Explanation, functional[*]

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Synonyms

Design explanation, ecological explanation, viability explanation

Definition

Functional explanations explain why certain organisms have certain traits rather than some conceivable alternatives by appealing to the advantages for those organisms of having those traits rather than the alternatives.

Characteristics

The term 'functional explanation' is sometimes used in a very wide sense, meaning any explanation in functional biology or even any explanation that refers to functions in any sense of 'function' (function, biological). This essay discusses functional explanations in a narrower sense, namely reasonings that purport to explain why certain organisms have a certain trait by elucidating why that trait is advantageous to or needed by those organisms. An example is the well known explanation of why many organisms have a circulatory system by Nobel Prize winner August Krogh in 1919 (see Krogh 1941). Applying Fick's law of diffusion, Krogh calculated that diffusion (passive transport) is too slow to provide the inner organs with oxygen at the rate needed to stay alive if the distance between the inner cells and the outside is more than 0.5 mm. The presence of a circulatory system solves this problem by providing an additional and faster means of transport. To avoid terminological confusion philosopher Arno Wouters introduced the terms 'viability explanation' (Wouters 1995) and 'design explanation' (e.g. Wouters 2007) to refer to functional explanations in this sense. Behavioral biologists and evolutionary biologists often call them 'ecological explanations'.

Functional explanations are part and parcel of biology, but they are not considered legitimate in other natural sciences such as physics and chemistry. Reductionist and structuralist schools in biology tend to reject functional approaches in biology, because they would rest on illegitimate teleological assumptions. Another worry concerns the possibility to provide evidence for counterfactual claims concerning what would happen if an organism lacked the trait to be explained.

Functional explanations are concerned with the way in which the different traits of a living system (organism) functionally depend on each other. Functional explanations

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point out that because an organism has certain traits (in the example of Krogh: a certain size and a certain level of activity), its ability to maintain the living state would diminish if the trait to be explained (the presence of a circulatory system) were replaced by a specific alternative (no active transport). The explaining traits are functionally dependent on the trait to be explained in the sense that the ability to maintain the living state of an organism with the explaining traits would diminish if the trait to be explained were replaced by the alternative, whereas replacing the trait to be explained would not make much difference if the organism lacked the explaining traits. For example, having a certain size and activity is functionally dependent on the presence of active transport because removal of active transport would diminish the life chances of organisms with that size and activity, whereas the replacement would have little effect on that organism's capacity to maintain itself if were small enough and not very active.

Functional dependence is a synchronic relation at the level of the individual (the size and activity of an organism are dependent on *that* organism having a system of active transport). The relation is not of a causal nature (see causality), but rather a constraint on what can be alive: our universe is such that living systems of a certain size and activity cannot exist without mechanisms for active transport. There may, of course, exist causal relations between the trait to be explained and its dependents (perhaps the transport system was maintained in the lineage because variants with a less well developed transport system were less active and for that reason eliminated by natural selection, or, perhaps, the activity of the developing organism influences the development of a transport system in the course of the ontogeny) but the functional dependence exists independent of the history of the organism and, hence, independent of these causal relations (it would exists also if the same organism arose out of different ontogenetic and evolutionary processes).

Functional explanations not merely identify the traits that are functionally dependent on the trait to be explained, they also account for the dependency itself. This is done by relating the dependency to invariant relations that result from the way the organism is wired and from more general invariant relations that scientists call 'laws'. Such an explanation often introduces a structure of functional dependencies intermediate between the trait to be explained and the dependent traits. For example, the structure of functional dependencies in Krogh's explanation is as follows: (a) the size and the rate of oxygen delivery functionally depend on active transport (follows from Fick's law of diffusion, a well-known law of physical chemistry), (b) the rate of oxygen consumption functionally depends on the rate of oxygen delivery (follows from the obvious invariance that the rate of consumption cannot be higher than the rate of delivery), (c) the rate of activity of the organism functionally depends on the rate of oxygen consumption (follows from a well-established invariant relation (very roughly: the more active the organism, the more oxygen it consumes) that results from the way in which those organisms generate the energy needed for their activities).

Several types of evidence support or undermine claims about the existence of a relation of functional dependence. *Comparisons* provide an important clue. It is necessary that all organisms with the dependent traits have the trait to be explained or a functional equivalent, but the support provided by comparisons for the conclusion that a certain trait is dependent on others is rather weak. *Experimental manipulation* provides better evidence. By producing organisms that are in relevant aspects similar to the real organism, except that the trait to be explained is replaced by an alternative one gets good evidence for the advantageousness of that trait. In order to provide evidence for or against the thesis that the need is due to the presence of the dependent traits, the dependent traits should be modified too. Techniques of genetic manipulation have greatly increased the possibilities to provide this kind of evidence. The *explanation* of a functional dependency on the basis of invariances is strong evidence for the existence of that dependency, provided that both the invariances and the assumptions on which the explanation rests are well established. Finally, the development of *simulation models* in systems biology offers a new and powerful way to provide evidence for or against functional claims because they allow for precise modifications of large numbers of relevant and potentially relevant variables *in silico*.

We can now see that functional explanations do not assume teleology. Functional explanations are concerned with what is needed or advantageous for staying alive, but they do not tell us how the required traits are brought about and, in fact, make no assumptions at all about how or why living systems and their traits come into being. For that very reason, they do not assume that traits are brought about because of their advantages, in order to fit the requirements or because something or someone had a certain goal.

Functional explanations are, nevertheless, crucial to understand life, because they show us how the characteristics of an organism fit into the requirements for being alive. Living systems exist far from thermodynamic equilibrium and can exist only because they are able to maintain themselves actively (that is by using energy). Although there are many ways to stay alive, not all combinations of matter will do. The ability of a system to maintain the living state is critically dependent on its organization, that is on the composition, character and arrangement of its parts and the order and timing of its activities. Causal explanations can tell us how a certain form of organization came into being and how that form of organization brings about the ability to stay alive, but not why certain forms of organization are able to stay alive and others not, nor why certain forms of organization are better in staying alive than others. This is the kind of understanding provided by functional explanations and this is why a combination of functional and causal explanations is needed to understand life (see explanation in biology).

The failure to understand the non-causal nature of functional explanations and the failure to understand how non-causal explanations can contribute to scientific understanding has instigated or strengthened many misconceptions. If it is, erroneously, assumed that all explanations purport to explain how the phenomenon to be explained was brought about, one might easily, but erroneously, take functional explanations as resting on the teleological assumption that traits of organisms are brought about because they perform a certain function. In response to this misconception one might reject functional explanations, erroneously, as illegitimately teleological, as both structuralist and reductionist biologists tend to do, or look for a place for teleology within the Darwinian theory of evolution, as many naturalistic philosophers tend to do. The idea that explanations should explain how the trait to be explained is brought about, might also lie behind the tendency to present the conclusion of functional explanations in evolutionary terms. Several books advertise a functional approach as an evolutionary one and an increasing number of articles presents functional explanations as showing that a certain trait "evolved as an adaptation for" or "was selected for" some advantage, need or dependent trait. This is unfortunate not only because of the teleological odor of this kind of conclusion, but also (and more importantly) because it suggests much more than the evidence allows (claims about selection require evidence about the variants that occur in the population, the occurrence of selection, the heritability of the trait, the structure of the population, and phylogenetic polarity, in addition to evidence about the advantageousness of the trait) (see explanation, evolutionary). It is also unfortunate that this way of presenting functional explanations has led some critics to reject functional explanations as mere speculation, thus ignoring the valid insights provided by functional explanations together with the unsubstantiated evolutionary conclusions drawn from them.

Cross-references

Causality
Constraint
Explanation, evolutionary
Explanation in biology
Function, biological
Teleology

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