Kant Yearbook
1/2009

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Preface

Over the last decade, academic research on Kant has grown to an extent that makes it almost impossible even for the well informed expert to ori entate herself in a specific domain of his philosophy. Be it monographs, articles, textbooks, anthologies, text editions or translations, the num bers of publications have steadily risen in all areas concerned with Kant's philosophy. This goes not only for European countries and, in particular, the United States, but equally for South America, especially for Argentine and Brazil. The growing interest in Kant's philosophy in countries like Russia or China, and Asia as a whole, is already begin ning to add substantially to this development. The *Kant Yearbook* is a re sponse to the international increase of the research on Kant's philoso phy. It is the *Kant Yearbook*'s intention to create a forum for the themati cally focused and innovative discussion of special topics in Kantian phi losophy on an international scale. For this reason, its preferred languages of publication are English and German. There already is, of course, a number of excellent journals dedicated to Kant such as the *Kant-Studien*, *Studi Kantiani*, or the *Kantian Review*. However, the *Kant Yearbook* is fundamentally distinct from these journals in that it publishes topic re lated annual volumes. Each annual topic will be announced by way of a call for papers. In order to ensure the scholarly quality of the contri butions, the editorial board of the *Kant Yearbook*, composed of re nowned international experts, will select papers for publication through a double blind peer review process. The format as an annual journal will thus allow the *Kant Yearbook* to react to current developments in re search on Kant's philosophy within a short period of time, and to ini tiate new research topics and directions. Ideally, each issue will represent the state of the art regarding its specific topic. The *Kant Yearbook* there fore equally welcomes historical and systematic articles, no matter from what philosophical school or orientation. The present first issue on Kant's teleology seems to be a successful example of that strategy. Com pared to the first and second *Critiques* this topic has traditionally been understudied. Nevertheless, recent historically as well as systematically orientated developments in this research area document a growing in terest in the often neglected "Critique of Teleological Judgment". The topic of the second issue of the *Kant Yearbook* in 2010 will be

"Metaphysics" followed by "Anthropology" and "Kant and Analytic Philosophy".

I would like to thank the members of the editorial board who unhesitatingly accepted my invitation to take on the difficult task of reviewing submissions and selecting papers for the *Kant Yearbook*. I am also very grateful to my former colleagues, in particular to Chris Eliot, from the Department of Philosophy at Hofstra University (New York) for supporting me in starting the *Kant Yearbook*. I thank my new colleagues at the Department of Philosophy at the University of Luxembourg for the friendly welcome they have extended to the *Kant Yearbook*. Special thanks go to the publisher De Gruyter and its editor in chief, Dr. Gertrud Grünkorn, for taking on the risky project of starting a new journal. And last but not least, thanks go to Christoph Schirmer and Claudia Hill from De Gruyter for helping me with the editorial work.

Luxembourg, February 2009 Dietmar Heidemann

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Teleology in Biology: A Kantian Perspective

Angela Breitenbach[1]

Abstract

One of the most widely debated issues in contemporary philosophy of biology is the problem of teleology. How are we to understand apparently teleological concepts, such as that of a "function", given our conception of science as providing causal explanations for natural phenomena? In this paper, I reconsider this debate from a Kantian perspective. The crucial contribution of the Kantian account is to argue both that teleology plays an important heuristic role in the search for causal explanations of nature and that it is for us an inevitable analogical perspective on living beings. The Kantian perspective, I shall argue, is not only compatible with the modern life sciences but can advance the debate about teleology in biology precisely because it does not interpret teleology naturalistically.

Introduction

The biological sciences are special within the realm of the natural sciences. They employ concepts that have long been taboo in physics and chemistry. Biologists may speak, for example, of the *functions* of biological traits and of genetic *programmes* that *control* biological processes. They may ask what a particular trait of an organ *is for*, or what *purpose* it has for the *functioning* of the organism as a whole. Expressions such as these sound unmistakably teleological. We are familiar with these concepts from the description of our own actions. We speak of a person, for instance, as acting for a purpose, as designing an object to perform a certain function, or as creating a programme to carry out a particular task. In the realm of human activity, purposes, functions and programmes thus involve the intentions of an intelligent agent, intentions that the agent aims to realise by means of her activities in the world.

1 I would like to thank Nick Jardine, Tim Lewens, Onora O'Neill and an anonymous referee from the *Kant Yearbook* for helpful comments on earlier drafts of this paper.

What, however, do the same concepts mean in the context of biology? Do they, as in the case of human action, require the existence of an intelligent agent? A positive answer would be incompatible with our modern conception of the task of science as providing explanations for natural phenomena without thereby resorting to supernatural design or purpose. Can we, then, explain teleological concepts in biology as referring solely to mind independent features of nature? What seems so special about teleological descriptions is that the purpose or the end of a functional process or programme, although they may lie in the future, somehow determine what goes on in the present. And yet, would this conception of a *final* causation not contradict the assumption that causes must precede their effects? Would it not conflict with our conception of science as explaining all natural phenomena by reference to *efficient* causes? How, then, can we make sense of the phenomenon of teleology in the biological sciences?

The problem of how to understand the use of teleological concepts in the life sciences is one of the most widely and controversially debated problems in contemporary philosophy of biology. It is surprisingly closely related to Kant's discussion of teleology and the purposiveness of nature. In this paper, I thus aim to cast some light on this modern debate by reconsidering it from a Kantian perspective. I shall start by surveying some of the recent approaches to the problem of teleology in biology (§1) and by investigating the epistemological status that these approaches attribute to teleological statements (§2). Commentators seem to disagree about the question whether teleological concepts can be explained in purely naturalistic terms or whether they entail analogical associations with intentional goal directedness. The Kantian conception of teleology, I shall show, is essentially analogical (§3). The crucial contribution of the Kantian account is to argue both that teleology plays an important heuristic role in the search for causal explanations of nature and, more fundamentally, that it is for us an inevitable analogical perspective on living beings. The Kantian approach to teleology thus introduces a focus that goes beyond any empirical investigation of nature. This is the focus on the very possibility of experiencing the living part of nature. By clarifying the relation between this Kantian account and empirical science (§4), I aim to show that the Kantian perspective is not only compatible with the modern life sciences, but that it can advance the debate about teleology in biology precisely because it does not interpret teleology naturalistically (§5).

1. Explaining Functions: Aetiology and Causal Roles

Most approaches to the problem of teleology in contemporary philoso phy of biology fall roughly into one of two categories. While aetiolog ical accounts explain the function of a trait by reference to the way the trait evolved, causal role theories argue that a biological trait has a func tion if it contributes to the working of a more complex biological sys tem. Both approaches seem to be motivated by certain rather plausible intuitions that lie at the basis of our teleological descriptions of nature.

The aetiological account of teleological statements in biology is a backward looking analysis. It is the particular developmental history of the trait of an organ which is taken to justify the functional descrip tion of that organ. Larry Wright, one of the chief proponents of the ae tiological account, analyses functional statements in biology in the fol lowing way:[2]

> The function of X is Z means,
> (a) X is there because it does Z,
> (b) Z is a consequence (or result) of X's being there.[3]

The second condition (b) states that what is called the function Z is a consequence of the trait or behaviour of X. The first condition (a), moreover, specifies that Z cannot just be *any* consequence of X. Rath er, (a) takes account of the claim that X's having or doing Z is, in turn, a reason for X's existence itself. A trait X is considered as having the func tion Z if it exists precisely because it does, or brings about, Z.

Condition (a) thus takes account of the claim that the function of X is Z purely in terms of efficient causes. Teleological explanations differ from ordinary causal explanations, however, insofar as they are interest ed not merely in the originating causes of a particular trait but, more specifically, in the consequences of the trait which have an effect on the originating causes of the trait itself. As specified by condition (a), the relevant consequences of the functional trait X are those that *feed back* into the efficient causes for X.[4] The capacity of pumping blood

2 Wright (1973) and (1976).
3 Wright (1973, 161).
4 Wright here takes up the notion of "feedback" that played an important role in the cybernetic accounts of the first half of the 20th century. Important expo nents of this area of research are, e.g., Rosenblueth, Wiener and Bigelow (1943), E. S. Russell (1945), Wiener (1948), Sommerhoff (1950), and von Ber talanffy (1952).

can thus be called a function of the heart, on Wright's account, because the following two conditions hold: the capacity to pump blood is a consequence of the presence of the heart (b), and the fact that the heart has the capacity to pump blood is the efficient cause of the existence of the heart itself (a).

And yet, how can the presence of the heart be the effect of an activity which is first made possible by the existence of the heart itself? Would the heart not be said to *cause itself?* Wright's account, it seems, is most plausibly understood when supplemented by a type token distinction.[5] Understood as a trait *type*, Z can then in condition (a) be taken to be among the efficient causes of X. The presence of Z in condition (b), however, can be considered to be a consequence of X if it is understood as a *token* of the trait type that was among the causes of X. Although the presence of the heart is the efficient cause of certain tokens of pumping activity, it was the fact that the heart had the capacity for the type of activity of pumping blood that was among the efficient causes of the existence of the heart in the first place.

Given this clarification, we can see how Wright's analysis was developed further by invoking the theory of evolution by natural selection. Inspired by evolutionary theory, Karen Neander interprets condition (a) as saying that X is there *because its ancestors did Z*, and *because they were favoured by evolution for doing Z.*[6] Similarly, Ruth Millikan calls an aspect of a biological trait its "proper function" if it positively influenced the natural selection of that trait.[7] The dark pigment of the wings of the peppered moth, for instance, can be said to have the function of providing camouflage because, due to providing camouflage, moths with darker wings were favoured by natural selection over moths with lighter wings. According to this aetiological reading, we can thus understand the function of a biological trait in terms of the trait's selection history.

Despite its widespread acceptance, however, the aetiological analysis faces a number of difficulties.[8] On the one hand, it seems plausible that mutations of certain organisms could contribute to the working of the

5 Cf. Allen, Bekoff and Lauder (1998, 6).
6 Cf. Neander (1991a and 1991b).
7 Millikan (1984, 17). Cf. also ibid. (1989).
8 Buller (1999, 1 ff) speaks of the aetiological account as the "core consensus" on the problem of teleology in biology, while Allen and Bekoff (1995, 612) characterise it as the "standard line" in the philosophy of biology.

organism from the very moment of their emergence.[9] *Pace* the aetiolog ical analysis, they could be said to perform a function even if they had not yet undergone a selection history. Thus, reference to selection his tory does not seem necessary for the ascription of functions to certain traits. On the other hand, it is also possible that the trait of an organ once had a positive effect on the natural selection of the organ although, today, it no longer exerts that effect. The human appendix, for example, was once selected for its capacity to produce enzymes that played an im portant role in the digestion of the vegetable food of our herbivore an cestors. It thus seems plausible to say that the appendix once had, but now no longer has, a function.[10] Having the right selection history, therefore, does not appear to be sufficient for the functionality of a bio logical trait either.

Both parts of this objection seem to be based on the conviction that the functionality of an organ is connected not only with its evolutionary history but also with the role that it plays within the organism as a whole. Thus, it may be argued that it is not the history of a trait but the causal role that it performs in some complex biological system that determines whether the trait has a function or not. Rather than looking back at the way the trait developed, this approach could be de scribed as forward looking, as characterising a function in terms of the contribution it makes to a corresponding system such as an organism.

The systems theoretic approach is primarily associated with Robert Cummins' analysis of functions as causal roles in complex systems.[11] To speak of the function of a biological trait is, according to Cummins, to

9 A number of authors have introduced, in this context, a thought experiment involving "instant organisms". Regarding their structural and material proper ties, we are supposed to think of these creatures as exactly identical to ordinary organisms. They only differ from ordinary organisms insofar as they are not the product of an evolutionary history but have emerged in an instance. Although, for example, the heart of an instant organism would perform the same activity of pumping blood as the heart of an ordinary organism, on the aetiological ac count we could not say that pumping blood was a function of the instant heart. Cf. for example Neander's "instant lions" (1991b, 179), and McLaughlin's "swamp mule" (2001, 89).

10 To avoid this problem of the aetiological account in dealing with rudimentary organs, some authors have proposed to restrict the relevant selection history of a trait to its most recent history. Cf. Godfrey Smith (1994). Although this pro posal may be able to limit the criticism raised here it does not seem to avoid the difficulty in principle.

11 Cummins (1975).

ascribe to the trait a capacity in which we are interested because of its contribution to a more complex capacity P of a containing system S. Talk of functions, on Cummins' account, is thus always implicitly dependent on an "analytical context".[12] It is dependent on our interest in analysing the capacity P of a biological system S as divisible into a number of other capacities of parts of, or processes within, S. By thus focusing on the role that a biological trait plays within a more complex system, Cummins' analysis has the advantage of avoiding the difficulties of the aetiological account. Thus, traits of an organism that, in the past, were selected because of certain capacities but that, today, no longer have these capacities should *not* be considered as functional. Other traits that are not the result of an evolutionary history but that play an important role in a complex system *can*, by contrast, be considered as having a function.

It may be objected, however, that Cummins' analysis does not account for the apparent *normativity* of functional claims. When we say that the function of the heart is to pump blood, we seem to imply that the heart would not be functioning properly if it did not pump blood. Cummins' analysis, however, is interested solely in the question whether the component of a system can be described as contributing in a particular way to the working of the system on the whole, but not whether the contribution of this component occurs *contingently* or whether we could say that the component *should* indeed have had that effect. On Cummins' account, it seems, we cannot distinguish between the contingent and the non contingent contributions that a trait of an organism makes to the working of the organism on the whole.

With his "naïve fitness account" Tim Lewens presents a modified account of Cummins' analysis that aims to overcome this difficulty:

> The function of a trait t is F iff traits of type T, of which t is a token, make a significant contribution to fitness by performing F.[13]

According to Lewens, too, the function of a trait is construed as its contribution to the capacity of a corresponding system. This capacity is defined as the organism's fitness. For organic systems this means that the relevant capacity of a system is its ability to survive and reproduce. Lewens adds, furthermore, that we can only attribute a function to a trait if the trait is an example of a homology type. Two traits thus be

12 Ibid., 190.

13 Lewens (2004, 102).

long to one and the same type if they have developed out of the same trait in a common ancestor.

With this specification, Lewens' interpretation can avoid the difficulties of Cummins' causal role analysis. Lewens can distinguish *typical* from *abnormal* contributions of a trait to the corresponding system by comparing the trait with other instances of its *type*. And he can make a claim about how the trait of a system *should* commonly contribute to the working of the system on the whole. Moreover, by restricting the relevant capacity of the containing system to its fitness, Lewens' account puts a limit to the function attributions that are possible on Cummins' account. Thus, in biology, a trait has a function only if it plays a role for the ability of the system to survive and reproduce.

2. The Epistemology of Functions: Naturalisation or Analogy?

The presented theories offer two very different approaches to the problem of teleology in biology. How, then, should we decide between these competing interpretations of functional statements? Before thinking further about an answer to this question, it will be fruitful to focus, first, on what these two types of interpretation have in common. For it seems that despite their differences, both the aetiological and the causal role accounts share a number of important assumptions.[14] They agree that teleological statements in biology assume neither the existence of intention or design, nor that of final causes. Instead, they argue that teleological concepts can be rendered in completely non teleological terms. When biologists speak of natural processes by means of teleological expressions, these accounts imply, they thus refer to processes that are ultimately explicable in terms of efficient causes. The aim of proponents of both the aetiological and the systems theoretic analysis is thus the *naturalisation* of teleology.[15]

The presented accounts insist that, in principle, teleological claims could be reduced to non teleological statements. And yet, they never

14 A number of authors have also proposed pluralistic accounts that aim to combine the aetiology of functions with their causal roles in a system. Cf. Millikan (1989), Griffiths (1993), Godfrey Smith (1994) and also McLaughlin (2001).

15 This seems true both for those authors who aim to analyse how teleological language is *in fact* used by biologists and those who are engaged in the project of giving a *theoretical definition* of teleological concepts.

theless reject the aim of replacing all teleological with non teleological expressions. Although functional concepts *can* be explained in non tel eological terms, it is argued, teleological statements nevertheless have a use that would be lost if they were translated into non teleological vo cabulary. Most proponents of both aetiological and systems theoretic ap proaches therefore give some argument explaining the nevertheless ap parent difference in meaning between teleological and non teleological statements. Wright, for example, speaks of the different *focus* of teleo logical and non teleological explanations. While causal statements are concerned with the originating *causes* of a particular trait, the emphasis of teleological statements lies rather on the *consequences* of that trait. Sim ilarly, Cummins argues that the focus of function ascriptions lies on a *specific type of causal role* that the trait under investigation contributes to a corresponding complex system. Both on the aetiological and the causal role account, teleological statements thus refer to natural causal process es, yet have implications that differ from those of statements solely about efficient causes.

Even if it is true, however, that the translation of teleological into causal explanations cannot account for the particular focus of teleolog ical statements it seems that teleological claims could nevertheless have been replaced by other, non teleological, expressions. Even if, in other words, teleological statements refer to a *particular type* of causal process, could we not distinguish this type by a particular form of *causal* state ment? Why, then, do we still find expressions in biology that, on first consideration, seem to imply intentional purposiveness? Why are teleo logical expressions so persistent in biological research? And why have they not been replaced by more neutral concepts?

According to Wright, teleological concepts in science are "dead an thropomorphic metaphors".[16] They were introduced into the consider ation of nature by a metaphorical extension of concepts known from human action. It was only as these metaphors "died", Wright argues, that teleological concepts took on a literal meaning. But why, one may ask, were these metaphors introduced in the first place? Why were they used in the biological but not in any of the other natural sci ences? Cummins speaks of the *adequacy* of teleology for certain systems: teleological explanations are adequate for some (organic) systems but not for other (inorganic) systems. But what is it that makes teleology ade

16 Wright (1976, 21). Sommerhoff makes a similar proposal in the context of his *analytical biology* (1950, 67 f).

quate for the description of some but not of other parts of nature? These questions suggest that, perhaps, the project of naturalising teleology is not ultimately sufficient as an answer to the problem of teleology in bi ology. For the project seems to leave open questions about the specific character of biology which appears to make the use of teleological con cepts so *adequate*. Perhaps, then, an analysis of the use of teleological terms in biology should clarify not only *what teleological concepts stand for* but also *why they should be employed* in the biological sciences at all.

What, then, would an alternative approach to the problem of tele ology in biology look like? Rather than focussing purely on the natural isation of teleological expressions, other authors have referred to the an alogical status of these concepts. According to Lewens' "naïve fitness ac count", for example, a teleological explanation is adequate only for those natural systems for which the analogy with an artefact seems ap plicable. Although teleological formulations in biology can be explained in non teleological terms, Lewens argues, these teleological statements nevertheless imply an analogy with a purposively designed object. Sim ilarly, Michael Ruse, a defender of the aetiological analysis of function statements, argues that we explain organic nature in teleological terms precisely because it *appears* to us *as if* organisms were produced according to purposes:

> Organisms seem as if designed; […]. It is for this reason that teleological thought is appropriate in the biological sciences; and because nonorganisms do not seem as if designed, teleological thought is inappropriate in the non biological, physical sciences.[17]

According to this analogical conception, we describe nature teleologi cally because it appears to us *as if* it were planned and created by an in telligent designer. The functional description of nature is really an an thropomorphic projection onto nature. Teleological concepts have a metaphorical meaning: they read into nature ideas that we are familiar with from the context of human activity. Despite their metaphorical sta tus, however, Ruse claims that the use of metaphorical concepts is nev ertheless fruitful for biological research. It should not be abolished, therefore, but employed as a heuristic tool.[18]

This second type of approach to the epistemological status of teleo logical expressions in biology thus rejects the position that any teleolog

17 Ruse (2000, 230 f). Cf. also Ruse (1981).
18 Ruse (2000, 231). Cf. Ratcliffe (2000).

ical statement can be reduced to a non teleological claim. More funda mentally, it questions the assumption that teleological statements refer solely to causal processes in nature. Functions, purposes or programmes, according to this second position, do not really exist in nature but only in the context of our metaphorical conception of nature. The wide spread use of teleology in the life sciences is thus explained by the claim that *nature itself seems to us as if it is designed*.

In raising the question why it is that biologists use teleological lan guage, this second, analogical, account seems to me to be engaged with the original problem of teleology in biology in a much more promising way than was the first, naturalistic, approach. And yet, Ruse's account remains rather general and leaves important questions unanswered. For we may ask further why, and in what way, nature seems design like to us. Ruse provides a survey of the development of biological the ories, pre and post Darwinian. He shows that all of these theories re garded nature as if it were designed. Yet, Ruse does not explain what is so special about our view of organic nature, and hence about our bio logical theories, that requires the assumption of design in nature.[19] Sim ilarly, Lewens answers the question for which systems his account of functions is relevant by simply claiming that "[t]alk of fuctions, prob lems, and purposes appears in contexts where artefact thinking is both practical and psychologically attractive."[20] But what is it that makes the artefact analogy *practical and psychologically attractive* in one but not in another situation? Again, Lewens does not say much to explain what it is that makes the artefact analogy, and hence the use of teleolog ical vocabulary, adequate in the case of biology.

Both Ruse and Lewens remain rather vague, too, about the dispens ability of teleological concepts in biology. According to both, it at least *seems* as if the subject matter of biology requires the use of teleological concepts. As a mere metaphor, or methodological tool, however, it is not clear why teleology has persisted in biology for so long. It is not ob vious, for instance, how to understand the combination of Ruse's claims that teleology can "in principle […] be eliminated", and yet, that with

19 Ratcliffe (2000), by contrast, attempts an explanation of this requirement in ar guing that, as human beings with the particular cognitive make up that we have, we need teleological concepts for our understanding of the natural world. Ratcliffe does not give any detailed explanation, however, of how tel eological concepts are supposed to structure our interaction with the world.

20 Lewens (2004, 122 f.).

out it, "we could not say very much".[21] More thought, it therefore seems, needs to go into the analogical nature of teleology in order for this second account of the epistemological status of teleology to be convincing. In the following, I shall be concerned with such an analogical approach in more detail. I believe that we can find a useful basis for it in Kant's teleological conception of nature.

3. A Kantian Account of Natural Teleology

Kant develops his teleological conception of nature mainly in the second part of his *Critique of Judgment*, the *Critique of Teleological Judgment*.[22] There, he argues that our experience of organic nature is essentially characterised in two ways. It is distinguished by a certain kind of organisation of the parts within the whole and by a reciprocal interdependency between the individual parts. If we consider, for example, "the structure of a bird, the hollowness of its bones, the placement of the wings for movement and of its tail for steering, etc." we think of the parts of the bird as determined by their function within the organism as a whole.[23] We can only understand the bird's eye by reference to the role that it plays for the visual capacity of the bird: we regard the eye as that organ which enables the bird to see. Moreover, in their directedness towards the existence and survival of the whole, the parts of an organism seem to influence, and cause, each other. While the movement of the bird's wings is dependent on the nutrition it receives through the functioning of the digestive organs, these organs, in turn, depend on the circulation of blood in the bird's body. The generation and growth of the organism as a whole, the proper working of its parts and the regeneration of damaged organs display not only a particular organisation but also a capacity for what Kant describes as *self-organisation*. It is this twofold characteristic of our experience of organisms, as both organised and self organising that, according to Kant, makes it necessary for us to characterise them in teleological terms.

21 Ruse (2000, 231) and Ruse (1981, 307).

22 References to Kant's works use the pagination of the Akademie edition (1900 ff.) (= AA) with the exception of the *Critique of Pure Reason* (*CPR*) which is referred to by citing the pagination of the original A and B versions. Translations of the *Critique of Judgment* (*CJ*) are taken from Kant (2000).

23 *CJ*, AA V 360.

Why, then, is it impossible, as Kant claims, to explain these particularly organic characteristics in non teleological, mechanical, terms? And how can this be squared with his claim in the *Critique of Pure Reason* that anything we can in principle experience must be caused?[24] According to Kant, mechanical laws explain natural processes in terms of the way in which parts of matter act on one another by means of their forces of attraction and repulsion. Mechanical laws thus specify the necessary connection between the effect and its cause as a relation between parts of matter. In particular, they explain the way that a material complex is caused by reference to the interactions between the forces of its material parts and the way these parts combine into a material whole.[25]

For our understanding of organisms this has important implications. For to explain a complex material thing by reference to the interaction of its material parts seems to be at odds with the idea that the parts themselves are there for the complex whole, that they have a function within the whole and that their role can only be understood in the context of the whole. To think of something as an organism is precisely *not* to understand it as a complex of parts, where the parts could exist independently of the whole. As Kant says, "nature, considered as a mere mechanism, could have formed itself in a thousand different ways without hitting precisely upon the unity" essential to the particular character of an organism.[26] According to mechanical laws, the organisation of a living being would thus have to be considered as a mere coincidence. It could not be regarded as a unity of parts that are determined precisely by their contribution to the whole. Thus, by reference to mechanical laws we simply cannot make sense of the particular organic dependency relation: we cannot grasp what it means to say that a material whole should determine the form and working of its material components.

If, then, we cannot explain organisms mechanically, how can we nevertheless make sense of their specific and apparently purposive character? What, in particular, does it mean to think of the parts of an organism as *contributing to*, or as *dependent on*, the whole? According to Kant, it is clear that we cannot *know* of any purposive activity in nature in the literal sense. Rather, the concept of a purpose is merely *read into*

24 Cf. *CPR*, A189/B232 ff.

25 Kant elaborates on this conception of mechanism in his *Metaphysical Foundations of Natural Sciences* (AA IV 465 ff.).

26 *CJ*, AA V 360.

nature: we seem to consider organisms in nature *as if* they were purposively organised and striving. Thus, teleological statements seem to project onto nature a property that we are acquainted with through our own purposive activity. We are familiar with the idea that a part should be there for the sake of the whole, for instance, from the purposive work of an artisan. The artisan produces her artefact according to an idea or a plan. Through her actions, she realises her idea by ordering certain materials in such a way that they combine to make up the intended product. In this sense, the individual components of an artefact are there for the artefact as a whole because the artist *intended* them to form part of the artefact. And in a similar way, it now seems, we can also make sense of the parts of an organism as being there for, and as having a function within, the organism as a whole if we think of the organism as the intended purpose of an intelligent designer.

The artefact analogy that both Ruse and Lewens refer to thus already plays a role in Kant's teleological conception of nature. And yet, this analogy between nature and the product of intelligent design only accounts for Kant's first characterisation of organisms as displaying purposive organisation. It does not account for their apparent self organisation, that is, for the way that organisms bring about themselves. While a product of art is characterised as "the product of a rational cause distinct from the matter", an organism, by contrast, cannot be conceived as the product of an *external* cause.[27] Rather than contributing to the purpose of an external intelligence, the parts of an organism seem to strive towards a purpose *internal* to the organism itself, that is, its own existence and survival. Kant therefore argues that the comparison with the purpose of an artisan "says far too little about [organic] nature and its capacity".[28]

On Kant's account, the self organising and striving character of organisms should not therefore be illustrated by the artefact analogy but is more adequately understood on the model of our own rational and purposive activity itself.[29] This, I think, is the idea behind Kant's claim that,

27 *CJ*, AA V 373.

28 *CJ*, AA V 374.

29 This important aspect of Kant's teleological conception of living nature has not, I believe, received the attention that it deserves. Many of the seminal treatments of Kant's teleological conception of nature, such as those presented by McFarland (1970), Löw (1980) and, to some extent, also McLaughlin (1990), ignore this aspect altogether. McFarland, for instance, argues that Kant "is […] still in the grip of the design designer analogy to the extent that he believes that we

although we cannot understand the idea of a natural purpose, we can at least think of it "in accordance with a remote analogy with our own causality in accordance with ends".[30] We thus reflect about nature by means of the way we usually think about our own rational purposive actions. In order to grasp the particular self organisation of an organism, and hence the directedness of the organism towards its own existence and development, we consider it by analogy with the capacity of reason to set itself ends and to direct its activity towards these ends. In experi encing something as organic, we thus transfer the idea of the purposive activity of our own reason onto nature.

If our teleological considerations of nature are based on an analogy, however, we must conclude that we can make no assertions about the existence or absence of purposes in nature. Our very concept of a nat ural purpose is an idea that can never be proved to have a real applica tion in nature. Kant's position entails that we can merely make state ments about our teleological *reflections* about nature, but not about the teleological character of nature *itself*. According to Kant, our teleological view of nature is thus of a different kind from any mechanistic concep tion. The former, as opposed to the latter, is no objective or categorical knowledge but a subjective and analogical mode of thinking about na ture.

What, then, can we learn from Kant's discussion of the teleological conception of nature? I believe that Kant's analysis gives flesh to Ruse's rather general claim that our teleological conception of nature is merely analogical. Moreover, in claiming that our teleological conception of nature is based on an analogy, Kant does not seem to be concerned merely with explicitly teleological statements such as "the function of X is Z". Rather, Kant seems to be interested in a much more general aspect of our teleological conception of nature. Thus, on Kant's ac count, to consider something in nature as organic is *already* to view it teleologically. Merely to understand, for instance, a tree *as an organic unit* is to view its parts as parts of a systematic whole and as contributing to the existence and survival of that whole. Similarly, to understand an eye *as an eye* is already to view it as part of a larger whole on which the eye depends for its existence and with reference to which it has the function of enabling vision. Kant's discussion shows that our very *concep-*

cannot understand organisms unless we regard them *as if* they were products of a designing mind" (111).

30 *CJ*, AA V 375.

tion of living nature inevitably presupposes teleological concepts. In this sense, the very *possibility* of organisms can only be grasped in teleological terms. According to the Kantian analysis, Ruse's statement that organic nature, for us, is design like can then be understood as the claim that we can conceive of something as organic *only* by considering it teleological ly.

This general aspect of teleology with which the Kantian account is concerned can be clarified by distinguishing between two levels of our teleological conception of nature. The general teleological conception of nature that Kant focuses on may be described as the fundamental level of our experience and understanding of organic nature as such. At this level, a teleological view seems inevitable. We may distinguish from this a second level on which parts of organic nature can explicitly be described in teleological terms. It is this second level that first seemed to prompt the question of how to make sense of teleology in biology. And it is this second level, too, with which the contributions to the de bate in current philosophy of biology seem to be exclusively concerned. When authors such as Wright and Cummins, on the one hand, but also Ruse and Lewens, on the other, discuss the problem of teleology in bi ology they are thus dealing with the problem of how we are to under stand the use of explicitly teleological expressions such as "function" or "purpose". They are not concerned with the more fundamental and implicit teleological perspective that, according to the Kantian ap proach, is necessarily involved in our consideration of organisms.

The insight that the Kantian account may provide, I would there fore like to argue, is that the use in biology of explicitly teleological con cepts is based on a more general teleological perspective on nature. And it is, I believe, the inevitability of this fundamental teleological view point that can explain the use of teleological expressions at the secon dary level. Thus, it is common to talk of purposes, functions and pro grammes in biology but not in physics and chemistry. The reason is that biology, unlike either physics or chemistry, is concerned with or ganic nature and that, if Kant is right, organic nature must be considered teleologically. It therefore seems natural to use an *explicitly* teleological language to talk about things the conception of which *implicitly* assumes a teleological perspective. And again, this analysis of our teleological view of nature elucidates a statement put forward by Ruse: "Organisms seem as if designed" (on the fundamental level of experience). "It is for

this reason that teleological thought is appropriate in the biological sci ences" (on the concrete level of biological research).[31]

With this Kantian interpretation of teleology in tow, we may now come back to the question of how to decide between the two compet ing explanations of teleology discussed in the first section: should teleo logical concepts in biology be understood as referring to the evolution ary history of the trait of an organism, or should they rather be con strued in terms of the causal role that the trait plays in a biological sys tem? On the Kantian account, this question refers to the secondary level of the heuristic use of teleological concepts. On this level, speaking of functions, purposes and programmes in nature can be understood as making heuristic assumptions for the study of the causal laws of nature. It follows, therefore, that a teleological consideration of nature is *legiti-mate* if it is *useful* for the search of causal explanations. Employing teleo logical language is justified if it helps us with our causal investigation of nature. If, then, we understand the use of teleological language in the biological sciences as a heuristic means based on analogy, we do not need to decide between the aetiological and the systems theoretic ap proach. Both analyses can be accepted on the condition that both figure as helpful heuristic devices for the study of nature. As long as biologists are interested in the investigation of the selection history of a particular organic trait as well as in the causal role that the trait plays in a complex organic system teleological vocabulary may be used in both the aetio logical and the systems theoretic sense.

According to the Kantian approach, we may thus understand the use of explicitly teleological language in the life sciences as a heuristic means of structuring projects and formulating questions in biology. Teleolog ical concepts can guide our biological research into the causal processes of nature without, however, being entirely reducible to causal state ments. While providing a useful means for the study of nature, teleolog ical concepts are ultimately based on a more general teleological under standing of nature. And it is this understanding which entails an analogy with our own rational purposive activity.

31 Ruse (2000, 230 f).

4. Kantian Teleology, Evolution and Systems Theory

The Kantian account clarifies why we might want to aim for more than a naturalisation of teleology as an explanation of teleological concepts in biology. According to the Kantian approach, concepts such as "func tion" or "programme" are based on a general teleological understanding of nature which, in turn, presupposes an analogy with our own capacity to act for ends. It is the necessity of this fundamental analogy, however, which may now be questioned. For it could be argued that even the general teleological perspective that, on Kant's account, makes it possi ble for us to consider something as organic at all is explicable by refer ence to the causal processes in nature. In particular, it could be claimed that our very understanding of organisms as apparently teleological sys tems can be understood in terms of evolutionary theory. Of course Kant could not have known about the theory that Darwin published in the *Origin of Species* half a century after Kant's death. And it is precisely this ignorance, it is claimed for example by Ernst Mayr, that led Kant to believe that the explanation of organic nature was impossible in prin ciple.[32] The essential character of living beings, Mayr argues, is explica ble not in purely mechanistic terms but by means of a historical analysis of their evolutionary development.

Thus, the first aspect of Kant's characterisation of organisms, the ap parently purposive arrangement of the parts of an organism within the organism as a whole, could be explained as an "adaptation" that is the result of variation and natural selection over a long period of time. Evo lution produces organisms that are well adapted to their environment and that, therefore, seem as if they were purposively arranged in order to survive in their environment. Yet, natural selection, Dawkins' "blind watchmaker", does not need to be understood in teleological terms. It is blind "because it does not see ahead, does not plan conse quences, has no purpose in view".[33] Furthermore, the second aspect of Kant's characterisation of organisms, the apparent directedness of an organism towards its own existence and survival and the way in which the organism develops through the mutual interaction of its parts, can be explained by reference to the historically evolved genetic programme of the organism. And since the concept of the genetic pro gramme is itself explicable in purely physical terms there is no need to

32 Cf. Mayr (1974) and (2002).
33 Dawkins (1988, 21).

resort to a teleological perspective in order to understand the organic in nature.

Mayr's objection differs from the aetiological analysis of teleological terms. For the objection does not resort to the evolutionary theory in order to *explain the meaning* of explicitly teleological terms, as proposed by Neander. Nor does the present criticism refer to the concept of evo lution by natural selection as a basis for the *definition* of teleology, as ar gued by Millikan. The theory of evolution is rather brought into play in order to give an *a posteriori* explanation of the apparently teleological character of organisms. According to Mayr, the seemingly teleological character of living beings is thus explicable in naturalistic terms by means of the Darwinian theory of evolution and the results of modern genetics:

> Darwin removed the roadblock of design, and modern genetics introduced the concept of the genetic programme. Between these two major advances the problem of teleology has now acquired an entirely new face.[34]

Modern evolutionary biology can, on this view, give a naturalistic ac count of the characteristics that, according to the Kantian approach, were described by means of the teleological analogy. Kant's teleological perspective that was claimed to be inevitable, could thus be considered as a merely useful or heuristic, but not necessary or irreducible, view of nature. Ruse's statement according to which we explain organisms tel eologically *because they seem as if designed* could thus be explained further by arguing that organisms seem as if designed *because they have evolved through variation and natural selection*.

Does this show, then, that Darwin (together with Watson and Crick) can be regarded as the *Newton of the blade of grass* which Kant thought to be impossible in principle?[35] Can the teleological conception of organisms, *pace* Kant, be naturalised after all? In order to answer this question, we need to distinguish very carefully between two concep tions of the teleology of nature. For, on the one hand, it seems correct that Darwin's theory refutes a metaphysically interpreted concept of tel eology according to which the world is construed as a product of an in telligent and purposively acting cause. Evolutionary theory thus proves unwarranted the idea of a god who provides the organism with the or gans necessary for its survival and who thereby adapts the organism to its

34 Mayr (1974, 113).
35 Cf. *CJ*, AA V 400.

environment. On the other hand, it is less clear that the theory of evo lution refutes the necessity of an epistemologically or conceptually inter preted function of teleology. For evolutionary theory does not seem to be concerned, as Kant is, with the question of how we should under stand the very *concept* of an organism. It does not seem to address the issue of how to conceive of the apparently purposive organisation and goal directedness of living beings. Rather, as Georg Toepfer has pointed out, it seems that in order to comprehend what evolution consists in we must *already* know what an organism is.[36] Yet, if the theory of evolution *presupposes* an answer to the question of living beings it cannot replace the teleological conception of organisms proposed on the Kantian ac count.[37]

It could be criticised, however, that although Darwin himself did not know how life emerged or how the first organisms originated, latest results in genetics and molecular biology have made great advances in this respect. While the theory of evolution by natural selection could be employed in order to naturalise the concept of the adaptation of an organism to its surrounding, the questions of how life first originated on earth and how individual organisms developed in such an apparently goal directed manner could be explained further by reference to devel opments at the molecular and genetic level. The theory of evolution, it could thus be argued, provides a naturalisation of the apparently teleo logical concept of an organism only in combination with molecular bi ology and genetics.

And yet, even if it is possible to explain the organisation and devel opment of organisms in purely naturalistic terms, it seems that we never theless first have to identify the organism by distinguishing it as a natural unity from its surroundings. We thus first of all need to identify some thing as a living individual before we can investigate its causes and its history. But it seems to be precisely this identification which is made possible by the teleological perspective analysed on the Kantian account but not by the evolutionary explanation of the apparently teleological character of organisms. Reference to the theory of evolution, an essen tially empirical theory, thus always seems to remain on the level of con

36 Toepfer (2004, 311 ff.).

37 This discussion has nothing to do, of course, with the historical question whether Kant should be read as a forerunner of Darwin. Haeckel (1889, 89 f.) counted especially the early Kant as one of Darwin's predecessors. A ref utation of this view is developed by Lovejoy (1959).

crete empirical explanations. Evolutionary explanations can clarify which natural processes brought about the existence of a particular thing that we experience as a purposively striving organism. Evolution ary explanations cannot, however, say anything about the epistemolog ical reasons that enable us to pick out something as a purposively organ ised unity in the first place. It is these latter reasons, however, with which the Kantian conception of teleology is concerned.

One might object at this point that rather than explaining the teleo logical appearance of living beings in evolutionary terms, we could nat uralise our teleological understanding of organisms by reference to the particular structures that define such apparently purposive systems. What, on the Kantian theory, was described as an analogical account of nature could thus be explained by means of the actual causal roles that figure in organic systems. This is the position defended by Toep fer.[38] He agrees with Cummins that the function of a trait is to be con strued in terms of its causal roles in a corresponding system. His proposal differs from the causal role accounts discussed in Section 1, however, in sofar as it does not regard the ascription of functions or purposes as an *explanation* of a particular natural trait but rather as the *identification* of certain natural systems. In contrast with the systems theoretic accounts discussed at the beginning of this paper, the primary task of teleology lies, on Toepfer's account, in the identification of a particular class of objects. Teleology, he claims, does not *explain* the working or develop ment of organic nature but offers a *description* of those systematic con nections between natural processes that we regard as teleological. Only by clarifying the inner structure of certain objects, he argues, is it possible to understand something as a teleological system at all. The identification of organisms is thus based, according to this approach, on the causal interdependence of the various parts of an organic system and does not require the Kantian analogy with our own rational capaci ty. We can thus explain Ruse's claim that *organisms seem to us as if they were designed* on the grounds that *they display a particular structure defined by what Toepfer calls circular causal processes*.[39]

38 Toepfer (2004, 320 ff.).

39 This "inner structure" of an organic system may be taken to refer to the way in which different parts of an organism influence and cause each other as well as the way in which external material is incorporated into the organism, enabling growth and the regeneration of damaged parts. Moreover, the particular causal structure of organisms may also be taken to include the way in which they pro

Can we conclude, then, that even if it is not the theory of evolution, it is the systems theoretic approach that can explain away the necessity of an analogical understanding of teleology? On the one hand it seems cor rect that the systems theoretic approach can explain the causal structures of the natural objects that we experience as organic beings. On the other hand, however, our experience of organisms seems to entail more than the experience of causal structures. Thus, the systems theoretic interpre tation may elucidate the way in which the individual parts of an organ ism depend on, and causally influence, each other. And yet, the ap proach does not seem to account for the apparent striving and directed ness which we associate with those characteristics that distinguish a liv ing organism from a dead object. It is not obvious, therefore, that the description of empirically cognisable causal connections exhaustively presents the conditions for our identification of organisms.

What seems to distinguish Toepfer's account from the Kantian ap proach is once more that on the former, the systems theoretic descrip tion of nature is presented as on the same epistemological level as the scientific study of circular causal relations. The investigation of the caus al roles that a particular trait of an organ contributes to the working of the corresponding organic system is, at the same time, an investigation into the conditions that make something an organism at all. On the Kantian account, however, the fundamental teleological experience of organic nature is distinguished from the investigation and description of the causal structures of natural objects. According to Kant, the teleo logical identification of organisms in terms of an interpretative reflection *first makes possible* the investigation of causal processes as processes that go on within an organism. And insofar as the former is a condition of the latter, the two occupy a different epistemological status. The natu ralistic approach to the systematic and organisational aspects of organic nature does not therefore seem to prove redundant the teleological anal ogy proposed on the Kantian account. The Kantian analogical approach to teleology introduces a focus that is not captured by any empirical in vestigation of nature. It is the focus on the very conceivability and pos sibility of the living in nature. In this sense, we can understand Hannah

duce offspring—either on their own or with a mate. The "inner structure" may then be understood to refer to that of both parent(s) and offspring. Toepfer's proposal could thus also be read to account for the definition of life that relies on the processes of metabolism and the reproduction of organisms. Yet, even if it is understood in this sense, it seems that the objections discussed below still apply.

Ginsborg's claim that evolutionary theory (and, I would add, systems theory) "would offer an empirical answer to what is, in effect, a conceptual problem".[40]

5. Kantian Teleology in Biology: Some Conclusions

The Kantian approach suggests, then, that all attempts to give a causal explanation of teleological concepts in the biological sciences should only ever be understood as secondary explanations of something that is already conceived of according to a teleological analogy. Teleological concepts in biology, on the Kantian account, thus have a twofold function. On the one hand, they are heuristic tools for the discovery of naturalistic causal explanations. On the other hand, however, they cannot be reduced to these purely naturalistic explanations because they are based on a more general teleological understanding of nature by analogy with our own purposive activity. In order to understand nature *as alive* we thus always have to judge it teleologically.

What, then, does this understanding of teleological concepts mean for the biologist? Should she go on using teleological concepts as a helpful heuristic tool? And in what sense are the teleological concepts of the Kantian analogical account compatible with our conception of the biological sciences? The Kantian account, it seems, is compatible, and hence can allow for, an analysis of the organism's workings in terms of its inorganic material parts. The Kantian account can allow for this kind of explanation insofar as it would be an explanation of the material processes that go on within the organism. The account must reject such a mechanical explanation, however, as an explanation of the essential character of the organism as a living being. For, as we have seen, the experience of organisms is characterised in a way that cannot be explained purely by reference to mechanical laws. The teleological view thus implies that there is something about our ordinary experience of empirical nature which falls outside the realm of the scientifically explicable. It is this particular character of living nature which we cannot explain, but can only elucidate by means of analogy. We may thus think of these two conceptions of nature, the causal mechanical and the teleological, as two different stories about, or perspectives on, one and the same object. Although the teleological conception seems inevitable

40 Ginsborg (2006, 467).

for the consideration of organic nature, a non teleological, mechanistic, explanation of the causal processes that determine the same object is possible. The Kantian account could thus justify teleology in biology by claiming that both teleology and mechanism are two convincing but mutually irreducible perspectives on nature.[41]

Granted, then, that our conception of nature implies two perspec tives, mechanistic and teleological, it might be objected that the teleo logical perspective is simply not relevant to biology. It may be argued that the task of biology is to deal with a conception of nature that is ul timately explicable in naturalistic terms. If we agree on the inevitability of the teleological perspective for an understanding of organic nature, however, this objection must be mistaken. For the project in biology to give explanations of nature in purely naturalistic terms can only be *about* organic nature if it entails a teleological perspective. We need a teleological outlook on nature in order to be able to think of ourselves as investigating, for instance, a tree or a bird's eye. Even in order to ex amine the causal processes that go on in an organic material object, we need to be able to *pick out* the object as an organised whole in the first place. Once we have allowed the teleological perspective we can then make use of teleological expressions as heuristic tools for the investiga tion of nature. In asking for the function of a particular organ, for in stance, we may be interested in an explanation of this function in terms of the underlying causal processes in nature. What exact aspect of the causal processes we are interested in when asking questions in tel eological terms may vary between cases. Following Cummins, when we raise the question "what is the function Z of organ X in system S?", we may be aiming at investigating the contribution that X makes to a par ticular capacity of S. Alternatively, following the aetiological account, we may be interested in the reasons for the existence of X, explicated in terms of the evolutionary history of X with respect to Z. The analyses presented by the causal role account and the aetiological theory can thus give us guidance for understanding what biologists may be expecting from their biological research. We should not assume, however, that what biologists expect to gain from an inquiry described in teleological terms is all there is to what those terms imply. The general teleological perspective, it seems, remains irreducible even for biology.

41 The necessary and mutually irreducible status of the mechanistic and teleolog ical perspectives is discussed in more detail in Breitenbach (2008).

The Kantian account can thus throw some new light on current dis cussions in the philosophy of biology. While others have argued that the Kantian conception of teleology cannot present any help to contempo rary philosophy of biology because Kant does not interpret teleology naturalistically[42], I suggest that Kant can advance the debate about tele ology in biology *precisely on the grounds* that he does *not* interpret teleol ogy naturalistically. The original perspective that the Kantian account can add to the debate is that teleological concepts have the function of both a useful heuristic in the search for causal explanations and a nec essary and irreducible perspective on living nature.

Bibliography

Allen, Colin, Bekoff, Mark (1995): Biological Function, Adaptation, and Nat ural Design, in: Philosophy of Science 62, pp. 609–622.

Allen, Colin, Bekoff, Mark, and Lauder, George (eds. 1998): Nature's Purpos es. Analyses of Function and Design in Biology, Cambridge, MA.

Bertalanffy von, Ludwig (1952): Problems of Life. An Evaluation of Modern Biological Thought, London.

Breitenbach, Angela (2008): Two Views on Nature. A Solution to Kant's An tinomy of Mechanism and Teleology, in: British Journal for the History of Philosophy 16, pp. 351–369.

Buller, David J. (ed. 1999): Function, Selection and Design, Albany, N. Y.

Cummins, Robert (1975): Functional Analysis, in: Journal of Philosophy 72, pp. 741–765.

Dawkins, Richard (1988): The Blind Watchmaker, London (first published 1986).

Ginsborg, Hannah (2006): Kant's Biological Teleology and its Philosophical Significance, in: G. Bird (ed.): Companion to Kant, Oxford, pp. 455–469.

Godfrey Smith, Peter (1994): A Modern History Theory of Function, in: Noûs 28, pp. 344–362.

Griffiths, Paul E. (1993): Functional Analysis and Proper Functions, in: British Journal for the Philosophy of Science 44, pp. 409–422.

Haeckel, Ernst (1889): Natürliche Schöpfungsgeschichte. Gemeinverständliche wissenschaftliche Vorträge über die Entwicklungs Lehre im Allgemeinen und diejenige von Darwin, Goethe und Lamarck im Besonderen, Berlin (first published 1868).

Kant, Immanuel (1900 ff.): Gesammelte Werke, ed. könglich preußische (später deutsche) Akademie der Wissenschaften, Berlin (= AA).

Kant, Immanuel (2000): Critique of Judgment, trans. Paul Guyer and Eric Matthews, Cambridge.

42 Cf. Zammito (2006).

Lewens, Tim (2004): Organisms and Artifacts. Design in Nature and Else where, Cambridge, MA.
Lovejoy, Arthur O. (1959): Kant and Evoution, in: B. Glass, O. Temkin and W. L. Straus (ed.): Forerunners of Darwin 1745–1859, Baltimore, pp. 173–206.
Löw, Reinhard (1980): Philosophie des Lebendigen. Der Begriff des Organi schen bei Kant, sein Grund und seine Aktualität, Frankfurt a. M.
Mayr, Ernst (1974): Teleological and Teleonomic. A New Analysis, in: R. S. Cohen and M. W. Wartofsky (ed.): Methodological and Historical Essays in Natural and Social Sciences. Boston Studies in the Philosophy of Sci ence, Boston, pp. 91–117.
Mayr, Ernst (2002): Die Autonomie der Biologie, in: Naturwissenschaftliche Rundschau 55, pp. 23–29.
McFarland, John (1970): Kant's Concept of Teleology, Edinburgh.
McLaughlin, Peter (1990): Kant's Critique of Teleology in Biological Explan ation, Lewiston, NY.
McLaughlin, Peter (2001): What Functions Explain: Functional Explanation and Self reproducing Sytems, Cambridge.
Millikan, Ruth G. (1984): Language, Thought and Other Biological Catego ries, Cambridge, MA.
Millikan, Ruth G. (1989): In Defense of Proper Functions, in: Philosophy of Science 56, pp. 288–302.
Neander, Karen (1991a): The Teleological Notion of Function, in: Austral asian Journal of Philosophy 69, pp. 454–468.
Neander, Karen (1991b): Functions as Selected Effects: The Conceptual Ana lyst's Defense, in: Philosophy of Science 58, pp. 168–184.
Ratcliffe, Matthew (2000): The Function of Function, in: Studies in the His tory and Philosophy of Biological and Biomedical Sciences 31, pp. 113–133.
Rosenblueth, Arturo, Wiener, Norbert, Bigelow, Julian (1943): Behaviour, Purpose and Teleology, in: Philosophy of Science 10, pp. 18–24.
Ruse, Michael (1981): Teleology Redux, in: J. A. and R. S. Cohen (ed.): Sci entific Philosophy Today. Essays in Honour of Mario Bunge, Dordrecht, Boston, London, pp. 299–309.
Ruse, Michael (2000): Teleology: Yesterday, Today, and Tomorrow?, in: Studies in the History and Philosophy of Biological and Biomedical Scien ces 31, pp. 213–232.
Russell, Edward S. (1945): The Directiveness of Organic Activities, Cam bridge.
Sommerhoff, Gerd (1950): Analytical Biology, London.
Toepfer, Georg (2004): Zweckbegriff und Organismus. Über die teleologische Beurteilung biologischer Systeme, Würzburg.
Wiener, Norbert (1948): Cybernetics, or Control and Communication in the Animal and the Machine, New York.
Wright, Larry (1973): Functions, in: Philosophical Review 82, pp. 139–168.
Wright, Larry (1976): Teleological Explanation, Berkeley.

Zammito, John H. (2006): Teleology Then and Now: The Question of Kant's Relevance for Contemporary Controversies over Function in Biology, in: Studies in History and Philosophy of Biological and Biomedical Sciences 37, pp. 748–770.

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