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Table of Contents

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What Was Kant's Contribution to the Understanding of Biology?

Abstract: Kant's theory of biology in the *Critique of the Power of Judgment* may be rejected as obsolete and attacked from two opposite perspectives. In light of recent advances in biology one can claim *contra* Kant, on the one hand, that biological phenomena, which Kant held could only be explicated with the help of teleological principles, can in fact be explained in an entirely mechanical manner, or on the other, that despite the irreducibility of biology to physico-mechanical explanations, it is nonetheless proper science. I argue in response that Kant's analysis of organisms is by no means obsolete. It reveals biology's uniqueness in much the same way as several current theorists do. It brings to the fore the unique purposive characteristics of living phenomena, which are encapsulated in Kant's concept of "natural end" and which must be explicated in natural terms in order for biology to become a science. I maintain that Kant's reluctance to consider biology proper science is not a consequence of his critical philosophy but rather of his inability to complete this task. Kant lacked an appropriate theoretical framework, such as provided later by modern biology, which would enable the integration of the unique features of biology in an empirical system. Nevertheless, as I show in this paper, the conceptual problems with which Kant struggled attest more to the relevance and depth of his insights than to the shortcomings of his view. His contribution to the biological thought consists in insisting on an empirical approach to biology and in providing the essential philosophical underpinning of the autonomous status of biology.

Introduction

Kant's view of the scientific status of biology, as implied in his analysis of living beings in the *Critique of the Power of Judgment* (*CJ*), may be summarized in the following two propositions: (1) in investigating organisms, one cannot rely on mechanical principles alone, but must also appeal to teleological principles; consequently, (2) since the mechanical mode of explanation is the only properly scientific type of explanation, one cannot regard the investigation of living beings as proper science. In light of recent advances in biology, one can attack this view from two opposite perspectives and conclude that Kant's theory of biology is obsolete.

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Some modern thinkers object to the first proposition on the grounds that biological phenomena, which Kant held could only be explicated with the help of teleological principles, can in fact be explained in an entirely mechanical manner. This objection is encouraged by the progress made in biology since Kant's time, especially in the fields of molecular biology and genetics. According to this view, biology is reducible to the physical sciences and, therefore, deserves the status of proper science.

Other scholars reject the view that biology is a branch of or reducible to the physical sciences. They agree with Kant that biology differs from physics in essential respects, yet they dismiss his claim that biology is not a proper science.

I argue in response that Kant's analysis of organisms is by no means obsolete. It reveals biology's uniqueness in much the same way as several current theorists do. It brings to the fore the unique purposive characteristics of living phenomena (i. e. two-way causality, program, and function), which are encapsulated in Kant's concept of "natural end" and which must be explicated in natural terms in order for biology to become a science. I maintain that Kant's reluctance to consider biology proper science is not a consequence of his critical philosophy but rather of his inability to complete this task. Kant lacked an appropriate theoretical framework, such as provided later by modern biology, which would enable the integration of the unique features of biology in an empirical system. Nevertheless, as I will try to show in this paper, the conceptual problems with which Kant struggled attest more to the relevance and depth of his insights than to the shortcomings of his view. His contribution to the biological thought consists in insisting on an empirical approach to biology and in providing the essential philosophical underpinning of the autonomous status of biology by systematically exploring its unique features.

The paper is divided into four sections. In the first section, I consider Kant's argument in the Analytic of the Teleological Power of Judgment. This argument addresses the problem of purposiveness vis-à-vis mechanism and highlights the conceptual difficulties posed by the purposive characteristics ascribed to organisms. In the second section, I briefly discuss the two opposite lines of objection to Kant's analysis of biology. In the third section, I reply to these objections. I show how the modern notion of genetic programs and the construal of function in terms of natural selection provide the missing theoretical framework and resolve the difficulties that Kant detected in the conceptualization of living beings. In the fourth and final section, I summarize the conclusions of the paper.

1 Kant's argument in the Analytic of the Teleological Power of Judgment

In the Analytic of the Teleological Power of Judgment Kant discusses the place of purposiveness in nature and analyzes the conceptual difficulties posed by introducing purposiveness into natural science.[1] In essence, the ground of the difficulties is that introducing purposiveness propels us to regard objects in two apparently incompatible ways, namely, as natural things and as possessing purposive features. Naturalness and purposiveness seem to clash, since as natural things objects are supposed to evolve through natural processes, while as possessing purposive features they appear to have internal organization which implies intentional design.

The problem, then, is that it seems that an object cannot be both natural and purposive, since purposiveness involves a type of causality that conflicts with the standard natural causality. The latter is a one-way causal connection, in which one thing (the cause) brings about a second thing (the effect), but not the other way around. Purposiveness, on the other hand, involves two-way causality, in which two things mutually condition one another. Human craftsmanship best illustrates this type of causality. Kant gives the example of building a house for the sake of profiting from the rent that will be paid for using it. In this case, the

1 In the *Critique of the Power of Judgment*, Kant discusses purposiveness in theorizing, aesthetics, and nature. In the first two domains, purposiveness is *subjective*, while in the third, it is *objective*. In theorizing, Kant identifies a purposiveness which he labels "formal" or "logical." This purposiveness is a transcendental principle of the reflective power of judgment that asserts an "agreement of nature with our faculty of cognition" (*CJ* AA 5:185), namely, a principle that makes it possible for us to advance in fulfilling our cognitive enterprise of putting the multiplicity of phenomena and empirical laws into a unified system of nature (see Allison 2001, 13–42). In aesthetics, purposiveness concerns the condition of the cognitive powers and the representational state of the subject. Finally, in nature purposiveness is assumed to pertain to objects. This objective purposiveness is either *formal* or *real* (i.e. *material*). That is, it concerns either the geometrical form of the object, or the concept of an end by which the object is possible (First Introduction (*CJ-FI*) to the third *Critique* AA 20:232; *CJ* §62 / AA 5:364). For the most part, in the Critique of the Teleological Power of Judgment, Kant is interested in real, objective purposiveness, namely, in natural teleology. Objective and real purposiveness is either *internal* or *relative* (i.e. *external*). The former pertains to the internal organization of certain objects and the latter to the usefulness of objects (*CJ* §63 / AA 5:366–369). Kant claims that it is internal purposiveness, which concerns the purposive features of organized beings, that justifies our teleological judgments. Put differently, it is the encounter with organized beings (i.e. organisms) that prompts us to admit purposiveness in nature and to introduce teleology into natural science (see *CJ* §65 / AA 5:375–376).

house and the rent can be considered reciprocally cause and effect of one another. On the one hand, building the house (and renting it) is the cause of the collected rent. On the other hand, the anticipated rent earned is what motivates one to build the house.[2]

Purposiveness in human craftsmanship involves intelligent intentions and planning.[3] The rent itself is not the efficient cause of the construction of the house. Rather, the construction of the house was motivated by the representation of the rent and carried out in accordance with a representation of a suitable model of the house. Thus, an intelligent agent, in whose mind the relevant representations arise, is involved in the production of artifacts. This is what Kant means when he claims that final causality is a connection between *ideal* causes and their effects, while natural efficient causality is a connection between *real* causes and their effects.

Artifacts are "products of art" and one is justified in ascribing their production to an artisan. By contrast, organisms are supposed to be "products of nature" and their purposiveness, therefore, cannot be attributed to an external designer. If they are supposed to involve two-way final causality, this causality must somehow be natural and real, not merely ideal. This would make organisms "natural ends" (*Naturzwecke*). The worry is that the notion of natural end, which serves to conceptualize organisms, may involve a contradiction.[4]

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2 See: "the house is certainly the cause of the sums that are taken in as rent, while conversely the representation of this possible income was the cause of the construction of the house" (*CJ* §65 / AA 5:372–373).

3 McLaughlin (1990, 38–39, 45) notes that Kant did not distinctly distinguish between the intention (*causa finalis*) and the plan (*causa formalis*). He observes that despite this ambiguity, it is quite clear that it is the *causa formalis* (and not the *causa finalis*) that figures in Kant's analysis of organisms.

4 This worry encapsulates the problem at the heart of Kant's discussion. In this respect, my interpretation differs from Ginsborg's interpretation of Kant's analysis of the teleological antinomy and study of organisms (especially as presented in Ginsborg 2004). Ginsborg recognizes two separate aspects of Kant's view of organisms that correspond to two kinds of mechanical inexplicability: one concerns purposiveness and the other naturalness. She then contends that only the first is relevant to the argument of the antinomy. By contrast, I argue that the combination of naturalness and purposiveness lies precisely at the heart of Kant's discussion. The unification of these two otherwise unproblematic notions gives rise to the troublesome concept of natural end and the teleological antinomy. We may encounter difficulties in explaining particular inanimate natural phenomena and purposive artifacts, but we can reasonably comprehend the concepts of "natural object" and "artifact" and find particulars that instantiate them (e. g. winds and clocks, respectively). On the other hand, we do face conceptual difficulties in attempting to comprehend organisms, which are supposed to be natural ends, and cannot claim to have empirical examples of genuine natural ends. See: "The concept of a causality through ends (of art) certainly has ob-

> ...in order to judge something that one cognizes as a product of nature as being at the same time an end, hence a **natural end**, something more is required if there is not simply to be a contradiction here. I would say provisionally that a thing exists as a natural end **if it is cause and effect of itself** (although in a twofold sense). (*CJ* §64 / AA 5:370)

An organism can be a natural end if its purposiveness does not depend on an external designer, but is rather embodied in it. That is, its internal organization is self-produced and is not the effect of an external agent. An organism, then, must be the "cause and effect of itself." As Ido Geiger succinctly puts it, the claim that an object *x* is an organism has the general form "*x* produces itself."[5]

Kant points out three unique processes in organisms which demonstrate their distinctive feature of self-production: reproduction, growth, and self-maintenance. Through reproduction, a *species* of organisms generates itself and in this way is both a cause and effect of itself. An organism of a certain species is brought into being by another member of that same species and, in turn, produces another conspecific.[6] In the process of growth, it is the *individual* organism that produces itself. Unlike mechanical growth (i. e. attaching external additions to the body), in organic growth an organism takes in materials from its surroundings, carefully processes and prepares them for its use, and then develops itself by means of the processed materials. Lastly, an organism produces itself in the sense that its parts maintain one another. The parts of an organism provide each other with materials essential for the growth and maintenance of the organism. Furthermore, if one part is damaged, the others will make up for it or even repair it in order to minimize the harm done to the proper functioning of the organism. Thus, each part provides for all the others, that is, for the whole organism, and each part depends on the other parts or the whole organism for its preservation and proper functioning.[7] Kant claims that in addition to the fact that "each part

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jective reality, as does that of a causality in accordance with the mechanism of nature. But the concept of a causality of nature in accordance with the rule of ends [...] can of course be thought without contradiction, but is not good for any dogmatic determinations, because since it cannot be drawn from experience and is not requisite for the possibility of experience its objective reality cannot be guaranteed by anything" (*CJ* §74 / AA 5:397).

5 Geiger (2009, 541).

6 Cf. Aristotle's famous statement that "man is born from man, but not bed from bed" (*Physics*, book 2, chapter 1, 193b8 – 9). Among modern philosophers, Fontenelle offers a clear expression of this view (Grene and Depew 2004, 83).

7 Kant illustrates this point with the example of a tree. The leaves of a tree get water and salts essential to their functioning from the soil, through the roots, trunk, and branches. They depend, for their preservation, on these parts of the tree. Yet they also sustain these other parts by providing them with the sugars they produce in photosynthesis.

is conceived as if it exists only **through** all the others, thus as if existing **for the sake of the others** and **on account of** the whole, i.e., as an instrument (organ)," each part is also "thought of as an organ that **produces** the other parts (consequently each produces the others reciprocally)." In other words, an organism is both organized and self-organizing, which is why it can "be called a **natural end**" (*CJ* §65 / AA 5:373–374).[8]

Now since living beings are thus considered beings in which the parts and the whole reciprocally depend on one another, it is not enough to employ in their case the standard mechanical mode of explanation alone, that is, to explain them as mere outcomes of the properties and forces of their parts.[9] Rather, the goal-directed growth of an organism[10] and the maintenance of its proper functioning appear to require a plan or program which governs and guides the operation of the parts. In Kant's words, a *representation* of the whole organism is required in order to account for the role each part has in the systematic life of the whole. To appeal to a representation of the whole in order to explain its form and the operation of its parts is, according to Kant, to explain by means of final causality (*CJ* §77 / AA 5:408).

The problem is how to empirically explicate the two-way causality or self-production involved in the concept of natural end. The organic processes discussed above illustrate this causality, but the associated conceptual difficulties still remain unresolved. The parts of a natural end build and maintain one another and thus the organism as a whole, and they do so in a way that seems to aim at a particular end and to be directed by a certain plan or program. But what precisely is this plan? One cannot assume that organisms, like artifacts, are generated according to a plan of an external designer, since this would imply that they are not natural things. Furthermore, matter itself cannot be regarded as intelligent designer, because this involves the contradictory notion of living matter (*CJ* §73 / AA 5:394–395). It therefore seems that we cannot avoid conceiving of the generation and regular functioning of an organism except as guided by a

8 See Quarfood (2006, 737–738).

9 See: "if we consider a material whole, as far as its form is concerned, as a product of the parts and of their forces and their capacity to combine by themselves (including as parts other materials that they add to themselves), we represent a mechanical kind of generation" (*CJ* §77 / AA 5:408); "it is entirely contrary to the nature of physical-mechanical causes that the whole should be the cause of the possibility of the causality of the parts, rather the latter must be given first in order for the possibility of a whole to be comprehended from it" (*CJ-FI* AA 20:236).

10 The parts of a human embryo, for example, do not construct one another in an arbitrary fashion. Rather, the initial zygote develops itself into a creature that will eventually have a specific form, namely, a form common to the members of the human species.

plan or representation of the whole organism, even though we do not know how to incorporate these notions into a coherent naturalistic view of living things.[11]

In short, it is insufficient to explain organisms merely by mechanical principles due to their purposive characteristics. However, the concept of natural end, which captures the internal purposiveness of organisms, is problematic and cannot have explanatory force until its inner difficulties are resolved.[12] We somehow make sense of it by a "remote analogy" with human intentional action (*CJ* §65 / AA 5:374–375; cf. §61 / AA 5:360). But this analogy is unsatisfactory, since the concept of natural end is incompatible with intentional design.[13] And yet, it remains unclear how the purposive features of organisms can be explicated in natural terms and without recourse to external design (*CJ* §74).

In the Dialectic of the Teleological Power of Judgment, Kant presents the difficulty involved in studying organisms as an antinomy between mechanism and teleology. In brief, his resolution of the antinomy is essentially based on two claims. First, both mechanism and teleology are regulative maxims of the power of judgment in its reflective use and the conflict, then, is a methodological one and concerns the appropriate way to investigate objects.[14] Thus in this context, mechanism, which is connected with the standard one-way causality, is the requirement to consider things as the outcome of the properties and forces of their parts, while the maxim of teleology instructs to regard organisms as objects in which each part has an essential function in the whole and in which nothing is in vain.[15] The second claim required for the resolution of the antinomy is that

11 For a discussion of Kant's analysis of the problem of part–whole relationship in organisms, see Cohen (2009, 14–19).

12 Recall that Kant worries that the concept of natural end may involve a contradiction (*CJ* §64 / AA 5:370, §74 / AA 5:396). For Kant this worry was pressing, since he insisted on considering organisms *natural* things, which excluded intentional design, but also highlighted their *purposive* character, which appeared to him to imply intentional design. In what follows, we will see how theories and concepts of modern biology serve to resolve this apparent contradiction. Unequipped with the ideas of modern biology, Kant opted in the Dialectic to resolve it by ascribing the ground of the purposive features of natural ends to a separate realm: to "something that is not empirically cognizable nature" or a "supersensible" substratum (*CJ* §74 / AA 5:396–397). In this way, one can *think* the concept of natural end without contradiction, but the price is that it becomes merely "problematic" and its objective reality cannot be established. See Shimony (2013, 202–203). On the inexplicability of *Naturzweck*, see Kreines (2005, 284–288).

13 For recent accounts of this analogy, see Illetterati (2014, 91–95); Breitenbach (2014).

14 By contrast, the teleological antinomy is not a conflict between constitutive principles of the power of judgment in its determining use and thus does not concern objective propositions regarding the possibility of objects or actual features of objects.

15 See: "**An organized product of nature is that in which everything is an end and reciprocally a means as well.** Nothing in it is in vain, purposeless, or to be ascribed to a blind mech-

both regulative maxims of mechanism and teleology stem from the peculiarity of the human understanding and must be combined in the investigation of objects displaying internal organization.[16] Nevertheless, Kant stresses that the maxim of mechanism is to be preferred and that the mechanistic mode of explanation has to be pursued as far as possible, since this maxim "constitutes scientific cognition of nature through reason" *(CJ-FI* AA 20:235).[17] And one may draw thereof the further conclusion, that since this is for us the only purely scientific mode of explanation, and since the investigation of organisms cannot be pursued by this means alone, biology cannot be considered proper science.

2 Two lines of objection

Much of the criticism leveled against Kant's discussion of the investigation of living beings can be distinguished into two polar lines of objection, both center on his analysis of the conflict between mechanism and teleology. On the one hand, critics argue that it is in fact possible to explain living phenomena purely by means of mechanistic principles and that, therefore, biology is proper science. On the other hand, some critics concur with Kant that explanations in the life

anism of nature" (*CJ* §66 / AA 5:376); "in an organized being nothing that is preserved in its procreation should be judged to be nonpurposive" (*CJ* §80 / AA 5:420).

16 I elaborate on this issue in Shimony (2018). It may be succinctly summarized as follows. As beings with discursive intellect, we employ concepts to conceptualize particular objects we encounter in experience. But our empirical concepts provide only a limited outline of objects. They suffice to identify objects in certain circumstances and to describe some features and behaviors of objects, but they never fully grasp the entire concrete particularity of individual phenomena and do not provide complete characterizations. Hence we are forced to explain things mechanically, namely, to proceed from the parts and features already outlined to the whole, which contains other features not yet explored. But this method is unsatisfactory in the attempt to explain organisms, since here, as Kant has shown in the Analytic, knowledge of the parts depends on knowledge of the whole. In this case, then, we must proceed on the basis of a *representation* (*Vorstellung*) of the whole organism and thus appeal to teleological principles.

17 See: "It is of infinite importance to reason that it not allow the mechanism of nature in its productions to drop out of sight and be bypassed in its explanations; for without this no insight into the nature of things can be attained" (*CJ* §78 / AA 5:410); "if [mechanism] is not made the basis for research then there can be no proper cognition of nature" (*CJ* §70 / AA 5:387); "We can and should be concerned to investigate nature, so far as lies within our capacity, in experience, in its causal connection in accordance with merely mechanical laws: for in these lie the true physical grounds of explanation, the interconnection of which constitutes scientific cognition of nature through reason" (*CJ-FI* AA 20:235). See also *CJ* §80 / AA 5:418.

sciences cannot be reduced to mechanistic explanations as in the physical sciences, but still insist that biology is proper science.

The first line of objection is encouraged by the progress made in the science of biology from Kant's time to the present, especially in the fields of molecular biology and genetics. According to this view, biology is reducible to the physical sciences and thus deserves the status of proper science. Paul Guyer, for example, maintains that contemporary scientists could reject Kant's argument for teleology because it turns on organic processes, which can in fact be understood by means of "our ordinary mechanical model of causation."[18] According to contemporary scientists, Guyer contends, the processes of reproduction, growth, and organic self-maintenance, which Kant invoked to elucidate his concept of natural end, can be explained by the powers of parts of organisms. Even if we currently lack mechanical explanations of each and every element of these processes, "contemporary scientists proceed in the confidence that 'mechanical' answers to these questions will be found."[19] They are also confident that they will find mechanical, evolutionary explanations for the existence of the mechanical bases of organic processes. Finally, Guyer claims that modern scientists would also reject Kant's teleological maxim, which instructs to regard organisms as objects in which each part has an essential function in the whole.

> ... although one might be tempted to say that contemporary scientists surely accept Kant's view that every part of an organism serves some function in the systematic life of the whole, although unlike Kant they are confident that a mechanical explanation of both the origination and the activity of every part of an organism can at least in principle be found, even that assumption may be indefensible: Stephen Jay Gould long argued that the mechanism of natural selection can carry along all sorts of non-functional by-products or "spandrels" that are mechanically connected with functional and selected traits, as long as those spandrels are not dysfunctional, that is, as long as they do not compromise the reproductive success of the organism; or traits can be carried along that were adaptive for an organism in an old environment but are no longer adaptive in a new or changed environment, as long as they are not too dysfunctional. These possibilities are reflected in contemporary genomics in the idea of stretches of "junk DNA" in chromosomes, by-products of past evolution, that can be carried along with the currently vital stretches of DNA as long as they do not harm the organism, that is, again, reduce the probability of its reproductive success. So even as a regulative principle the idea that every part of an organism is a vital and valuable part of it as an internally purposive system seems doubtful. (Guyer 2006, 342–343)

The second line of objection focuses on Kant's strict physicalist criteria for science. On Kant's view, a field of investigation counts as proper science to the ex-

18 Guyer (2006, 342).

19 Ibid.

tent that it proceeds by means of mechanical reasoning and is formulated mathematically. Since chemistry, biology, and psychology do not satisfy these criteria, Kant did not consider them proper sciences.[20]

By contrast, contemporary scientists and philosophers of science do not doubt that biology is a genuine science, primarily because of how the discipline has developed since Charles Darwin's *On the Origin of Species* (1859). Francisco J. Ayala claims that Darwin's greatest accomplishment was that "he brought the design aspects of nature into the realm of science. The wonderful designs of myriad plants and animals could now be explained as the result of natural laws manifested in natural processes, without recourse to an external Designer or Creator."[21] Ernst Mayr criticizes the attempt to identify science with physics, which has led to the downgrading of biology. He accuses Kant of being one of the prominent thinkers who entrenched the physicalist view of science:

> Physics with a mathematical foundation became the exemplar of science for Galileo, Newton, and all the other greats of the Scientific Revolution. This physicalist interpretation dominated the thinking of the philosophers of science. And this remained so for the next three hundred fifty years. Curiously, it was quite generally ignored in discussions of science in those centuries that there were now also other sciences. Instead, these other sciences were squeezed into the conceptual framework of physics. Mathematics remained the earmark of true science. Kant certified this opinion by saying "there is only that much genuine [*richtig*] science in any science, as it contains mathematics." And this greatly exaggerated evaluation of physics and mathematics has dominated science until the present day. What would be the scientific status of Darwin's *Origin of Species* (1859), which contains not a single mathematical formula and only a single phylogenetic diagram (not a geometric figure) if Kant had been right? (Mayr 2004, 14)[22]

20 For assertions of the mechanical criterion of proper science, see note 17 above. The clearest expression of the mathematical criterion of proper science appears in the *Metaphysical Foundations of Natural Science:* "in any special doctrine of nature there can be only as much *proper* science as there is *mathematics* therein" (AA 4:470).

21 Ayala (2000, 287). On the preceding pages Ayala explains that Darwin's work was a further step in the scientific revolution which originated in Copernicus. The Copernican revolution consisted in adopting the belief that the universe is governed by natural laws that account for natural phenomena. Copernicus, Galileo, and Newton demonstrated that this was the case in the inanimate world, while Darwin completed the revolution by applying this view to the living world as well.

22 On Mayr's view, the roots of the physicalist view of science lie in the fact that at the origin of philosophy of science, advances were primarily made in the physical sciences of mechanics and astronomy. This led philosophers to take it for granted that all the different sciences were in effect modeled after physics.

3 Replies to the objections

Both lines of objection revolve around Kant's analysis of the conflict between mechanism and teleology. At stake here is the question of whether explanations in the life sciences can be formulated in purely mechanical terms and whether biology is reducible to physics.[23] I will start this section by briefly replying to the first objection, and then turn to elaborate on the second objection. As we will see, the discussion of the second objection will also serve as an indirect answer to the first.

In reply to the first objection, we may begin by noting that the question of the reducibility of biology to physics is far from being decided. This, as a first step, wards off Guyer's objection. Guyer appears to squeeze present-day biologists into a homogeneous group of contemporary scientists who unanimously proceed in the confidence that all living phenomena can in principle be mechanically explained, in a manner characteristic of the physical sciences.

It seems, however, that there is no unanimity on this issue.[24] Moreover, Mayr and Ayala, two eminent evolutionary biologists, are clear examples of scientists and philosophers of science who argue for the irreducibility and autonomous status of biology. In fact, for Mayr, it is precisely the processes of reproduction, growth, and maintenance, which Guyer claims contemporary scientists regard as capable of being explained in physical terms, that mark an essential difference between living and inanimate phenomena, much as they did for Kant:

> Owing to their complexity, biological systems are richly endowed with capacities such as reproduction, metabolism, replication, regulation, adaptedness, growth, and hierarchical organization. Nothing of the sort exists in the inanimate world. (Mayr 2004, 29)

Thus the problem with Kant's position is not so much his claim that explanations of organisms are not reducible to physico-mechanical explanations, but rather the conclusion drawn from it to the effect that the investigation of living

23 Clark Zumbach (1984, 6) likewise maintains that the central philosophical issue in the Critique of the Teleological Power of Judgment is the question of reductionism. Cf. Geiger (2009, 543).

24 In a recent book, entitled *Contemporary Debates in Philosophy of Biology*, the first debated subject is the question of reductionism. Evelyn Fox Keller and John Dupré provide the contributions to this debate and respectively suggest affirmative and negative answers. See also the editors' introduction to this section. For a list of other modern philosophers of science and biology who argue for "the rehabilitation of teleology against its reductivist critics," see Schönfeld (2000, 273 n. 75).

phenomena is not proper science. This is the gist of the second line of objection. And with respect to this objection, Kant's theory of the life sciences may indeed seem outdated. In view of the progress biology has made since Kant's time, one might argue that Kant's discussion of the subject is shortsighted and limited by the state of the sciences of his day.

Nevertheless, I maintain that much can be said in favor of Kant's position, precisely in connection with this objection. I will argue that Kant advanced a non-reductivist view of the life sciences that is similar to several current theories of biology. What prevented Kant from considering biology genuine science was mainly that he lacked the theoretical resources to construe the teleological features of his theory of organisms in natural terms. This accords with Kant's claim in *Teleological Principles* that "in a natural science everything must be explained *naturally*, because otherwise it would not belong to this science." He adds that we reach the boundary of science when we use "the last of all explanatory grounds that can still be confirmed by *experience*" and transgress it when we introduce "self-concocted powers of matter following unheard-of and unverifiable laws." And since organisms exhibit internal organization which Kant could not explicate by verifiable naturalistic principles, he concluded that explaining the origin of their teleological features, "provided it is at all accessible to us, obviously would lie outside of natural science in *metaphysics*" (AA 8:178–179). By contrast, the mechanistic mode of explanation seemed perfectly naturalistic. I suggest that Kant regarded mechanism as a necessary condition of proper science because it was the only purely naturalistic mode of explanation available to him.[25] He does not provide in the third *Critique* a systematic reason for his enthroning of mechanism as exclusively necessary criterion of science. To the contrary, as stated above, both maxims of mechanism and teleology are equally regulative and both stem from the peculiarity of the human understanding.[26] So

25 This was crucial for Kant. He insisted on considering organisms natural and on an empirical approach to the investigation of organisms; he maintained that the fact that we are obliged to attribute purposive features to organisms does not license us to infer that they are intentional products of an external designer (*CJ* §65 / AA 5:373–374, §74 / AA 5:397). His insistence on a naturalistic approach in the third *Critique* constitutes a decisive shift from his pre-critical view presented in the *Only Possible Argument* (1763), according to which the purposive features of the organic world are directly instituted by God (see Shimony 2013, 185–192). Kant made this shift despite the fact that he did not have a satisfactory naturalistic account of the purposive aspects ascribed to organisms.

26 Note in particular that the regulative maxim of mechanism of the third *Critique* does not follow from and is not identical with the transcendental principle of causality of the first *Critique*. The latter merely implies the existence of a general connection of cause and effect (see

there is no transcendental reason to accept the one and reject or downgrade the other.[27]

Kant, in particular, could not find a way to explicate in natural terms the notions of plan and function, which he regarded as crucial to the explanation and understanding of organisms. He was unable to see how they could be conceived without recourse to an intelligent designer. As we will now see, future advances in the life sciences show that Kant's emphasis on the role of plans and functions in these sciences was on the mark. They also show how Kant's worry can be settled, namely, how to explicate plans and functions in natural terms and thus how to disentangle the difficulties involved in Kant's concept of natural end. To make this point, I will now consider Ernst Mayr's discussion of the notion of genetic programs and Francisco J. Ayala's explication of function in terms of Darwin's idea of natural selection.[28]

Kant, we have seen, maintains that the representation or the plan of the whole organism is essential to any account of a living being. He argues that the appeal to such plans differentiates living from inanimate objects. Like inanimate objects, living beings observe the physical laws of nature. But unlike inanimate objects, we conceive of them as evolving in accordance with a certain plan. Modern biology elucidates Kant's idea in natural terms by means of the notion of "genetic programs." A program, according to Mayr, is a

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CPR A 189/B 232). Mechanism, on the other hand, adds specific content to this connection of cause and effect, namely, that the whole is the effect of the properties and forces of its parts.

27 For a different approach, see van den Berg (2014). Van den Berg argues that only mechanical explanations observe the criteria of proper science presented in the *Metaphysical Foundations*. Therefore, mechanical explanations constitute the single type of scientific explanation. But even if van den Berg is right, the crucial point is whether these criteria are a necessary consequence of Kant's critical philosophy. I argue (Shimony 2018), by contrast, that Kant's transcendental analysis acknowledges both mechanism and teleology: due to our peculiar discursive understanding we are indeed required to pursue mechanical explanations, but we are also required to appeal to teleological principles when investigating objects which do not readily lend themselves to mechanical explanations. Interestingly, Mensch (2013) turns the issue on its head. She argues that Kant's critical system was modeled on biological ideas (in particular, epigenesis). And if this is correct and reason operates on the basis of "organic logic," surely reason must be able to accommodate biology as proper science.

28 I focus on Mayr's "teleonomy" because of his lucid clarification of the meaning and role of genetic programs in the organic world. And, of course, since Mayr was one of the most prominent biologists to accuse Kant for advancing physicalist criteria for science and, consequently, for holding an obsolete view of biology, it was all the more appropriate to use Mayr's ideas to show how in actual truth Kant's view anticipated Mayr's own firm position regarding the autonomy of biology. I supplement the consideration of Mayr's ideas with discussions of John Dupré's notion of "downward causation" and Siegfried Roth's analysis of "templating."

> coded or prearranged information that controls a process (or behavior) leading it toward a goal. The program contains not only the blueprint of the goal but also the instructions for how to use the information of the blueprint. A program is not a description of a given situation but a set of instructions. (Mayr 2004, 53)

In a manner similar to Kant, Mayr maintains that being controlled by plans or programs differentiates living and inanimate processes. As Mayr explains,

> all biological processes differ in one respect fundamentally from all processes in the inanimate world; they are subject to *dual causation*. In contrast to purely physical processes, these biological ones are controlled not only by natural laws but also by *genetic programs*. This duality fully provides a clear demarcation between inanimate and living processes. (Mayr 2004, 30)

Mayr regards such dual causality as "perhaps the most important diagnostic characteristic of biology."[29] He stresses that programs are essential to living phenomena and that borrowing "the term program from informatics is not a case of anthropomorphism."[30] Genetic programs are the product of evolution and can be rendered entirely naturalistically in terms of the DNA of the genome.[31]

Kant's view of organisms as involving plans and two-way causality is also reflected in the current concepts of "downward causation" and "template-directed synthesis." John Dupré uses the former to signify causation acting from a system on its constituent parts. He employs it to defend the thesis that biology is not reducible to physics and chemistry, and in particular, that "the properties of constituents cannot themselves be fully understood without a characterization of the larger system of which they are part." He concentrates on organic systems at the molecular level, and not only at the level of the whole organism, as Kant does.[32] Also focusing on the macromolecular level, Siegfried Roth employs the notion of "template-directed synthesis," or simply "templating," to highlight the distinctive organizational features of sequence-based macromolecules of living cells. He argues that the core processes of molecular biology cannot be simply explained by the open-ended chemical reactions at the lower level. Rather,

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29 Mayr (2004, 30).

30 Ibid., 55.

31 Mayr notes that the idea of a plan poses a problem for the physics-oriented philosopher of science, but not for the biologist: "Accepting the concept of program seems to cause no difficulties to a biologist familiar with genetics or to any scientist familiar with the working of computers. However, programs [...] do not exist in inanimate nature. Traditional philosophers of science, familiar with only logic and physics, therefore have had great difficulty in understanding the nature of programs" (Mayr 2004, 53). Cf. Roth (2014, 287).

32 Dupré (2010, 32, 42–43).

they are also controlled at a higher level by templates containing information and instructions for producing a specific outcome and enzymes catalyzing certain reactions and proofreading errors in the course of producing this outcome. Thus, "one can argue that templating reactions have special organizational features that permit their classification as primitive forms of goal-directedness and intentionality in nature." Roth's main achievement lies in showing that molecular biology, often taken as the vehicle for reducing biology to physics and chemistry, reveals in fact the irreducible organizational features of organic macromolecules. Accordingly, Roth concludes that molecular biology "has molecularized [Kant's] idea of a natural end and thus provides a deep understanding of why organisms are unique among all physical objects in our world."[33]

Regarding the place of function in biological explanations, it will be instrumental to consider Francisco J. Ayala's discussion of the issue. Kant's teleological maxim instructs us to assume that nothing in an organism is in vain and to look for the function of each and every part in the life of the organism. For Kant, this constitutes a further characteristic that demonstrates the uniqueness of the study of living beings and its irreducibility to physics. Ayala similarly considers teleological and functional explanations both indispensable for biology and constitutive of its autonomous scientific status.

> I will propose that biology is distinct from the physical sciences in that it uses patterns of explanation, and makes recourse to laws, that do not occur in, nor can be reduced to, those formulated in the physical sciences. Specifically, I shall seek to show that teleological explanations constitute patterns of explanation that apply to organisms while they do not apply to any other kind of objects in the natural world. I shall further claim that although teleological explanations are compatible with causal accounts, they cannot be reformulated in nonteleological language without loss of explanatory content. Consequently, I shall conclude that teleological explanations cannot be dispensed with in biology.[34]

In a manner similar to Kant, Ayala draws an analogy between natural teleology and human craftsmanship. The analogy exposes both the similarities and the differences between the two cases. As in Kant's discussion, the difference is that in human craftsmanship, the object is produced by an external designer, whereas in natural teleology, the design or functional features of organisms come about by natural processes.[35] For Kant, the concept of natural end was problem-

33 Roth (2014, 288, 290).

34 Ayala (2000, 283). Ayala remarks on the denial of teleology: "It is in any case amusing to read statements of denial of teleology in articles and books pervaded with teleological language and teleological explanations" (ibid., 298 n. 21).

35 Ibid., 302.

atic precisely because it involved both the functional aspects of organisms and the necessity of explaining their generation in terms of natural processes, while a suitable conceptual framework that would account for their natural generation was missing.

Ayala maintains that Darwin's principle of natural selection provides the missing framework in the following way. Structures, organs, and behaviors of organisms are said to be teleological when they serve a certain function or are directed toward certain ends. Ayala offers the examples of birds' wings, whose function is to enable flying, eyes, which are used for seeing, and kidneys, which regulate the composition of blood. To explain a feature teleologically means to show that it exists because it contributes to a certain property of the system. Birds have wings *because* wings enable birds to fly, and human beings have eyes *because* eyes enable human beings to see. Ultimately, wings and flying, and eyes and seeing, are adaptations that have come about *because* they increase the reproductive success of their carriers. "It is in this sense," Ayala summarizes, "that the ultimate source of teleological explanation in biology is the principle of natural selection."[36]

Ayala's ideas may also be used to reply to Guyer's objection that, *contra* Kant's teleological maxim, not every part of an organism makes an essential contribution to the well-being of the whole. According to Ayala, there are several ways in which features of organisms may relate to function. An organism may have (1) features which have arisen by natural selection due to their usefulness and which are still useful, (2) features which have arisen by natural selection due to their usefulness but have lost their usefulness and are now neutral to the reproductive fitness, (3) features that have come about as incidental consequences of other features that are useful and are now neutral to the reproductive fitness, and (4) features that have come about as incidental consequences of other features that are useful and which have become functional over time.[37] In all these cases, either the origin of the feature under discussion or its preservation, or both, are explained by either direct or indirect reference to some function. Thus, the fact that a certain part does not presently have a vital role in the life of the organism does not eliminate function from the discussion.[38] It merely means that Kant's maxim should be modified in the following way: in the explanation of a feature of an organism, look for the relevant function. Even if a

36 Ibid., 300. Cf. Mayr (2004, 31–32).

37 This is consistent with Stephen Jay Gould's position cited by Guyer.

38 Ayala (2000, 303) also emphasizes that the fact that the evolution of organisms involves stochastic events does not imply that their features are not teleological.

feature is not currently useful or was not directly generated through natural selection, its connection to one or another function may explain its presence.[39]

4 Conclusion

The considerations presented in this paper show that Kant's theory of biology is by no means obsolete and is actually not so far removed from contemporary views that consider biology an autonomous science. We have seen that on Kant's view the investigation of living beings essentially differs from and is irreducible to the physical sciences. Concerning the scientific status of biology, I have argued that Kant's reluctance to regard it as proper science is mainly due to his inability to construe teleological features in natural terms. After all, his most fundamental dictate was that "in a natural science everything must be explained *naturally*." Furthermore, his rigid mechanistic criterion for science does not follow from the constitutive conditions of cognition propounded in his critical philosophy. Rather, the requirement of employing mechanical explanations stems from a special feature of our human understanding, which also requires an appeal to teleological principles in the investigation of organisms. Therefore, acknowledging that biology is a genuine science does not require any significant modification to Kant's critical philosophy. His philosophical system is in fact consistent with a more liberal view of science, one which encompasses biology as well. Moreover, I maintain that if recent advances in biology and in the philosophy of biology – the conceptualization of the idea of design without designer in terms of genetic programs, the understanding that two-way and downward causality does not involve "causation from the future" and is thus compatible with the second analogy,[40] and the formulation of teleological and functional explanations in terms of natural selection – had been available to Kant, he probably would not have refused to consider biology proper science.

To conclude, Kant's contribution to the understanding of biology consists, first, in insisting on practicing it empirically. He insisted that organisms should be studied empirically and without appeal to an external designer, despite the fact that he lacked the appropriate theoretical system in which their purposive

39 Geiger (2009, 538) suggests that in *CJ* (§66 / AA 5:377) Kant indeed qualifies his maxim in this way.

40 See McLaughlin (1990, 152–153). This point has been further reinforced by philosophers of biology who have shown that there is no conflict between causal and teleological explanations, since the latter involve no mystical backward causation from the future. See Ayala (2000, 304–306); Mayr (2004, 61).

features could be explicated in natural terms. He was willing to pay the explanatory cost of employing the problematic concept of natural end to conceive organisms, as long as the recourse to an external designer is avoided. This may seem trivial to modern readers, but one has to bear in mind the state of biology in Kant's time and recall that precisely this was, according to Ayala, Darwin's greatest accomplishment, namely, that he brought the teleological aspects of nature into the realm of empirical science and thereby completed the scientific revolution originated in Copernicus.[41] Secondly, Kant contributed to the understanding of biology by philosophically establishing its autonomous status. He advanced essential theses acceptable to current supporters of the view that biology is an autonomous scientific discipline: that living beings develop in accordance with a plan; that one should conceive of organisms as systems that involve two-way or downward causation (i.e. as natural ends); that certain unique processes distinguish them from inanimate objects; and that teleological (or functional) explanations are indispensable to the investigation of organisms.[42] All these testify that Kant was *en route* to the modern view of biology as autonomous science. It was left for later generations to disentangle the difficulties that Kant detected in the concept of natural end and to explicate in natural terms the generation and function of organic wholes. But Darwin's brilliance and the advancements made by his followers should not diminish Kant's achievement.[43] To the contrary, in light of their enterprise, Kant's conceptual struggles attest more to the depth of his insights, than to the shortcomings of his theory.

41 Cornell (1986) suggests that Kant was even stricter than Newton and Darwin in his demand to detach science from theistic assumptions.

42 Cf. Roth (2014, 285–290) for arguing for the deep parallels between Kant and molecular biology. Cf. Lotfi (2010) for a positive appraisal of the contribution and relevance of Kant's critique of natural teleology.

43 Michael Ruse, while acknowledging Kant's essential contribution to the progress toward modern biology, likens Kant to Moses: "Like Moses, [Kant] was never to enter the promised land – Israel for the one, evolution for the other – but he did lead us to the borders" (Ruse 2006, 415).

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