind in Life* note 15, p. 456). Again, doesn't this prevent them from performing cognitive acts?

### *Inner Organization*

In addition to these worries concerning the notion of cognition, i.e., openness, one may also question the characterization of inner organization provided in *Mind*

*in Life*. Autopoietic processes establish the system as a "unity of space" (p. 101). To count as autopoietic, a system must be "housed within and interdependently linked to a semipermeable boundary. The crucial property is that the membrane is not a mere containment device for the reaction network; rather it is produced and maintained as a product of that network. This propriety is decisive for characterizing an autopoietic system as an autonomous individual" (p. 105). This notion of boundary, however, is not easy to understand in the framework defined by dynamic approaches. Indeed, the latter insists on the organizational, structural, functional properties characterizing autonomous systems. This perspective does not easily welcome the necessity of a boundary. Is the latter supposed to be material (geographical) or can it be functional, organizational? Thompson specifies that interpreting boundary to mean "only semipermeable membrane or skin is too narrow. Rather, what is important is that the system produce and regulate its own internal topology and functional boundary" (p. 121). What matters is to keep the difference between the self-produced system and its correlative environment, but is a material boundary necessary for that, or is it sufficient to maintain organizational discontinuities?

The conception of the autopoietic boundary is central because it is related to the conception of the *inner* organization of the system. As mentioned earlier, both in the order of mind and of life, Thompson conceives of "information" as enacted, i.e., as correlational with the inner organization of the informed system. He also mentions that "the (self) generation of an inside is ontologically prior to the dichotomy in–out" (Moreno and Barandiaran, 2004, quoted in *Mind in Life*, p. 79; see also pp. 224–225). How would such ontological priority cohere with the characterization of the autopoietic system as *structurally coupled* to its environment, i.e., as co-constituted by its openness *and* its inner organization?

*Artificial Selfhood?*

Given the criteria defined by the dynamic approach, mind and life are both characterized by their inner organization and openness. One can question whether these criteria would be too weak, in that they would downplay the fundamental differences between mind and life (e.g., in terms of cognition). I would now like to question whether these criteria would be too strong: Does rooting mind in life exclude non-biological instantiation of selfhood, and if yes, is this justified?

Let us take as an example the case of neuronal networks hooked to a robotic body (see for example the research done by Steve Potter and Ben Whalley). It has been shown that such a neuronal network can organize itself spontaneously, and according to the perturbations coming from the environment, through the robotic body equipped with motor and sensory apparatus. It thus seems that the "organism" as a whole (brain and body embedded in an environment) can *in some way* be characterized as an autonomous and dynamic system. How does this cohere with the fact that evidently, only part of the "organism" is biological? In other terms, what should be privileged in the conception of selfhood: "top–down" autonomy focusing on the relational organization between the organism and its environment, which the robot has to a certain extent, or "bottom–up" autonomy focusing on the energetic and thermodynamic requirements, which the robot lacks to a certain extent (p. 46)? For Thompson, it is "acceptable for some of the components not to be produced by reaction in the system, as long as these components play a necessary and permanent role in the production of other components" (p. 110). In the system composed of the self-

organized neuronal network and of the robotic body, the "brain" and the "body" are surely necessary for each other's organization and functioning. In this sense, can this "bioartificial" system be adequately characterized as an autonomous system in a way which is relevant for the determination of a form of selfhood?

To consider this question, it is relevant to mention that the specificity of autopoiesis, i.e., self-production, is not only that components of the system produce and repair each other, but also that they "exist by means of one another" (p. 135). Autopoiesis is thus not only a way to function but also a way to exist: the self (at whichever level) *exists* through its self-production. On this point, there is a fundamental difference between machines and organisms. While in machines "material parts are logically independent of and temporally antecedent to the whole they determine . . . in organisms parts are determined by their presence in the whole" (pp. 135–136). One may add: in organisms but not in machines, parts both function *and exist* depending on their belonging to the whole.

This latter point, if relevant, would speak against a characterization of selfhood only in functional, structural, organizational terms to also take in account the material implementation dynamically constituting the system in question: "an organism is a material being, and its reality at any given moment coincides completely with its material constitution. Yet, its identity cannot be based on the constancy of matter because its material composition is constantly renewed" (p. 150), and one may add that its material composition is constantly renewed *by its own functioning*. This way of reconciling function and matter is best expressed by Jonas' evocative phrase: "the organic form stands in a dialectical relation of *needful freedom* to matter" (1966, quote in *Mind in Life*, p. 150). As Thompson defends, understanding this relation of needful freedom between functioning and matter, self and world, mind and life, may be the most promising way "to make a headway on one of the outstanding philosophical and scientific problems of our time — the so-called explanatory gap between consciousness and nature" (pp. ix–x).

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