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On the Genesis, Continuum, and the Lowest Bound of Selves

Reshma Joy
Indian Institute of Technology Ropar, India

Abstract In the history of philosophy, the concept of self has been perennially elusive. The philosophical quest to understand the self is rife with phenomenological and metaphysical analyses, often overlooking other kinds of selves present in the biological realm. To systematically explore this question of non-human selves, I categorize the literature on philosophical and biological notions of self into the biogenic, the zoogenic, and the anthropogenic approaches to self. This article attempts to chart the genesis, the continuum, and the lowest bound of the self. Further, I enumerate challenges in developing a biogenic approach to self or taking the concept of self all the way down in the phylogenetic tree.

Keywords Basal cognition. Biopsychism. Biogenic approach. Cognition. Mind. Self. Zoopsychism.

Summary 1 Introduction. – 2 The Continuity Thesis and Its Variations. – 3 The Anthropogenic Approach to Self. – 4 The Zoogenic Approach to Self. – 5 The Biogenic Approach to Self. – 6 The Technogenic Approach to Self. – 7 Challenges in Tracing the Natural History of the Self. – 8 Conclusion.

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1 Introduction

The concept of self is an unending philosophical conundrum. From 'no-self' theories to that of the 'minimal self', theories of self have multiplied, most of which are mutually incompatible. While the no-self theories assert that there is no permanent or autonomous self, the minimal self theories maintain that there is an immediate pre-reflective awareness of self. Varieties of no-self theories range from Hume (1739) to Metzinger (2004) to Buddhism, whereas Strawson (1999) developed the concept of minimal self, which Gallagher (2000) and Zahavi (2017) extended further. These notions of minimal self overlap with the theories of bodily self primarily expounded by Bermúdez et al. (1998), De Vignemont (2011), and others, as we shall see the concept of bodily self is central to the investigation of non-human selves.

In his paper *The Self and the SESMET* (1999), Strawson mentions around twenty-six different kinds of selves like the social self, the ecological self, the linguistic self, the verbal self, the narrative self, and the extended self – to mention a few. These theories of self are extremely diverse and differ in the context in which they are studied. For example, the notion of the social self proposes that an individual's conception of self results from interactions with others in society (Mead 2015). The ecological self, akin to the bodily self, defines the self in terms of an individual's situatedness and active relationship with the immediate physical environment (Neisser 1995).

On a closer examination of the above theories of self, we can identify a common thread connecting all of them, *i.e.*, the anthropocentric nature of such theories. Both realist and anti-realist theories (no-self theories) of self equally subscribe to anthropocentrism. For instance, Olson (1998) has identified a problem in defining the self. He remarked that for every answer to the question of the definition of self, there is another answer that is completely incompatible and unrelated. He underlined that in our attempt to define self from a particular point of view. There is a possibility that we undermine other valid views of self. Thereby, he points out the impossibility of achieving a unified conception of self and suggests abandoning the usage of the term 'self' altogether from our parlance.

What I find problematic in all theories that consider anthropocentrism as the norm in defining the self is their neglect of the possible notions of self in non-human organisms. This neglect certainly poses questions about species-chauvinism regarding selfhood, like: are there no other selves beyond that of the homo sapiens? Are humans the only privileged species to acquire selves among millions of other different species? Doesn't the existence of the self admit the question of origination? When and how did the self originate? Can we trace the origin of self to the origin of life? These are difficult questions to answer, and they emphasize the necessity to probe into the biological

nature of the self. If the notion of self is immune to the question of its biological and evolutionary origins altogether, then the presence of self in human beings appears to be an exception.

Moreover, at times, the impression of exceptionality lurks in conceiving the self as a non-biological entity altogether. On the other hand, if a better biological and evolutionary explanation of the reality of self is to be made available, we could systematically explore the possibility of non-human selves. This exploration of non-human selves will enable us to abandon species-chauvinism and conceive ourselves as a link in the great chain of the evolutionary continuum. Further, the question of the genesis of the self will aid in unravelling the possible existent selves beyond the human socio-linguistic horizon and physiology.

In this article, I will critically examine the autopoietic bodily conception of the self and the cognitive goal-directed approach to the self. Among all the different varieties of selves available to us in the anthropocentric literature of self, the most biocentric definition of self is produced by the school of bodily self, which treats the self as an embodied natural entity. Along with notions of bodily self, a novel cognitive goal-directed approach to self formulated by Levin (2019; 2022) helps to unravel the notion of self of different biological entities. Along with the bio-genesis of the self, this article will also probe the lowest bound of the self possible in the natural world and the life-self continuum[1] with reference to the bodily self and cognitive approach to self. I will begin the article with the history of the life-mind continuity thesis, which asserts that our mental traits evolved from other animals, like physiological traits. Other organisms possess mental traits as we do, but the complexity may vary from higher animals to lower animals. Then, I will classify different approaches to self based on their subject of study as the anthropogenic, the zoogenic, and the biogenic approaches to the self. Finally, since the article focuses on the genesis, the possibility of a life-self continuum, and the lowest bound of self, I will elaborate in detail on the biogenic approach and the models available within the biogenic approach.

I begin the discussion on non-human selves in section 2 by wading through the overarching philosophical theme of the continuity thesis. Subsequently, in this section, I will present a brief history of the thesis and its variations found in the literature, including that of weak and strong continuity thesis, zoopsyschism and biopsychism, and mind-life continuity thesis and the field of basal cognition and biogenic approach. **[Fig. 1]** juxtaposes the different varieties of the continuity thesis and the sub-varieties of the thesis. Section 3 of the article sketches the classical anthropogenic approach to self and brings

1 Similar to the life-mind continuity thesis, in this paper, I coin the term life-self continuity thesis. The life-self continuity thesis asserts that life is always accompanied by the self.

out the deep anthropocentrism rooted in classical theories. This section makes an argument for naturalism and picks out the bodily self from the anthropogenic approach as a starting point to ponder upon non-human selves. Section 4 introduces the zoogenic approach to self and the primary characteristics of this approach. Further, the section elaborates on reafference and how various thinkers extend this aspect of bodily self to accommodate non-human animals. Section 5 details the biogenic approach and basal cognition. Sub-sections 5.1 and 5.2 discuss autopoietic and cognitive models, respectively. Section 6 introduces another variety of self we find in literature, the technogenic self. **[Tab. 2]** plots all the different varieties of selves discussed in this article. Section 7 enumerates various challenges we face while developing a biogenic approach to self, namely that of the over permissivity in the cognitive model, the paradox of perspectival realism of self presented by the biogenic approach, and entangled concepts which form three types of the continuum: the cognition-life continuum, the cognition-self continuum, and the life-self continuum. Section 8 concludes this article by recapitulating the biogenic answers to initial questions, and **[Tab. 3]** tabulates answers. The article ends with a suggestion to furnish an empirically robust criterion for the self, which should be exclusive to biological organisms.

2 The Continuity Thesis and Its Variations

Before pondering upon the non-human selves, it is important to discuss the *mental status* of animals in traditional philosophy and the shift to the continuity thesis. The traditional accounts of the soul or psyche overlook non-human beings, like Plato's (Allen 2006) account in *The Republic,* which compared the irrationality of human beings with that of animals. In *On the Soul* and *Nicomachean Ethics*, Aristotle (2018, 2014) denied reason to animals.[2] St. Augustine (2009), in *The City of God*, maintained that animals exist for humans' sake, and in *Eighty-Three Different Questions* (Augustine 2010), writes that everything is made for man's use because man is bestowed with reason. Descartes, in *Discourse on Method* (1987), considered animals as mere automata since they lack the faculty of language and reason.

2 However, Aristotle's (1991) categories represented in the Porphyrian tree maintain that there is continuity in terms of his classification of categories, such as substance (extended type), a body (animate type), animal (rational type) human (particular type). Thinkers like Sorabji (1995) have argued that Aristotle considers animals to have memories, perceptions, desires, and emotions so hat they can be said to bear a mind. Again, in Aristotle's terminology, he marks that the soul is available to the category of animals (or, for that matter, any living thing), but the reason is ascribed only to humans. The ability for speech and reasoning characterizes the discontinuity in Aristotle.

Descartes also denied the capacity to feel pleasure or pain to animals. Smith (1963) termed this cartesian position as the *monstrous thesis*. Further, Harrison (1992) captured the essence of the cartesian monstrous theory by adopting Malebranche's words: "They eat without pleasure, cry without pain, grow without knowing it. They desire nothing, fear nothing, know nothing"[3] (Harrison 1992, 219).

Heidegger (1996) claimed that animals are world-poor (*weltarm)*. Heidegger restricted his usage of 'existence' to human beings, excluding animals and inanimate beings since they lack language and historicity. The accounts of St. Augustine and Descartes maintain that humans are uniquely and strikingly distinct from the rest of the living organisms. In other words, these accounts highlight the discontinuity in the evolutionary chain between humans and other animals. However, today, the study of cognition and mind is slowly abandoning this deep-rooted species chauvinism (Lyon 2006; Bekoff 2002; Griffin 2001) by studying different cognitive behaviors and acknowledging intelligence that lies beyond the peripheries of the human nervous system in different biological organisms. They maintain that there is mental continuity between humans and the rest of the beings. This continuity thesis explored by the current thinkers has a long tradition. It was Aristotle who propounded this thesis for the first time, and we can identify its lasting influence in the Romantics (Steiner 2005). Even before Darwin's systematic formulation of the theory of evolution by natural selection (1859), the idea of continuity appeared in the works of Hume (1739) and Darwin's contemporary Schopenhauer (1818).[4] The primary mandate of the continuity thesis is captured in the Darwinian dictum, which states that "The difference in mind between man and the higher animals, great as it is, is certainly one of degree and not of kind" (Darwin 1871, 105).

Further, the continuity thesis is found in the works of Spencer (1872), Haeckel (1892), Dewey (1929), Jonas (1966), Maturana and Varela (1991). The continuity thesis has two major varieties today: *zoopsychism* and *biopsychism*. Haeckel was the first to use both terms. He termed the inheritance of mind in every life form as biopsychism and zoopsychism as the notion that grants mind to only animals.[5] Further, the use of the terms appeared in the recent works by Godfrey-Smith (2016) and Thompson (2022). Thompson conceptualizes zoopsychism

3 Cottingham (1978) challenged this classical interpretation of Descartes and remarked the monstrous theory is vague and ambiguous.

4 During the second half of the 19th century, one may notice thinkers addressing the continuity thesis largely inspired by their interest in Eastern traditions. Especially the notions which emphasize the interconnectedness of humans and the nature.

5 Haeckel's (1892) tripartite categorization includes panpsychism, biopsychism, and zoopsychism. He subscribes to the philosophy of panpsychism rather than that of biopsychism and zoopsychism.

to recapitulate notions that attach mentality to animals or organisms with a nervous system. Likewise, drawing from Dewey and Spencer, Godfrey-Smith (1994) divides the continuity thesis into strong and weak continuity theses. Similar to biopsychism, strong continuity maintains that the "*mind is life-like*" (Godfrey-Smith 1994) and that the basic organizational properties of mind and life are the same. The weak continuity thesis, zoopsychism, maintains that everything that possesses a mind is alive, but everything that is alive may not possess a mind. Jonas (1966), with his philosophical biology, maintains that the process of metabolism gives rise to the primal aspect of the mind. This phenomenological variety of biopsychism proposed by Jonas, Maturana, and Varela was later subsumed under the neologism of life-mind continuity thesis. The life-mind continuity thesis later formed the crux of the Autopoietic Enactivist school[6] of 4E philosophy.[7]

The other modern variations of biopsychism are the novel and budding areas of basal cognition (BC) and the biogenic approach (BA). These areas provide us with a unique way to think about the mental capacity of different organisms. BC deals with the fundamental processes necessary to sustain the organism, including cell-to-cell signaling, bioelectricity, etc. These processes evolved long before the nervous system existed (Lyon 2006; Keijzer et al. 2013; Baluška, Levin 2016; Levin 2019, 2021, 2022; Lyon et al. 2021). BC treats these processes as cognitive in nature. BA to the mind starts with rethinking the philosophy of the mind from a biological perspective rather than from a psychological perspective (Lyon 2006). Both are rooted in numerous empirical studies with the philosophical quest to divorce the concept of cognition from its anthropomorphic veneer, which unraveled the astonishing mental capacities possessed by the inhabitants of the microcosmos. BA's fundamental presupposition is its commitment to mental continuity between humans and other living organisms (Lyon 2006). BA employs empirical data, whereas the life-mind continuity theory expressed in Autopoietic enactivist literature is primarily an ontological theory. The concept of autopoiesis is yet to gain empirical validation. Zolo, who is a critic of autopoietic theory (1990), writes that

> Autopoiesis does not designate any specific feature of biological phenomena and cannot be identified either with the reiterative cellular loop or with homeostatic mechanisms. Unity, autonomy, and "closure"

6 Autopoietic Enactivism brings enactivism and autopoietic theory together. Ward et al. (2017) define autopoietic enactivism as the theory that grounds cognition in the "biodynamics of living systems".

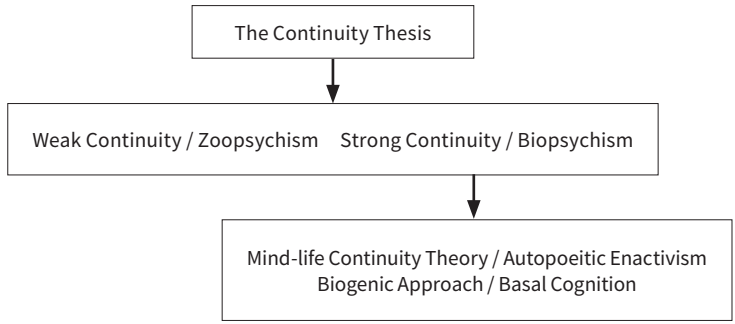
7 The 4E (Embodied, Embedded, Enacted and Extended) approach emphasizes the role of body, environment, along with brain in the act of cognition. 4E approaches question the central claims of classical theories of cognitive science like computationalism and representationalism. See Newen et al. 2018.

> are not empirical features. Rather, they are theoretical concepts synonymous with autopoiesis and self-production. (Zolo 1990,65)

Autopoietic theory has seen only limited success in the biological sciences. Scheper and Scheper (1996) elaborate on the tautological nature of the theory and claim that the theory is empirically untestable and lacks explanatory power. Escobar (2012) disagrees with Scheper and Scheper over the empirical nature of the theory, and he details other major issues with the theory, like that of self-referentiality.

Nonetheless, the continuity thesis and BA fall broadly under the 4E approach to cognition.[8] The BC and BA are the most empirically grounded variations of biopsychism. The primary focus in BA and BC remains on cognition; nonetheless, the literature covers the overarching themes in the philosophy of the mind. I will discuss more about BC and BA in section 4 of this article. **[Fig. 1]** plots the varieties of the continuity thesis in the literature.

Figure 1 Varieties of Continuity Thesis



Unlike the concept of mind or cognition, the concept of self is more perplexing. Nonetheless, the thesis provides a framework to rethink capacities like cognition, agency, sentience, etc., which are traditionally considered to be exclusive to humans and argues that such capacities are ubiquitous in the biological world. With this framework in the backdrop, in the following sections, I will explore the continuity of self.

Even though there are scattered discussions on unconventional notions of self like that of the *immune self* (Chernyak, Tauber 1991;

8 Lyon (2006) points out that the biogenic approach can be accommodated under the 4E school. However, not all strands of thought in 4E are biogenic.

Tauber 1994) in the philosophy of biology,[9] a systematic exploration of the genesis and the phylogenetic continuum of self is a poorly explored area. In this article, I venture into BA, where we find latent thoughts about the self, pointing towards a life-self continuum. Along with BA, zoopsychist literature has also produced significant ideas on the concept of self in non-human animals. Drawing from Lyon and Haeckel, I classify these theories of self into three approaches, namely, as the anthropogenic, zoogenic, and biogenic approaches. This scheme will provide a course to organize numerous possibilities of self beyond human psychology. The following sections, 3, 4, and 5, will elaborate on these approaches in detail.

3 The Anthropogenic Approach to Self

The classical philosophical theories of self maintain a human-centric approach to defining the self. I term them as the anthropogenic approach to self. These anthropogenic approaches include the conceptions of self like that of the social self, the verbal self, the narrative self, etc., as mentioned earlier. In addition, this approach includes various aspects of self that are studied from a biological perspective in fields like psychiatry, where the concept of self is studied with reference to different psychopathologies (Saas 2001; Parnas, Sass 2003), but they still main human-centric approach to self. This human-centric approach is characterized by studying the self from phenomenological, introspective, psycho-social, linguistic, narrative, and theological perspectives from a first-person point of view.

The schools within this approach, like that of the social self, investigate the self by tracing its origins to society and *others*, whereas schools, like the linguistic self, examine the notion of the self within the paradigm of language and memory. Similarly, the narrative self presents a hermeneutical view and theological conception of self, theorizes the self as a metaphysical substance bestowed by a divine being, and so on.[10] At times, this approach leads to the denial of self or anti-realism regarding the existence of self,[11] as mentioned in the introductory section of this article. The anthropogenic approaches are often imbued with notions of human exceptionalism. Human exceptionalism is the notion that humans are superior to other animals.

9 The immune self refers to the inherent capacity of the immune system in an organism's body to recognize foreign elements entering the body. Thereby possessing a primitive ability to distinguish the self and the other.

10 For a detailed history of the anthropogenic self, see Barresi, Martin 2011.

11 In this article, I argue for the realist account of self. From a biological perspective an organism requires a form of unity or a form of organismal identity that can persist over time to ensure its survival.

For instance, Dennett (2017) attributes human exceptionalism to the unique role culture plays in human evolution. This view maintains that humans are different from other animals not in degree but in kind. These accounts altogether overlook the concept of non-human selves and ignore the evolutionary history of self. Various definitions of self provided by the different schools in this approach are too narrow and stringent. Extending these definitions beyond human subjects to accommodate different non-human agents would be a dead-end. For example, consider the Dennettian conception of narrative self (Dennett 1992), which involves autobiographical memory or autonoetic consciousness (Tulving 1985). Autonoetic consciousness is a kind of consciousness that involves an organism's ability to mentally time travel into the past and future.[12] According to the current consensus and empirical evidence, only *Homo sapiens* are bestowed with this unique variety of consciousness. Such notions of self are too narrow, which provides no space for non-human animals.

However, recent attempts to naturalize phenomenology by Zahavi (2010) and Gallagher (2012) are based on various empirical studies and phenomenological accounts. Naturalized phenomenology also considers the numerous accounts of the bodily self and the ecological self, which can aid us in thinking about the self in unambiguous natural terms and enable us to extend selfhood to non-human animals.

Therefore, I begin the quest to understand the natural history of self by analyzing the bodily self of the anthropogenic approach. The literature on the bodily self provides us with a unique *segue* to ponder upon the genesis and phylogeny of the self, which in turn compels us to examine novel ideas emerging from the philosophy of biology and cognitive science closely. While there are numerous phenomenological dimensions of bodily self within the anthropogenic approach, this article will primarily focus on the empirical perspectives that elucidate the concept of self embedded in an organism's physical body.

4 The Zoogenic Approach to Self

The bodily self is a non-dualistic and anti-transcendental account of self. This view maintains that the self is embodied, or in other words, the self is embedded in the human body. This notion of self highlights how bodily mechanisms like that of proprioception (Sherrington 1898) and reafference (von Helmholtz 1866) contribute to the awareness of self. Proprioception is a form of perception that provides information about bodily positions like the positions of muscles, limbs, etc. Therefore, proprioceptive awareness is treated as

12 It is closely related to the Bischof-Köhler hypothesis.

the awareness of one's own body that is extended in space. Reafference is the process where an organism perceives that the sensation it experiences results from its own bodily movements. It is often contrasted and juxtaposed with exafference, the process where an organism perceives that sensations are caused by the external world.

These conceptions of bodily self can be extended to include non-human animals, as such processes are not exclusive to humans. Within this framework of bodily selves, the pre-reflective bodily awareness (which arises from the bodily mechanism of proprioception and reafference) is often treated as self-awareness and self-consciousness. This intrinsic relationship between the bodily self and the self-consciousness is captured by Bermúdez (2011, 166) with the following premises.

1. The self is embodied.
2. First-person bodily awareness provides perceptions of bodily properties.
3. First-person bodily awareness is a form of self-perception.
4. Therefore, first-person bodily awareness is a form of self-consciousness.

In this argument, the deduction of self-consciousness from self perception is built on the premise that first-person bodily awareness contains certain aspects that are also forms of self-consciousness, like introspection and autobiographical memory. This implies that the first-person bodily awareness is self-specifying. Another aspect of the bodily self in the literature includes the bodily ownership or the sense of ownership and the bodily agency or the sense of agency. Bodily ownership is the "sense that I am the one who is undergoing an experience" and bodily agency is "the sense that I am the one who is causing or generating an action" (Gallagher 2000, 15).[13]

Such notions of self-consciousness and bodily self-awareness can be extended beyond the limits of human psychology and human physiology. The various aspects of the bodily self have been employed in studies of the non-human self in the past, like mirror experiments and self-recognition methods (Gallup 1970; Povinelli et al. 1993) of comparative psychology. These studies shed light on animals' capacity to recognize themselves in the mirror (here, the capacity of self-recognition is treated as an integral part of self-awareness). However, the mirror experiment had its own limitations; it could not accommodate

13 Gallagher (2000, 15) also conceives of this form of bodily ownership and bodily agency as two aspects of minimal self. Gallagher explains as the "basic, immediate, or private something" that remains after when all "unessential features of self" are stripped away. However, Gallagher underlines that the minimal self is dependent on "brain processes and an ecologically embedded body". Along with Gallagher, Strawson (2011) and Zahavi (2011) have articulated their versions of minimal self.

a wide variety of animals with varied senses and attention patterns. Considering the lack of success of various animals in mirror self-recognition tests, de Waal (2019) suggests that we should adopt a gradualist perspective on self-awareness. de Waal opines that our ideas of self-awareness are akin to the *Big Bang theory*: self-awareness came into existence out of nowhere. The Big Bang attitude to self-awareness still dominates the philosophical studies on self and cognitive sciences as well. These attitudes can be eliminated if we take into consideration various aspects of the bodily self.

Deeply rooted in phenomenology and ecological traditions,[14] the bodily self today takes center stage in numerous studies on the self in cognitive science. Further, the extension of bodily self to accommodate non-human selves can be seen in DeGrazia's tripartite classification of animal awareness (2009): Bodily Self-awareness, Social Self-awareness, and Introspective Self-awareness, which presents bodily self-awareness as the primary form of self-awareness. He remarks that every sentient animal possesses such bodily self-awareness. Bermúdez (2018) hints at non-linguistic and prelinguistic creatures possessing a nonconceptual point of view.[15] The work of Jékely, Godfrey-Smith, and Keijzer (2021) elaborates on the phylogenetic rendition of bodily self. They allude to the process of reafference to explain the concept of bodily self in animals with rudimentary nervous systems.

Neuroscientist Hendricks refers to this process of differentiating sensory inputs as the essence of sentience.[16] The concept of reafference and bodily self is also elaborated by Legrand (2006). The concept of reafference and corollary discharge appears in many naturalistic renditions of bodily self. Corollary discharge is defined as a pathway that allows animals to recognize their own actions (Sperry 1950; von Holst, Mittelstaedt 1950).

Further, Gallagher draws from Firth (1992) and explains the possibility of realizing his version of the minimal self with sense of agency and sense of ownership in neurophysiological terms of efference

14 Neisser (1995) describes the ecological self as the self which can be directly perceived with reference to the physical body. Nonetheless, the works of ecological theorists (Gibson 1966; Neisser 1995; Rochat, Hespos 1997) focus more on ontogeny than phylogeny.

15 Bermúdez (2018) explains that the nonconceptual point of view enables an organism to take a route to navigate its environment and to realize that its perception of the world is influenced by its activity of taking the route. Bermúdez highlights that the nonconceptual point of view has two principal components; nonsolipsistic and spatial awareness.

16 Taken from Ed Young's *An Immense World* (2022). Young reports a personal conversion between Hendricks and him, where Hendricks refers to the process of reafference as the base of animal sentience.

copies[17] and comparator model.[18] However, these accounts remain silent on the prospects of bodily self in non-human animals and the applicability of the principle to lower organisms. Jékely, Godfrey-Smith, and Keijzer (2021) further extend the concept of marked reafference and the origin of bodily self to accommodate animals with nervous systems. They do not deny the primal form of self to unicellular organisms or organisms without a nervous system. However, they emphasize that non-neural animals are restricted to limited coordination and agency. "Their bodies, while materially unified, are not tied together as selves in the same way that a neural animal is" (Jékely, Godfrey-Smith, Keijzer 2021, 3).

Along with the reafferent principle and corollary discharge, they relate the origin of the complex bodily self to the origin of the nervous system. The bodily self models based on reafference underline how the self and the other distinction arose in the animal psyche or, in other words, how animals became aware of the physical reality of their own body and the external world.

I term the above account as the zoogenic approach to self, where the nervous system is treated as the epicenter of the self – the zoogenic approach to the self grants self to only animals and organisms with nervous systems. Given the significant developments in the area of aneural cognition in recent years and the argument pertaining to the ubiquity of cognition in all life forms, which I examined in section 2, I further suggest that we should not limit the definition of self only to animals with a nervous system instead we must explore the possible forms of selves in aneural organisms. Even though unorganized, there exists literature that points to the direction of the self-life continuum/the existence of self in every form of life. The present literature on aneural self warrants that we examine it closely and do not restrict ourselves to nervous-centric ideas of self.

Along with the zoogenic self, we can find many strands of thought in the literature that associate the self only with the human brain. These descriptions of the self are incredibly narrow. Moreover, the survey of various literature on the self and brain maintains that finding neural correlates of self in the human brain is highly improbable (Vogeley, Gallagher 2011). Given all this, we must look beyond the zoocentric approach to self. In the next section on the biogenic approach, I will focus on how the concept of self can be understood in aneural organisms or organisms without a nervous system.

17 Efference copies are the copies of the efferent signals that are sent from the brain to efferent organs. These copies aid the process of reafference. It is also speculated that the efference copies play a key role in consciousness, see Vallortigara 2021.

18 Comparator model is the theoretical model for action control. Proposed by Frith (1992), the model includes numerous components like feedback loops, predicted state, desired state, etc.

5 The Biogenic Approach to Self

The quest for understanding the genesis of self takes us to the emerging areas of basal cognition. In basal cognition, numerous empirical studies question the uniqueness of the nervous system (Lyon 2006; Levin 2019, 2020; Levin, Keijzer et al. 2021; Lyon et al. 2021). Here, I mark the need to distinguish the definitions of the zoogenic approach from BA. Zoopsychism, the overarching idea of equating the genesis of self or mind or cognitive capabilities with the emergence of the nervous system, challenges the continuity thesis of life in the mind. Zoopsychism falls under the paradigm of the weak continuity thesis of Godfrey-Smith. Zoopsychism proposes that there was a sudden awakening of biological beings into the light of sentience with the evolution of the nervous system. This classification between neural and aneural understanding of mind, cognition, and self is missing in general accounts of BA. However, this classification is better fleshed out in the works of Thompson (2022) and Godfrey-Smith (2016). BA is a bottom-up approach that calls for a Copernican revolution in the study of the mind (Lyon 2021). Any theory that builds on the principles of biology is part of BA (Lyon 2006). BA asks us to revisit our methods of understanding the mind and cognition. It is the family of approaches welded together by relevant themes and motivations (Sims 2021). It is an explanatory framework that treats cognition as a biological function, a set of mechanisms that enable storing, processing, and acquiring information at any biological level (Lyon 2006), including that of the subcellular level (Baluška, Levin 2016).

Similarly, BC primarily deals with aneural organisms, a research field furnishing astonishing data on unicellular organisms' cognition. This notion of cognition without the brain, especially in unicellular organisms, is scattered throughout the scientific literature. Darwin (1880) and his son Francis were the first to propound the root-brain hypothesis, the idea that the root-apex of plants functions like a brain. Likewise, Timsit and Gregoire (2021) maintain that Binet, Jennings, Loeb, and Gelber initiated 'neuron-free neuroscience'. Goodwin (1977) was the first to use the term 'cognitive biology'. Bray (1995) claims that cytoskeleton filaments and ribosomal protein networks in cells mimic different functions of neuronal networks. Kondev (2014) makes an astonishing statement that the E. coli cells exhibit free will. In addition to this, the cellular basis of consciousness by Reber (2016), plant neurobiology and plant cognition by Calvo Garzon (2007), Baluška and Mancuso (2009), Garzón and Keijzer (2009), Calvo and Trewavas (2020), and so on bring out numerous cognitive capacities of microbes and plants. These claims form a significant part of BC and BA literature today.

BA is further categorized into the self-organizing complex systems theories (SOCS) and the autopoietic theory of Maturana and Varela

(1980). Self-organizing systems theories highlight the connections between thermodynamics and cognition, and autopoietic theories underline the intrinsic relation between living and cognition (Lyon 2006; Sims 2021). BA deals with cognition and mind, we find latent schools of thought on the self within the BA. I term them the autopoietic model of self and cognitive model of self. The autopoietic model of self highlights the emergence of the bodily self embedded in the process of autopoiesis, and the cognitive model presents a functionalist account of the self. These models provide us with the likely candidates for the lowest bound of the self in the biotic world and possibly will shed some light on the genesis of the self.

5.1 Autopoietic Models of Self

Autopoiesis was coined by Varela and Maturana (1980, 1987, 1991) to answer the question of life. It serves to distinguish life from non-life. The etymological meaning of autopoiesis is *self-producing*. Primarily, autopoiesis was theorized as the process that explains the intrinsic interrelated nature of life and cognition. An autopoietic system is considered a self-organizing and self-producing system. An autopoietic system has a boundary. The boundary generates reactions inside the boundary, and the reactions inside the boundary determine the boundary. This cyclical network of reactions enables the demarcation of the 'self' and the 'other'. Autopoietic theorists maintain that this cyclical logic (Luisi 2003) is the basis of life, and it gives rise to the 'self' at a cellular level. Therefore, autopoietic theory entails that the self is an invariant of life. The theory also maintains that living itself is a cognitive process. A living system's interaction with its environment is treated as cognition in the autopoietic framework. A similar account of boundary and self can be found in the early work of Dennett (1989). Further back in history, the idea of self-organization and life was explored by Kant in the *Critique of Judgement* (1987). The literature on Autopoietic enactivism (Weber, Varela 2002; Barandiaran et al. 2009; Froese, Di Paolo 2011) takes the life-mind continuity thesis as its central theme and discusses different fundamental aspects of self with the processes of sense-making (Weber, Varela 2002), adaptivity (Di Paolo 2005), etc. Sensemaking is better explained with the example of a bacterium moving towards the sucrose-rich gradient; this movement represents the significance that the organism attaches to its external world or environment. The process of sense-making brings forth the world to the organism. Further, adaptivity is defined as an organism's struggle to maintain its organizational integrity, and this process renders the organism a form of individuality and identity.

Thompson captures the concept of bodily self and cognition encapsulated in the autopoietic theory via sense-making with the following propositions:

> Life = Autopoiesis and Cognition.
> Autopoiesis entails the emergence of the bodily Self.
> Emergence of Self entails emergence of world.
> (Thompson 2007, 158)[19]

Another account of self was proposed by Glasgow (2018), wherein he articulated the account of the minimal self in unicellular organisms with the three conditions of *intrinsic reflexivity*, namely self-maintenance, self-reproduction, and self-containment. Glasgow maintains that for any organism to attain minimal selfhood, it must fulfil all three conditions. The condition of self-reproduction is Glasgow's addition to the autopoietic theory of Maturana and Varela's theory. In contrast, Maturana and Valera maintained that self-maintenance/self-organization is ontologically prior to self-reproduction. Nevertheless, Glasgow's theory also falls under the autopoietic framework since it is based on the autopoietic theory. Autopoietic models consider a single cell as the lowest bound of the self. Despite ample work produced on the theory of autopoiesis, it still remains as a theoretical framework for understanding life, self, and cognition. Contrary to other strands within the biogenic approach, the autopoietic theories lack robust empirical findings to validate the mechanism of autopoiesis in living systems. A single cell is a complex system with thousands of interconnected molecular networks; from what kind of networks the autopoietic reactions emerge is still an unanswerable question.

5.2 Cognitive Model of Self

A cognitive account of the self emerges in the recent writing of Levin. Levin's biogenic approach theorizes the concept of self in functionalist cognitive terms. Unlike the autopoietic theory, the cognitive model of self is deeply rooted in novel empirical findings. Empirical findings of unconventional modes of intelligence and the incredible

19 However, Thompson does not subscribe to this notion of autopoietic bodily self. Thompson maintains that "it seems unlikely that minimal autopoietic selfhood involves phenomenal selfhood or subjectivity, in the sense of a pre-reflective self-awareness constitutive of phenomenal first-person perspective" (Thompson 2007, 162). In his recent work *Could All Life Be Sentient?* (2022) Thompson again raises similar concerns. However, the proponents of autopoietic enactivism use terms such as 'point of view' while explaining the concepts of sense-making which distinctly highlights the involvement of subjectivity in this process of sense-making (Kee 2021).

ability of various non-neural entities to navigate different morphological problem spaces form the bedrock of the cognitive self. Unconventional modes of intelligence include forms of bodily intelligence embedded in somatic cells, such as the memory of muscle cells. Levin draws from James' (1981) test for minimal mentality and elaborates on how cells display collective intelligence during the process of morphogenesis (Levin 2023). He maintains that intelligence is ubiquitous in biological systems. The classical parameters of intelligence, like problem-solving, memory, and decision-making, are not bound to the nervous system. These attributes of intelligence are exhibited in genes in cells to organs in a biological system, and to non-living entities (Levin 2021). Levin defines the self as "a coherent system emerging within a set of integrated parts that serve as the functional owner of associations, memories, and preferences and acts to accomplish goals in specific problem spaces where those goals belong to the collective and not to any individual components" (Levin 2022, 40). He maintains that this definition can accommodate different kinds of selves – minimal, complex, artificial – cells, organisms, humans, machines, etc. The boundary of the self in this account is malleable. The self can expand its boundaries and dissipate into smaller selves in a biological system. The expansion and dissipation of self in the cognitive account sets it apart from autopoietic models, where the boundary conditions define the system, and the boundaries are not flexible like that of the cognitive model.

Further, he proposes that selves can be classified by a spatiotemporal scale and by the type of goals they can pursue. Levin terms this notion of self as the "Cognitive Light Cone Theory of Self". The light cone theory of self advocates for a continuum of selves that ranges from simple to complex to artificial. Complex selves, like humans, can think beyond their present time and space. They transcend their mere needs – such selves are concerned with climate change and the life of stars, etc. In contrast, simple selves, like those of ticks, are concerned about nothing more than food, and their goals are limited, immediate, and not complex, like that of the human species.

The complexity of cognition is also defined by the complexity of goal-directedness, which in turn defines the different degrees of selves. He terms this approach as TAME- *Technological Approach to Mind Everywhere* (Levin 2022). This approach is concerned with recognizing minds across the spectrum or studying mind-as-it-can-be.[20] Levin explains three foundational aspects of TAME: first, its commitment to gradualism. Second, a substrate-independent-functional approach to self and agency; and third, conceiving the mind, the self, and the agent as engineering problems. Its radical commitment

20 Adopted from Artificial Life's motto: life as it can be.

towards gradualism takes the concepts of cognition, mind, and self *all the way down* to the subcellular level. Self is substrate-independent, which can be realized in biological and non-biological systems. Levin also maintains that the distinction between the life and non-life organism and machine is redundant. The engineering treatment offers a different paradigm to view agency, mind, and self in an experimental framework, thus taking these concepts beyond the intricacies of philosophical debates. Hence, this approach maintains goal-directed machine is also a kind of self. With this account, Levin provides a unified theory of self with a simplistic apparatus to grade the different varieties of possible selves.

6 The Technogenic Approach to Self

The technogenic approach to self is the extension of the continuum of self. The approach extends the concept of self to non-natural, artificial, and technical entities. The primary variety of the technogenic self is the robotic self. The robotic self comprises humanoid robots engineered to mimic different aspects of the anthropogenic or the zoogenic self. Tony Prescott and iCub[21] have been working on robotic selves; their research focuses on selves in humanoid robots engineered to mimic various aspects of anthropogenic selves. Prescott and Camilleri (2019) detail their fascinating work in progress with a control architecture called distributive adaptive control or DAC (Verschure et al. 1992; Verschure 2012), which can generate different varieties of anthropogenic selves like the ecological, the extended, the interpersonal, the conceptual and the private self in robots. Studies on the robotic self often take insights from developmental psychology and developmental robotics (Hafner et al. 2020). Furthermore, Hafner (2019) probed the robotic self with Gallagher's minimal self model.

Further, in Takeno's (2012) work, the mirror recognition experiment explores the robotic self. This debate leads us to the possibility of artificial minds, artificial phenomenal consciousness, etc. It warrants us to examine the intricacies of technopsychism closely. A full-fledged detailed survey of the robotic self is beyond the scope of the article. However, we must note that both autopoietic and cognitive models can be extended to accommodate various technogenic selves. Technogenic selves are often an extension of anthropogenic, zoogenic, and biogenic selves. In **[Tab. 1]**, I juxtaposed the landscape of varieties of selves discussed in the paper.

21 iCub robots are humanoid robots that resemble a three-year-old child. iCub robots' cognitive capabilities are scaffolded using principles of embodied cognition.

Table 1 Different Approaches and Models of Self

Approach	Models	Definitions and mechanisms	Subjects of the study	Definitions and Criteria of self
Anthropogenic	The Social self, The Verbal self, The Narrative self, The Minimal self, etc.	First-person perspective, psychosocial structures, language, Brain process, etc.	Human	Different models explain the self with different definitions.
Zoogenic	Reafferent models of the self	Reafference	Animals	Animals with marked reafference possess the bodily self.
Biogenic	The Autopoietic model of self The Cognitive model of self	Autopoiesis Goal-direct-ed cognition	Biological entities Non-biological entities and biological entities	The process of autopoiesis gives birth to the bodily self. Goal-directed cognition is treated as the hallmark of the self.
Technogenic	Robotic model	Mimicking various aspects of other approaches.	Non-Biological entities	Realization of various aspects of anthropogenic and zoogenic selves are taken as the criteria of self.

7 Challenges in Tracing the Natural History of the Self

There are various challenges associated with unravelling the natural history of the self. This section will enumerate the significant hurdles. Nonetheless, the list is not exhaustive.

7.1 All Too Permissive

Fred Adams' charge against the biogenic approach to cognition in his paper *Cognition wars* (2018) is that the approach makes cognition all too permissive. The continuum of cognition lacks a strict criterion that can demarcate cognition and non-cognition. The concept of cognition is extended so much that the concept itself becomes redundant. The

concept of self in the cognitive model faces similar issues. Diluting the criteria for self makes it so permissive that almost anything and everything can qualify as self. Consider Monod's claim (1970)[22] that the goal-directed activity of proteins is cognitive, and goal-directed activity being the criterion for self in the cognitive model, and it eventually creates a self-bloat.[23] This takes us to something similar to panpsychism about the self. The self in biological systems appears to be unique and different from that of non-biological entities, possessing a kind of intrinsic inwardness. Here, we need to investigate the uniqueness of biological selves. The plot of a unified theory of self fails to capture the nuances of the inwardness of self in biological entities. Just as di Primio et al. (2000) captured the essence of the challenge of over-permissivity in minimal cognition with the phrase, "seeing cognition everywhere is virtually equivalent to seeing it nowhere in particular", in the context of the biogenic self, it can be said that seeing the self everywhere is virtually equivalent to seeing selves nowhere in particular. The cognitive model is also not biological in nature, and it does not underline any biological principle; instead, it provides a framework within which we can locate the selves of the biological entities.

7.2 The Paradox of Perspectival Realism

Both schools maintain that we can find selves at different levels of a biological entity, from cells to organisms. However, at the same time, it is also true that we experience a single unified self. This question of a single unified self has divided philosophers over the ages. The question gave birth to different realist and anti-realist accounts of the self in the history of philosophy. The biogenic approach renders perspectival realism about selves. The self exists; multiple selves exist within a given system. A single prominent self exists from the perspective we look at it. The unified complex self we experience, which connects the organism with its environment, is real from our frame of reference. The complex selves of anthropogenic philosophers do exist from the organismal lens, which dissipates when we look closer into the biological system of the organism. All cells in our body have selves, then different systems like that of the immunological system in our body work like a self, but somehow all work together to form a single unified self which we experience in our day-to-day life. Cancer is an example of

22 Levin (2021) maintains that a minimal degree of goal-directedness is present in particles.

23 Self bloat is loosely adopted from cognitive bloat objection against the extended mind hypothesis. The objection states that supersizing mind would inevitably lead to the whole world being a part of mind. Similarly diluting the concept of self would inevitably lead to the position that everything possesses a self, thus creating a self bloat.

the cell-self dissipating from the system and acting without regard to the system. Cancer cells replicate and propagate themselves selfishly, disregarding and endangering the host system (Levin 2019). Each biological system possesses a Russian doll model of self. The unified self dissipates when one looks at a biological system through a microscopic lens. Varela addressed this point with the neologism of meshed selves or the "Selfless Self" (1990), and Levin (2021) christened this problem of the unified self as the dark matter of cognitive science.

7.3 Entangled Concepts and the Continuum Theses

The models within the biogenic approach fail to provide classifications or distinguishing criteria or definitions for the self, cognition, and life. The autopoietic school maintains that life=cognition=self. The properties that define minimal life, minimal cognition, and minimal self are the same. The cognitive model treats goal-directed cognition as self. These entangled concepts often lead to cyclical fallacy and equivocation of terms like cognition, life, and self.

Nevertheless, these entangled concepts of the biogenic approach give three types of continuum theses:

The cognition-life continuum
The cognition-self continuum
The life-self continuum

The cognition-life continuum: both autopoietic and cognitive models maintain the cognition-life continuum. However, cognition can happen without biological life in the cognitive model. The cognitive model is a functionalist model of the self. Functions are substrate-independent. Therefore, cognition can be realized in non-life, non-biological systems. The cognitive model maintains that life always accompanies cognition, but cognition does not always accompany life.

The cognition-self continuum: both models maintain the cognition-self continuum. The cognitive model scales different kinds of selves based on goal-directed cognition. Conversely, the autopoietic model treats life, self, and cognition as a set sharing the same properties. Both models maintain an implicit relation between cognition and self.

The life-self continuum thesis: both models maintain the continuum of life-self. Nevertheless, the cognitive model entertains the possibility of the genesis of self and cognition prior to that of life. The concept of life remains dispensable in the cognitive model, opening up the possibility of the genesis and evolution of self and cognition prior to life. Therefore, within the biological realm's periphery, the cognitive model maintains a weak continuum, *i.e.*, life always accompanies self, but self need not accompany life.

The autopoietic model entails that autopoiesis is the essential property of the concept of life. From autopoiesis, self-organization and self-distinction arise, which define the bodily self. The autopoietic model maintains a strong continuity between self and biological life, *i.e.*, self always accompanies biological life, and biological life always accompanies self.

8 Conclusion

To unravel the questions of genesis, lowest bound, and the continuum of self in this article, I ventured into the biogenic approach. In it, we found two models that present us with two different answers. In the autopoietic model, the genesis of the biological self is traced to the genesis of the biological cell. Whereas in the cognitive model, the genesis of the self remains ambiguous. The autopoietic model's lowest bound of the self is a single cell, whereas in the cognitive model, again, ambiguity prevails. The autopoietic model maintains a strong life-self continuum, whereas the cognitive model maintains a weak one. **[Tab. 2]** recapitulates the biogenic positions on these fundamental questions.

Table 2 Genesis, Lowest Bound, and the Continuum

	Autopoietic model	**Cognitive model**
Genesis	Along with the cell	Ambiguous
Lowest bound	A single cell	Ambiguous
Self-Life continuum	Strong continuum	Weak continuum

Defining the self and pondering the genesis, the continuum, and the lowest bound of self is a riveting research field. However, defining the concept of self and scrutinizing the biological processes that give rise to the self in different organisms is an uneasy task. We also find incommensurability of selves in the literature. Every approach provides different models to observe the self.

In this article, I searched for the genesis, the continuum, and the lowest bound of self to unearth the varieties of selves available within the phylogenetic tree and the necessary processes involved in giving rise to self, mainly from biogenic and zoogenic approaches. The article provides a landscape of various approaches to self and details numerous drawbacks of each approach. Drawbacks include anthropogenic approaches being extremely attenuated and zoogenic approaches failing to account for the genesis of the primal self. The biogenic autopoietic model is more of a theoretical approach which is yet to furnish strong empirical evidence to validate the theory. Moreover,

the cognitive model makes the concept too simplistic and permissive. To facilitate the study of the self in BA, we need to furnish a mark/criterion for the primal self. The mark of self must be a robust criterion backed by empirical evidence and a process or mechanism that is unique to biological systems. This criterion will help to distinguish the self from the non-self and eliminate the drawbacks of the current models. However, such a definition must not be too anthropogenic or zoogenic, limiting the concept of self only to our species or organisms with the nervous system. We must steer our quest to discover a unified biological theory of self that can capture the evolution of the self in the light of novel empirical evidence. The approaches and the models classified in the article are a humble attempt to inaugurate a new field of study that deals with the evolution of the biological self.

References

Adams, F. (2018). "Cognition Wars". *Studies in History and Philosophy of Science Part A*, 68, 20-30. https://doi.org/10.1016/j.shpsa.2017.11.007.

Allen, R.E. (2006). *Plato. The Republic*. New Haven: Yale University Press.

Aristotle, A. (1991). *The History of Animals 9.13*. Transl. by D.M. Balme.Cambridge, MA: Harvard University Press. Loeb Classical Library.

Aristotle (2018). *On the Soul: And Other Psychological Works*. Transl. by F.D. Miller. Oxford: Oxford University Press.

Augustine, S. (2009). *The City of God*. Transl. by M. Dods. Peabody: Hendrickson Publishers.

Augustine, S.; Mosher, D.L. (2010). *Eighty-Three Different Questions: A New Translation*. Washington DC: CUA Press.

Baluška, F.; Levin, M. (2016). "On Having No Head: Cognition Throughout Biological Systems". *Frontiers in psychology*, 7, 902. https://doi.org/10.3389/fpsyg.2016.00902.

Baluška, F.; Mancuso, S. (2009). "Plant Neurobiology: From Sensory Biology, Via Plant Communication, To Social Plant Behavior". *Cognitive processing*, 10, 3-7. https://doi.org/10.1007/s10339-008-0239-6.

Barandiaran, X.E.; Di Paolo, E.; Rohde, M. (2009). "Defining Agency: Individuality, Normativity, Asymmetry, and Spatio-Temporality in Action". *Adaptive Behavior*, 17(5), 367-86. https://doi.org/10.1177/1059712309343819.

Barresi, J.; Martin, R. (2011). "History As Prologue: Western Theories of the Self". Gallagher 2011, 33-56. https://doi.org/10.1093/oxfordhb/9780199548019.003.0002.

Bekoff, M. (2002). *Minding Animals: Awareness, Emotions, and Heart*. Oxford: Oxford University Press.

Bermúdez, J.L. (2011). "Bodily Awareness and Self-consciousness". Gallagher 2011, 155-82. https://doi.org/10.1093/oxfordhb/9780199548019.003.0007.

Bermúdez, J.L. (2018). *The Bodily Self: Selected Essays*. Cambridge, MA: MIT Press. https://doi.org/10.7551/mitpress/9780262037501.001.0001.

Bermúdez, J.L.; Eilan, N.; Marcel, A. (eds) (1998). *The Body and the Self*. Cambridge, MA: MIT Press. https://doi.org/10.7551/mitpress/1640.001.0001.

Bray, D. (1995). "Protein Molecules As Computational Elements in Living Cells". *Nature*, 376(6538), 307-12. https://doi.org/10.1038/376307a0.

Calvo Garzón, F. (2007). "The Quest for Cognition in Plant Neurobiology". *Plant Signaling & Behavior*, 2(4), 208-11. https://doi.org/10.4161/psb.2.4.4470.

Calvo Garzón, P.; Keijzer, F. (2009). "Cognition in Plants". Baluška, F. (ed.), *Plant-Environment Interactions: From Sensory Plant Biology to Active Plant Behavior*. Berlin: Springer, 247-66. https://doi.org/10.1007/978-3-540-89230-4_13.

Calvo, P.; Trewavas, A. (2020). "Physiology and the (Neuro)biology of Plant Behavior: A Farewell to Arms". *Trends in Plant Science*, 25(3), 214-16. https://doi.org/10.1016/j.tplants.2019.12.016.

Chernyak, L.; Tauber, A.I. (1991). "The Dialectical Self: Immunology's Contribution". *Organism and the Origins of Self*. Dordrecht: Springer, 109-56. Boston Studies in the Philosophy of Science 129. https://doi.org/10.1007/978-94-011-3406-4_6.

Cottingham, J. (1998). "A Brute to the Brutes? Descartes' Treatment of Animals". *Philosophy*, 53(206), 551-9. https://doi.org/10.1017/s0031819100026371.

Crisp, R. (2014). *Aristotle: Nicomachean Ethics*. Cambridge: Cambridge University Press.

Darwin, C. (1859). *On the Origin of Species*. London: John Murray.

Darwin, C. (1871). *The Descent of Man, and Selection in Relation to Sex*. London: John Murray.

Darwin, C. (1880). *The Power of Movement in Plants*. London: John Murray.

De Vignemont, F. (2011). "A Self for the Body". *Metaphilosophy*, 42(3), 230-47. https://doi.org/10.1111/j.1467-9973.2011.01688.x.

de Waal, F.B. (2019). "Fish, Mirrors, and a Gradualist Perspective on Self-Awareness". *PLoS Biology*, 17(2). https://doi.org/10.1371/journal.pbio.3000112.

DeGrazia, D. (2009). "Self-Awareness in Animals". Lurz, R.W. (ed.), *The Philosophy of Animal Minds*. Cambridge: Cambridge University Press, 201-17. https://doi.org/10.1017/cbo9780511819001.012.

Dennett, D. (1989). "The Origins of Selves". *Cogito*, 3(3), 163-73. https://doi.org/10.5840/cogito19893348.

Dennett, D. (1992). "The Self as a Center of Narrative Gravity". *Arguing About the Mind*, 4, 237.

Dennett, D.C. (2017). *From Bacteria to Bach and Back: The Evolution of Minds*. New York: WW Norton & Company.

Descartes, R. (1987). *Discours de la méthode. Texte et commentaire par Étienne.* Paris: Vrin.

Dewey, J.(1929). *Experience and Nature*. New York: Dover.

Di Paolo, E. (2005). "Autopoiesis, Adaptivity, Teleology, Agency". *Phenomenology and theCognitive Sciences*, 4(4), 429-52. https://doi.org/10.1007/s11097-005-9002-y.

di Primio, F.; Müller, B. S.; Lengeler, J. W. (2000). "Minimal Cognition in Unicellular Organisms". Meyer, J.A. et al. (eds), *SAB2000 Proceedings*. Honolulu: Hawaii International, 3-12.

Escobar, J.M. (2012). "Autopoiesis and Darwinism". *Synthese*, 185, 53-72. https://doi.org/10.1007/s11229-011-9875-y.

Frith, C.D. (1992). *The Cognitive Neuropsychology of Schizophrenia*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Froese, T.; Di Paolo, E. (2011). "The Enactive Approach: Theoretical Sketches From Cell to Society". *Pragmatics & Cognition*, 19(1), 1-36.https://doi.org/10.1075/pc.19.1.01fro.

Gallagher, S. (2000). "Philosophical Conceptions of the Self: Implications for Cognitive Science". *Trends in Cognitive Sciences*, 4(1), 14-21. https://doi.org/10.1016/S1364-6613(99)01417-5.

Gallagher, S. (ed.) (2011). *The Oxford Handbook of The Self*. Oxford: Oxford University Press.

Gallagher, S. (2012). "On the Possibility of Naturalizing Phenomenology". Zahavi 2012, 70-93.

Gibson, J.J. (1966). *The Senses Considered as Perceptual Systems.* Boston: Houghton Mifflin.

Glasgow, R. (2018). *Minimal Selfhood and the Origins of Consciousness*. Würzburg: Würzburg University Press.

Godfrey-Smith, P. (1994). *Spencer and Dewey on Life and Mind*. Brooks, R.A.; Maes, P. (eds), *Artificial Life IV*. Cambridge, MA: MIT Press, 80-9.

Godfrey-Smith, P. (2016). "Mind, Matter, and Metabolism". *The Journal of Philosophy*, 113(10), 481-506. https://doi.org/10.5840/jphil20161131034.

Goodwin, B.C. (1977). "Cognitive Biology". *Communication & Cognition,* 10(2), 87-91.

Griffin, D.R. (2001) *Animal Minds: Beyond Cognition to Consciousness*. Chicago: University of Chicago Press.

Haeckel, E. (1892). "Our Monism: The Principles of a Consistent, Unitary World-View". *The Monist*, 2(4), 481-6. https://doi.org/10.5840/monist18922444.

Hafner, V.V.; Loviken, P.; Pico Villalpando, A.; Schillaci, G. (2020). "Prerequisites for an Artificial Self". *Frontiers in Neurorobotics*, 14(5). https://doi.org/10.3389/fnbot.2020.00005.

Harrison, P. (1992). "Descartes on Animals". *The Philosophical Quarterly*, 42(167), 219-27. https://doi.org/10.2307/2220217.

Heidegger, M. (1996). *The Fundamental Concepts of Metaphysics: World, Finitude, Solitude*. Bloomington: Indiana University Press.

Hume, D. (1739). *Treatise of Human Nature*. Oxford: Oxford University Press.

James, W. (1981). *The Principles of Psychology*. Cambridge (MA): Harvard University Press.

Jékely, G.; Godfrey-Smith, P.; Keijzer, F. (2021). "Reafference and the Origin of the Self in Early Nervous System Evolution". *Philosophical Transactions of the Royal Society B*, 376(1821), 20190764. https://doi.org/10.1098/rstb.2019.0764,

Jonas, H. (1966). *The Phenomenon of Life*. New York: Harper and Row.

Kant, I. (2000). *Critique of the Power of Judgment*. Ed. by E. Matthews. Transl. by P. Guyer. Cambridge: Cambridge University Press.

Kee, H. (2021). "Phenomenology and Naturalism in Autopoietic and Radical Enactivism: Exploring Sense-Making and Continuity From the Top Down". *Synthese*, 198, 2323-43. https://doi.org/10.1007/s11229-018-1851-3.

Keijzer, F.; Van Duijn, M.; Lyon, P. (2013). "What Nervous Systems Do: Early Evolution, Input–Output, and the Skin Brain Thesis". *Adaptive Behavior*, 21(2), 67-85. https://doi.org/10.1177/1059712312465330.

Kondev, J. (2014). "Bacterial Decision Making". *Physics today*, 67(2), 31-6. https://doi.org/10.1063/pt.3.2276.

Legrand, D. (2006). "The Bodily Self: The Sensori-Motor Roots of Pre-Reflective Self-Consciousness". *Phenomenology and the Cognitive Sciences*, 5(1), 89-118. https://doi.org/10.1007/s11097-005-9015-6.

Levin, M. (2019). "The Computational Boundary of a 'Self': Developmental Bioelectricity Drives Multicellularity and Scale-Free Cognition". *Frontiers in Psychology*, 10, 2688. https://doi.org/10.3389/fpsyg.2019.02688.

Levin, M. (2021). "Life, Death, and Self: Fundamental Questions of Primitive Cognition Viewed Through the Lens of Body Plasticity and Synthetic Organisms". *Biochemical and Biophysical Research Communications*, 564, 114-33. https://doi.org/10.1016/j.bbrc.2020.10.077.

Levin, M. (2022). "Technological Approach to Mind Everywhere: An Experimentally-Grounded Framework for Understanding Diverse Bodies and Minds". *Frontiers in Systems Neuroscience*, 16. https://doi.org/10.3389/fnsys.2022.768201.

Levin, M. (2023). "Collective Intelligence of Morphogenesis as a Teleonomic Process". Corning, P.A. et al. (eds), *Evolution "On Purpose": Teleonomy in Living Systems*. Cambridge, MA: MIT Press, 175-9. https://doi.org/10.7551/mitpress/14642.003.0013.

Levin, M.; Keijzer, F,; Lyon, P.; Arendt, D. (2021). "Uncovering Cognitive Similarities and Differences, Conservation and Innovation". *Philosophical Transactions of the Royal Society B*, 376(1821), 20200458. https://doi.org/10.1098/rstb.2020.0458.

Luisi, P.L. (2003). "Autopoiesis: A Review and a Reappraisal". *Naturwissenschaften*, 90, 49-59. https://doi.org/10.1007/s00114-002-0389-9.

Lyon, P. (2006). "The Biogenic Approach to Cognition". *Cognitive Processing*, 7(1), 11-29. https://doi.org/10.1007/s10339-005-0016-8.

Lyon, P. (2015). "The Cognitive Cell: Bacterial Behavior Reconsidered". *Frontiers in Microbiology*, 6, 264. https://doi.org/10.3389/fmicb.2015.00264.

Lyon, P. (2023). "The Study of the Mind Needs a Copernican Shift in Perspective". https://aeon.co/essays/the-study-of-the-mind-needs-a-copernican-shift-in-perspective.

Lyon, P.; Arendt, D. (2021). "Uncovering Cognitive Similarities and Differences, Conservation and Innovation". *Philosophical Transactions of the Royal Society B*, 376(1821), 20200458. https://aeon.co/essays/the-study-of-the-mind-needs-acopernican-shift-in-perspective.

Lyon, P.; Keijzer, F.; Arendt, D.; Levin, M. (2021). "Reframing Cognition: Getting Down to Biological Basics". *Philosophical Transactions of the Royal Society B*, 376(1820), 20190750. https://doi.org/10.1098/rstb.2020.0458.

Maturana, H., Varela, F. (1980). "Problems in the Neurophysiology of Cognition". *Autopoiesis and Cognition: The Realization of the Living*, 41-7. https://doi.org/10.1007/978-94-009-8947-4_5.

Maturana, H.; Varela, F. (1987). *The Tree of Knowledge: The Biological Roots of Human Understanding.* Boulder: New Science Library; Shambhala Publications.

Maturana, H.; Varela, F. (1991). *Autopoiesis and Cognition: The Realization of the Living*, Berlin: Springer Science & Business Media.

Mead, G.H. (2015). *Mind, Self & Society*. Chicago: University of Chicago Press.

Metzinger, T. (2004). *Being No One: The Self-Model Theory of Subjectivity*. Cambridge, MA: MIT Press.

Monod, J. (2014). *Le hasard et la nécessité. Essai sur la philosophie naturelle de la biologie moderne*. Paris: Editions du Seuil.

Neisser, U. (1995). "Criteria for an Ecological Self". Rochat, P. (ed.), *The Self in Infancy: Theory and Research*. Amsterdam: Elsevier, 17-34. https://doi.org/10.1016/s0166-4115(05)80004-4.

Olson, E.T. (1998). "There is No Problem of the Self". *Journal of Consciousness Studies*, 5(5-6), 645-57.

Povinelli, D.J.; Rulf, A.B.; Landau, K.R.; Bierschwale, D.T. (1993). "Self-Recognition in Chimpanzees (Pan Troglodytes): Distribution, Ontogeny, and Patterns of Emergence". *Journal of Comparative Psychology*, 107(4), 347. https://doi.org/10.1037/0735-7036.107.4.347.

Prescott, T.J.; Camilleri, D. (2019). "The Synthetic Psychology of the Self". Ferreira, M.I.A.; Sequeira, J.S.; Ventura, R. (eds), *Cognitive Architectures. Intelligent Systems, Control and Automation: Science and Engineering.* Berlin: Springer Nature, 85-104. https://doi.org/10.1007/978-3-319-97550-4_7.

Reber, A.S. (2016). "Caterpillars, Consciousness and the Origins of Mind". *Animal Sentience*, 1(11), 1. https://doi.org/10.51291/2377-7478.1124.

Rochat, P.; Hespos, S.J. (1997). "Differential Rooting Response by Neonates: Evidence for an Early Sense of Self". *Infant and Child Development*, 6(3-4), 105-12. https://doi.org/10.1002/(SICI)1099-0917(199709/12)6:3/4<105::AID-EDP150>3.0.CO;2-U.

Sass, L.A. (2001). "Self and World in Schizophrenia: Three Classic Approaches". *Philosophy, Psychiatry, & Psychology*, 8(4), 251-70. https://doi.org/10.1353/ppp.2002.0026.

Sass, L.A.; Parnas, J. (2003). "Schizophrenia, Consciousness, and the Self". *Schizophrenia bulletin*, 29(3), 427-44. https://doi.org/10.1093/oxfordjournals.schbul.a007017.

Scheper, W.J.; Scheper, G.C. (1996). Autopsies on autopoiesis. *Behavioral Science*, 41, 1-12.

Schopenhauer, A. (1818). *Arthur Schopenhauer: The World as Will and Presentation*, vol. 1. London: Routledge. https://doi.org/10.1002/bs.3830410101.

Sherrington, C.S. (1898). "Further Note on the Sensory Nerves of the Eye Muscles". *Proceedings of the Royal Society*, 64, 120-1. https://doi.org/10.1098/rspl.1898.0075.

Sims, M. (2021). "A Continuum of Intentionality: Linking the Biogenic and Anthropogenic Approaches to Cognition". *Biology & Philosophy*, 36(6), 51.

Smith, K. (1963). *New Studies in the Philosophy of Descartes*. London: Macmillan.

Sorabji, R. (1995). *Animal Minds and Human Morals*. Ithaca: Cornell University Press. https://doi.org/10.1007/s10539-021-09827-w.

Spencer, H. (1872). "The Survival of The Fittest". *Nature*, 5(118), 263-4. https://doi.org/10.1038/005263c0.

Sperry, R.W. (1950). "Neural Basis of The Spontaneous Optokinetic Response Produced by Visual Inversion". *Journal of Comparative and Physiological Psychology*, 43(6), 482. https://doi.org/10.1037/h0055479.

Steiner, G. (2005). *Anthropocentrism and Its Discontents: The Moral Status of Animals in the History of Western Philosophy.* Pittsburgh: University of Pittsburgh Press.

Strawson, G. (1999). "The Self and the SESMET". *Journal of Consciousness Studies*, 6, 99-135. https://doi.org/10.1093/acprof:oso/9780198777885.003.0003.

Takeno, J. (2012). *Creation of a Conscious Robot: Mirror Image Cognition and Self-Awareness*. Boca Raton: CRC Press.

Tauber, A.I. (1994). "The Immune Self: Theory or Metaphor?". *Immunology Today*, 15(3), 134-6. https://doi.org/10.1016/0167-5699(94)90157-0.

Thompson, E. (2007). *Mind in Life: Biology, Phenomenology, and the Sciences of Mind*. Cambridge, MA: Harvard University Press.

Thompson, E. (2022). "Could All Life Be Sentient?". *Journal of Consciousness Studies*, 29(3-4), 229-65. https://doi.org/10.53765/20512201.29.3.229.

Timsit, Y.; Grégoire, S.P. (2021). "Towards the Idea of Molecular Brains". *International Journal of Molecular Sciences*, 22(21), 11868. https://doi.org/10.3390/ijms222111868.

Tulving, E. (1985). "How Many Memory Systems Are There?". *American Psychologist*, 40(4), 385. https://doi.org/10.1037/0003-066x.40.4.385.

Vallortigara, G. (2021). "The Efference Copy Signal as a Key Mechanism for Consciousness". *Frontiers in Systems Neuroscience*. https://doi.org/10.3389/fnsys.2021.765646.

Varela, F. (1991). "Organism: A Meshwork of Selfless Selves". *Organism and the Origins of Self*. Dordrecht: Springer, 79-107. Boston Studies in the Philosophy of Science 129. https://doi.org/10.1007/978-94-011-3406-4_5.

Varela, F.; Maturana, H. (1972). "Mechanism and Biological Explanation". *Philosophy of Science*, 39(3), 378-82. https://doi.org/10.1086/288458.

Verschure, P.F.; Kröse, B.J.; Pfeifer, R. (1992). "Distributed Adaptive Control: The Self-Organization of Structured Behavior". *Robotics and Autonomous Systems*, 9(3), 181-96. https://doi.org/10.1016/0921-8890(92)90054-3.

Verschure, P.F. (2012). "Distributed Adaptive Control: A Theory of the Mind, Brain, Body Nexus". *Biologically Inspired Cognitive Architectures*, 1, 55-72. https://doi.org/10.1016/j.bica.2012.04.005.

Vogeley, K.; Gallagher, S. (2011). "Self in the Brain". Gallagher 2011, 111-36. https://doi.org/10.1093/oxfordhb/9780199548019.003.0005.

von Helmholtz, H. (1866). "Handbook of Physiological Optics". *Handbuch der Physiologischen Optik.* Hamburg: Voss.

Von Holst, E.; Mittelstaedt, H. (1950). "Das Reafferenzprinzip (Wechselwirkun5 gen zwischen Zentralnervensystem und Peripherie)". *Naturwissenschaften*, 37, 464-76.

Ward, D.; Silverman, D.; Villalobos, M. (2017). "Introduction: The Varieties of Enactivism". *Topoi*, 36, 365-75. https://doi.org/10.1007/s11245-017-9484-6.

Weber, A.; Varela, F. (2002). "Life After Kant: Natural Purposes and the Autopoietic Foundations of Biological Individuality". *Phenomenology and the Cognitive Sciences*, 1(2), 97-125. https://doi.org/10.1023/a:1020368120174.

Young, E. (2022). *An Immense World: How Animal Senses Reveal the Hidden Realms Around Us.* Toronto: Knopf Canada.

Zahavi, D. (2010). "Naturalized Phenomenology". Schmicking, D.; Gallagher, S. (eds), *Handbook of Phenomenology and Cognitive Science*. Berlin: Springer, 2-19. https://doi.org/10.1007/978-90-481-2646-0_1.

Zahavi, D. (ed.) (2012). *The Oxford Handbook of Contemporary Phenomenology.* Oxford: Oxford University Press

Zahavi, D. (2017). "Thin, Thinner, Thinnest: Defining the Minimal Self". Durt, C.; Fuchs, T.; Tewes, C. (eds). *Embodiment, Enaction, and Culture: Investigating the Constitution of the Shared World*. Cambridge, MA: MIT Press, 193-200. https://doi.org/10.7551/mitpress/10799.003.0013.

Zolo, D. (1990). "Autopoiesis: Critique of a Postmodern Paradigm". *Telos*, 86, 61-80. https://doi.org/10.3817/1290086061.