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Biological Function

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Synonyms

Adaptation; Biofunction; Causal role; Fitness effect; Purpose; Selected effect

Definition

In biology, functions are attributed to the traits, behaviors, and parts of living things. A thing's function can refer to its purpose, a benefit it confers on an organism, or the causal role it contributes to a more complex system capacity.

Introduction

Biologists attribute functions to a diversity of natural phenomena, from chemical and cellular processes to the organs, traits, and behavior of organisms. It is common for them to say, for example, that the koala's pouch has the function of protecting its young, that the function of the bee dance is to direct other bees to pollen, or that chlorophyll in plants functions to absorb light and convert it into energy. Yet the term "function" is ambiguous, carrying importantly different meanings and occupying distinct explanatory projects in the biological sciences. This entry will introduce two characteristic features of biological functions, then overview three dominant analyses, each of which targets a distinct sense in which functions are conceptualized in the biosciences.

Functions, Teleology, and Normativity

What do biologists mean by "function"? In its most basic sense, "function" can simply refer to an effect something produces (Hardcastle 2002). For example, when geneticists say that amino acids function to catalyze RNA transcription, they just mean that RNA transcription is an effect brought about by amino acids. In some cases, however, when biologists assign functions, they seem to be saying something more.

Functions are commonly associated with two qualities. The first is purposiveness or "teleology": functional ascriptions seem to tell us why something exists (Neander 1991). A koala's pouch is for protecting its young, and chlorophyll's purpose in plants is to transforms light into energy. The second is *normativity*: a thing's function often determines the standards by which it operates. Often biologists wish to say that, even when something fails to do something, it nonetheless *should* have. A single plant that does not produce chlorophyll *fails* to fulfill its function, and so is in a state of *dys*function.

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The teleological feature functions has, in particular, provoked controversy and consternation (Neander 1991). It is easily accommodated in the case of artifacts, where we can articulate what something it is supposed to do by referencing human goals. The function of a microwave, for example, is to heat food because its inventor designed it for this use. In biology, however, the goal is to define function naturalistically, without presupposing the existence of a human, or supernatural, designer.

This has led some sceptics to suggest that functions do not belong in science (Davies 2003). This stance, however, sits uneasily with the ubiquitous and explanatorily powerful use of functional explanation in biology (Garson 2016). Analyses of biological function thus tend to either provide a naturalistic interpretation of teleology or else define function in a way that carries no commitment to it.

Causal Role Functions

The Causal Role analysis defines biological function in non-teleological terms. The motivation behind this approach is not merely the perceived impossibility of naturalizing teleology, but a need to accommodate a widespread and non-purposive sense of function in biology (Cummins 1975; Hardcastle 2002). In many contexts, biologists are less concerned with explaining why an entity or trait exists than they are in analyzing the causal role it plays in a biological system (Cummins 1975; Amundson and Lauder 1994).

Briefly put, a causal role (CR) function is the output a system's component produces that contributes to a system-level capacity (Cummins 1975). Take, for example, the function of the heart. The heart is a subcomponent of the cardiovascular system, which circulates oxygen, nutrients and hormones throughout the body. Within this complex system, the heart contributes to circulation by pumping blood. The CR analysis thus says that the function of hearts is to pump blood.

However, referring to *the* function of hearts is slightly misleading. A component's CR function is always assigned relative to a system capacity that biologists are interested in (Hardcastle 2002). As complex systems possess a multitude of capacities, a component can be subject to more than one kind of functional analysis. Biologists can provide a functional analysis of a heart's blood pumping, or they might instead be interested in analyzing the beating noise it makes, its size, or its weight. A system component can be assigned several functions, depending on the interests of researchers.

The CR account is pragmatic in spirit and places few limitations on what natural phenomena biologists can subject to functional analysis. However, it faces two key criticisms.

First, its neglect of teleology means it cannot distinguish between a function and a "fortuitous effect" (Neander 1991). In the realm of artifacts, we think that a vase can be used as a paperweight or a pen-holder, but its *proper* function is to hold flowers. Similarly, goes the intuition, a heart produces a range of effects which are not its proper function. The heart's beating noise, for example, helps doctors diagnose cardiac pathology, but the heart's function is not to make noises.

Second, the CR account struggles to accommodate the normativity of functions (Neander 1991). The kind of functional analysis that the CR account generates describes what a system's component does is, as opposed to what is ought to do. A consequence of this is that biologists cannot say that a heart in cardiac arrest is malfunctioning; rather, it merely lacks the function of pumping blood, in much the same way that it lacks the function of photosynthesizing light or deterring nocturnal predators.

Selected Effect Functions

The Selected Effect (SE) theory aims to naturalize teleology (Millikan 1984; Neander 1991). Recall that functions are teleological when they tell us what something is for: hearts are for pumping blood; chlorophyll is for photosynthesis; etc. According to the SE theory, a thing's function *qua* purpose is determined by facts about its causal history. While in the case of artifacts, the relevant causal history concerns the decisions of a designer; in the case of biological entities, the designer is supplanted by Darwinian processes of natural selection.

SE functions are borne by traits that are *adaptations* – traits that organisms possess because they have given their ancestors a survival advantage. A trait's SE function is whichever of its effects is responsible for this advantage. For example, zebra stripes are thought to deter disease-carrying flies. Some biologists hypothesize that fly-deterrence is what led the striped phenotype to be reproduced over time: historically, zebras with stripes survived to leave more offspring than those without. If this hypothesis is correct, zebra stripes are an adaptation, and their function is to deter flies.

The historical constraint allows the SE analysis to distinguish between functions and accidental benefits (Griffiths 1993). Let's say that as well as their fly-deterrence effect, stripes also camouflage zebras from predators. On the CR account, both effects could be considered a function of the stripes. The SE analysis, in contrast, says that insofar as stripes were only selected because they deter flies, the fly-deterrent effect is their function, and camouflage is merely a "fortuitous effect."

This constraint also enables the SE analysis to deal with normativity (Griffiths 1993). A traits' SE function is not simply one of its current causal capacities, but the one that has produced fitness benefits for members of its ancestral lineage (Garson 2016). This means that an organismic trait can have a function even in cases where it fails to perform it. Thus, we can say that a heart in cardiac arrest malfunctions because it fails to pump blood because pumping blood is the effect for which ancestral hearts were selected.

However, the SE analysis has a more limited scope than the CR account. Exactly how limited depends on how common adaptations are, and there is disagreement over this (Godfrey-Smith 2001). Nevertheless, there are other kinds of traits that biologists wish to subject to functional analysis, including vestiges (traits that are no longer an adaptation), spandrels (traits that were never an adaptation), and non-heritable traits of sterile animals (Hardcastle 2002). Finally, determining a trait's selection history, or whether it was selected at all, can also be very difficult, and for this reason, the SE analysis has been considered over-demanding (Garson 2016).

Fitness-Contribution Functions

The practical problems of studying selection history aside, biologists are often interested in the current fitness of a trait, or the likelihood it will be selected, rather than the selective regime that caused it to be reproduced (Bigelow and Pargetter 1987). While the fitness-contribution (FC) theory defines biological function using the conceptual resources of evolutionary theory, it is forward-looking: the function of a trait is the effect it contributes – or is disposed to contribute – to organismic fitness, regardless of the trait's causal origin (Bigelow and Pargetter 1987).

According to the simplest version of the theory, a trait has a FC function if it is *adaptive:* that is, when it raises the average fitness of organisms who possess it, when compared with those that do not. Take, for example, Darwin's dark peppered moth, which proliferated in polluted urban environments. The moth prevailed because its color, in this context, was adaptive: it enabled it to hide from predators. The FC function of the darker phenotype trait is thus to camouflage moths, because camouflage increases the likelihood that it will survive and reproduce more than moths with a lighter-colored phenotype.

What this example illustrates, however, is that a trait's fitness is environment-dependent. A single trait can have a high average fitness value under one set of environmental conditions, and a low average fitness value under another. While a dark-colored phenotype aided the survival of peppered moths in polluted cities, it was a likely target for predators in the countryside, where lighter moths proliferated. Environment-dependence makes function-attributions unstable, with traits having different functions depending on time and place (Garson 2016).

The Propensity Theory is a version of the FC theory that tries to deal with this by specifying that a trait's function is whatever fitness advantage it is *disposed* to confer on an organism in its "natural habitat" (Bigelow and Pargetter 1987). This means that a trait can in principle have a stable function across environments that are hostile or unfavorable. The task of defining a "natural habitat," however, is unclear and unsettled. Indeed, if the natural habitat is simply the environment in which the trait evolved, then biologists can no longer bracket the trait's history, a key reason for preferring it over the SE account (Garson 2016).

Conclusion

The foregoing analyses can agree, in principle, on what function something has. Hearts can have the function of pumping blood because this effect contributes to circulation (CR), is the product of natural selection processes (SE), or increases the fitness of organisms who possess them (FC).

Even in cases where they agree, however, the three senses of function perform an importantly different explanatory purpose (Godfrey-Smith 1993). The SE function explains why a trait is there, the CR sense of function explains how a component part contributes to a systemic capacity, and the FC explains how a trait contributes to an organism's fitness in a contemporary environment.

The fact that these three senses of biological function are associated with distinct and fecund explanatory projects makes function pluralism, the position that there is more than one legitimate concept of function within biology, a plausible stance (Godfrey-Smith 1993).

Cross-References

- ▶ Adaptation
- ▶ Adaptation and Natural Selection
- ▶ Byproducts of Adaptations
- ▶ Evolutionary History
- ▶ Evolutionary Mismatch
- ▶ Evolutionary Teleology
- ▶ Functional Fixity
- ▶ Function vs. Capability
- ▶ Identifying Adaptive Functions
- ▶ Just So Stories
- ▶ Loss of Adaptations
- ▶ Natural Designs
- ▶ Physiological Mechanisms
- ▶ Proximate Mechanisms

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