Functions in Biological and Artificial Worlds
Comparative Philosophical Perspectives

edited by
Ulrich Krohs and Peter Kroes

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1 Philosophical Perspectives on Organismic and Artifactual Functions

Ulrich Krohs and Peter Kroes

The nature of functionality is one of the big and difficult questions shared by the philosophies of biology and of technology. The ascription of a function to a biological trait goes beyond a mere description of what the trait does. Mammalian hearts move blood and, like most but not all other hearts, they move it through the animal's blood vessels. This biological finding is descriptive in the same way that the geological finding that magma chambers below the base of volcanoes extrude lava out of a crater through a conduit in the volcano or the physical finding that two masses attract each other are descriptive. However, biologists ascribe to the heart not only the action but also the function of pumping blood. In contrast to the mere description, the function ascription allows one also to talk about malfunction or dysfunction, a situation in which a function is impaired or not performed at all (Neander 1995; Davies 2000). This contrasts sharply with the situation in physics. Physicists do not talk about malfunction if some expected physical interaction does not occur but rather about a new phenomenon that requires explanation (though they may refer to malfunctioning technical equipment). Even an inactive volcano is not said to have a malfunctioning magma chamber. In such cases the descriptors "dormant" and "extinct" are used in a metaphorical way to refer to a volcano that is no longer active. In contrast to the findings of these other natural sciences, biological function ascriptions do involve reference to a norm (in a weak, nonmoral sense), which delineates dysfunction from function.

Functionality is not restricted to biological entities. The most obvious domain of function ascription is technology. Again, the ascription of a function to, for instance, an Archimedean screw, goes beyond being a mere description of what this technical artifact does when it moves water upward. It is the function of an Archimedean screw to move water upward, that is, it is supposed to or ought to move water upward. As a consequence, just like biological organs, technical artifacts may dysfunction. In the domain of technology, functionality is even more familiar than in biology and it is often claimed that the concept stems from the former field and that its proper use may be primarily in relation to technical artifacts. Here the intentionality of designers, makers, and users comes into the picture and may well be the source of the normativity of technical functions.

It turns out, however, that also with respect to technical functions, things are not that easy.

Entities of a third kind, namely social institutions, are also often described in a functional way. We are convinced that functional approaches to sociology may also profit from a comparative perspective when analyzing functions, but that is not included in the present comparative approach. The reasons are as follows. First, there is much less consensus among sociologists than among biologists or technicians on whether or not the systems they are dealing with should really be conceived as functional systems. Sociological structuralism manages without function ascriptions, so the problem of functionality seems to depend much more on the general approach adopted within the sociological field than in the fields dealt with in this volume (Krohs 2008a). Second, social institutions, if conceived functionally, combine aspects that are found to be relevant to function ascriptions in biology (evolution, development, and organization) and to technology (designing, use, and, again, organization), probably blended in many different proportions. Insofar as these aspects exhaust the notion of "social functions," the latter do not add a new perspective to the ones included in this book.

It should be mentioned that there are more than the clear-cut cases of functional systems so far mentioned. Between each of these poles, all kinds of hybrid systems are to be found (figure 1.1). There are biotechnological hybrids, such as genetically engineered organisms. There are systems that are described as intermediates between biological organisms and

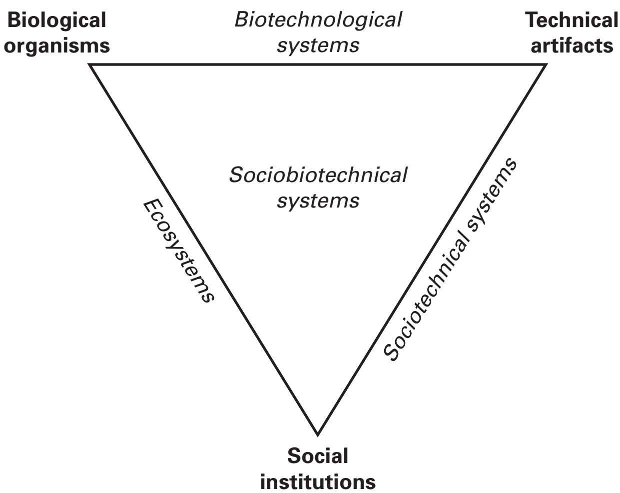

Figure 1.1
A map of the kinds of functionally organized entities. While the entities shown in the corners of the triangle are typically the subject of inquiry within the respective disciplines of biology, technology, and sociology, the intermediate and hybrid systems often, but not always, belong to transdisciplinary fields of research.

social institutions, such as insect states and possibly also ecosystems as conceived in synecology. Intermediates of a third kind are sociotechnical systems such as a company running a factory or—paradigmatically—a coal mine. These can be located on the map of functionally organized entities between technical artifacts and social institutions. Finally, there are sociobiotechnical systems, which involve all three kinds of aspects. Among these systems are farms together with companies that are active in the biotechnological production sector.

For the reasons mentioned, we confine the scope of the present volume to the cases of biological organisms and technical artifacts. Considerations pertaining to hybrids thus are included only where they relate to intermediates between these two kinds of systems.

Given that organisms and artifacts have both been described in functional terms since antiquity, it is not surprising to find in the history of philosophy and also in biology and technology many attempts to use entities of one kind as a model or explanation for another. The transfer goes in both directions—compare the machine analogy for biological organisms (Descartes 1985a [1637], 1985b [posth. 1664]; La Mettrie 1960 [1747]) and see the evolutionary account of technological development (Basalla 1988; Ziman 2000; Lewens 2004). With respect to functions, it was taken for granted that the concept of a technical function is the better-understood concept in a seminal contribution to the debate: "Of the two, natural functions are philosophically the more problematic" (Wright 1973). Artifact functions became a kind of implicit point of reference in the discussion on biological functions (Millikan 1984; Kitcher 1993). Unfortunately it turned out that philosophy of technology was far behind its twin discipline at those times: the concept of a "technical function" was not at all well explicated. When this was taken up as a philosophical challenge, it turned out to be all but an easy task to resolve. In fact philosophy of technology often relied upon theories of function from the biological domain. This had two strange and undesired consequences. First, as far as theories of biological function refer to specific biological processes such as evolution by natural selection or to features characteristic of living organisms—not all, but some of the most prominent ones do—it seems rather artificial to transfer them to technology. Second, and worse still, the definitions are at risk of becoming circular insofar as the technological concepts themselves are explicated in terms of biological concepts.

In the early days of philosophizing about functions, the divide between the biological and the artificial world was not yet an issue. Aristotle conceived of all entities and processes in the world as being subjected to four causes or origins (*aitiai*), one of which was the teleological cause, inherent in the answer to "what for" questions (Aristotle, *Physica*). He even maintained that objects like a stone have a goal that causes it to fall: its natural place is on the ground or in the center of the universe. However, teleology—goal-directedness—is in fact a much stronger concept than functionality. But his concept of "*energeia,*" the actuality of an entity, in its application to living entities may indeed be seen as a forerunner of present-day concepts of function: according to Aristotle, this is the way living entities are “working.” Aristotle often used the alternative term *entelecheia,* which translates “having the end within itself,” when writing in particular on the *energeia* of living entities. Though this is not a clear terminological distinction in his writings, the use of the term *entelecheia* may show how close he conceived the connection between the *energeia* and ends or goals to be. Notably he often explains the *energeia* of living entities by means of technical analogies. Already his talk about “organs” involves this analogy, since *organon* is Greek for “tool.”

During and after the Renaissance, teleology was banned from the physical world, and causality within physical processes became restricted to effective causality. Kant then noticed that biological organisms cannot be conceived of without some kind of reference to teleology, but he banned the goals of goal-directedness and gave teleology the status of a regulative idea—something we need to assume in an “as if” mode to understand living nature but not something that constitutes nature. What remains is teleological judgment instead of teleological explanation: we cannot do without this kind of judgment but we cannot know whether teleology is indeed present (Kant 2007 [1791]). For Kant the reason for needing teleological judgment at all was that there is “cyclic causality” in living organisms. What is well known to us, for instance, from feedback control, was unimaginable to him—an explanation of a causal chain being closed to a loop in strictly physical terms. For him only linear or branched causal chains were imaginable. He had of course no concept of a system far from equilibrium or of a dissipative system, which makes cyclic causal processes easily understandable. Nevertheless he anticipated modern concepts of regulation in his notion of cyclic causality, which he related to teleological judgment. So in Kant’s writing we encounter the idea that biological functionality is related to a particular organization of a living entity rather than to goals.

1.1 The Challenge of Dysfunction

We have already seen that wherever a function is ascribed, dysfunction immediately comes into play. A function may be performed well or poorly or even not at all. One refers to or poses a norm when ascribing a function, a norm that may not be met. However familiar expressions like “a bad heart” or a “good coffee machine” may sound, explicating the normative aspects of functions is not a trivial undertaking at all. Several major problems arise. In the first place, function talk sits uneasy within a naturalistic approach to the world, an approach that roughly takes the outcomes of modern science and its descriptive methodology as its point of departure. Within a “naturalistic” perspective, the ascription of functions to objects, in particular natural objects, is rather problematic. In contrast to the Aristotelian approach, the idea that physical objects or chemical substances have functions has lost its validity in modern physical sciences. Only within the biological sciences has the attribution of functions to organs, traits, or the behavioral patterns of organisms stayed alive and it is, according to many biologists, an indispensable facet of their conceptual toolkit. They claim that an adequate description and explanation of biological phenomena requires recourse to the notion of function. If that is indeed the case, then the problem of how normative statements with regard to functions may be reconciled with the underlying descriptive methodology arises. One way to avoid this conflict is by assuming that there are, after all, norms in at least biological nature. In that case the statement “this is a bad heart” is simply the objective description of a normative state of affairs in the biological world. This leads to a form of normative realism—that is, the idea that there are normative states of affairs in the world—with all its problematic aspects. Another way to avoid the conflict is by denying that function talk is necessary in the biological sciences. In his contribution to this volume, Davies argues that biologists who cling to function talk are suffering from “conceptual conservatism” and that function talk should be given up. If that is done, it becomes possible to remain faithful to the descriptive methodology but again at a considerable price: as far as statements like “this is a bad heart” or “this heart ought to behave like this or that” have any meaning at all, they describe nonnormative states of affairs. Whether this is an adequate interpretation of the meaning of prima facie normative statements with regard to functions remains controversial.

In the second place, it is far from clear how normative statements about technical artifacts are to be interpreted. One of the first attempts to interpret the “goodness” of artifacts stems from von Wright (1963). In contrast to normative statements about biological entities, normative statements about technical artifacts appear to be intimately related to human action. Humans make use of technical artifacts and it is quite common to (partially) ground the functions of technical artifacts in intentional human action (Kroes and Meijers 2006). This grounding of technical functions in intentional human action opens the possibility to explicate normative statements about technical artifacts in terms of normative statements about human action. The contribution by Franssen to this volume contains one of the rare attempts to spell out the details of how this might be done. It shows that the interpretation of normative statements about technical artifacts is far from self-evident.

1.2 Disanalogies Between Biology and Technology

The main disanalogy between functions in biology and technology that immediately springs to mind is indeed functions’ relation to intentional human action. Theories of biological functions make no reference to human intentionality (Searle [1995] being a notable exception). By contrast, in most theories of technical functions, human intention plays a constitutive role in the sense that without human intention (of designers, producers, users, etc.) it does not make sense to claim that technical artifacts have or may be attributed functions. Within the technological domain, functions may be interpreted in terms of means-ends relations and the ends involved may be simply interpreted as the ends of human beings. Within the biological domain, an interpretation of functions in terms of means-ends relations is much more problematic because the status of ends within the biological world is problematic.

This difference in the role of intentionality with regard to the notion of function in biology and technology may prove to be a major obstacle to attempts to develop a unified account of normative aspects of biological and artificial functions. This is simply a special aspect of the general problem of whether it is possible to develop a general theory of functions applicable to the biological and the artifactual domains. If indeed the normative aspects of technical artifacts are derivative of human action, then the prospects for such a general theory of functions appear dim. By analogy, the normativity of biological functions of organs, for instance, would have to be grounded in the use organisms make of such organs. However, generally speaking, it hardly makes sense to say that organisms make use of their organs. Moreover, grounding the normativity of biological functions in the use that humans make of organisms seems out of the question, since their organs have functions independent of any human use.

The search for a unified account of normativity may be in vain for different reasons. To start off with, there may well be different sources of normativity in biology and technology. Another possibility is that with respect to biology, talk about normative functions may not be justified. The problem is that there is a difference between regarding the reference state of a particular function as brought into being, for example, through natural selection, and viewing its very status as a reference as a product of evolution. Some contributions to this volume deal with the difficulty of establishing a naturalized, nonnormative account of biological function (McLaughlin; Davies).

Another disanalogy between the fields is that a technical artifact is usually ascribed a function as a whole, while organisms as wholes are not considered to have functions. The function of a car is to enable rapid movement on streets, the function of a lathe is to turn wood or metal workpieces, the function of a molding press is to form plates. But killing mice or looking majestic is not the function of an eagle, nor is it the function of a dormouse to sleep for a considerable part of the year. So while in biology functions are only ascribed to components of organisms, artifacts-as-wholes do have functions. This need not mean that the difference holds from any perspective. It may well be that the functions of artifacts-as-wholes are relational with respect to the system in which they are used, for example, to a functionally organized sociotechnical system (Krohs 2008a). On the other hand, moving up one level in biology we have to consider ecosystems as conceived in synecology. If these can be described as functionally organized, then organisms may well have functions-as-wholes insofar as they are components of an ecosystem. What remains to be seen, however, is whether the concept of an ecological function is normative in the same sense as functions in sociotechnical systems.

1.3 A Brief Survey of the Parallels Between the Fields

Despite the differences discussed in the past two sections, there are many parallels between organisms and artifacts. If there are reasons to apply the concept of "function" to both kinds of entities, it seems plausible to look for them in such shared or at least similar features. An obvious parallel that holds between organisms and the more complex of the technical artifacts is to be found in hierarchically organized systemic structure. Consequently one of the basic notions of function refers to function as the role of a component within a system (Cummins 1975; his concept is more elaborate than is apparent from this sketch; cf. the contribution of Mark Perlman in this volume). However, such a notion is also applicable to many physical systems, such as solar systems, atoms, or the hydrological cycle, precisely because it lacks normativity. One has thus to look at more peculiar parallels when explicating a notion of normative functionality. We list several in this section, pointing each time to the differences between both fields with regard to each aspect and clarifying the different terminology used in both fields to refer to comparable features.

Another important parallel, apart from organization, is to be found in evolution, which occurs in the biological and technical realms. Just as mammals and birds evolved from reptiles, so jet planes are said to have evolved from less sophisticated airplanes. However, the underlying processes of variation and the retention of variants may follow largely different mechanisms in both cases. Variation is mostly considered to be blind in the organismic case and directed within the technical domain. As an aside—looking for the origin of this parallel, it should be observed that Darwin (1988 [1859]) describes the process of natural selection as parallel to the breeding process, that is, to a process that belongs at least partly to the artificial domain.

Biological development finds its equivalent in technical construction. In both cases, deviations from what may be regarded as developmental pathways fixed in the genome or as instructions laid down in a construction plan may occur. So development and construction really do have a modifying influence on the resulting entity and to that extent on its functionality or functional organization. Again the influences in the technical domain, but not in biological cases, are at least in part intentional.

In a way biological reproduction may be paralleled with technical series production. However, in the biological case propagation and multiplication are the sources of variation, while in engineering there is usually avoidance of variation in the multiplication process. Instead variation is sought in separate steps.

A final parallel we want to mention is the way in which biological and technical entities retain their integrity. Biological recovery, regulation, and self-repair can be seen as counterparts to technical maintenance and repair. The big difference is that usually these processes are internal in biological organisms, being performed autonomously to the degree laid down in or allowed for by the internal structure of the organism. There are often strict limits to biological regeneration. Mammals cannot regenerate lost limbs, though many amphibians can and do. In technical cases maintenance and repair are brought about by external agents, partly on a regular basis and partly ad hoc, in accordance with requirements and feasibility.

Various theories of function refer to one or more of the aspects mentioned. Insofar as these aspects are shared between the fields—though differently termed—it seems promising to apply theories of function that refer to one or more of the topics in both fields (Krohs 2008b). However, the already-mentioned differences show that any unified approach also has to face the fundamental differences between the biological and the artificial realms. On the other hand, in the growing class of biotechnical hybrid systems these differences may either fade out or else the hybrids might at least prove that the occurrence of biological functions is not excluded from the technical world and vice versa.

1.4 The Aim of This Volume

Up until now contributions to the debate on the concept of "function" usually have been biased in that they are oriented to one of the fields. The other field was used just as a reference—without acknowledging that the problems on the other side are as big as those an author sees in his or her own field. Due to this habit, the authors forfeited the chance to profit from a view that takes both fields in question into account. This book aims at doing justice to both sides, to the functionality of organisms and of artifacts, and it aims to present proper philosophical analyses of the concept of function from a perspective that embraces both fields of function ascription. In this way it aims at a better understanding not only of the concept of "function" itself but also much more generally of the similarities and differences between organisms and artifacts insofar as they are related to functionality. The contributions to this volume fulfill this aim by presenting ontological, epistemological, and phenomenological comparisons. This helps clarify problems that are at the very center of the philosophies of biology and technology. The results are also valuable to the philosophy of social science.

This volume also seeks to contribute to the emancipation of the philosophy of technical artifacts. Within philosophy, artifacts in general, but technical artifacts in particular, have been neglected for a long time. It is only during the past decades that artifacts have become a topic of philosophical analysis in their own right (Dipert 1993; Preston 1998; Thomasson 2003, 2007; Hilpinen 2004). Even within this emerging field of the philosophy of artifacts, *technical* artifacts often play only a marginal role and if they are taken into consideration it is usually in the form of technical artifacts that are produced by craftsmanship and not by modern engineering. However, it is one thing to compare a beaver dam to a stone ax but another thing to compare it to a modern Airbus 380. If we take into account the complexity in the structure of the technical artifacts involved as well as the complexities of the production processes, then we may question on valid grounds whether stone axes are representative for modern engineered technical artifacts. Whether the constitutive role of human intentions and of physical structures in realizing the functions of these different kinds of technical artifacts may be treated in the same way is, for instance, debatable. Such problems belong to the philosophy of engineering design, a field that is virtually nonexistent (Kroes and Meijers 2001; Krohs 2004).

Philosophers of biology and of technical artifacts may learn a lot from a comparative analysis of functions in both domains, even where such an analysis leads to the conclusion that we are dealing here with two fundamentally different kinds of functions. In such a case we have to develop, for instance, different explications of the normativity associated with these different kinds of functions and stop using misleading analogies between function talk in both domains. However, it would surely be premature to draw such a conclusion. It is precisely the recent development of functional theories for technical artifacts that offers a unique opportunity for such a comparative approach. The overall question about the extent to which it will be possible to arrive at a common interpretation for the notion of "function" that is viable for both the domains of biology and technology remains an open issue. This volume presents a number of significant results that must be taken into account in future discussions about the possibility of a unified function theory for biology and technology.

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