Function, biological*

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Synonyms

Definition

The activity, role, value or purpose of a part, activity or trait of an organism.

Characteristics

Terms like 'function', 'functions' and 'functional' are used in many different ways. The 2005 edition of the *New Oxford American Dictionary* gives as the first meaning of 'function': "an activity or purpose natural to or intended for a person or thing" with "Vitamin A is required for good eye function" as an example. This definition is suitable as a general characterization of the term 'function' and at the same time it contains the seeds of many confusions about the notion of biological function, especially because it talks about 'activity or purpose' and 'natural to or intended for'.

The idea that biological function is somehow related to purposes and the idea that there can be natural purposes in addition to intended ones has been a source of inspiration for philosophical discussion. In the 1950s and 60s philosophers of science of a logical positivist inclination searched for ways to define the notion of biological function without appeal to purpose. Since the 1980s many philosophers think that evolutionary theory provides us with a notion of natural purpose that can be used to develop a naturalized account of purposes, norms and meaning in the philosophy of mind and language. According to these 'etiological theories' it is the natural purpose and, for that matter, the 'proper function' of a trait of an organism to produce the effects for which that trait was maintained in the process of natural selection in the (possibly recent) past of that organism's population (cf. Wright 1976; Millikan 1989; Neander 1991). In the philosophical debate that emerged in reaction to these theories many different understandings of function and functional explanations have been developed (see Wouters (2005) and Garson (2008) for overviews).

In biology, the connotation of 'function' is usually not purpose but activity, in a broad sense of that term, including 'what it does', 'how it works', and 'how it is used'. For example, 'functional morphology' is typically defined as the study of the form of organisms and their parts in relation to their activity and use. The many articles yielded by a Google Scholar search on 'structure and function' typically discuss both

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the way in which a part of an organism is build (its structure) and the way it works (its function). Within this broad sense of function as activity, two uses of the term function can be distinguished: function as activity in a stricter sense (what it does and how it works) and function as biological role (how it is used).
'*Function as activity*' refers to what a system does by itself (in abstraction of its effects on its environment) and the way it works–internally (e.g., the way in which the activity is generated) or externally (e.g., the order of its changes). The notion of function as what it does is typically used to distinguish form (or structural) characteristics from functional characteristics. The form characteristics of a system concern its appearance (shape, volume, color, pattern, texture etc.), structure (composition, size and spatial arrangement of the parts, e.g. amino acid sequences) and statics (hardness, weight, mass etc.); the functional characteristics of a system concern its activity (frequency, order, velocity, momentum, reaction rates, oxygen consumption, kinetic energy, etc.). For example, talk of 'functional homology' might refer to a common pattern in muscle movement, whereas talk of 'structural homology' might refer to a common pattern in the spatial arrangement of the muscles. The notion of function as how it works is typically used to make comparisons. For example, when it is said that the heart's ventricle functions as a pressure pump en the atrium as a suction pump one compares the way in which these two systems work.
The notion of *function as biological role* refers to the role of a system in enabling life. In general, role functions concern the role of a system or activity in bringing about an organized characteristic of an encompassing system (a role function of a brake is to enable the driver to stop the car, because stopping the car is how the brake contributes to the car's organized ability to transport people). The *biological* role of a part of an organism is the role of that part in bringing about the organism's state of being alive. For example, the main biological role of the glycolysis is the production of ATP, because that is how the glycolysis contributes to an organism's ability to stay alive. Note that role functions are positions in an organization rather than measurable properties.
Ascriptions of biological roles are the handle to understand life. Just as it is possible to explain how a company works by means of an organization chart that outlines the tasks of the different functionaries and departments and the way in which they interact, the ability of an organism to stay alive can be explained by outlining the roles the different organ systems play in bringing about the living state. The ability of each organ system to perform its biological role, in turn, can be explained by describing the roles the different parts of that systems play in bringing about that ability, and so on, until a level is reached at which the relevant subsystems can be explained in terms of the physical and chemical characteristics of the molecules that make up that subsystem (cf. Cummins 1975). Such an organization chart provides a unifying framework for biology that relates detailed studies of specific mechanisms at different levels to the general aim to understand life.

Yet another use of the term ‘function’ stems from behavioral biology. In this area of study ‘function’ often refers to the advantages of behaving in one way rather than another. More generally, the notion of *function as biological advantage* (also called ‘survival value’, ‘adaptive value’ or ‘biological value’) is used to refer to the way in which a certain trait influences the life chances of an organism in a certain environment as compared to other traits that might replace it. An advantage of a trait in a certain environment is an ability resulting from that trait due to which the life chances of organisms with that trait are higher than the life chances would be of organisms in which that trait were replaced by another one (cf. Canfield 1964; Bigelow and Pargetter 1987).

Advantage articulations compare organisms with a certain trait with similar organisms in which that trait is replaced by another one (or removed). The hypothetical organisms with which the real organisms are compared need not be real. Quite often a comparison is made between a real organism and a hypothetical organism that cannot possibly exist and the point of the comparison is precisely that: to show that it cannot exist (because it lacks an essential ability).

Advantages differ from role functions in many ways. Advantages are abilities to solve certain problems, not positions in an organization. Advantages are, unlike role functions, relative to an environment and to the traits used for comparison. In addition, role functions are typically attributed to parts or activities, whereas advantages are effects of traits (that is of the properties of systems or activities, including the presence of certain items or the performance of certain activities). It is, for example, the biological role of the heart (a part of an organism) to pump the blood around, whereas pumping blood by means of a heart (a trait) is advantageous relative to pumping blood by means of beating blood vessels (the trait for comparison) in environments with certain types of prey and predators because this allows for faster oxygen transport (an ability resulting from the presence of a heart), which allows the organism to be more active and, hence, to escape from predators or to catch prey in situations were an organism with beating blood vessels would not be able to do so (more distal abilities resulting from that trait).

Functional biology can be defined as the study of how living systems (organisms) and their parts work. Functional biologists are concerned with two kinds of explanations that deal with synchronic relations between the different parts and activities of organisms and the environment in which they live: mechanistic explanations (also called ‘causal explanations’) and functional explanations (also called ‘ecological explanations’ or ‘design explanations’). The ascription of role functions is central to explanations of both kinds (see explanation in biology).

Mechanistic explanations address questions about how a certain biological role is performed (e.g. ‘how does the glycolysis generate ATP?’), by describing a mechanism that produces the behavior that enables that system to perform this role. Because of their concern with biological roles, mechanistic explanations in biology are sometimes called ‘functional explanations’ or ‘functional analyses’ (especially by philosophers) (cf. Cummins 1975). This kind of explanation is discussed in the essay on mechanistic explanation (explanation, mechanistic).

Functional explanations address questions about why a biological role is performed the way it is (e.g. 'why do many pathways that generate ATP start by activating their substrate?)' by pointing to the advantages of performing the role in that way rather than in some conceivable alternative way (cf. Wouters 2007). This kind of explanation is often called 'functional explanation' (especially by biologists) because it is concerned with the advantages of certain forms of organization rather than with the question of how those forms are brought about. It is discussed in the essay on functional explanation (explanation, functional).

Biological roles also play an important role in certain explanations in evolutionary biology (the study of the history and dynamics of lineages of organisms), especially in adaptation explanations. Adaptation explanations (also called 'selection explanations') are evolutionary explanations that explain certain characteristics of a population as the result of past interaction in that population between variants that differed in their fitness. If a certain trait evolved because the fitness of past variants having that trait was higher than that of their competitors lacking that trait because the presence of that trait improved the performance of a certain role function, one might say that the trait evolved as an adaptation for performing that role function. For this reason, adaptation explanations are sometimes called 'functional explanations' (especially by philosophers) (cf. Brandon 1990). This kind of explanation is discussed in the essay on evolutionary explanation (explanation, evolutionary).

Cross-references

Explanation, evolutionary
Explanation, functional
Explanation, mechanistic
Explanation in biology

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