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Function and Teleology

Abstract: Teleology is the study of purposes and goals. While humans and other intelligent creatures can act on purposes, are there purposes in nature, too? Biologists often explain the development of organisms, the behavior of plants and animals, and the working of body parts and processes, in terms of their "purposes," "goals," or "functions." This gives rise to a philosophical problem: how can we make sense of teleological language in the life sciences? Important philosophical definitions of "biological function" include the selected effects theory, the goal-contribution theory, and the causal role theory, among others. A related problem is understanding the concept of "goal directedness."

Key words: Teleology; teleonomy; teleological explanation; biological function; goal directedness; selected effects theory; causal role theory; goal-contribution theory

Key concepts:

- Teleology is the study of goals and purposes.
- Teleological language such as "function," "goal," and "purpose" is prevalent in the life sciences.
- Philosophers and scientists disagree about whether teleological language is consistent with modern science and its avoidance of supernatural explanations.
- Philosophers debate the correct definition of "biological function."
- The "selected effects theory" holds that the function of a trait depends on what it was selected for, by natural selection.
- The "goal-contribution theory" holds that a function of a trait depends on its contribution to survival or reproduction.
- The "causal role theory" holds that a trait's function depends on its contribution to some interesting system capacity.
- It's possible that biologists use "function" in multiple senses.
- There are philosophical problems surrounding the concept of goal directedness as well.

Introduction

Teleology is the study of purpose and goals. It derives from the Greek word *telos*, which is usually translated as "goal." Human beings and other intelligent creatures can act on purposes and goals, but are there purposes in nature, too? Do trees, rocks, or the parts of living organisms have purposes or goals? To better understand the debates about teleology, it's helpful to look at the history of teleology in science (Ruse 2018; Allen and Neal 2020).

For Aristotle (382-322 BC), the world was governed not only by prior causes, but by purposes. If one wanted to know why a rock rolled down a hill, it wasn't enough to point out that somebody pushed it and gravity did the rest. One also had to consider its purpose. The purpose or goal of the rock is to reach its natural resting place near the center of things. Aristotle famously distinguished between four different causes of something: its formal cause (the way it's organized), its material cause (the matter of which it's composed), its efficient cause (the forces that propelled it into being) and its final cause (its purpose or end).

For Aristotle, purpose was even more evident in the realm of life than in the non-living realm. It was obvious to him that the purpose of teeth is to help us chew food, and that the purpose of the eye is to see. Specifically, for Aristotle, to state a trait's purpose is to explain why the trait exists at all. Why do people have teeth? Because teeth are good for chewing. Trying to understand why the parts of the body exist without knowing what they're for, for Aristotle, would be like trying to understand why a car has an engine without understanding its purpose.

To explain why something exists by citing its purpose is known as a "teleological explanation." For example, to say that "zebras have stripes because stripes are good at deterring biting flies" is an example of a teleological explanation, since the existence of the trait is explained, in part, by citing one of its useful effects. But this raises a deep question: how can the *purpose* of a trait explain why it exists? How does the fact that stripes are good for deterring biting flies explain why zebras have stripes? Of course, when it comes to a car's engine, there's no problem in understanding how, in stating its purpose (locomotion), you're also explaining why the engine exists. Engines exist because intelligent beings wanted an efficient way to get around, and they knew engines would help them achieve that goal, and so they manufactured them. But do those explanations work for nature? When we say that zebras have stripes because stripes are good at deterring biting flies, are we postulating the existence of a divine creator who made them for that reason? Unfortunately, Aristotle was not entirely clear on what these purposes really were. Did nature's purposes require a mind or intelligence? Or could there be a non-intelligent form of purposiveness? Aristotle scholars still debate this question.

About 1500 years later, the theologian and philosopher Thomas Aquinas (1225-1274) revisited the problem of teleology from a theistic perspective. For Aquinas, purpose in nature ultimately comes from God. The reason that the purpose or function of teeth is to chew is because that's why God made them. For Aquinas, discovering the purpose or function of an organ had important moral implications. For example, he thought it was immoral to use one's reproductive organs in a way that couldn't possibly lead to reproduction, because that contradicts the purpose that God had in mind when he made them. Even today, many scientists disparage "teleology" in the life sciences because they think that *all* talk of purpose and function in nature presupposes theism. Some theorists prefer to use the term "teleology" only for the theistic sense, and "teleonomy" to describe the sort of "quasi-teleology" of nature (Pittendrigh 1958). A major challenge for philosophers today is to examine whether we can understand talk of purpose, function, and goal-directedness in nature without presupposing theism.

Historians of science often write that final causes were abandoned during the scientific revolution. Great thinkers like Francis Bacon (1561-1626), René Descartes (1596-1650) and Galileo (1564-1642) argued that scientists should restrict their study to observable causes of

events rather than to speculate on God's ultimate purposes. But the claim that the scientific revolution dispensed with final causes is a great oversimplification. While it's true that scientists largely abandoned purposes in physics and chemistry, purpose has always occupied a central place in the study of the living world. Biologists routinely ask after the purpose, function, or end of an organ or trait. What's the purpose of the silverfish's wiggling movement? What's the function of zebra stripes? How to best explain the goal directed behavior of ants removing a corpse from a colony? Such language is alive and well in the life sciences.

Such locutions raise a problem not only for scientists, but for philosophers of science. Can we make sense of teleological language in biology – the language of "purpose," "function," and "goal" – in a way that's consistent with modern science and its repudiation of supernatural causes? Or is teleological language always wedded to the supernatural realm? Today, most philosophical discussion of teleology in nature centers specifically on the meaning and validity of the concept of biological function, though some philosophers also write about the related concept of goal directedness.

Understanding what biological functions are isn't just a philosophical puzzle. It has real scientific consequences. For example, geneticists often debate with one another about what proportion of the human genome is functional. Unfortunately, geneticists are unable to answer this question decisively because they don't agree entirely on the definition of "biological function" (Doolittle 2013). Similarly, psychiatrists often find themselves mired in debates about whether a certain cognitive style, such as ADHD, involves a brain dysfunction, or whether it represents normal cognitive functioning in its own right (Swainpoel et al. 2017). These debates impact how we address it as a society, and our willingness to use medication for it. "Restoration ecology" is a branch of ecology that is devoted to restoring damaged ecosystem functions. But what counts as an "ecosystem function?" (Odenbaugh 2010). Is an "ecosystem function" just any ecosystem service that happens to be useful to us? Or do such functions exist independently of their usefulness to people? These questions have important practical implications.

The biological functions debate

The function of the heart is to pump blood. The function of the liver is to detoxify the blood. According to our best current evidence, the function of zebra stripes is to deter biting flies. Sometimes it's hard to say just what the function of a certain trait is, such as the giraffe's long neck, or a certain gene sequence, but the concept of biological function doesn't seem to be particularly difficult to understand.

At closer glance, however, functions have at least three peculiar characteristics. First, a function of a trait isn't just any effect it happens to produce. The function of the heart is to pump blood, not to make beating sounds that you can listen to through a stethoscope, though it does both of those things. Why do we just pick out one or a very few of a trait's effects and call those its "functions?"

Second, anything that has a function is also capable of malfunctioning or being dysfunctional. The fact that the heart is capable of functioning well implies that it is also capable of functioning

poorly. What is it for a trait to dysfunction? There are two related questions: first, what does it mean to say that a trait is dysfunctional? Second, what sorts of evidence do we need to show that a trait is dysfunctional?

A third puzzling feature of function is that, at least in much of ordinary biology, functions are meant to be explanatory. When biologists say that the function of zebra stripes is to deter biting flies, they're generally trying to explain why zebras have stripes (Caro et al 2013). But how can an effect of zebra stripes explain the existence of those very stripes? Put differently, function statements often appear to be teleological explanations. They cite a useful effect of a trait as part of an explanation of that trait's very existence. How can this be so?

In sum, a good philosophical account of biological function should, at the very least, help us understand the difference between functions and side effects, and it should help us understand the difference between function and dysfunction. Ideally, it should also help us understand whether and how function statements are teleological explanations. In the following, I'll survey some of the mainstream approaches to biological function.

The goal-contribution theory of function

Here is one rather obvious point of view: the difference between a function of a trait and mere side effect is that a trait's function helps the organism survive or reproduce. The reason the function of the heart is to pump blood, and not to make beating sounds one can listen to through a stethoscope, is that pumping blood helps creatures with hearts survive. A function of a trait is some benefit that's relevant to survival and reproduction (e.g., Canfield 1964; Boorse 1976; Bigelow and Pargetter 1987; Walsh 1996).

There's an obvious problem for this point of view. Let's suppose that a function of the heart is to pump blood, and not to make beating sounds, because pumping helps us survive. But the fact that hearts make beating sounds that you can listen to through a stethoscope helps us survive too. After all, when doctors listen to your heart through a stethoscope, they can often detect abnormalities and protect you from dying of heart disease. But we usually consider making beating sounds as one of the heart's side effects, not a function. Therefore, the mere fact that a trait does something that occasionally helps us survive isn't sufficient for giving it a function.

Perhaps we should say, instead, that the function of a trait consists in its "typical" contribution to survival or reproduction. A function of the medulla is to regulate breathing because that's how it typically contributes to survival and reproduction. This avoids the problem of the heart and beating sounds, since it's quite unusual for beating sounds to actually help us survive.

This solution raises a new problem, however. We can call it the problem of "atypically performed functions." The medulla typically benefits us by regulating breathing, but occasionally it benefits us by triggering the gag reflex. Most of us would hold that triggering the gag reflex is a function of the medulla, despite the fact that it's only performed atypically. Put differently, whether a trait's effect is a "function" or not doesn't seem to depend entirely on how

typically that effect is performed. Although some think the goal-contribution theory can be modified to avoid that problem, it's worth considering other approaches.

The selected effects theory of function

A second approach to functions is the selected effects theory. According to the selected effects theory, the function of a trait is, roughly, whatever it was selected for by natural selection or some comparable selection process (Millikan 1989; Neander 1991). The reason the function of the heart is to pump blood, rather than to make beating sounds, is that the heart was shaped by evolutionary natural selection to pump blood. From an evolutionary point of view, the fact that it makes beating sounds is a side effect, not a function. It doesn't matter how frequently or infrequently the latter effect happens to benefit us today.

Perhaps the most important virtue of the selected effects theory is it helps us understand how functions can be explanatory. When I say the function of the zebra stripes is to deter biting flies, I'm pointing to some effect of stripes that, in the past and by natural selection, helped striped zebras out-reproduce stripeless zebras. Therefore, by citing the function of stripes, I'm indirectly explaining why zebras today have stripes at all. The selected effects theory makes sense of the teleological character of function statements in a way that's consistent with modern science.

One open question for selected effects theorists is how broadly, or narrowly, to interpret the notion of a selection process (Garson 2019). Is evolutionary natural selection, the kind that takes places over multiple generations, the only kind of selection process that creates new functions? Or can trial-and-error learning, wherein one behavior comes to be retained over another because of its useful effects, be considered a "selection process" that creates functions? What about the sort of "selection process" that takes place when a person deliberately chooses one solution over another because of some imagined benefit? I'll restrict my attention to the evolutionary sort of function.

One problem for the selected effects theory is that it seems too inclusive. It would count vestigial traits as functional, even though by definition they are functionless. Long ago, the appendix was probably selected for aiding digestion. The selected effects theory would imply that it has the function of aiding digestion now, which is false.

Most theorists solve this problem by saying that the sort of selection events that are relevant for function are recent selection events – those that took place in the recent past (Griffiths 1993; Godfrey-Smith 1994). In this view, the appendix does not have the function of aiding digestion because it wasn't recently selected for aiding digestion. Of course, that raises the question of how to decide what counts as recent.

A deeper problem with the selected effects view is that it seems too exclusive. It does not give functions to useful traits on their first appearance in nature. Suppose that a flower beetle is born with a gene mutation that gives it an enhanced immunity to a common pesticide. According to the selected effects theory, that gene mutation, when it first arises, would not have the function of immunity because it hasn't yet been selected for immunity. For some theorists, that seems like a counterintuitive result, and one that runs against how biologists often talk.

The causal role theory of function

A third approach is known as the causal role theory of function (Cummins 1975; Hardcastle 1999; Craver 2001). One prominent version of the theory holds that a trait's function is just an effect by which it contributes to some larger system capacity. In this view, we could say that the function of the stomach is to break down food because that's how it contributes to the body's capacity for digestion. We could also say that the function of the heart is to pump blood because that's how it contributes to the body's capacity for blood circulation.

An obvious problem with the causal role theory is that it is far too inclusive. Pretty much any effect of a trait can count as its "function," since pretty much every effect of a trait contributes to some system capacity or another. One could say that, on the causal role theory, a function of the heart is to go into cardiac arrest, because that's what explains the organism's capacity to die of heart attack. Or one could say that the function of the immune system is to attack its own cells because that's what contributes to the capacity of the system to undergo autoimmune disease.

Causal role theorists generally respond by saying that the function of a trait depends in some way on the goals and interests of the researchers who are in the business of attributing functions. This implies that functions depend, partly, on human mental states. A downside of this approach is that debates in biology about whether something has a function, or what function it has – say, whether the function of the giraffe's long neck is reaching or fighting – aren't entirely settled by objective facts, contrary to how biologists often think about it.

Other views of function and function pluralism

There are other views as well, and each has its own strengths and weaknesses. An emerging view is the organizational theory of function (Mossio et al. 2009). In this view, the function of a part of a system depends on how it contributes to the maintenance of the system as a whole in thereby to its own self maintenance. For example, one would say that the function of the heart is to pump blood because that's how it contributes to the maintenance of the organism and thereby indirectly to its own persistence. One benefit of the organizational view is that it seems to show how function statements can work as teleological explanations. When we attribute a function to a trait, we're saying what the trait does that explains its own continued existence.

Another approach is the modal theory of function (Nanay 2010). It holds that whether an effect of a trait for an individual organism is a function or not depends on whether there's a hypothetical (or counterfactual) scenario on which that particular effect *would* enhance that organism's fitness. For example, suppose Sam the eagle has a broken wing and cannot fly. What would it mean to say that the function of Sam's wing is to fly? It means that there's a possible scenario in which Sam uses his wing to fly, and in that scenario, his fitness is enhanced.

One possibility that many philosophers have considered is that the term "function" doesn't have a single meaning even within biology, but it has different meanings in different contexts. Perhaps

when evolutionary biologists use the term function, they often mean it in the selected effect sense of the term, but that when, say neuroscientists use it, they mean it in the causal role sense of the term. As one might imagine, the question of how many different senses of the term "function" there are in biology, and in which contexts each sense is used, has become fairly controversial among philosophers of science (Sterner and Cusimano 2019). Most philosophers are willing to accept that there probably is some plurality of usages within biology, but they argue about how many different senses there are and in which contexts they're likely to appear.

Goal Directedness

As I noted, there are other aspects of teleology in addition to the functions debate. A second, related, debate, concerns the notion of goal directedness. We often attribute goals to organisms in the living world, in ways that do not seem to presuppose intelligence. We might say that the sunflower is goal directed toward facing the sun, or a bacterium is goal directed toward moving up a food gradient.

One way that goals differ from functions is that we often attribute goals to entire organisms (or other biological systems), but functions only to the parts of organisms. We say that the boa has the *goal* of eating a bird, but that the boa's pit organs have the *function* of detecting infrared radiation that the bird emits. The very idea of goals and goal-directedness seems to be connected far more closely to the idea of intelligence and even consciousness than the idea of functions.

Are these creatures really goal directed, or only goal directed in an "as-if" way? These are questions that a good theory of goal directedness should answer. Unfortunately, while philosophical interest in goal directedness seems to have waned in the 1970s, there are signs of a renewed interest in the topic (Trestman 2012; McShea 2012). Scientists and philosophers are beginning to appreciate anew how deeply the language of goals and goal-directedness is woven into the sciences of life (Okasha 2018; Ball, 2020; Levin & Dennett, 2020).

While it might be tempting for some to dismiss the whole debate about functions and goals as of merely philosophical significance, that would be an error. As I noted above, questions about the meaning (or meanings) of the term function are implicated in specific scientific debates pertaining to genetics, ecology, psychiatry, and other areas. Moreover, thinking philosophically about biological functions leads us to a conceptual problem that lies at the heart of modern science. Does purpose exist in nature?

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