


Rational Organicism—Goethe, Steiner, and the Intuitive Understanding of Plants and Animals

Christoph J. Hueck 

Akanthos Academy

ABSTRACT

This paper examines the philosophical foundations of Goethe's morphological studies, in particular his concept of the 'archetypal plant', which can be described as the dynamic principle of a living surface that governs plant formation through alternating processes of expansion and contraction. The Austrian philosopher Rudolf Steiner claimed that Goethe's approach offers a scientifically grounded approach to understanding organic form and development through what may be termed empirically based, productive intellectual intuition, namely the mental reconstruction of an organism's formative principle and laws. Here it is shown that Goethe's rational organicism, as elaborated by Steiner, provides a conceptual and methodological framework that suggests a solution to the long-standing problem of understanding organismic properties like autopoiesis, autonomy and agency. Yet, Goethe struggled to identify a comparable principle for animals. Steiner argued that animal life is determined by a psychological principle—a non-physical centre of sensation and movement that structures the organism in relation to its environment—and that this, too, can be grasped in productive intuition. The paper reconstructs the animal archetype by delineating its essential features: the relations between its interior and exterior, realized in sensory, nutritive and motor functions. The study concludes that Goethe's rational organicism can serve as a methodological complement to the organicism of the current philosophy of biology.

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The greatness of [Goethe's] thought becomes apparent only when one tries to bring it to life in one's mind. One then realizes that it is the nature of the plant itself translated into the idea, which lives in our mind just as much as in the object. (Steiner [1884 ff.] 1987, 12–13)

1. Introduction

Organisms are characterized by a holistic structure that emerges through goal-directed, autonomous processes. While materially constituted and subject to physico-chemical

CONTACT Christoph J. Hueck  hueck@akanthos-akademie.de  Akanthos Academy, D-70188 Stuttgart, Germany

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laws, their distinctive organismic properties resist explanation in materialistic and mechanistic terms (Gilbert and Sarkar 2000). This tension was thoroughly examined by Immanuel Kant, who argued that organisms must be *judged* as purposive, self-generating wholes that determine their parts, but that we cannot *explain* these properties, because we cannot derive them ‘from a principle which must (...) be capable of being clearly cognized and specified’ (Kant [1790] 2008, 412). According to Kant, human understanding can only proceed from the parts to the whole (Kant [1790] 2008, 407), but in organisms the whole determines the parts. Indeed, it has often been argued that organisms cannot be understood by reductionist approaches (Brigandt and Love [2008] 2023), and this assertion is supported by the fact that, despite unprecedented success in molecular biology, it is still impossible to generate organisms *de novo* in the laboratory (Porcar et al. 2011; Kauffman 2013). Consequently, philosophers and theoretical biologists increasingly turn away from reductionist interpretations of organisms and instead view them as purposive and autopoietic systems and autonomous agents (Moreno and Mossio 2015; Walsh 2015; Rosslénbroich 2023; Švorcová 2024). However, it remains a central challenge not only to describe these essential properties of organisms, but also to explain them.

At the same time, as Kant’s analysis appeared in the *Critique of Judgment*, Johann Wolfgang von Goethe published a short treatise, *An attempt to Explain the Metamorphosis of Plants* (Goethe [1790] 1965c),¹ in which he argued, in contrast to Kant, that a wholistic understanding of organisms is indeed possible. Goethe described how different organs of flowering plants—seeds, leaves, calyx, corolla, stamens, pistil, and fruit—can be understood as metamorphic realizations of a general principle, which he called the ‘leaf.’² According to Goethe, the plant’s structure is generated by this principle through threefold expansion and contraction with progression—from seed to stem-leaves, from calyx to flower, and from carpels to fruit and to seeds again. Goethe called this concept of a lawfully metamorphosing principle the sensual-supersensible ‘archetypal plant’ (*Urpflanze*) (Goethe [1831] 1965a, 79–80).

Much has been written about Goethe’s science and his view of nature (cf. the bibliographies in Schmid 1940; Mandelkew 1980; Amrine 1996; Müller 2000; Danneberg 2018). Some referred to him—‘in somewhat disparaging terms’, as Timothy Lenoir noted (Lenoir 1987, 23)—, as an essentialist and typologist who ushered idealistic morphology as ‘a fusion of Plato’s essentialism with aesthetic principles’ (Mayr 1982, 457). The theoretical biologist Edward S. Russell considered Goethe’s archetypal leaf a fantasy that ‘can hardly be taken seriously as a scientific theory’ but conceded that even though ‘Goethe’s morphological views were lacking in definiteness he hit upon one or two ideas which proved useful’ (Russell 1916, 52).

Others were more appreciative. The biocyberneticist Bernhard Hassenstein asserted that ‘a morphology-based biology will only be able to hold a candle to its big sister, the exact natural sciences, when it has learned from Goethe that morphology also demands the sharpest methodological rigor’ (Hassenstein 1951, 354–355). The zoologist Adolf Portmann called Goethe an ‘intensely empathetic observer’ of nature (Portmann 1987, 139) and wrote about his method that ‘the observer brings utmost objectivity into play, yet at the same time preserves the wealth of his world of symbols, of his inwardness (...); sensation and thinking celebrate their sublimest reconciliation’ (Portmann 1987, 143).

However, no one was as enthusiastic about Goethe's natural science as the Austrian philosopher Rudolf Steiner (1861–1925), who provided the most comprehensive analysis of Goethe's scientific approach. Steiner, who was one of the first editors of *Goethe's Natural Scientific Writings*, considered Goethe's morphological works 'a scientific achievement of the first order' because 'they establish the theoretical basis and method for the study of organic nature' (Steiner [1884 ff.] 1987, 70).³ He even compared Goethe to heroes of the physical sciences: 'Goethe is the Copernicus and Kepler of the organic world' (Steiner [1884 ff.] 1987, 107); 'he arrived at fundamental ideas that have the same significance for the science of the organic as Galileo's basic laws for mechanics' (Steiner [1884 ff.] 1987, 119).

What Goethe had thought and worked out in detail about this or that area of knowledge of nature seemed to me to be of less importance than the central discovery that I had to attribute to him. I saw this in the fact that he had discovered *how one must think about the organic* in order to come to an understanding of it. (Steiner [1923 ff.] 1982, 112; italics added)

Goethe himself wrote that by 'contemplating an ever-creative nature', one can become 'worthy of mental participation in its productions' (Goethe [1820] 1965, 878–879), that is of cognizing nature's generative principles. He claimed that it is possible to develop an intuitive '*awareness of the essential form* with which nature only ever plays, as it were, and playfully brings forth the manifold life' (Goethe 2004, to Charlotte von Stein, 7. July 1786; emphasis added).

Thus, the question arises as to how this 'awareness of the essential form' can be understood. Friedrich Schiller, in his first extended discussion with Goethe, argued that the archetypal plant was an idea, not an experience as Goethe had claimed (Goethe [1817] 1965, 867), and some scholars still consider Goethe's archetype to be merely a general scheme, abstracted from the phenomena (Classen-Bockhoff 2001, 1153). However, Goethe famously responded to Schiller's objection that he could 'see' his ideas with 'the eye of the mind' (Goethe [1817] 1965, 868; Förster 2001).

Steiner has extensively discussed and philosophically explained this 'seeing with mental eyes' as Goethe's essential method of 'intuitive power of judgement' [*anschauende Urteilskraft*]. Interestingly, though, while he praised Goethe's achievement with respect to the principle of plant formation, he was critical about Goethe's attempt to understand the archetype of animals. Steiner claimed that in the case of animals, Goethe indeed only produced an abstract scheme, not 'a living idea that is filled with content according to the basic laws of animal formation' (Steiner [1897] 1990, 136). According to Steiner, plants and animals differ significantly with respect to their archetypal, generative principles.

Here, I discuss these differences in detail. I start by arguing why Goethe achieved to explain the generative principle of plants in scientific terms (section 2). In section 3, I discuss Goethe's search for the archetype of vertebrate animals and discuss Steiner's critical notion that Goethe did not find it as he found that of plants. In section 4, I describe Steiner's presentation of the differences between plants and animals and discuss them in terms of Goethe's intuitive power of judgement, and in section 5, I further elaborate on the essential principle of animals. In section 6 I discuss why Goethe's intuitive method allows to view an archetype not only as heuristic, but as an ontological principle. I conclude in section 7 by suggesting that Goethe's method, which can be called *rational organicism*, provides scientific explanation of the essential properties of organisms.

2. Goethe's Rational Organicism

Goethe once summarized his method as follows:

Two requirements arise in us when we observe natural phenomena: to get to know them completely and to appropriate them through reflection. (...) If we can see an object in all its parts, grasp it correctly and *bring it forth again in our minds*, then we may say that we intuit it in a proper and higher sense, that it belongs to us, that we have attained a certain mastery over it. (Goethe [1805] 1965, 863; emphasis added)

Apparently, Goethe's scientific approach was not about explaining natural phenomena in terms of mechanistic causality. Rather, he remained within the realm of the phenomena and dealt with them in a distinctive way. This approach is particularly important for understanding organisms since they invariably manifest as holistic entities. Although mechanistic processes can be discerned within them, these processes cannot explain the complexity and integrity of living things (Rosslenbroich 2023).

Comprehensive observation of the phenomena under investigation, along with their mental reproduction ('bringing them forth again in our minds'), constitute fundamental aspects of Goethe's scientific method. A thorough empirical approach ensures the highest possible degree of objectivity and fidelity to the facts, while the imaginative activity of 'recreating' the phenomena facilitates an intuitive understanding of their generative principles. In the first of his *Introductions to Goethe's Natural Scientific Writings* (hereafter: *Introductions*), Steiner elaborated on this mental reproduction, emphasizing its significance in achieving a deeper insight into the essence of the organism:

The significance of [Goethe's conception of] plant metamorphosis (...) does not lie in the discovery of the individual fact that leaf, calyx, corolla, etc., are identical organs but in the magnificent intellectual structure of a living whole of interdependent laws of formation that emerges from it and which determines the details, the individual stages of development, from within. The greatness of this thought, which Goethe then sought to extend to the animal world, becomes apparent only when one tries to *bring it to life in one's mind*, when one undertakes to ponder it. One then realizes that it is the nature of the plant itself translated into the idea, which *lives in our mind just as much as in the object*. (Steiner [1884 ff.] 1987, 12–13; emphasis added)

In his autobiography, Steiner wrote that if one imaginatively allows the forms of a plant to emerge from one another in accordance with their inherent formative laws, 'one constructs the whole plant. One recreates in one's mind the process by which nature actually designs the plant' (Steiner [1923 ff.] 1982, 114).

Indeed, Goethe referred to the archetypal plant as the 'concept of how we could generate it for us [*wonach wir sie uns ausbilden könnten*]' (Goethe 2004, to von Nees von Esenbeck, August 1816).

With this model and the key to it, one can then invent plants ad infinitum that must be consistent, that is to say, they may not actually exist, but they could exist and are not mere pictorial or poetic shadows and illusions, but have an inner truth and necessity. (Goethe 1965-1978, 503)

Goethe's *Urpflanze*, therefore, is a conceptual rule for mental (re)construction of a plant's structure. Eckart Förster, who discussed Goethe's natural scientific approach in

detail, interpreted the notion of a ‘model’ and the ‘key to it’ as two clearly distinguishable aspects of the archetypal plant. Förster understands the model as the *constructive element*, that is the ‘ideal leaf’, while the key to it as the *constructive rule*, i.e. the process of formation and transformation through expansion and contraction with progression (Förster 2012, 274).

However, while the idea of threefold expansion and contraction can easily be imagined, the concept of an ‘ideal’ or ‘transcendental’ leaf is rather elusive. The Goethean biologist Andreas Suchantke discussed this concept in a seminal essay and suggested to understand the ‘essential leaf’ as the idea of a living, metabolizing surface:

In contrast (...) to the animal, the surface of the plant is not a boundary that shields the interior of the body from the environment (...), but a transparent filter and passage area, where the processual encounter of substances takes place, which on the one hand come from the surrounding atmosphere, (...), and on the other hand from the (...) soil. Both (...) are permeated by the life forces of the organic in this boundary layer area and raised to a higher level. (Suchantke [1929/30] 1983, 377)

This interpretation renders Goethe’s concept much more comprehensible. However, not only did Goethe’s ‘essential leaf’ require additional elaboration beyond Goethe’s own representations. The description of the plant’s development also requires further terms—in addition to expansion and contraction—which Goethe already suggested himself: division [*Entzweiung*], e.g. of the seed into the polarity of the root and stem (Goethe [1795] 1965a, 123–124), as well as the ‘vertical tendency’ of the stem and the ‘spiral tendency’ of its lateral organs (Goethe [1831] 1965b).

One can imagine how these principles generate the structure of a plant: the seed divides into the polarity of a supporting pole in the moist and dark (root) and a developing pole in the dry and light (green shoot). The plant extends vertically, directed by gravity and light, successively forming lateral organs on the shoot in a more or less spiral arrangement. The whole complex exhibits threefold expansion and contraction with progression: first *successive* (from seed to stem leaves to bud), then *adjacent* (from calyx to petals to pistil and stamen), and finally *nested* (from carpels to fruit to seed). The process thus follows a spatiotemporal logic that does not allow for a further step in this series—to continue the plant’s life, the cycle must begin again. Finally, the environment influences plant formation, promoting expansion in spring and summer and contraction in fall and winter.⁴

Taken together, these complex, dynamic and intertwined ideas represent major aspects of the morphological principle of dicotyledonous plants. By ‘bringing it forth’ in our mind, dynamically moving through it ‘forward and backward’, ‘we may say that we intuit [the plant] in a proper and higher sense, that it belongs to us, that we have attained a certain mastery over it’ (Goethe [1805] 1965, 863).

Why does mental reconstruction of a plant’s development promote understanding? Steiner addressed this question by drawing a parallel to the rational mode of thinking employed in mechanics:

[M]echanics satisfies the desire for understanding because it generates concepts in the human mind in a rational way, which it then finds realized in the sensory experience of the inanimate. Goethe [was] the founder of an organic science that relates to the animate in the same way. (Steiner [1923 ff.] 1982, 113)

Kepler's laws, for example, can be derived purely mathematically and can also be found in the movements of planets. The reconstruction of natural phenomena according to mathematical concepts allows insight into their constitutive principles.⁵ According to Steiner, Goethe was seeking an organic science based on the model of a quasi-mathematical explanation of nature:

Goethe wanted to grasp the qualitative aspect of plant design in terms of the rigor and clarity of mathematical thinking. Just as one sets up mathematical equations in which only particular values are used to encompass a multitude of individual cases under a general formula, Goethe searches for the archetypal plant, which is all embracing in terms of quality and spiritual reality. (...) Goethe seeks the still completely formless archetypal plant and endeavors to derive from it the plant forms, just as the mathematician derives the particular forms of lines and surfaces from an equation. (Steiner 1984, 17–18)

To be clear: Steiner did not mean that Goethe was seeking a mathematical explanation of natural phenomena. Rather, he referred to an explanation that, *like* mathematical formulas, can be derived entirely through intellectual construction. Indeed, Goethe called the *Urpflanze* a 'general formula [which] is applicable to all plants' (Goethe 2004, 3089). Förster explained that like mathematical concepts are formed by pure thought (according to Kant: constructed in pure intuition) and then rediscovered in sensory experience; the idea of the *Urpflanze* 'cannot (...) be discovered in the external world, but only in the intuitive understanding. Once it has been discovered, however, its effects can be rediscovered' (Förster 2012, 275).

Thus, Steiner claimed that Goethe attempted to introduce a true science of the organic:

What Goethe wanted was nothing other than to banish all dark and unclear ideas such as 'life force', 'formative drive' and so on from science and to find natural laws for them. However, he wanted to find laws for organics in the same way as they had been found for mechanics, physics and chemistry, not simply to adopt those existing in these other fields. (...) Goethe wanted an independent organic science that had its own axioms and its own method. (Steiner [1891] 1989, 274–275)

This Goethean method can be called *rational organicism*.

3. Discussion of Goethe's Osteological Type of Vertebrate Animals

After Goethe had found and described the principle of plant formation, he turned his attention again to osteological studies.⁶

In doing so, I soon felt the need to establish a type by which all mammals could be examined in terms of their similarities and differences. Just as I had previously sought out the archetypal plant, I now sought to find the archetypal animal, that is, ultimately, the concept, the idea of the animal. (Goethe [1807] 1965, 21)

Goethe wrote several 'drafts' in which he attempted to derive the archetypal animal by compiling lists of corresponding bones of different vertebrates.⁷ He viewed these lists as 'general guides through the labyrinth of forms', a 'framework', and a 'general scheme, (...) to which both humans and animals are subordinate, with which the classes, the sexes, the genera were compared, and by which they were judged' (Goethe [1790] 1965a, 373).

Experience must first teach us the parts that are common to all animals and how these parts differ. The idea must prevail over the whole and abstract the general picture in a genetic way. Once such a type has been established, even if only as an attempt, we can very well use the previously customary comparative ways to examine it. (Goethe [1795] 1965b, 233–234)

This, however, sounds more like a plan for future research than the description of a concrete intuition, as Goethe had achieved in plant morphology. Thus, the literary scholar Hans Joachim Becker commented:

[While Goethe] “was able to round off his plant-morphological work into a coherent whole, he was not yet able to achieve this in the *First Draft of a General Introduction to Comparative Anatomy*. One is tempted to view *The Metamorphosis of Plants* as Goethe’s journeyman piece in morphology. The difficulty of the work on the masterpiece—the comparative anatomy of vertebrates – can be seen from the frequency and extent of the formulation attempts. In the *First Draft*, the treatment of the subject is far less systematic, and the presentation is far less taut than in the *Metamorphosis of Plants*. The author’s uncertainty is equally evident in the title of the work, in the first part of which he repeatedly restricts the plan to develop a comparative anatomy”. (Becker 1998, 699; my transl.)

Similarly, Hassenstein wrote that Goethe’s osteological type ‘did not arise from intuition’ but was ‘a construction’: it ‘was never envisioned by Goethe in a specific form [like the archetypal plant was], and, given the way it was created, it could only at best have been envisioned as an ‘average mammal skeleton consisting of mean-value bones’ (Hassenstein 1951, 335; my addition).

Steiner also had a differentiated view of Goethe’s anatomical studies. He not only criticized their abstract schematism but also noted the deeper reason for it, namely, that Goethe had not penetrated the living intuition of the animal type. In *Goethes Worldview*, Steiner wrote:

Goethe did not succeed in proceeding (...) to the laws of the formation of the whole animal shape. However much he tried to find the type of animal form, nothing analogous to the idea of the archetypal plant was achieved. He compared animals with each other and with humans and tried to obtain a general picture of the animal structure, according to which nature forms the individual shapes as a pattern. This general image of the animal type is not a living idea that is filled with content according to the basic laws of animal formation and thus, as it were, recreates the archetypal animal from nature. It is only a general concept that is abstracted from particular appearances. It establishes what is common to the manifold animal forms; but it does not contain the lawfulness of animality. (Steiner [1897] 1990, 136; emphasis added)

Steiner did not further elaborate on this rather apodictic assertion at this point. However, he had already discussed the problem of the animal type in the *Introductions*.⁸ How did he conceive of the ‘lawfulness of animality’?

4. Steiner on the Concepts of Plants and Animals

In the first *Introduction*, Steiner compared and fundamentally determined the formative principles of plants and animals.

In nature, the organism appears to us in two main forms: as a plant and as an animal; in both in different ways. The plant differs from the animal in the lack of *real* inner life. In the

animal, the latter appears as sensation, voluntary movement, etc. The plant has no such soul principle [*seelisches Prinzip*]. It is still completely absorbed in its outward appearance, in its *form*. The entelechical principle determines life from one point, so to speak; thus, it appears that all the individual organs are formed according to the same formative principle. The entelechy appears here as the formative power of the individual organs. (...) What makes the plant a plant, a *certain formative power*, is at work in the same way in each of its organs. (...) The formation of the plant thus progresses from stage to stage, forming organs; each organ is identical to every other, that is the same in terms of the principle of formation but different in appearance. The inner unity of the plant expands, as it were, into the breadth; it unfolds in the manifold, loses itself in it, so that it does not, as we shall see later in the animal, gain a concrete existence endowed with a certain independence, which, as the centre of life, confronts the manifold of the organs and uses them as mediators with the external world. (Steiner [1884 ff.] 1987, 89–91)

[I]n the animal, that higher principle that governs each individual part presents itself to us concretely as that which moves the organs, uses them according to its needs, etc. (Steiner [1884 ff.] 1987, 35)

Thus, Steiner distinguished plants and animals by the fact that the ‘entelechical principle’ manifests in plants only in spatiotemporal formations, whereas in animals, it ‘gains a concrete existence’, which to a certain degree is independent of the bodily organization.

In the case of the animal (...) life does not lose itself in externality, but separates and distinguishes itself from corporeality, using the physical appearance only as a tool. It no longer expresses itself as a mere ability to shape an organism from within but as something that is still there outside the organism, as its dominant power. The animal appears as a self-contained world, a microcosm in a much greater sense than the plant. It has a centre that every organ serves. (Steiner [1884 ff.] 1987, 96)

However, according to Steiner, this ‘centre’ not only *uses* its organs as ‘mediators with the external world’ but also *forms* its organs according to its needs:

In the animal, each organ appears to come from that centre; the centre, in line with its nature, forms all organs. The form of the animal is thus the basis for its external existence. However, it is determined from within. The animal’s way of life must therefore be based on those internal formative principles. (Steiner [1884 ff.] 1987, 96)

Nevertheless, Steiner also emphasized in *Outlines of an Epistemology of Goethe’s Worldview* that the organs of organisms acquire their specialized shapes in relation to their respective environments:

We know very well that specialization [of forms] comes from outside influence. (...) We gain information about the fact that just this particular form has developed, when we study the environment of a being.” However, “[w]e must base such effects of external circumstances on something that (...) actively determines itself from within under the influence of those circumstances. (Steiner [1886] 1979, 101)

Goethe wrote accordingly, that

The essential form is, as it were, the inner core, which is formed in different ways through the determination by the external element. It is precisely because an animal has been formed from the outside as well as from the inside that it acquires its external purposiveness. However, the external element can transform the external form after itself rather than the internal one. (Goethe [1790] 1965b, 229)

Thus, in Steiner's view, an *entelechical principle*, a 'power that calls itself out of itself into existence' (Steiner [1884 ff.] 1987, 83), works in both plants and animals. In plants, this principle fully embodies itself within the spatiotemporal, physical organization of the plant's organs. In animals, on the other hand, the entelechical principle also generates organs; however, it is not entirely absorbed within them but rather remains independent to a certain extent and uses the organs as tools to satisfy its needs. The 'soul principle' of the animal manifests itself in the animal's abilities to sense its environment and to move within it.

From an external point of view, these elaborations must be incomprehensible since it sees the physical forms of the organisms but not the entelechical principle by which they are formed. This entelechical principle can be grasped only through productive intuition. In *Outlines of an Epistemology of Goethe's Worldview*, Steiner described this form of intuitive thinking:

Our mind must (...) work much more intensively in grasping the [organic] type than in grasping the [inorganic] natural law. It must generate not only the form but also the content. It must undertake an activity that, in inorganic natural science, is performed by the senses and which we call intuition. At this higher level, the mind itself must therefore be intuitive. Our power of judgment must *view in thinking* and *think in viewing*. Here, as Goethe first set out, we are dealing with an intuitive power of judgment. (Steiner [1886] 1979, 109)

In the first *Introduction*, Steiner explained that:

If we want to recognize organic nature, we have to grasp (...) *the conceptual as such*; it has to have its own content from itself, not from the spatiotemporal senses. (...) What is necessary for such a grasp? A power of judgment that can give a thought another substance [*Stoff*] than just that which is taken in through the external senses – one that can grasp not only the sensually perceptible but also the purely ideal for itself, separate from the sensual world. We can call a concept that is not derived from the sense world by abstraction but that has a content [*Gehalt*] flowing from it and only from it an *intuitive concept* and the knowledge of it an intuitive one. What follows from this is clear: *an organism can only be grasped in the intuitive concept*. (Steiner [1884 ff.] 1987, 82–83)

If we thus mentally create (or recreate, for that matter) the plant in its metamorphic development, the animal in its sensitive reactions and desireful movements, then we intuitively grasp their different entelechical principles. In other words, if we imaginatively *do* what the plant does (i.e. generate and transform its organs) or *do* what the animal does (i.e. use its organs to fulfil its needs), then we come to understand them. When we mentally recreate a plant's metamorphic formations, we 'see' how its essential principle realizes itself via expansion and contraction in space and time, thereby 'losing itself in externality'. If we mentally recreate an animal's sensitivity and desire, then we 'see' that the animal has a 'centre', a 'soul principle' in which its sensitivity concentrates and from which its desire springs. We also intuitively 'see' that this centre is not identical to its corporeality but rather that it uses its organs, its senses and limbs, as 'meditators with the external world'. Furthermore, we realize that in each animal, all organs and their functions are perfectly adapted to each other. Since they all serve the animal's 'centre', 'each organ appears to come from that centre' (and, at the same time, is perfectly adapted to its environment).⁹ Therefore, while the essential principle of the plant has

only formative power, the essential principle of the animal has both formative *and* sentient and desiring power.

How then can one conceive of the archetypal animal, the generative principle or ‘lawfulness of animality’ (which, according to Steiner, Goethe did not find)? Obviously, an answer to this question can be found only through intuitive thinking.

5. Construction of the Animal Archetype

The archetype of the animal contrasts with that of the plant in fundamental ways related to structure, function, and its relationship with the environment. A plant dynamically embodies its archetype, the ‘essential leaf’ (i.e. a living surface), in spatio-temporal expansion and contraction with progression. In contrast, according to Steiner the animal archetype must be viewed as a nonphysical principle, a ‘psychological centre’ that relates to its environment through sensitivity and desire and that realizes itself in the animal’s reactions and motility. While the living surface of the plant is functionally oriented toward its exterior, the animal is essentially characterized by its interior functions. Thus, while the plant expands outward, the animal ‘invaginates,’ forming internal cavities and organs that facilitate its relationship with the external world.

The animal relates to its environment by receiving sensory stimuli and nourishment and by acting according to its needs. While the archetypal, constructive element of a plant is a surface that promotes the exchange and transformation of physical substances, the *constructive element* of an animal can, in a first approximation, be regarded as a *cavity*, – an interior space separated from the external environment by an outer protective shell or skin – yet one that, through its organs, enables various forms of exchange between the interior and its surroundings. And while the constructive rule of the archetypal plant is a threefold spatio-temporal expansion and contraction (cf. Förster, above), the *constructive rule* of the animal archetype is a threefold *relationship of the interior to the exterior*: through the sensing of external stimuli (outside → in); through uptake, metabolism, and excretion of organic substances (outside → inside → out); and through its initiation of movements (inside → out). The animal archetype, therefore, realizes itself in three primary functions and their corresponding organ systems: sensitivity (senses, nerves), metabolism (lungs, blood system, digestive tract), and motility (muscles, limbs).¹⁰

Plants are sessile and grow in a vertical direction between the influences of sunlight and gravity, leading to their radial symmetry. In contrast, the animal archetype (sensitivity and desire) expresses itself in the ability of directed movement toward a perceived goal in a predominantly horizontal orientation with a clear front and back, head and tail, leading to bilateral symmetry of the body. In addition, plants have an open form that can potentially grow endlessly (‘losing themselves in externality’), while animals end their growth in a closed shape, facilitating their ‘inner’, psychological life.

Plants use the energy of the sun to build up organic substances from water and CO₂, while animals break these substances down, producing water and CO₂, thereby transforming the sun’s energy into autonomous motility. An animal’s body structure and organ systems, its ability to sense and move within its environment, and its ability to use metabolic energy to support its life and its psychological functions, are therefore inseparably related to each other and can be viewed as the expression of the animal’s

archetype (i.e. of its constructive element and constructive rule as described above). Ultimately and appropriately, while the plant's principle alternates between expansion and contraction, the animal's essential principle oscillates between waking and sleeping.¹¹

In this way, the archetype of the animal can be constructed in a purely intellectual, quasi-mathematical style and subsequently rediscovered in sensory experience.

6. From Epistemology to Ontology

Steiner claimed that Goethe strove for 'an independent organic science that had its own axioms and its own method' (Steiner [1891] 1989, 274–275). To live up to its name, such *rational organicism* would therefore have to solve the enduring riddle of the organism. Kant had emphasized that organisms must be judged as autonomously developing, teleologically organized beings, but that they could not be explained as such, since these properties presuppose an idea of the whole. Ideas, however, cannot be ontological principles of nature, for 'we do not take [nature] to be an intelligent being' (Kant [1790] 2008, 359). Here, I suggest that Steiner's interpretation of Goethe's approach suggests a solution to this dilemma.

To fully grasp this approach, it is crucial to note once again that the structure, interaction and development of the parts of an organism cannot be explained causally and analytically. The root does not cause the flower, as the warmth of the water causes the rise of the mercury column in the thermometer.¹² In an organism, the parts are *not* mutually cause and effect of each other—as Kant erroneously asserted (Kant [1790] 2008, 373)—but rather mutually necessary *conditions*. 'No flower without the root' does not mean that the root is sufficient for explaining the flower. Steiner wrote:

The living is a self-contained whole that sets its conditions from within itself. In the juxtaposition of its parts, as in the temporal succession of the states of a living being, there is an interrelation that does not appear to be conditioned by the sensually perceptible properties of the parts, not by the mechanical-causal determination of the latter by the earlier, but which is governed by a higher principle that stands above the parts and states. It is determined by the nature of the whole that a particular state is set as the first, another as the last; and the succession of the intermediate states is also determined within the idea of the whole. (Steiner [1884 ff.] 1987, 34–35)

Therefore,

All sensual qualities [of the organism] appear (...) as a consequence of something *that is no longer perceptible to the senses*. They appear as a consequence of a higher unity that hovers above the sensual processes. It is not the shape of the root that determines that (...) of the leaf, etc., but all these forms are determined by something that stands above them, which itself is not a sensually perceptible form; they are there for each other, but not through each other. (...) We cannot deduce what we perceive with our senses from conditions that can be perceived with our senses. We must include elements in the concept of processes that do not belong to the world of the senses. (...) We have to grasp *the unity* conceptually if we want to explain the phenomena. (Steiner [1884 ff.] 1987, 73–74)

In saying this, Steiner touched on the very point that Kant had also alluded to and where biology and philosophy continue to founder. Because the organism cannot be explained by the interactions of its parts, ideal elements *must* be included in the explanation. However, as long as one hesitates to grant these ideal components an ontological

status and maintains that sensually perceptible phenomena can only be caused by other sensually perceptible phenomena, the explanation remains caught in a circular argument.

Steiner countered this epistemological circle with the argument that Goethe had succeeded—albeit only in the beginnings—in finding the laws of organic formation in a similar way to how one finds the laws of physics through purely intellectual construction (which, of course, is based on the observable phenomena as its template to be explained). Steiner showed that by thinking in *flexible, living concepts* (‘when one tries to bring them to life in one’s mind’), one can ideally *experience* the generative processes of the organism and their constitutive principles (Hueck 2025). In this way, the living principle that brings about the formation of an organism is no longer thought of only in an abstract way but is observed, if not with the senses, but at an intellectual level. Thus, this principle is no longer merely heuristic but acquires an ontological status: ‘One then realizes that it is the *nature of the plant itself* translated into the idea, which lives in our mind just *as it lives in the object*’ (Steiner [1884 ff.] 1987, 12–13; emphasis added). In other words, by ‘intuitive power of judgment,’ as Goethe called it, one ‘sees’ with the ‘eye of the mind’ the ideal principle that is actually at work in the plant or that shapes and moves the animal and makes it a living, holistic, developing organism. What one grasps in this way is just as undoubtedly real as what one perceives with physical senses. This is why Goethe claimed that ‘I have ideas without knowing it, and even see them with eyes’ (Goethe [1817] 1965, 868).

This ‘seeing with the mind’s eye’ is not receptive but rather a *productive* process (Förster 2001; Pfau 2010). We have to generate the content of the thought, have to give it its own substance [*Stoff*], as Steiner said (Steiner [1884 ff.] 1987, 82–83), in productive intuition. This is a major difficulty in understanding Goethe’s rational organicism because we are deeply accustomed to accepting as objective only what can be perceived in a receptive mode. It can be claimed that we are dealing here with deeply rooted prejudices. Steiner illuminated them through his precise analysis of Goethe’s approach to organic cognition.¹³

7. Conclusion

In this article, I describe *rational organicism*, a method for cognition and scientific explanation of organisms developed by Goethe and interpreted by Steiner. Steiner considered Goethe’s organicism to be explanatory because it facilitates the construction of organic laws in an intellectual manner that can then be rediscovered in the phenomena—analogous to how mathematical laws are applied in physics or chemistry.

Today’s philosophy of biology ascribes properties to organisms such as autopoiesis (self-formation), autonomy (self-determination), and agency (self-efficacy) (Rosslénbroich 2023). Although this view is much closer to our real-world experience of organisms than the view that they are genetically programmed, statistically selected survival machines, the above terms remain mere descriptions if one cannot grasp their ontological status (Wolfe 2024, 2010). What Kant showed for the teleology of the organism applies equally to organic autopoiesis, autonomy and agency. Through Goethe’s intuitive method of rational organicism, these concepts can be apprehended as ontologically real. One comes to ‘see’ these principles with the ‘mind’s eye’. It is no longer necessary to derive the purposive self-generation of organisms from mechanistic principles – as,

for instance, Stuart Kauffman attempted with his concept of ‘work-constraint cycles’ (Kauffman 2000). Rather, autopoietic forces and laws may be acknowledged as a reality that forms the foundation for the empirical investigation of organismic life. Therefore, Goethe’s rational organicism can be regarded as a method that complements the organicism of the current philosophy of biology.

In applying Goethe’s method, one also arrives at the notion that nature consists of more than just dead matter and that there is a realm of living reality of its own, which cannot be observed and researched by the physical sciences but is accessible in phenomenologically guided, intuitive contemplation (Hueck 2025). Kant was right that the essence of the organism lies within a ‘supersensible substrate of nature’, but he appears to have been wrong in claiming that this supersensible substrate is unknowable to us (Kant [1790] 2008, 410).

The properties of organisms mentioned above can be summarized in the Aristotelian term *entelechy*, ἐν (inner) τέλος (goal, purpose) ἔχειν (to have): to have one’s goal within oneself. This paper attempted to show how organic entelechy can be grasped through intellectual intuition as an ontologically real and effective principle. ‘Entelechy is the power that calls itself out of itself into existence’ (Steiner [1884 ff.] 1987, 83). ‘For anyone who has grasped the ‘forming-itself-according-to-itself’ of the entelechical principle, this constitutes the solution to the riddle of life. Another solution is impossible because this is the essence of the issue itself’ (Steiner [1884 ff.] 1987, 99). Goethe’s archetype is therefore not an abstract blueprint, as has sometimes been claimed, nor is it a Platonic, otherworldly idea. ‘It is the nature of the plant [or of the animal] itself translated into the idea, which *lives in our mind just as much as in the object*’ (Steiner [1884 ff.] 1987, 12–13).

Notes

1. Both books appeared at the Easter Book Fair in Leipzig, 1790 (Schmid 1940, 8; Förster 2012, 166).
2. Goethe called ‘the leaf’ a ‘transcendental’ principle (Goethe [1788] 1965, 130) and emphasized that

we would obviously need a general term to describe this organ that metamorphosed into such a variety of forms. (...) For now, however, we must be satisfied with learning to relate these manifestations both forward and backward. Thus, we can say that a stamen is a contracted petal or, with equal justification, that a petal is a stamen in a state of expansion; that a sepal is a contracted stem leaf with a certain degree of refinement, or that a stem leaf is a sepal expanded. (Goethe [1790] 1965c, 57)

3. All translations of Goethe’s and Steiner’s texts are my own.
4. For further aspects of plant development, especially with respect to its environment, see Suchantke (2011).
5. This aligns with Kant’s view of scientific explanation as ‘derivation from a principle which must (...) be capable of being clearly cognized and specified’ (Kant [[1790] 2008], 412), since ‘we have complete insight only into what we can make and accomplish according to our concepts’ (Kant [[1790] 2008], 384).
6. Already in 1784 he discovered the premaxillary bone in humans (Goethe [1784] 1965) and began to search for a ‘general bone type’ (Goethe [1784] 1965, 311).
7. *Attempt on the Form of Animals* (Goethe [1790] 1965a); *First Draft of a General Introduction to Comparative Anatomy, Based on Osteology* (Goethe [1795] 1965b); *Lectures on the First*

Three Chapters of the First Draft of a General Introduction to Comparative Anatomy, Based on Osteology (Goethe [1796] 1965).

8. This method was often used by Steiner: he formulates statements that can only be fully understood in the context of other of his texts and leaves it to the reader to establish these connections. Just as the individual organs of a plant cannot be fully understood in isolation but only in terms of their connecting principle, Steiner's ideas often cannot be found directly in his texts but must be found in the relationships between them. Steiner's way of presentation therefore requires a Goethean approach to his texts.
9. In this way, it also becomes an intuitive experience that the animal is embedded psychologically and behaviourally in a certain environmental context as described by Jakob von Uexküll (Uexküll [1934/1957] 1992), and that its organs are formed both in accordance to its needs and in perfect adaptation to its environmental conditions. This idea, which goes back to Aristotle, was discussed at length by Martin Heidegger (Heidegger [1929/30] 1983, 319 ff.) and recently by Anne Sophie Meincke (Meincke 2023).
10. The reproductive system and the animal's immune system require additional intuitive conceptions which relate to the concept of continuing individuality, which in turn relates to the concepts of species, systematics, and evolution. These relations cannot be discussed here in detail.
11. For further aspects of intuitive characterization of the differences between plants and animals cf. Hartmann (1945).
12. Genes also do not cause the organism. They are necessary conditions – 'highly sensitive organs' in the words of the geneticist Barbara McClintock (McClintock 1993, 198) –, but do not suffice to explain the life, development and structure of an organism (Moss 2004; Robert 2004). However, just as the macroscopic structure of an organism can be understood through rational organicism in intuitive contemplation, so can its molecular components and their functions (genes, proteins, etc.). This will be shown in detail in another publication.
13. In his later, anthroposophical writings, Steiner showed how one can strengthen and deepen one's intuitive perception of the organic through simple and targeted mental exercises until it is experienced as real as the external, physical world (Steiner [1904/1905] 1992).

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ORCID

Christoph J. Hueck  <http://orcid.org/0009-0008-2513-1919>

References

- Amrine, Frederick. 1996. *Goethe in the History of Science: Bibliography, 1776-1949 (Vol 1), 1950-1990. (Vol 2)*. New York: Peter Lang Publishing.
- Becker, Hans J. 1998. "Über die Metamorphose der Pflanzen — Morphologische Schriften." In *In Goethe Handbuch in vier Bänden*, edited by Hans D. Dahnke, 690–702. Stuttgart: J.B. Metzler Verlag.
- Brigandt, Ingo, and Alan C. Love. [2008] 2023. "Reductionism in biology." In *In Stanford Encyclopedia of Philosophy: Winter 2023 Edition*, edited by Edward N. Zalta and Uri Nodelman, 1–54. Stanford: Metaphysics Research Lab.
- Classen-Bockhoff, Regine. 2001. "Plant Morphology: The Historic Concepts of Wilhelm Troll, Walter Zimmermann and Agnes Arber." *Annals of Botany* 88 (6): 1153–1172. <https://doi.org/10.1006/anbo.2001.1544>.

- Danneberg, Lutz. 2018. "Goethe und die Naturwissenschaften - mit Blick auf die Philosophie, die Antike und die übrigen Wissenschaften." Auswahlbibliographie. <https://de.scribd.com/document/475587785/Goethe-V02-doc>.
- Förster, Eckart. 2001. "Goethe and the "Auge des Geistes." *Deutsche Vierteljahrsschrift für Literaturwissenschaft und Geistesgeschichte* 75: 87–101.
- Förster, Eckart. 2012. *The Twenty-Five Years of Philosophy: A Systematic Reconstruction*. Cambridge, MA: Harvard University Press
- Gilbert, Scott F., and Sahotra Sarkar. 2000. "Embracing Complexity: Organicism for the 21st Century." *Developmental Dynamics* 219 (1): 1–9. [https://doi.org/10.1002/1097-0177\(2000\)9999:9999<:AID-DVDY1036>3.0.CO;2-A](https://doi.org/10.1002/1097-0177(2000)9999:9999<:AID-DVDY1036>3.0.CO;2-A).
- Goethe, Johann W von. 1965–1978. *Italienische Reise*. 1. Aufl. Edited by Siegfried Seidel. BA 14. Berlin: Aufbau-Verlag.
- Goethe, Johann W von. 2004. *Briefe*. Edited by Mathias Bertram. DB 10. Berlin: Directmedia Publishing.
- Goethe, Johann W von. [1784] 1965. "Über den Zwischenkiefer des Menschen und der Tiere: Handschriftlich, mit Tafeln; Zur Morphologie, Bd. I, Heft 2 (1820)." In *Naturwissenschaftliche Schriften II: Botanik. Vergleichende Anatomie. Zoologie.*, edited by Siegfried Seidel, 1. Aufl. 287–328. BA 24 Berlin: Aufbau-Verlag.
- Goethe, Johann W von. [1788] 1965. "Botanik als Wissenschaft: Handschriftlich im Nachlass." In *In Naturwissenschaftliche Schriften II: Botanik. Vergleichende Anatomie. Zoologie.*, edited by Siegfried Seidel, 1. Aufl. 127–132. BA 24. Berlin: Aufbau-Verlag.
- Goethe, Johann W. von. [1790] 1965a. "Versuch über die Gestalt der Tiere: Handschriftliches Fragment." In *Naturwissenschaftliche Schriften II: Botanik. Vergleichende Anatomie. Zoologie.*, edited by Siegfried Seidel. 1. Aufl., 371–380. BA 24. Berlin: Aufbau-Verlag.
- Goethe, Johann W. von. [1790] 1965b. "Versuch einer allgemeinen Vergleichungslehre: Handschriftlich." In *Naturwissenschaftliche Schriften II: Botanik. Vergleichende Anatomie. Zoologie.*, edited by Siegfried Seidel. 1. Aufl., 226–231. BA 24. Berlin: Aufbau-Verlag.
- Goethe, Johann W. von. [1790] 1965c. "Die Metamorphose der Pflanzen: Zur Morphologie, Bd. I, Heft 1 (1817)." In *Naturwissenschaftliche Schriften II: Botanik. Vergleichende Anatomie. Zoologie.*, edited by Siegfried Seidel. 1. Aufl., 22–57. BA 24. Berlin: Aufbau-Verlag.
- Goethe, Johann W. von. [1795] 1965a. "Vorarbeiten zu einer Physiologie der Pflanzen." In *Naturwissenschaftliche Schriften II: Botanik. Vergleichende Anatomie. Zoologie.*, edited by Siegfried Seidel. 1. Aufl., 111–133. BA 24. Berlin: Aufbau-Verlag.
- Goethe, Johann W. von. [1795] 1965b. "Erster Entwurf einer allgemeinen Einleitung in die vergleichende Anatomie, ausgehend von der Osteologie: Zur Morphologie, Bd. I, Heft 2 (1820)." In *Naturwissenschaftliche Schriften II: Botanik. Vergleichende Anatomie. Zoologie.*, edited by Siegfried Seidel. 1. Aufl., 231–269. BA 24. Berlin: Aufbau-Verlag.
- Goethe, Johann W. von. [1796] 1965. "Vorträge über die drei ersten Kapitel des ersten Entwurfs einer allgemeinen Einleitung in die vergleichende Anatomie, ausgehend von der Osteologie: Zur Morphologie, Bd. I, Heft 3 (1820)." In *Naturwissenschaftliche Schriften II: Botanik. Vergleichende Anatomie. Zoologie.*, edited by Siegfried Seidel. 1. Aufl., 269–288. BA 24. Berlin: Aufbau-Verlag.
- Goethe, Johann W. von. [1805] 1965. "Polarität: Schriften zur Wissenschaftslehre." In *Naturwissenschaftliche Schriften I: Schriften zur Farbenlehre. Schriften zur Wissenschaftslehre.*, edited by Siegfried Seidel. 1. Aufl., 863–864. BA 23. Berlin: Aufbau-Verlag.
- Goethe, Johann W. von. [1807] 1965. "Bildung und Umbildung organischer Naturen: Zur Morphologie. Bd. I, Heft 1 (1817)." In *Naturwissenschaftliche Schriften II: Botanik. Vergleichende Anatomie. Zoologie.*, edited by Siegfried Seidel. 1. Aufl., 11–21. BA 24. Berlin: Aufbau-Verlag.
- Goethe, Johann W. von. [1817] 1965. "Glückliches Ereignis: Zur Morphologie, Bd. I, Heft 1 (1817)." In *Naturwissenschaftliche Schriften I: Schriften zur Farbenlehre. Schriften zur Wissenschaftslehre.*, edited by Siegfried Seidel. 1. Aufl., 864–869. BA 23. Berlin: Aufbau-Verlag.
- Goethe, Johann W. von. [1820] 1965. "Anschauende Urteilskraft: Schriften zur Wissenschaftslehre." In *Naturwissenschaftliche Schriften I: Schriften zur Farbenlehre. Schriften*

- zur *Wissenschaftslehre.*, edited by Siegfried Seidel. 1. Aufl., 877–879. BA 23. Berlin: Aufbau-Verlag.
- Goethe, Johann W. von. [1831] 1965a. “Der Verfasser teilt die Geschichte seiner botanischen Studien mit: Kürzere Fassung: Zur Morphologie, Bd. I, Heft 1 (1817): “Geschichte meines botanischen Studiums.” In *Naturwissenschaftliche Schriften II: Botanik. Vergleichende Anatomie. Zoologie.*, edited by Siegfried Seidel. 1. Aufl., 62–84. BA 24. Berlin: Aufbau-Verlag.
- Goethe, Johann W. von. [1831] 1965b. “Über die Spiraltendenz der Vegetation: Handschriftlich.” In *Naturwissenschaftliche Schriften II: Botanik. Vergleichende Anatomie. Zoologie.*, edited by Siegfried Seidel. 1. Aufl., 153–174. BA 24. Berlin: Aufbau-Verlag.
- Hartmann, Otto J. 1945. *Die Gestaltstufen der Naturreiche und das Problem der Zeit.* Halle (Saale): Niemeyer.
- Hassenstein, Bernhard. 1951. “Goethes Morphologie als selbstkritische Wissenschaft und die heutige Gültigkeit ihrer Ergebnisse.” In *In Goethe-Jahrbuch (12): 1950*, edited by Andreas B. Wachsmuth, 333–357. Weimar: Hermann Böhlau Nachfolger.
- Heidegger, Martin. [1929/30] 1983. *Die Grundbegriffe der Metaphysik: Welt - Endlichkeit - Einsamkeit.* Frankfurt am Main: Vittorio Klostermann.
- Hueck, Christoph J. 2025. “Empirical Vitalism: Observing an Organism’s Formative Power Within an Active and Co-constitutive Relation Between Subject and Object.” *History and Philosophy of the Life Sciences* 47 (9): 1–19. <https://doi.org/10.1007/s40656-024-00649-z>.
- Kant, Immanuel. [1790] 2008. *Critique of Judgement: Edited by Nicholas Walker. Translated by James Creed Meredith.* AA V. Oxford: Oxford University Press.
- Kauffman, Stuart. 2000. *Investigations.* New York: Oxford University Press.
- Kauffman, Stuart. 2013. “What is Life, and can we Create It?” *BioScience* 63: 609–610. <https://doi.org/10.1525/bio.2013.63.8.2>.
- Lenoir, Timothy. 1987. “The Eternal Laws of Form: Morphotypes and the Conditions of Existence in Goethe’s Biological Thought.” In Amrine, Zucker, and Wheeler, 17–28.
- Mandelkow, Karl R. 1980. *Goethe in Deutschland: Rezeptionsgeschichte eines Klassikers, Bd. I, 1773–1918.* München: C. H. Beck.
- Mayr, Ernst. 1982. *The Growth of Biological Thought: Diversity, Evolution, and Inheritance.* 11th ed. Cambridge: Mass. Belknap Press of Harvard Univ. Press.
- McClintock, Barbara. 1993, December 8. “The Significance of the Response of the Genome to challenge: Nobel lecture, Karolinska Institute (Stockholm).” In *Nobel Lectures, Physiology or Medicine 1981–1990*, edited by Tore Frängsmyr, and Jan Lindsten, 180–199. Singapore: World Scientific Publishing Co. <https://www.nobelprize.org/prizes/medicine/1983/mcclintock/lecture/>.
- Meincke, Anne S. 2023. “Hervorbringende ‘Organe bildende Kraft?’” *Deutsche Zeitschrift für Philosophie* 71 52–80. <https://doi.org/10.1515/dzph-2023-0003>.
- Moreno, Alvaro, and Matteo Mossio. 2015. *Biological Autonomy: A Philosophical and Theoretical Enquiry 12.* Dordrecht: Springer Netherlands.
- Moss, Lenny. 2004. *What Genes can’t do.* Cambridge: MIT Press.
- Müller, Irmgard. 2000. “Goethes Farbenlehre und Morphologie in den Naturwissenschaften des 20. Jahrhunderts.” In *In Goethe-Jahrbuch (116): 1999*, edited by Werner Keller, 234–244. Stuttgart: J.B. Metzler Verlag.
- Pfau, Thomas. 2010. ““All is Leaf”: Difference, Metamorphosis, and Goethe’s Phenomenology of Knowledge.” *Studies in Romanticism* 49 3–41.
- Porcar, Manuel, Antoine Danchin, Victor de Lorenzo, Vitor A. Dos Santos, Natalio Krasnogor, Steen Rasmussen, and Andrés Moya. 2011. “The Ten Grand Challenges of Synthetic Life.” *Systems and Synthetic Biology* 5 (1-2): 1–9. <https://doi.org/10.1007/s11693-011-9084-5>.
- Portmann, Adolf. 1987. “Goethe and the Concept of Metamorphosis.” In *Goethe and the Sciences: A Reappraisal*, edited by Frederik Amrine, Francis Zucker, and Harvey Wheeler, 133–145. Dordrecht: Reidel.
- Robert, Jason S. 2004. *Embryology, Epigenesis, and Evolution: Taking Development Seriously.* Cambridge: Cambridge University Press.

- Rosslenbroich, Bernd. 2023. *Properties of Life: Toward a Theory of Organismic Biology*. Cambridge: MIT Press.
- Russell, Edward S. 1916. *Form and Function: A Contribution to the History of Animal Morphology*. London: John Murray.
- Schmid, Günther. 1940. *Goethe und die Naturwissenschaften. Eine Bibliographie*. Halle (Saale): Leopoldina.
- Steiner, Rudolf. 1984. *Philosophie und Anthroposophie: Gesammelte Aufsätze 1904-1923*. 2. Aufl. GA 035. Dornach: Rudolf Steiner Verlag.
- Steiner, Rudolf. [1884 ff.] 1987. *Einleitungen zu Goethes naturwissenschaftlichen Schriften: Zugleich eine Grundlegung der Geisteswissenschaft (Anthroposophie)*. 4. Aufl. GA 001. Dornach: Rudolf Steiner Verlag.
- Steiner, Rudolf. [1886] 1979. *Grundlinien einer Erkenntnistheorie der Goetheschen Weltanschauung: Mit besonderer Rücksicht auf Schiller*. 7. Aufl. GA 002. Dornach: Rudolf Steiner Verlag.
- Steiner, Rudolf. [1891] 1989. *Methodische Grundlagen der Anthroposophie 1884 - 1901*. 3. Aufl. GA 030, 265–288. Dornach: Rudolf Steiner Verlag.
- Steiner, Rudolf. [1897] 1990. *Goethes Weltanschauung*. 8. Aufl. GA 006. Dornach: Rudolf Steiner Verlag.
- Steiner, Rudolf. [1904/1905] 1992. *Wie erlangt man Erkenntnisse der höheren Welten?* 24. Aufl. GA 010. Dornach: Rudolf Steiner Verlag.
- Steiner, Rudolf. [1923 ff.] 1982. *Mein Lebensgang - eine nicht vollendete Autobiographie: Mit einem Nachwort herausgegeben von Marie Steiner 1925*. 8. Aufl. GA 028. Dornach: Rudolf Steiner Verlag.
- Suchantke, Andreas. 1983. “Das Blatt - der wahre Proteus: Wie weit ist Goethes Metamorphosenlehre heute noch aktuell?” *Die Drei* 6:371–388.
- Suchantke, Andreas. 2011. *Metamorphosis: Evolution in action*. Hillsdale, NY: Adonis Press.
- Švorcová, Jana, ed. 2024. *Organismal Agency: Biological Concepts and Their Philosophical Foundations*. Cham: Springer International Publishing.
- Uexküll, Jakob von. [1934/1957] 1992. “A Stroll Through the Worlds of Animals and Men: A Picture Book of Invisible Worlds.” *Semiotica* 89 319–391. <https://doi.org/10.1515/semi.1992.89.4.319>.
- Walsh, Denis M. 2015. *Organisms, Agency, and Evolution*. Cambridge: Cambridge University Press.
- Wolfe, Charles. 2010. “Do Organisms Have an Ontological Status?” *History and Philosophy of the Life Sciences* 32:195–232. <https://www.jstor.org/stable/23335072>.
- Wolfe, Charles. 2024. “Varieties of Organicism: A Critical Analysis.” In *In Organization in biology*. Vol. 33, edited by Matteo Mossio, 41–58. Cham: Springer International Publishing.