University of Groningen

The logic of functional explanation in biology

Kuipers, Theo A.F.

Published in:
EPRINTS-BOOK-TITLE

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
1986

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Kuipers, T. A. F. (1986). The logic of functional explanation in biology. In *EPRINTS-BOOK-TITLE* (pp. 110-114)

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

THE LOGIC OF FUNCTIONAL EXPLANATION IN BIOLOGY

Theo A. F. Kuipers
University of Groningen

1. Introduction.

After a sketch of the two standard explications of functional explanations (Nagel, Hempel) and a survey of the main objections to them, there will be proposed a totally different explication. First we will present a meaning analysis of specific and general functional statements. Then we reconstruct the biologist's train of thought in the process of producing a functional explanation, with a specific functional statement as the main product.

Lack of space permits only the inclusion of formalized versions of the crucial parts of this paper. It will be clear that many more claims and questions can be stated in a precise, formal way.

We start with three examples of generally accepted (specific) functional statements/explanations: *a.* the function of chlorophyll in plants is to enable them to perform photosynthesis, *b.* the heartbeat in vertebrates has the function of circulating blood through the organism, *c.* the function of the fanning movement by sticklebacks is to supply the eggs with oxygen.

2. Standard explications.

The following schemes give simplified and slightly adapted versions of the explications proposed by Nagel (I) and Hempel (II),¹ respectively. We put MP for 'meaning postulate' and 's-organisms' are organisms of a certain type *s*.

(I)	H(s,y)	s-organisms have (perform/produce) trait (process/phenomenon) y
	N(s,x,y)	trait x of s-organisms is <i>causally necessary</i> for trait y
	MP	if N(s,x,y) then: if H(s,y) then H(s,x)
<hr/>		
	H(s,x)	s-organisms (must) have trait x.
(II)	A(s)	s-organisms function adequately
	A(s) → H(s,y)	trait y is a necessary condition for A(s)
	S(s,x,y)	trait x of s-organisms is <i>causally sufficient</i> for trait y
	MP	if S(s,x,y) then: if H(s,x) then H(s,y)
<hr/>		
	H(s,x)	s-organisms (must) have trait x.

3. Objections to the standard explications.

	I	II
<i>a.</i> No valid argument	—	+
<i>b.</i> no evolutionary-historical (ultimate) component	+	+
<i>c.</i> no explicit role for functional statements	+	+
<i>d.</i> no clear correspondence with research practice	+	+
<i>e.</i> no difference between explanation and prediction	+	—
<i>f.</i> no room for functionally equivalent traits	+	—

Lack of space prevents the elaboration of these objections, but *a, e* and *f* are well-known from the literature, whereas *b, c* and *d* speak for themselves.

4. Towards a non-standard explication.

The *leading intuition* of our explication is that there is a valid argument involved, but that the 'standard conclusion', viz. that s-organisms (must) have trait x in question ($H(s,x)$), is not the proper conclusion. Our *claim* is that our explication captures the kernel of unproblematic examples, leaving room for modifications, complicated cases and new, related 'why- and how-questions'. A *particular modification* should be mentioned already now. In the examples *a* and *b* of Sect. 1 the 'function-trait' (y in our schematizations) is primarily a trait of the organisms, whereas in example *c* it is primarily a trait of the environment (viz. eggs supplied with oxygen). The presentation will sometimes presuppose the first type of function-traits, claiming in general that the necessary modifications to include also the second type are not difficult to imagine.

Our explication consists of two steps: meaning analysis, followed by a reconstruction of the biologist's train of thought.

5.1. Meaning analysis of specific functional statements.

Consider a specific functional statement (a specific f.s.) of the form:

$FH(s,x,y)$: the (or one) function of trait x of s-organisms is to contribute to trait (process/phenomenon) y (assuming $x \neq y$ throughout).

As a first approximation we propose the following meaning postulate

$$(1) \quad FH(s,x,y) \underset{MP}{\approx} H(s,x) \ \& \ H(s,y) \ \& \ P(s,x,y) \ \& \ P(s,y,\omega)$$

where the following abbreviations are used:

$H(s,\alpha)$	:s-organisms have (perform/produce) trait (process/phenomenon) α ,
$P(s,\alpha,\beta)$	:trait α of s-organisms is a positive causal factor for trait β ,
ω	:reproduction and survival.

Remarks: *a.* Besides the *two descriptive components* there are *two causal-nomological components*. Of the latter, assuming $y \neq \omega$, the first one, i.e. $P(s,x,y)$, may be called *the proximate component*, the second one, i.e. $P(s,y,\omega)$, *the ultimate component*. *b.* The ultimate component, telling that y is a positive causal factor for reproduction and survival, corresponds of course to what biologists call, in terms of the theory of evolution, (positive) *adaptive* or *survival value*. More specifically, the claim of the theory of evolution is that, as a rule, x became a trait of s-organisms due to selection along the lines suggested by the combination of the ultimate and proximate component. *c.* There arise two types of specific functional statements: if $y \neq \omega$, $FH(s,x,y)$ is called a proximate f.s. and $FH(s,x,\omega)$ is called an ultimate f.s. *d.* Assuming that $H(s,\omega)$ and $P(s,\omega,\omega)$ are both tautological and that $P(s,\alpha,\beta)$ is transitive, it is easy to derive that a proximate f.s. implies both corresponding ultimate ones. *e.* Our proposal (1) can be seen as a modified version of the, mutually distinct, proposals of Ruse and Van der Steen.²

5.2. Meaning analysis of general functional statements.

Consider now the general f.s.

$FH(s,x)$: trait x of s-organisms is functional.

The following meaning postulate seems inevitable:

$$(2) \quad FH(s,x) \underset{MP}{\approx} (\exists \gamma) FH(s,x,\gamma)$$

Remarks: *a.* ' $(\exists \gamma)$ ' represents the existential quantifier 'there is a γ such that'. *b.* It is

easy to check that $FH(s,x)$ now implies $FH(s,x,\omega)$, i.e. that x is ultimately functional. c. Moreover, it is clear that it is possible that x is ultimately functional, but not proximately. That plovers have a stable clutch-size of 4 (in their present type of environment) provides an example.

6.1. Train of thoughts in a functional explanation

1	Verified descriptive statement	$H(s,x) !$	}	heuristic phase	}	synthetic part FUNCTIONAL SPECIFICATION
2	question	Why $H(s,x) ?$				
3	general f.s. as hypothesis	$FH(s,x) ?$				
4	specific f.s. as hypothesis	$FH(s,x,y) ?$	}	test phase		
		i.e. by (1):				
	descriptive hypothesis	$H(s,y) ?$				
	proximate causal-nom. hyp.	$P(s,x,y) ?$				
	ultimate causal-nom. hyp.	$P(s,y,\omega) ?$	}	deduction phase	}	analytic part FUNCTIONAL GENERALIZATION
5.1	falsification, back to 3	not- $FH(s,x,y) !$				
5.2	or verification, hence answer	or				
	verified specific f.s.,	$FH(s,x,y) !$				
	hence, first, as a side-step	by (2) and EG				
6	verified general f.s.	$FH(s,x) !$				
	and then to					
7	new, related questions, see below.					

Remarks: a. 'EG' stands of course for the undisputed logical rule of inference called 'Existential Generalization'. b. The scheme is designed for *proximate functional explanations*, i.e. $y \neq \omega$; it can be simplified somewhat for an *ultimate functional explanation*, i.e. $y = \omega$. c. Our claim is of course that the *process* of producing a functional explanation is characterized by the above scheme, and that *the main product* is the corresponding specific (proximate or ultimate) functional statement; an interesting *by-product* is the valid implication of the corresponding general functional statement, it explains the philosopher's conviction that there is, in some way or other, a valid argument involved. d. The train of thoughts is, due to step 4, essentially hypothetic-deductive, although not of the standard nomological form.

6.2 New, related why- and how-questions.

After a successful functional explanation there arise, as indicated in step 7, new, related questions. In particular, given a proximate functional explanation in terms of $FH(s,x,y)$, it is natural to ask: a. Why have s-organisms trait y ? b. Is y the only function of x for s-organisms? c. Why do s-organisms not have the functional equivalent trait x' , instead of x ? d. How do the proximate and ultimate causal-nomological components come true, i.e. what are the mechanisms involved, are they directively organized? e. Did x indeed evolve along the suggested evolutionary lines?

In case of an ultimate functional explanation, the questions c., d. and e. apply also to some extent, but the primary question is now of course: f. Is it also possible to give a proximate functional explanation? As suggested already, at the end of Sect. 5, this need not be true, as e.g. in the case of the plover's clutch-size.

6.3. Principle of functionality.

It is plausible to formulate the principle:

PF All (common) traits of organisms of a certain type are functional (at least ultimately). It is clear that PF, taken as descriptive generalization, is false. Counterexamples are well-known: vestigial or rudimentary traits (such as tonsils, appendix, etc.) are by definition no

longer functional, though they were functional in an earlier stage of development or a former environment. Moreover, there are traits that are no more than causal by-products of functional traits, e.g. the heart sounds caused by the heartbeat. Hence, PF is to be considered as a methodological and heuristic principle, leaving room for expectations.

7. *Objections reconsidered.*

It is easy to check that the objections raised against the standard explications (see Sect. 3) do not apply to our explication. In particular: *Ad. a.* There is a valid argument involved; however, $H(s,x)$ is not the conclusion, but $FH(s,x)$; $H(s,x)$ is an explicit premise, in view of (1), hence a trivial conclusion, even implied by $FH(s,x)$. *Ad. b.* There is a straightforward evolutionary-historical component, viz. $P(s,y,\omega)$, without troublesome 'effects as causes'. *Ad. c.* Functional statements, specific and general ones, play an explicit role. *Ad. d.* The scheme in Sect. 6.1. corresponds essentially to the practice of biologists in functional research. *Ad. e.* There is no prediction claim with respect to $H(s,x)$, hence there is an essential asymmetry between the prediction and the (functional) explanation of $H(s,x)$. It is important to note that there are nevertheless two fundamental prediction claims involved, viz. in the two causal-nomological components. *Ad. f.* In case of a proximate functional explanation there is room for the conceptual possibility of functionally equivalent traits.

8. *Concluding remarks.*

As far as it is justified to talk about biological natural kinds, it is possible to interpret the explication as dealing with functional explanation of natural kind laws.

More detailed or modified explications can of course be developed, without changing the general set-up.

Our claims are restricted to biology, but it will be worthwhile to try to modify our proposal such that it becomes adequate for functional explanation in sociology, psychology and economics. On the other hand, this will not be easily possible for minimality-explanations in physics, e.g. in terms of shortest distance, for such explanations seem to lack something like an ultimate component.

Elsewhere³ we have given a related explication of intentional explanations, and there we 'predicted' the possibility of the present paper: intentional and functional explanations have the same logical structure, the crucial difference is the meaning decomposition of specific intentional and functional statements, respectively.

In general, there are in our opinion *two main types of explanation: explanation by subsumption* (under a law or theory), as it occurs in natural *and* social sciences, and *explanation by specification* (intentional, functional or otherwise).

One of our next hypotheses is that there is also some overlap, viz. causal explanations (of a specific kind): they can be seen as explanations by subsumption under a causal law (in a strict sense of this term) *or* as explanations by causal specification.

However this may be, it seems to be that explanation by subsumption is, in principle, always possible, but not always interesting. On the other hand, explanation by (some type of) specification is not always possible, but it is, as long as we are not familiar with the answer, always interesting.⁴

ENDNOTES

- ¹ Nagel, E., *The structure of science* (London 1961), p. 403. C. Hempel, *Aspects of scientific explanation* (New York 1965), p. 309–310. For a recent treatment along the standard lines, see the very stimulating book of A. Rosenberg, *The structure of biological science* (Cambridge 1985), Ch. 3.
- ² Ruse, M., *The philosophy of biology* (London 1973), p. 186. W. v. d. Steen, *Algemene methodologie voor biologen* (Utrecht-Antwerpen 1982), p. 71.
- ³ Kuipers, T., “The logic of intentional explanation” *Communication and Cognition* Vol. 18.1/2 (1985). (I would no longer defend the third objection, p. 180.)
- ⁴ I like to thank in particular Rick Looijen and Sjaak Swart for their very useful comments.

* * *