THESIS

PROLIFERATIVE ETIOLOGICAL FUNCTIONS IN BIOLOGICAL SYSTEMS

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ABSTRACT

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This work will examine functional conceptions in biology, and argue that problems arise when etiological accounts of function are applied to traits contained within a biological system. In the first chapter, prominent analyses of functional language will be examined, with a special interest paid to etiological analyses of biological functions. The second chapter will pose a problem for these etiological analyses that arises out of an aspect of functional traits in biological contexts: functional traits are often nested within containing systems, and etiological analyses of function seem to ascribe the functions of the parts of systems to those systems themselves. There is thus a proliferation of functions at a systemic level as the functions of the components contained within a system are ascribed to the systems that contain them. Furthermore, this proliferation seems to ascribe contradictory functions to systems, and makes more confusing the distinction between the "functions in" a system and the "functions of" a system. The final chapter will examine three possible solutions to this problem: one solution will attempt to prevent the ascription of functions to systems by carefully interpreting what it means to "cause" a system, one will attempt to ground functions in actual influences entities have on their own replication and proliferation, and the final one will reframe the etiological analyses of functions as a specific sort of explanatory project in line with dispositional analyses.

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CHAPTER 1

INTRODUCTION

In the 1950s, an immunologist named Bruce Glick noticed an interesting relationship between the immune systems of chickens and a small fluid-filled sack just above the birds' cloaca. This small chunk of skin and lymphoid tissue had first been described by the Italian surgeon and anatomist Hieronymus Fabricius all the way back in 1621, and had been named the bursa of Fabricius in his honor, though little honor came from the coronation: the small chunk of tissue remained an obscure anatomical and zoological curiosity for over four centuries before Glick and his colleagues noticed that the tissue seemed to play an important role in the bird's ability to generate antibodies. Birds who had had this organ removed early in their lives lost the ability to produce normal antibody responses to pathogens: when injected with *Staphylococcus* bacteria, the amount of antibody in the blood of the resected birds would barely rise above pre-infection levels, and they fought off infection far less effectively than birds who had not undergone the removal of the tissue. Over the course of several years, Glick and his colleagues eventually determined that the bursa of Fabricius was a site of immune cell maturation in birds: certain white blood cells would develop and mature in the lymphatic tissue of the bursa and through this development and maturation the cells would acquire the ability to generate specific responses to pathogens.[1]

It seems clear that Glick and others discovered something when they determined the role that this small organ played in immune cell development, in spite of the fact that the physical

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[1] D. Ribatti et al, "The contribution of Bruce Glick to the definition of the role played by the bursa of Fabricius in the development of the B cell lineage," *Clinical Experimental Immunology*, 145(1) (2006): 1-4.

organ was discovered and described three centuries earlier. For the first time, Glick's discovery made it possible to articulate what the bursa of Fabricius *did*, or maybe what the organ was *for*. Alternatively, a might say that Glick and his colleagues discovered the bursa of Fabricius's *purpose*, or perhaps that they discovered the reasons behind *why it was there*.

Biology differs from chemistry and physics in its routine employment of functional language, and the role that functions play in biological discovery, the nature of biological explanation, and the understandings that we have of biological systems as goal-directed or purposeful entities. The traits and systems of living things are described and explained by referring to what they do: hearts pump blood, nocioreceptors generate neural impulses in response to noxious stimuli, and immune systems protect organisms from infection. Yet functions are not merely actions: hearts and nocioreceptors and immune systems do many things and perform many actions that are not their functions. Rather, functions seem to be a special category of biological actions or processes, a category that seems to be closely tied to what an entity's purpose is in a biological system.[2]

Functional language is an odd feature of biology's scientific argot. The use of functional language is common in the social sciences, applied fields like engineering, and fields like psychology and ecology. However, biology is unique in that it is one of the few 'natural' sciences that so regularly and pervasively speaks in these purposeful terms: chemists do not speak about what boron is for, nor do physicists seek to determine what gravity's purpose is. Outside of appeals to metaphor, physics and chemistry eschew "function-talk:" purposes in these natural sciences are seen as spooky, and as departures from the norms that place physical laws

[2] Alternatively, one might speak of what a biological trait is supposed to do, or perhaps what it *did* or what its purpose *was*, depending on where one stands on philosophical issues in biological description and explanation. Peter Achinstein, *The Nature of Explanation,* (New York: Oxford University Press, 1983): 272-278.

and observational language at the center of the scientific project. The fact that functions seem appropriate in one scientific enterprise and not others seems philosophically interesting, especially since those who make recourse to functional language generally recognize that functional entities are constituted by chemical elements and physical interactions. Furthermore, as the case of Glick and company demonstrates, functions seem to be the sort of thing that can be *discovered*, in much the same way that a physical law and chemical element is discovered.

Curiously, our use of functional language in biology most closely mirrors the language we use to refer to human-designed artifacts. The traits of such artifacts are often described in purposeful terms: the function of the windshield wipers' blade is to clear the windshield of water because the blade was designed to clear water from windshields; likewise the purpose of the claw on a hammer is to pull nails because its shape and orientation makes it an effective nail-puller. [3] Such descriptions appeal to certain events that surrounded the artifact's design, or to certain roles that the artifact can perform, or—in cases of things that function poorly—the roles that they were thought to be capable of performing by the person who designed them. In other words, human-designed artifacts are attributed functions based on an appeal to what those artifacts *were designed to do*.

Articulating what an artifact was designed to do is, from a philosophical standpoint, relatively straightforward: a person has a certain belief that a thing, fashioned in a certain way, can perform a certain task, and determining the function to the artifact is a matter of determining the intention of the designer. Yet if the functions of artifacts can be defined by appealing to the

[3] Two different types of artificatual function are being referred two in these two separate examples: the windshield wiper case can be understood as an invocation of the wipers' *design* function, while the claw's usefulness as a nail-puller can be seen as a reference to use function or service function, in the way in which the above example is phrased. None of these categories should be understood as being exclusive of one another, and the claw of a hammer does indeed possess a design function identical to the use/service function stated above. See Peter Achinstein, *The Nature of Explanation*, (New York: Oxford University Press, 1983): 272-278.

intentions or mental states of their designers, this does little to lessen the mysterious nature of functional language in the biological sciences.[4] Biological traits and biological systems are not the sort of things that are intentionally designed, and they are only rarely the sorts of things that are intentionally used. If the features of the functional language are similar, it seems that the methods by which biological entities come to possess functions will be dramatically different. Thus the puzzle arises: what does it mean to refer to the function of a biological trait or system? What does a biologist mean when they speak about the function of the heart, or the purpose of nocioreceptors, or the role of the thymus in lymphocyte development?

APPROACHES TO (AND CRITERIA FOR) FUNCTIONAL ASCRIPTION

These questions turn out to be surprisingly difficult to answer, and philosophers of biology have yet to agree on a unified solution to the problem. Nonetheless, developments in the second half of the twentieth century have given rise to two major approaches to understanding functional ascription in the biological sciences. The first approach seeks to ground functions to the causal history of biological entities, and to account for the purposes and roles that we attach to those biological entities in the circumstances that brought about their presence. These approaches are known as "etiological" approaches, for their method of arriving at functional claims makes appeal to the causes (almost exclusively interpreted as the evolutionary causes) of the trait or system that possesses the function.[5] This approach has gained widespread acceptance

[4] Peter McLaughlin, *What Functions Explain: Functional Explanations and Self-Reproducing Systems* (New York: Cambridge University Press, 2007): 46

[5] "Trait" can mean either an attribute, property or characteristic, or it can refer to a genetically-determined biological characteristic (i.e. "phenotypic trait"). It seems that this later definition is encompassed in the former, and biological-characteristic traits are attribute-property traits, although whether or not this is actually the case is a question that will not be investigated here. For the purposes of this paper, the word "trait" will refer to this more expansive definition of the term and not the narrow genetic definition. Furthermore, whether or not biological systems are traits (rather than something that arises out of traits) will not be assumed, and the term 'trait or system' will be used when discussing functions in general terms.

and is quite promising, and as we shall see its various formulations possess features that allow for stable and seemingly precise function ascription. They may even allow for an understanding of biological functions that interprets them not as scientific concepts but as naturally existing things: etiological functions may be articulated in such a way that functions can be understood as being ‘out there,’ existing in the natural world prior to, and independent of, our ascription or articulation of them.

In contrast to etiological theories, dispositional approaches seek to root our functional ascriptions in appeals that do not go beyond present-day circumstances, the dispositions of traits and systems, and a specific explanatory project. Understanding function, by these accounts, is not done by looking into evolutionary history: assigning functions is essentially an explanatory exercise that examines the present-day capacities and dispositions of the components of a complex system, and uses these capacities and dispositions in order to explain the properties of the systems that contain them. Unlike etiological approaches, this more complex dispositional approach to biological functions does not require any appeal to the evolutionary past, nor is it constrained by the historical circumstances under which certain traits and systems emerged. To this extent, it seems to accord with certain intuitions we have about functional language, and about how the history of a thing seems ancillary to (though often correlated with) its function: one does not often think about the history of the hammer when describing its functions, after all. This accommodation of intuition comes at a price, for unmooring a functional ascription from historical circumstance can lead to difficulty about how functions are to be assigned to traits in a consistent and appropriate manner. Functions do not appear to be trivial, nor do they seem to be dependent only on our explanatory projects, and accommodating *this* aspect of function becomes much more difficult if the etiological approach is abandoned.

Both of these approaches have their partisans and have successfully addressed some of the philosophical problems surrounding functional ascription. Despite this earned place in the philosophical examination of functional concepts, however, neither has yet produced a complete solution to the problems and puzzles of function. Nonetheless, each view satisfies a couple of criteria that are thought to be essential to how biological functions ought to be conceived and how they are to be properly assigned or recognized.

First of all, functions are ascribed to traits and systems even when particular instances (or 'tokens') of those traits or systems do not in fact end up performing the functions that are ascribed to them. The heart's function is to pump blood, and this functional ascription seems to obtain even in cases when the heart does not actually pump. If an organism is born with a non-functioning or malfunctioning heart, the functions ascribed to that particular organ do not change. Indeed, in cases where a defective heart fails to pump, the organ is said to be "malfunctioning" or "dysfunctional," terms which imply a function.[6] Thus, a successful account of functions must provide a method of ascription that is based on more than merely the observed effects or consequences of some particular trait or system.

Along with this first criterion, accounts must allow for a principled distinction to be made between functions and 'accidents.' In vertebrates the heart's function is to pump blood, but there are many things the heart does besides pump blood: it makes heart sounds, it gives off electrical signals that are detected by the sensors attached to an electrocardiogram, it converts glucose into carbon dioxide and water, and so forth. These abilities to make noise, to generate electrical signals, and to burn glucose are properties of the heart, and they are all activities of the heart, but

[6] Ruth Garrett Millikan, *Language, Thought, and Other Biological Categories: New Foundations for Realism.* (London: MIT Press, 1980): 29.

it does not follow that they are thus functions of the heart: there seems to be more to having a function than the possession of some property, capacity, or activity.[7]

Finally, functions are "forward looking:" they impart an aspect of purpose on the things to which they are ascribed, in the sense that they describe a thing in terms of what it is there for, or what end the functioning thing is directed towards. How, exactly, this forward-looking aspect of functions is interpreted varies greatly depending on the view, but analyses of biological function have to accommodate and be capable of describing and explaining the means by which this purposeful or teleological aspect of our function conceptions is established.[8]

THE ETIOLOGICAL VIEW AND WRIGHT'S BI-CONDITIONAL

While biological entities are not the sorts of things that are designed, an examination of the parallels between artifacts and traits can nonetheless provide a starting point for functional articulation. Ascribing functions to artifacts involves appealing to the events surrounding the artifact's creation: a designer produces an item in the belief that the particular item will be useful for achieving some desired result, and this belief serves as means of ascribing that particular function to that object.[9] The means by which an artifact comes to possess a function is through an appeal to a causal-historical 'story' that invokes the circumstances that led to the creating of the function-bearer.

Analogously, accounts of biological function can be developed which incorporate stories about the causal histories of biological things. The approach will obviously need to be adjusted,

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[7] Larry Wright, "Functions." *The Philosophical Review*, 82(2) (1973): 142, and Collin Allen, Marc Bekoff, George Lauder, *Nature's Purposes* (Cambridge: The MIT Press, 1998): 1-3.

[8] Kenneth Schaffner, *Discovery and Explanation in Biology and Medicine* (Chicago: University of Chicago Press, 1993): 406.

[9] Richard Sorabji, "Function." *Philosophical Quarterly* (14(57), 1964): 291-302

for appeals cannot be made to the mental states of designers, and concepts like ‘usefulness’ and ‘desirability’ will need to be reformulated in such a way that they do not refer to the mental states of an agent. Yet the relationship between virtues like usefulness and desirability to a designer and fitness, survivability and fecundity to the forces of natural selection are analogous: just as increased usefulness and desirable outcomes drive the creation of functional artifacts, increases in fitness conferred by certain biological traits enable the continued perpetuation of the types of traits in progeny.[10] Thus accounts that seek to ground functions in the historical factors that brought functional entities about will substitute the desires of a designer with beneficial adaptations and evolutionary fitness.[11]

The limitations of the correspondence between the functions of intentional designs and those that arise from the design-like mechanisms of natural selection should be recognized. Intentional design is an explicitly forward-looking process: a designer anticipates a required function, and designs something capable of performing that function. Natural selective forces, in contrast, are backward-looking: ‘tokens’ of traits are passed on because they served a useful function in the past. Furthermore, natural selection lacks the clarity of an artifact’s functional ascription, for reference to natural selection is not an appeal to a singular creative event, but to a drawn out incremental history.[12]

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[10] These close parallels between natural selective pressures and conscious design have been commented on in several treatments of functional description and explanation in biological contexts. See Philip Kitcher, “Function and Design,” *Nature’s Purposes: Analysis of Function and Design in Biology*, ed. Collin Allen et al. (Cambridge: The MIT Press, 1998): 480-492.

[11] Peter McLaughlin, *What Functions Explain: Functional Explanations and Self-Reproducing Systems* (New York: Cambridge University Press, 2007): 84

[12]Ernst Nagel, “Teleology Revisited.” *Nature’s Purposes: Analysis of Function and Design in Biology*, ed. Collin Allen et al. (Cambridge: The MIT Press, 1998): 224.

The goal of an etiological analysis is thus to capture the functional aspects of biological entities by appealing to the causal-historical accounts of how these entities came to be, but in a way that doesn't appeal to a designer's beliefs or to forward-looking notions of usefulness. The most important an influential attempt at this sort of solution was published in 1973 by Larry Wright. Wright's paper, simply titled *Functions*, begins by noting the ties between our concept of function and goal-direction: when we attribute a function Y to some trait X we oftentimes attach, either explicitly or implicitly, to this attribution a claim that "X is there *in order to* do Y." In our everyday uses of functional language, the relationship between function and purpose is oftentimes quite straightforward. If a police officer in the middle of an intersection is functioning as a traffic director, for example, we understand that assigning the police officer this function implies that she is there *in order to* direct traffic.

Functions, Wright points out, oftentimes imply goals or goal-directed behaviors. The traffic-directing police officer has goals that derive from her function: she is to keep traffic flowing smoothly, to prevent traffic congestion and accidents, and so forth. This implied goal-direction is present in cases of functional artifacts and objects as well as in cases with people, though the objects themselves do not have goals in any sort of conscious or intentional way. "The traffic signal is there in order to direct traffic" is a statement that provides the traffic signal a functional description (that of a "traffic-directing device") from the associated goals that the signal has of relieving congestion and preventing accidents. Furthermore, this formulation is not substantively different from the functional language used to describe the police officer, despite the fact that one is an artifact engaging in a goal-directed behavior and the other is an agent engaging in similar behavior.

This connection between goals and functions does not hold in every case, however. Goal-directedness is only a predicate of behavior: when one speaks of traffic police or traffic signals as having goals, this implies that the actions undertaken by the officer or the traffic light are in accordance with such goals. Yet there are many functional entities that do not "behave," as Wright points out. Chairs and windpipes have functions, yet they are not the sorts of things that display goal-directedness.[13] Nor are all functional behaviors goal-directed (blinking one's eye seems to have a biological function, but need not be done in the pursuit of any goal), and even when functional behaviors possess goals, they oftentimes will vary from each other. A bluebird who builds a nest engages in a goal-directed behavior (the behavior of nest building), but the function of that behavior (creating an environment that is suitable for the incubation of eggs and the nursing of offspring) is distinct from the goal.

Despite these differences, there is something to the connection between goal-direction and functional description: a specific sort of explanatory power is imparted by functional descriptions onto the traits that they are attached to. Such descriptions act as answers to certain "why" questions about the traits they're describing: to state something's function is to state some goal that the thing has or an end-state that the thing works towards, and this goal or end-state serves as an explanation for why the particular thing is there. The question "why is that police officer in the middle of the intersection?" can be answered by appealing to the goal the officer has ("the police officer is there in order to direct traffic") or by a functional description of a police officer ("the police officer is directing traffic"). According to Wright, to say that the

[13] The processes that led to the production of chair or windpipes may well have had aspects of goal-directedness, but this should not be conflated with the objects themselves. Larry Wright, "Functions," *The Philosophical Review*, 82(2) (1973): 140.

function of X is to Y is to say that X's doing Y is *why* X is there in the manner and configuration it is.[14]

The relationships between explanations for why a particular thing is there and the goal it seeks are compelling, but while the goals of functional entities act as explanations for the presence of the entities, the explanations that we have for the presence of those entities will not always refer to particular functions. Wright gives an example of oxygen in the bloodstream: when describing the metabolic processes of aerobic organisms, atmospheric oxygen is assigned a function: oxygen functions as the terminal electron acceptor in the series of oxygenation reactions that produce the energy that drives cellular processes. In this analysis, the function of oxygen in the body is to act as an electron acceptor, or (perhaps more broadly) to enable the production of energy.

However, there are other explanations for the oxygen's presence in the bloodstream of aerobic organisms besides its functional explanation. Hemoglobin proteins bind to the atmospheric oxygen in the lungs or gills and then transport it throughout the body. In this particular system, there are two different causal explanations for the presence of oxygen in the organism. One account says that the oxygen is present in order to accept electrons in energy-generating reactions; the oxygen is there because it will be the final electron acceptor in the oxidation reaction chain. This account seems to fit nicely with the function that we normally take oxygen to have in aerobic organisms, and provides reason to believe that there is a connection between the causes of a trait's presence and that trait's function. However, there is an alternative

[14] One may also say that Y is the *reason* that X is there, or that X is there *because* it does Y. No matter how precisely this is phrased, the explanatory goal is the same: the presence of X is explained by appealing to some particular effect or product produced by X, or by appealing to a goal that X is directed towards. Larry Wright, "Functions," *The Philosophical Review*, 82(2) (1973): 156-157.

causal account for oxygen's presence in the bloodstream: the oxygen is there because it bound to hemoglobin molecules.[15]

Recall that one of the criteria for a successful account of functional language is the ability to differentiate between functions and accidents in a principled way: functions are a special class of actions, capacities, or dispositions. Yet defining functions as explanations for why something is there does not do enough to separate functions from accidents. Both energy production and hemoglobin binding explain oxygen's presence in the bloodstream. Despite this, one account seems to be in line with the actual functional description of oxygen in aerobic organisms, while the other seems like more of an accidental aspect of how the element happened to get into the bloodstream of aerobic organisms.

An additional criterion is needed in order to exclude the non-relevant causal factors that contribute to the presence of a trait from functional ascription. This second criterion, Wright argues, is another relationship between functions and the traits that possess them: the functions of a trait are direct *consequences* of that trait's being present. In legitimate functional ascriptions, the function is being brought about by the trait that possesses it; the trait is an efficient cause of the function that it possesses.[16] Thus the function of oxygen in the bloodstream is to accept electrons in energy producing reactions, because the function that oxygen has (the enabling of energy producing reactions) are directly brought about by the presence of that oxygen (along with the other cellular machinery responsible for metabolism). However, oxygen's presence in the bloodstream is not an efficient cause of hemoglobin binding: in fact, the bonds between

[15] Larry Wright, "Functions," *The Philosophical Review,* 82(2) (1973): 159.

[16] Peter McLaughlin, *What Functions Explain: Functional Explanations and Self-Reproducing Systems* (New York: Cambridge University Press, 2007): 96.

hemoglobin and oxygen get weaker once red blood cells exit the lungs or gills and travel into the more poorly oxygenated regions of the bloodstream.[17]

This consequential aspect of functions allows Wright to make a distinction between functions and mere accidents while still preserving the causal-explanatory aspect of functional language. By paring away all causal explanations for the presence of traits that are not responsible for the presence of the functions they're assigned, Wright is able to eliminate many inappropriate causal-explanatory accounts from functional candidacy. By combining these two criteria, Wright arrives at an elegant bi-conditional definition of the concept of a function:

To say that the function of X is Y means that:

(a) X is there because it does Y
(b) Y is a consequence (or a result) of X's being there[18]

Note that the consequential (or feedback) criterion is expressed by condition (a), and the etiological explanatory condition remains present in Wright's definition in condition (b). While etiological formulations that are specific to biology will require a more detailed formulation beyond Wright's basic criteria, these two requirements for assigning functions to traits will recur throughout the various articulations of etiological functional accounts.[19]

[17]Hemoglobin, however, does have the function of transporting oxygen in the bloodstream because (in part) oxygen's presence in the blood is directly brought about by hemoglobin. Thus, the efficient causal relationship between functions and traits is asymmetrical: hemoglobin directly brings about oxygen's presence in the bloodstream, but oxygen does not directly bring about hemoglobin. David Nelson and Michael Cox, *Principles of Biochemistry 5th Ed.* (New York: W.H Freeman, 2008): 158-159.

[18] This second conditional is sometimes paraphrased as "Y is there because of X;" in such a case this 'because' is expressing an efficient causal relationship, rather than the looser, more general "because" that Wright employs in his first conditional. The two different notions of 'because' so closely paired is confusing and ambiguous in a way that Wright himself avoids (Peter McLaughlin, *What Functions Explain: Functional Explanations and Self-Reproducing Systems* (New York: Cambridge University Press, 2007): 96).

[19]Larry Wright, "Functions." *The Philosophical Review*, 82(2) (1973): 161. These terms are often referred to as the feedback term and the dispositional term, respectively (Peter McLaughlin, *What Functions Explain: Functional Explanations and Self-Reproducing Systems* (New York: Cambridge University Press, 2007): 96).

Unpacking this bi-conditional formulation can help reveal the nuances of Wright's functional account and reveal what his interpretation of functions carries with it. In keeping with the criteria that accounts of functional ascription are attempting to satisfy, the conditions should not be read as empirical claims about the particular thing 'X' or its particular function 'Y.' Candidates for functional ascription do not need to actually perform an action Y in order to be assigned the function Y. Making condition (a) into a claim about X's successfully accomplishing Y is to turn functions into a success term, which in turn eliminates malfunctioning or dysfunctional traits from functional ascription. This requirement is not in line with our everyday conceptions of functions, and thus it's an interpretation that Wright is seeking to avoid.[20]

Furthermore, turning condition (a) into an empirical claim seems to necessitate that the X mentioned in (a) actually exist, and that these existing things have been observed doing something Y. Such existential claims which would seemingly prohibit functional ascriptions in a large number of seemingly conventional cases: engineers assign and discuss the functions of a cables on a space elevator, and it seems inappropriate to deny them recourse to functional descriptions of such cables merely because they have yet to build the elevator to which they are attached. Furthermore, we do not need to build the elevators in order to learn the functions of the components; these functions can be ascertained beforehand. More importantly for cases of biological functions, certain mental processes or diffuse biological systems may have functions that elude direct examination of successful performance, yet Wright's account wants to provide an account within which such functional attributions can be made.[21]

[20] Larry Wright, "Functions," *The Philosophical Review*, 82(2) (1973): 157-158.

[21] *Ibid,* 160 (footnote 19).

Instead, “X is there because it does Y,” should be read as a dispositional claim rather than an empirical claim. To say that X has the disposition to do Y is to make a claim that things like X (or suitably close to X in the relevant respects and under the relevant conditions) have a tendency-or would have a tendency-to do Y in certain conditions or circumstances, even if those circumstances are not presently manifested.[22] When it is said that the function of the heart is to pump blood, it is taken to mean something like ‘various hearts, across a wide (though not exhaustive) range of circumstances, have a tendency to pump blood through the various circulatory systems of which they are a part, when the surrounding conditions are within relatively normal ranges.’[23] Via this dispositional account, it becomes possible to differentiate functions from mere description: functional claims are not about what things do, but about what they *tend* to do, in certain conditions.

Furthermore, as mentioned previously, the “because” needn’t be interpreted in a particularly strict sense: Wright is not saying that X needs to be *directly* causally responsible for some Y in an efficient sense; rather, the causal relationship Wright has in mind is “the ordinary, conversational, causal-explanatory sense”[24] of the word. This allows functional descriptions such as “oxygen’s function is to enable energy production in cells” despite the fact that direct causal responsibility for energy production is far more complex.

> “Because” is, of course, to be understood in its explanatory rather than evidential sense. It is not the “because” in, “It is hot because it is red.” More important, “because” is taken (as it ordinarily is anyway) to be indifferent to the philosophical reasons/causes distinction. The “because” in “He did not go to class because he wanted to study” and in “it exploded because it got too hot” are both etiological in the appropriate way. And finally, it is worth pointing out here that in this sense “A because B“ does not require that

[22] Robert Klee, *Introduction to the Philosophy of Science: Cutting Nature at its Seams* (New York: Oxford University Press, 1997): 56.

[23] Larry Wright, “Functions,” *The Philosophical Review*, 82(2) (1973): 157-158.

[24] *Ibid*

> B be either necessary or sufficient for A. Racing cars have airfoils because they generate a downforce (negative life) which augments traction. But their generation of negative lift is neither necessary nor sufficient for racing cars to have wings: they could merely be for aesthetic reasons, or they could be forbidden by the rules. Nevertheless, if you want to know why they are there, it is because they produce negative lift. All this comes to saying "because" here is to be taken in its ordinary, conversational, causal-explanatory sense.

It is difficult to overstate the effect Wright's analysis has had on the current understanding of functional language in the philosophy of biology. By providing an account of functions that incorporates a backward-looking causal structure, he has provided a view of function that is very well suited for biological science in the post-Darwinian age. All biological life, and all components that make up biological organisms, are understood and explained in an historical context: the fact that organisms have the features they have and behave the way they do are understood as consequences of their evolutionary history, and relationships among all life forms are understood and explained in terms of similar biological structures, systems, and processes inherited by common ancestry and modified by selective pressures.

Wright recognized that his project was well suited to accommodate natural selection: natural selection is a process that relies upon the consequences arising from some particular entity as a means to bring about (either directly or indirectly) the perpetuation of that particular entity. In these etiological and consequential senses, the process very much resembles the conscious selection of artifacts based on outcome.[25] While the actual mechanism of selection may vary between conscious cases and those cases occurring in evolutionary history, both of Wright's conditionals are satisfied by both conscious selective processes and natural selective processes. Thus it is natural for Wright's etiological formulation to be recruited to analyze biological functions within a framework of evolutionary biology and helps to explain the overlap of artifacts and natural systems in our functional language.

[25] *Ibid*, 163-164

Another significant benefit is conferred by etiological accounts due to their grounding in the evolutionary past: such grounding helps ensure that fixed functions can be designated across various analytical frameworks. We conceive of functions in biology as something that exist prior to, and independent of, our assignment of them: the function of the bursa of Fabricius was to maturate B-cells before that function was articulated by a scientist. Traits and systems are present in organisms *in order to* perform certain functions, and these traits and systems exhibit goal-directed behavior prior to our understanding and articulation of that behavior. Furthermore, there are functional descriptions that are appropriate and others that are inappropriate; to say that the function of the heart is to produce heart sounds or the function of oxygen is to bind to hemoglobin seems confused. As discussed below, Cummins-style dispositional accounts of function are not necessarily able to designate functions for a particular trait consistently when the system under analysis shifts: the function of the heart may be to pump blood in certain systemic analyses, but in other analyses (an analysis of cardiac sonography, for example) the function of the heart might very well prove to be the production of heart sounds. This limitation within these sorts of dispositional accounts is a serious defect, for it seems to render functional descriptions far too contingent on the framework of systemic analysis employed. Cummins admits as much in his own account of functional analysis, yet argues that this shortcoming is not a serious problem because most of these systemic framings will be unnecessary from any explanatory standpoint.[26] While this may be true in most cases, there seems to be more wrong with such flexibility in functional ascription than mere explanatory superfluity.

[26]Robert Cummins, "Functional Analysis," *The Journal of Philosophy,* 72(20) (1975): 192

VARNER AND THE WELFARE CRITERION

Wright’s etiological formulation grounds the ascription of functions across contexts of analysis, and the versatile framework provides a method for ascribing functions that can be applied to artifacts, biological systems, social systems, and a variety of other entities. The versatility of his account comes at a price, however: problems arise for Wright’s analysis in biological contexts due to the account’s vagueness. In order to develop an account of function in biology, appeals to more than merely origin and maintenance through feedback will be required in order to properly articulate functions.

The first issue with Wright’s analysis arises from the first conditional “X is there because it does Y.” “X is there because it does Y” can be understood to imply that X *originated* due to its performance of Y or that X (or tokens of type X) is merely *maintained* through the performance of Y. If the later interpretation of the conditional is adopted, some odd functional ascriptions seem to result: under a maintenance interpretation of ‘because,’ it can be said that the function of a wrench wedged in gears is to jam a drawbridge (if the wrench should happen to come to rest into the drawbridge gears) because (1) drawbridge-jamming is a consequence of the wrench’s being present and (2) the wrench is there because it jams the drawbridge. This seems like an inappropriate function to attach a wrench that just so happens to find itself wedged between gears, yet, it seems to satisfy the criteria for functional ascription if the first criterion is read as a claim about the maintenance of a trait.

Wright defends himself from this objection by clarifying the proper interpretation of the first conditional: it is not enough merely to say that the function-bearer is maintained through the performance of some task, but rather that it actually originates, and subsequently propagates and replicates, through such a feedback mechanism.[27] This interpretation of the first conditional excludes those problematic cases like the drawbridge-jamming wrenches.

This 'origins' interpretation of the first conditional does not always exclude carefully formulated problematic cases. A stick in a river that becomes trapped in a whirlpool that its presence helps to create can be said (counterintuitively) to have the function of whirlpool-generation because (1) the whirlpool is a consequence of the stick's presence and (2) the stick would be washed away (would not have come to rest or propagated itself there) without the generation of the whirlpool. These cases might be dismissed as trivial, except that there are biological entities that originate via various feedback processes, which are maintained through the performance of various activities, yet who are generally denied as having functions at all: organisms and living creatures are maintained in such a way, yet we do not necessarily ascribe functions to whole organisms.

Given Wright's account, the following functional ascription can be formulated: the function of rabbits is to replicate themselves because (1) rabbit replication is a consequence of rabbits' being there and (2) rabbits are there because they replicate themselves.[28] Note that the origination of the function-bearer (the function-bearer, in this case, being the entire rabbit) is through the same feedback mechanism that was used to assign functions under Wright's accounts. Likewise, the replicative habits of rabbits do figure into the causal-explanatory account of why there are rabbits, and finally rabbits do indeed have a disposition towards replication. The functional ascription seems to fit into Wright's carefully formulated account, yet it seems

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[27] Larry Wright, *Teleological Explanations* (Berkeley: University of California Press, 1976): 114-115.

[28] Peter McLaughlin, *What Functions Explain: Functional Explanations and Self-Reproducing Systems* (New York: Cambridge University Press, 2007): 99.

inappropriate to say that an organism like a rabbit has a function. The various constituents of organisms have functions, we generally understand, and these functions contribute to the presence and persistence of organism as a whole.[29] Wright's account, however, does not seem to possess the tools by which the correct functional ascriptions *within* organisms can be distinguished from the ascription of functions to organisms themselves.

Not only does Wright's formulation have no means of excluding organisms from possessing functions, it also seems committed to ascribing functions to things that seem, given our intuitions, useless or 'accidental' aspects of living organisms. Wright's system permits the function of 'replication' to be assigned to segments of "junk DNA" that sit idle between the coding segments of DNA and replicate themselves despite the fact that they (seemingly) fail to confer any utility to their hosts.[30] Wright's account has no ability to make distinctions between the propagation of useless DNA and the propagation of those segments of DNA that are beneficial. The inability to limit the attributions of functions to organisms and the inability to discriminate between useful and useless biological characteristics both arise from an attempt to provide a functional account that has no reference to the *benefit* of the system which possesses the function bearer.[31]

This is not an oversight on Wright's part: introducing the requirement for systemic benefit into accounts of functional language introduces a complexity to functional determinations

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[29] It could well be the case that organisms have *ecological* functions; in an ecological context it could be the case that a particular organism (the wolf, for example) could possess a function (the function of culling rabbit populations); for present purposes I will assume that ecological functions are distinct from biological functions.

[30] Peter Godfrey-Smith "A Modern History Theory of Functions," In Collin Allen et. Al. *Nature's Purposes* (Cambridge: The MIT Press, 1998): 457

[31] Mark Bedau, "Where's the Good in Teleology?" In In Collin Allen et. Al. *Nature's Purposes* (Cambridge: The MIT Press, 1998): 266.

that are difficult to circumscribe. Many different benefits arise from traits that are not ‘functions’ of those traits, and Wright believed that he could capture the essential aspects of the welfare provision through the causal-historical and feedback mechanisms alone, while dodging the problematic aspects of what benefits to welfare “count” as functional benefits.

Furthermore, providing an account that incorporates all of the possible systems that could bear functions is a rather difficult task. If the framework is required to work for artifacts, biological and/or psychological systems, social frameworks and so forth, it may be impossible to reliably articulate a beneficiary. The functions of artifacts may benefit the artifact that contains them, or of the designer or user of that artifact, or both. Likewise, it can be difficult to reliably define a ‘system’ across functional contexts: “for most conscious functions of artifacts, systems must often be hacked out of the environment rather arbitrarily…it is just not clear in what system the newspaper jammed under the door is functioning.”[32]

Fortunately, the problems associated with systemic indeterminacy are not as difficult to solve as long as one restricts their functional account to biological contexts specifically. As Wright acknowledges, in biology “the system S is typically a natural unit, easy to subdivide from the environment: the organism itself.”[33] Organisms come to possess the traits that they do because the functions of those traits provided some benefit to the organisms that had them in the past: for example, the rabbit has a heart because the correct functioning of previous hearts benefited (or contributed to the evolutionary fitness of) previous rabbits, as did the correct functioning of past eyes, kidneys, and other components.[34]

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[32] Larry Wright, *Teleological Explanations* (Berkeley: University of California Press, 1976): 107.

[33] *Ibid.*

[34] Wright’s reluctance to incorporate a benefit criteria into his articulation of function in biological contexts had an additional source: articulating what it means for an organism to “benefit” from a particular function can be exceptionally difficult. Altruistic behavior, for example, might increase the fitness of a population, but whether or

Incorporating this welfare criterion into Wright's otherwise standard etiological account allows for the ability to screen out inappropriate functional ascriptions to organisms, and to the traits and systems that conferred no benefit on the ancestors of the organism that contains them, all the while maintaining the other virtues of the etiological framework. Gary Varner provides a modification of Wright's account in his paper "Biological Functions and Biological Interests," that adds a welfare condition to Wright's bi-conditional while making otherwise minimal changes:

Y is a biological function of X in O (an organism) if and only if:

(a) O has X because achieving Y was adaptive for O's ancestors, and
(b) Y is a consequence of O's having X [35]

The contribution to welfare that Varner appeals to is a specific sort of benefit: functional benefits in biological contexts are, under functional analyses, generally agreed to be evolutionary benefits to the fitness of the organism (or possibly the group or species or possibly both) that possesses them. The aspects of biological functions that contribute to survival and fecundity are those aspects that ensure the presence and propagation of biological traits, and since etiological functional analyses attempt to account of functions by appealing to the presence and propagation of various traits, functions will be understood based on their contribution to survival and fecundity. By incorporating into condition (1) the requirement that functions to have been

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not such behavior benefits the organism that behaves altruistically seems far from obvious: benefits to a community or to a species are not benefits to that "typically natural unit, easy to subdivide from its environment." One might attempt to define benefit strictly in terms of evolutionary fitness, but this doesn't seem warranted either: should kidneys become an evolutionary disadvantage in some supposed future, the creatures that still possess them will likely benefit from their kidney function, regardless of the costs to the fitness of the species. For the following discussion of Varner and Ruse, this aspect of benefit will be ignored, despite the implications that the question has on the social traits and behaviors that organisms possess. Michael Ruse, "Introduction to Part VII," in *The Philosophy of Biology*, New York, Oxford University Press (1998): 445.

[35] Gary Varner, "Biological Functions and Biological Interests," *The Southern Journal of Philosophy*, 28:2 (1990). For purposes of continuity, the conditionals above have been switched in order that the causal-historical conditional and the feedback conditional remain in the same order as Wright's account.

adaptive for O's ancestors, Varner incorporates a welfare condition that makes specific reference to the relevant events of evolutionary history that can anchor the assignment of functions to currently existing traits and systems by appealing to those events, and their causal relationship to the continued presence and persistence of the function-bearers.

RUSE AND ADAPTATION

While Varner, in line with Wright, seeks to imbue functional language with an ability to explain the current presence of those traits which possess functions, there is one final aspect to functional language that arises when considering the relationship between functions and benefits. There is something in our intuitive conception of functions that seems to require that the benefits of a function should, at least generally, be beneficial to the organisms that *currently* possess them. Benefiting an organism is not, as Varner's account supposes, merely an *historical* claim but a claim about present circumstances.

The root of this intuitive position about functions, according to Michael Ruse, is that functional conceptions in biology carry with them not only the descriptive and explanatory contents that Wright and Varner insist upon, but also ascribe a certain purposefulness to the things that possess them. The natural world, both pre- and post- Darwin, seems to be very design-like: organisms appear to us to have been put together in such a way that their various structures and systems have goals or tasks that they are meant to accomplish. Of course, the design-like aspect of organisms is understood as arising from a dramatically different process, yet despite this change in the origins of the design the teleological content of our biological conceptions remains unaltered: "the most important fact about the arrival of the *Origin,* is that from the point of view of the teleology in biology, *it did not make the slightest bit of difference*.

Before Darwin people cheerfully said that the eye existed in order to see. After Darwin people cheerfully said that the eye existed in order to see."[36]

Attempts to articulate functions without appealing to current benefit is misguided, for they fail to incorporate the purposefulness that extant biological entities seem to have. Thus, while Ruse is ultimately agnostic about the ontological status of teleological properties, it nonetheless seems that our conceptions of function ought to at least reflect the seemingly teleological aspects of organisms and their constituents.[37] While past adaptation shapes the functions of biological entities, it is nonetheless mistaken to therefore conclude that the *only* contributions to welfare that matter for functional ascription are the benefits that those entities provided in the evolutionary past. Present benefits seem equally important to understanding the functions of biological entities then past benefits; the close analogies between design functions and natural functions arise because of our noticing that natural functionaries *currently* have a purpose in the organisms that possess them, just like designed functionaries do.

In order to incorporate this aspect of present usefulness or benefit into an etiological analysis, Ruse adds an additional criterion to the bi-conditionals of Wright and Varner in order to accommodate the fact that functional entities need to provide present adaptive benefit to the containing organism.[38] Furthermore, since Ruse is interested in specifically articulating the functions of biological entities in terms of present and past adaptive circumstances, he phrases his causal-explanatory conditional explicitly in terms of adaptation:

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[36] Michal Ruse, "Teleology Redux." In *Scientific Philosophy Today: Essays in Honor of Mario Bunge*. Boston: D. Reidel Publishing (1982): 302.

[37] *Ibid,* 307.

[38] As mentioned in footnote 34, there are traits and systems that provide evolutionary benefit, but not to the organisms that possess them, but instead to that organism's offspring, community, or species. If "adaptive benefit" is understood as including selective fitness, some of these problems can be accommodated.

The function of X in O is to do Y if and only if:

(1) O actually does (or can do) Y by means of X
(2) Doing Y is adaptive for O; and
(3) X in O is an adaptation (for doing Y)[39]

Ruse's addition of criterion (2) further refines and clarifies Wright's etiological formulation: the functions of traits must pursue ends that are presently adaptive.

Ruse (along with Varner) makes explicit appeal to adaptation in his etiological account of function, and like Wright's language the use of "adaptive" and "adaptation" require a certain amount of analysis and interpretation. "Adapt" is an ambiguous verb, which could mean, alternatively, (a) to make something more suited to a particular use or purpose, or (b) to change by naturally selective forces in such a way that an organism or species becomes more suited to its environment. If the first interpretation of "adapt" is incorporated into the interpretation of Ruse's (or Varner's) conditionals, the means by which functions are defined seems to become circular: conditional (3) is interpreted as "Y is the function of X if X's purpose is to Y." Rational reconstructions of function were supposed to provide a means to determine and understand purposes, so appeals to purpose in order to define functions beg the question at hand.

The more appropriate interpretation of "adapt" is the definition that appeals to the biological processes of natural selection, and that makes use of a non-purposeful description. In short, a thing is adaptive (or is an adaptation) based on its particular causal history: saying something is an adaptation is saying that tokens of the type X have, by doing some Y that benefited previous organisms O that contained prior tokens of that same type, have had some

[39] This reformulation is a formalization of Ruse's account of function courtesy of Peter Mclaughlin (Peter McLaughlin, *What Functions Explain: Functional Explanations and Self-Reproducing Systems* (New York: Cambridge University Press, 2007): 87). In its original form, Ruse states it as follows: "If x has the function y, then x does y, x is an adaptation, and y is adaptive-it helps with survival and reproduction [of O]." (Michael Ruse, "Functional Statements in Biology," *Philosophy of Science*, 38:87 (1971): 87-95)

causal input into the production of future tokens of that type X.[40] The claim that X is an adaptation is a historical claim about that trait's contribution to the persistence and propagation both of future tokens of X and the organisms (or the kin, or group or species of organisms) that contain X. This later definition does not make appeal to purpose or use, and thus avoids the question-begging aspects of the alternative interpretation of the conditional statements that evoke adaptation as a criteria for functional ascription.

Despite their agreement on the importance of adaptation on the articulation of biological function, Ruse and Varner disagree on a controversial aspect of biological functions. In his three conditions, Ruse is claiming that functions must benefit the organisms that contain them, and that this aspect of biological functions is intrinsic to the concept itself. The function of the heart is to pump blood, according to this account, because blood-pumping is beneficial to the organism that contains the organ. As unproblematic as this aspect of functional language seems, there are instances in which it seems more suspect. The biological functions responsible for rapid fat-accumulation in times of caloric plenty certainly had past benefit to humanity's ancestors, though they arguably lack present benefit for a significant portion of the human population. In this sort of case, however, it seems a bit strange to insist that a function has suddenly ceased to exist due to the fact that external circumstances have suddenly changed: functions seem resident in the traits and systems that possess them, not in the relationship between those organisms and the environments that surround them. The goal-directed character of the traits that possesses those functions has not changed, nor does functional language lose its ability to explain the presence of functional traits. Should an enquirer ask "why do birds have wings?" the reply that appeals to the

[40] Peter McLaughlin, *What Functions Explain: Functional Explanations and Self-Reproducing Systems* (New York: Cambridge University Press, 2007): 87

wings' function will remain the same even if flying suddenly becomes disadvantageous to birds. If the contents and processes of a particular system remain unaltered, it seems inappropriate to deny that the process is no longer a function merely because the present circumstances have change in such a way that a once-helpful process has, by historical accident, suddenly turned harmful.[41]

Resolving this conflict between forward-looking and historical conceptions of benefit in functional language is a project that is too complex for this present work, and it is a controversy within etiological interpretations that can be easily accommodated by framing the following arguments within each of the competing interpretations. The arguments about etiological accounts of function that follow will incorporate both Varner and Ruse's accounts in tandem with one another in order to reflect this uncertainty and debate within etiological analyses. Furthermore, this accommodation will help to demonstrate that the arguments that follow are more entrenched in the foundations of etiological analyses than can be remedied with quick adjustments to welfare conditions.

MILLIKAN AND PROPER FUNCTIONS

In the case of artifacts, we're usually able to clearly distinguish between the various *uses* for objects in certain contexts and their true *purposes*: a chair can be used as a doorstop, a footstool, a barricade, or a myriad of other things. Changes in the circumstances under consideration might say that chairs hold open doors, or prop up feet, or keep houseguests out of particular rooms. However, none of these possible uses alters our understanding of the fact that chairs are *for* sitting, regardless of how they're employed. Likewise, should chairs somehow outlast humans, and should a future species of intelligent creature come to conceive of and use

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[41] Kim Sterelny, Paul Griffiths, *Sex and Death: An Introduction to the Philosophy of Biology,* Chicago: University of Chicago Press (1999): 225

these chairs as footrests and doorstops, it seems that none of these circumstances would change the fact that chairs were made in order to be sat upon, and that their purpose was to provide seating.

All of this is to say that articulating something's function is to make a claim about what something is 'really' for, what its purpose 'really' is, and to exclude all those other accidental or co-opted uses that the thing may have. This exclusive-purposive aspect of functional ascription seems particularly strong in biological contexts, where exceptionally complex structures, many of which are never observed or described by scientists, persist and propagate through generations because of their uses.

In biological contexts, an etiological formulation is able to be articulated and understood by appealing to the evolutionary outcomes of particular traits: a trait that leads to the increased fitness of a particular organism will lead to greater survival and reproductive opportunity for that organism, and this greater propagative success in turn ensures the continuing presence of the trait in the progeny of the particular organism.[42] No judgments about the relationships between traits and dispositions are required, nor are discoveries or observations by intelligent observers required in order for specific traits to actually have such functions. The claim that functions exist prior to and independent of our conceptions or assignments of them is an affirmation that there are such things as proper functions.

[42] A paraphrase of Karen Neander's account of etiological functions in evolutionary biology, see Karen Neander "Functions as Selected Effects: The Conceptual Analyst's Defense," *Philosophy of Science,* 58 (1991): 168-184. Neander's account is more rigorous in that it requires that the emergence of a particular phenotype in a species' gene pool be causally related to the selective success produced by a particular trait's presence within the species' genotype. This allows for a conceptual articulation of proper functions by means of genotypic perseverance and propagation over time, but it does exclude certain problematic instances non-selective functional traits (so-called 'junk DNA cases) and co-opted use.

Proper functions share a great deal in common with our conceptions of functions: in both cases, they are relationships between entities and the actions that those entities perform. However, this relationship requires no conceptual mediation by some intelligent perceiver, but is instead establish though some state of affairs in the world. The apparent overlap between evolutionary processes, the seeming purposiveness of non-intelligent living things (both present and past), and the etiological accounts of our functional concepts presents an opportunity to articulate an account of functions that exist independently of our concepts, and that in fact give rise to our concepts about them.

Ruth Millikan is one philosopher who has leveraged Wright's etiological strategy of articulating functions in order to develop a theory of proper biological functions. Millikan's argument is that functions are qualities that naturally arise out of self-reproducing entities. Self-reproducing systems must possess characteristics that allow for the possibility of reproduction and perpetuation, and these characteristics ensure the perpetuation of similar self-reproducing systems and (by extension) the characteristics that ensure such perpetuation. By providing a recursive account of how self-reproducing systems get reproduced, and what contributions by what characteristics enable such reproduction, functions can be articulated based solely on historical events: functions will be those processes performed by particular items in order to assure their own reproduction and perpetuation.[43] In cases where certain 'tokens' or instances of a particular item perform activities that allow for or contribute to the reproduction of other tokens of those particular entities through the performance of certain activities, those activities will constitute the proper functions of those entities in question: the individual traits and systems

[43] Ruth Millikan, "In Defense of Proper Functions," *Natures Purposes: Analysis of Function and Design in Biology*, ed. Collin Allen et al. (Cambridge: The MIT Press, 1998): 297.)

that possess proper functions come to possess them by virtue of the contributions to reproductive success made by the prior-existing traits. As Millikan puts it, Y is the proper function of X if:

(1) Historically, X has significantly often done or enabled Y
(2) The particular item x_i ascribed the function of doing (or enabling) Y *actually* originated as a reproduction of some token x_h that itself *actually* did (or enabled) something like Y in the past and by doing this *actually* contributed to (is part of the causal explanation of) the production of x_i[44]

Like Wright, Millikan gives a sort of bi-conditional criterion for functional ascriptions: a causal criterion provides a link between the trait in question and a particular outcome, and a consequential (or feedback) criterion attaches a particular outcome. However, unlike Wright, Millikan links activities to traits based on the *actual* reproduction of more tokens of the particular item. While the structure of the etiological relationship is roughly the same as in Wright's account, it goes much further and grounds the relationship in the actual facts of the natural reproduction of particular items, and not in the conceptual relationships between items and the functions that we assign to them.

Beyond this, Millikan's etiological account of proper functions serves to give an alternative account of functional statements are, and why functional descriptions and explanations are employed in various non-biological (or, more accurately, non-self-reproductive) contexts. For Millikan, proper functions are to be understood as the paradigm cases of a

[44] Peter McLaughlin, *What Functions Explain: Functional Explanations and Self-Reproducing Systems* (New York: Cambridge University Press, 2007): 105. This is a reconstruction of Millikan's definition courtesy of Peter McLaughlin, who formulates Millikan's definition of proper function in order to highlight the bi-conditional formulation similar to Wright's etiological account. Millikan's definition of proper functions, appears in context as follows: "for an item *A* to have a function *F* as a "proper function," it is necessary (and close to sufficient) that…(1) *A* originated as a reproduction of some prior item or items that, *due* in part to possession of the properties reproduced, have actually performed *F* in the past, and *A* exists because (causally historically because) of this or these performances [or] (2) A originated as the product of some prior device that, given its circumstances, had performance of F as a proper function and that, under those circumstances, normally causes F to be performed by *means* of producing items like *A*." (Ruth Millikan, "In Defense of Proper Functions," *Natures Purposes: Analysis of Function and Design in Biology*, ed. Collin Allen et al. (Cambridge: The MIT Press, 1998): 295.)

particular type of descriptive language: functional descriptions and explanations seem more or less successful or correct in relation to how well they correspond with cases of 'proper function.' Proper functions, by this understanding, are the "unitary phenomenon that lies behind all the various sorts of cases in which we ascribe purposes or functions to things, which…*accounts for* the existence of the various analogies upon which applications of the notion 'purpose' or 'function' customarily rest."[45] Our other uses of functional language, like our attributions of functions to traffic lights and chairs, are given the meaning they have because they draw an analogous comparison between themselves and these proper functions.[46]

NON-ETIOLOGICAL APPROACHES AND FUNCTIONAL ANALYSIS

In 1628, the English physician William Harvey published *De Motu Cordus* ("On the Motion of the Heart and Blood"), wherein he described, for the first time, the mechanism of the heart and the role it played in circulation. Blood, Harvey discovered, was not generated in the liver to be slowly absorbed by the bodily tissues, but it instead circulated rapidly throughout the entire body in a specialized vasculature, propelled through its journey by the ventricles of the heart. "It must therefore be concluded," he wrote, "that the blood in the animal body moves around in a circle continuously and that the action or function of the heart is to accomplish this by pumping. This is only reason for the motion and beat of the heart."[47]

Harvey's contribution to the modern understanding of physiology is impressive: few discoveries of the 17th century have survived so far into the present day with as little revision or

[45] Ruth Millikan, "In Defense of Proper Functions," *Nature's Purposes: Analysis of Function and Design in Biology*, ed. Collin Allen et al. (Cambridge: The MIT Press, 1998): 301.)

[46] *Ibid*, 302

[47] Domenico Ribatti**, "**William Harvey and the discovery of the circulation of the blood," *Journal of Angiogenesis Research*, 1(3) (2009): 3.

amendment as his articulation of the function of blood. What is interesting about Harvey's work with regard to a philosophical analysis of function is that centuries before Darwin, Harvey seemed to be perfectly capable of discerning what the function of the heart was as soon as he became aware of the constitution and mechanisms of the vasculature. He did so with no awareness of the etiology of the heart's formation, nor did he have any access to the evolutionary accounts of heart development that would later be employed to explain the organ's presence by appeals to causal-historical formulations.

The fact that functions can be articulated without an awareness of (nor an interest in) the causes that brought a trait or system about do not provide a knock-down refutation of the etiological accounts of function described above. These accounts of functional ascription are not meant to be rules for the how scientists ought to assign biological functions. The accounts are meant to be analyses and reconstructions of our functional concepts (or, in the case of Millikan, of natural functions as they exist) and to how these concepts come to have the meaning they do. None of this precludes the assignment of a function without utilizing an etiological framework; rather it means that functional ascriptions will be correct or incorrect to the extent that they line up with causal-historical accounts.

However, Harvey's correct functional ascription *does* suggest that the employment of functional description and explanation may not be as closely tied to etiology as the etiological accounts suggest. Harvey was able to clearly articulate the function of the heart once he became aware of the underlying mechanism of the organ and the context in which that organ operated. Similar examples can be found throughout the history of biology, and they suggest that the etiological account of biological functions might not be as accurate nor adequate an analysis of the philosophical problems as it first appears.[48]

The main alternative account of functional concepts seeks to describe functions not as conceptions that arise from a certain kind of causal history, but instead as fundamentally explanatory tools that are put to use to understand the abilities of systems, especially complex systems. The most influential of these accounts, first put forth by Robert Cummins in 1975, is a method of functional analysis that has come to be known as the dispositional account.

Cummins approach to functional description seeks to explicate functional descriptions not by referring to any casual story of their presence, but instead by making judgments about the contributions of certain dispositional traits or capacities in the components of a complex system to various outcomes of that system.[49] By itself, cataloging the dispositions of the pieces of a system is not sufficient for adequate functional description, for any single trait has many dispositions that are not functional dispositions. The heart has a disposition towards pumping, but also towards sinking when submerged in a bath of ice water and towards dissolving in a vat of acid. Likewise, the heart is capable of pumping, of making heart sounds, of supporting the thymus and (under certain morbid conditions) of being used as a paperweight. [50] Merely

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[48] Ernst Nagel, "Teleology Revisited." *Nature's Purposes: Analysis of Function and Design in Biology*, ed. Collin Allen et al. (Cambridge: The MIT Press, 1998): 221.)

[49] Cummins gives two examples of this sort of instantiation: solubility and a disposition he refers to as elevancy (the tendency of an object submerged in water to rise under its own power). In order to explain either of these dispositions, Cummins provides an explanation that ultimately attaches the disposition to some constituting *physical* fact about the object; solubility is explained by the polarity of the molecules that make up the object, and elevancy is explained by the density of the object. However, this doesn't mean that Cummins' dispositional account is limited to physical dispositions or capacities: any complex system is eligible for analysis for explanation by functional analysis, and one of his key concerns is to show how functional analysis could function as the main form of psychological explanation (Paul Griffiths, "Functional Analysis and Proper Functions," *The British Journal of Philosophy of Science*, 44(1993): 410).

[50] Cummins speaks of dispositions and capacities as seemingly interchangeable characteristics; to say that the heart is disposed to pumping is analogous to saying that the heart has the capacity to pump. Dispositional description seems more suited to an instantiation-oriented explanatory strategy, while capacities seem more suited to his

appealing to dispositions or capacities, the distinction between function and accident cannot be consistently articulated, and Cummins is left with a rather non-specific method.

In order to distinguish between functional dispositions and non-functional dispositions, Cummins employs an approach he refers to as "the analytical strategy." Functions are notable for their explanatory capabilities, he notes, and the entities that we normally seek to explain by appealing to functions are usually parts of a containing system that is composed of many separate parts and subparts, each of which has its various dispositions and capacities. This larger containing system has some attribute that we are seeking to explain and/or understand, and we accomplish this by examining the contributions that the various components make to that attribute. By examining the dispositional tendencies or capabilities of the constituent parts in relation to the larger containing system, it becomes possible to pick out which dispositions or capacities possessed by the parts contribute to the overall system's ability to exhibit the aspect that we are seeking to explain or understand. Thus, we differentiate functions from mere dispositions based on their contribution to the interesting attributes of the containing system.

Cummins explains this strategy by giving an example of an assembly line. An assembly line has an aspect to it that we might seek to investigate: specifically, it has a capacity[51] to produce some complex product. The assembly line has an interesting capacity: raw materials are fed into the assembly line, and a complicated finished product will emerge from the far end. Were we to view the assembly line as an idiotypic system (i.e. as a "black box" type system

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analytical explanatory strategy. Cummins notes that these two ways of speaking about objects are slightly different, and that one may want to speak of functions as capacities rather than dispositions. See Robert Cummins, "Functional Analysis," *The Journal of Philosophy*, 72(20) (1975): 760 (footnote 17).

[51] "Disposition" seems like an awkward term for the ability of an assembly line to produce a complex outcome, as Cummins notes (Robert Cummins, "Functional Analysis," *The Journal of Philosophy*, 72(20) (1975): 760). The term "capacity" seems more appropriate.

where its inner workings are obscure) the line would be nearly miraculous: raw steal, plastic and rubber would enter one end of a factory, and a completed car would emerge from the other.

However, there is no need to appeal to miracle if one examines the assembly line as a system composed of various individual machines: the assembly line's capacity (C) can be understood and explained by examining the various machines and stations along the assembly line. Each machine along the assembly line has many different dispositions and capacities: they have dispositions to make noise, dispositions to consume electricity, and so forth. However, in order to produce the complex final product, each machine along the assembly line will have capacities (C_1, C_2….C_n) that make specific contributions that give rise to the line's final product. If we are attempting to understand or explain the assembly line's capacity to produce this complex product, we can understand this capacity by appealing to the capacities of the various stations along the line, noting the capacities that make a contribution to the overall system's capacity (C) that we are seeking to explain or understand.

This is the analytical strategy that allows Cummins to differentiate between functions and mere accidents without appealing to any etiological account of the traits themselves. By focusing on the capacities and dispositions of the component parts of a system, the dispositional account is able to separate functions from accidents by appealing only to the containing system, and those aspects of the containing system that we are seeking to explain. A component's function is that capacity or disposition (C_1) in a system that has a place in the appropriate and adequate account for the system's overall capacity C.[52] In the example of an automobile assembly line, we might say that a welding station's *function* is to join two large sections of the chassis. This function is separated from the non-relevant capacities of the welding station (the capacities to produce a

[52] Robert Cummins, "Functional Analysis," *The Journal of Philosophy*, 72(20) (1975): 762-763.

bright light, generate heat, to consume pressurized carbon dioxide, etc.) because when one seeks to understand the capacity of the assembly line to produce cars, the welding station's capacity to join the two large sections of the chassis together at the appropriate point in the assembly line figures into the appropriate and adequate explanation of that process. Likewise, there is no adequate account of the assembly line's production of cars that invokes the consumption of pressurized carbon dioxide by a welding machine.[53] These capacities and dispositions of the component machinery in the assembly line are incidental to the overall analytical account of the system's capacities, and they can thus be discarded as candidates for functional description.

Cummins points out that analyses of biological systems can work in an analogous fashion. Rarely are accounts of biological function given without reference to some containing system (cellular function is explained within a framework of a containing of an organ, for example, and organ function is explained in terms of an organism, etc.). When we seek to separate the functions out from the non-relevant effects of the various entities of interest, we appeal to the containing systems' various capacities and dispositions in order to make the relevant determinations between functional and non-functional dispositions. We determine the heart's function to be blood pumping because we are able to explain blood circulation through an appeal to the heart's blood-pumping capacity. Harvey was capable of articulating the function of the heart without any sort of etiological appeal, this line of argumentation asserts, because he did not need any etiological context to determine the function: he had determined the various capacities of the heart and was able to fit them into an explanatory framework that accounted for

[53]There is an explanation of the *welding machine's* capacity to join two pieces of metal that appeals to electrical consumption and pressurized carbon dioxide, and *this* explanation will yield the functions of pressurized carbon dioxide and electricity in the welding process. What relationship the functional explanations of the welding machine bear to the functions of the welder as a component of the assembly line is an interesting and complex issue, but it is beyond the scope of the present discussion.

the circulation of blood. The reason Harvey was able to exclude ‘making heart sounds’ from his functional ascription is because there was no appropriate nor adequate explanation for the body’s remaining alive that invoked the heart’s sound producing capacities in any sort of explanatory framework.

Various uses of our functional language in biology can be accommodated by Cummins framework, and like Wright’s analysis the account purports to provide a unifying account of functional language. However, there are certain problems with this framework, which Cummins himself notes. Imagine that we seek to explain the sonographic capacities of the cardiovascular system; given such a systemic framework, the following functional analysis seems entirely appropriate:

> Each part of the mammalian circulatory system makes its own distinctive sound, and makes it continuously. These sounds combine for form the “circulatory noise” characteristic of all mammals. The mammalian circulatory system is capable of producing this sound at various volumes and various tempos. The heartbeat is responsible for the throbbing character of the sound, and it is the capacity of the heart to beat at various rates that explains the capacity of the circulatory system to produce a variously tempoed sound.[54]

This analysis, unlike those mentioned above, DOES seem to suggest that a function of the heart is the production of heart sounds, so long as we are seeking to explain a phenomenon (the circulatory noise) that is appropriately and adequately explained by appealing to heart sounds. As in the examination of previous containing systems, there is an aspect of the containing system that we are seeking to explain (the “circulatory noise” of mammalian circulatory system). In such a context, we can explain the capacity of this containing system by appealing to the capacities of the subparts of the containing system; in particular, we explain circulatory noise by appealing, in part, to the capacity of the heart to produce heart sounds.

[54] *Ibid*, 763.

This analysis seems problematic; the function of the heart seems to change from what it is normally though to be. When the phenomenon that we were seeking to explain shifted from circulation to circulatory noise, the function of the heart shifted accordingly. Yet nothing about the heart changed: the explanatory goal seems to determine what functions will be ascribed to a particular trait. This has dramatic consequences for how functional claims are to be interpreted: functions become context dependent, and their correctness is determined by their explanatory capabilities within a given context.

Cummins points out that functional descriptions of various traits often *do* change when the analytical frameworks under which they are examined change, and this pluralism about functions is meant to be a feature of his account, not a fault.[55] Imagine, for example, the seams of a baseball: an analysis of baseball construction will likely contain a functional claim about the seams of a baseball holding the pieces of the leather cover together. However, an analysis of pitching mechanics will claim that the seams function as spacers for a pitcher's fingers. Neither functional ascription contradicts the other, exactly; it's only that the system under analysis has shifted. Individual entities may have various functional descriptions depending on the containing system in which the analysis is being conducted, and this aspect of functional analysis seems (at least in some cases) to accord with our commonplace understandings of functional descriptions and explanations.

Another problem with this analysis (and it is a problem that Cummins himself recognizes) is that this analysis attaches a function to the heart that is oddly trivial. Heart sounds do not require any sort of functional explanation in order to be understood; we know the underlying reasons for the existence of heart sounds just fine, and explaining such sounds

[55]Paul Griffiths, "Functional Analysis and Proper Functions," in *The British Journal of Philosophy of Science,* 44(1993): 437

through a functional analysis (as opposed to a mechanical analysis) seems to obscure the relevant reasons underlying the phenomenon rather than illuminating them. Various principles of fluid mechanics and acoustics are perfectly capable of providing an appropriate explanation for the presence of heart sounds. Appealing to functions is superfluous.

This aspect of his account makes it seem as though the dispositional approach can explain *too many* aspects of complex systems: if we adjust the containing system and the aspect that we're seeking to understand to a sufficient degree, and then further define attributes within that containing system in a dispositional way such that these dispositions can contribute to the overall attribute under investigation, it allows us to attach functional descriptions to dispositions and capacities within systems for which there seems to be no such need.

This unnecessary multiplicity of functions hints at another charge leveled against Cummins account of functions. By abandoning any attempt to explain the presence of traits or systems through appeals to their functions, Cummins likewise loses the appeal to purposes and teleological ends that etiological accounts are able to summon in order to discriminate between functions and accidents. Etiological accounts are able to anchor purposes to certain traits and systems by appealing to the casual-historical conditions that brought them about, and the feedback systems that maintained them. These functional claims are able to maintain themselves across various systems of analysis, because the causal-historical and feedback claims that explain the existence of the traits and systems do not meaningfully change over time.

Cummins has no recourse to such a strategy, however. Since functional determinations are dependent on the system under analysis, the functional ascriptions of various traits can shift dramatically (and, as Cummins himself admits, unnecessarily) across analytical frameworks. The consequence is an inability to meaningfully discriminate between a trait's ability to *function as* something, and articulations of *the function* of a trait, or a trait's *purpose*.[56] This seems problematic, for our normal understandings of functions (especially in biology) are able to easily distinguish between traits natural and their co-opted use.

Recall Wright's example of hemoglobin molecules in the bloodstream: it seems clear that the function of hemoglobin is to bind to oxygen and transport it to tissues. However, the properties of hemoglobin are such that the molecule has a disposition (or a capacity) towards tightly binding to carbon monoxide gas: this tight binding occupies all the oxygen binding sites, eventually leading to asphyxiation due to an inability to transport oxygen to tissues. In a certain analytical framework (say a physiological analysis of an asphyxiating person) the disposition or capacity that explains the containing system's disposition is certainly hemoglobin's high affinity for carbon monoxide. However, this doesn't preclude our intuitive judgment that, despite this disposition, hemoglobin's *purpose* is nonetheless to bind to oxygen in order to transport it to surrounding tissues. That intuition is present despite the shifting of our analytical framework, and suggests that disposition-style accounts may be suffering from some conceptual deficits.

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[56] Ruth Millikan, "In Defense of Proper Functions," *Natures Purposes: Analysis of Function and Design in Biology*, ed. Collin Allen et al. (Cambridge: The MIT Press, 1998): 302.)

CHAPTER 2

SYSTEMIC LEVELS IN BIOLOGICAL SCIENCE

This chapter will argue that there is a problem with the etiological formulations of functional ascription summarized in chapter one, and that these problems arise from the different systemic levels that make up biological inquiry. In order to begin to describe these problems in detail, a bit of conceptual housekeeping about what can be meant by ‘system’ in a biological context must be attended to. In some of the analyses so far described, functions have been explicitly defined in terms of the system they inhabit: in Cummins’ account of functional explanation, the ability of a containing system to generate an output is the explanandum that drives the explanatory analysis that determines functional ascription. In the etiological analyses of Ruse and Varner, traits and their peculiar functions were likewise defined within the context of the living system, and Wright seemed to imply (at least in places) that the organism, as a clear and straightforward biological entity, is the main containing system for organic functions in the biological sciences.[57][58]

Biology, by its very nature, is a science that is filled with reference to various systems. Living things are made up of complex networks of associating components, each acting in concert with one another in order to produce various outcomes. Organisms are often referred to as “living systems,” and are said to reside in “ecosystems” while simultaneously containing “digestive systems” and “circulatory systems.” Added to these are the less-tangible “immune

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[57] Larry Wright, *Teleological Explanations* (Berkeley: University of California Press, 1976): 106-107.

[58] In her treatment of proper functions, Millikan rejects any reference to a containing system, relying instead on a token being a reproduction of a previous token, similar in relevant ways, which enabled some capacity or behavior. This allows Millikan to offer means by which etiological accounts can escape the problems that arise from the arguments that follow, as will be shown in the third chapter. (Peter McLaughlin, *What Functions Explain: Functional Explanations and Self-Reproducing Systems* (New York: Cambridge University Press, 2007): 107)

systems” and “metabolic systems” that perform the tasks essential for life. In order to get clear about the meaning of the term, some attention must be paid to the formalized (and less formalized) definitions that have been adopted in the biological sphere.

In its most formal and well-defined meaning, ‘system’ is an anatomical and physiological term that refers to two or more tissues or organs (an organ being two or more types of distinguishable tissue structurally joined with one another) that share a particular function.[59] The digestive system consists of the organs (stomach, intestine, etc.) that have the functions of breaking down and absorbing nutrients. While the digestive system is physically contiguous, there is no requirement for the organs of a system to be physically continuous: the endocrine system consists of the glands distributed throughout the body that secrete hormones into the bloodstream. The inclusion of glands in the endocrine system is determined based on their functions the glands have: if a particular gland secretes hormones into the bloodstream in order to signal to distinct target organs or tissues, they’re included as a part of the endocrine system.

The tight definitional connection between functions and systems is worth unpacking. When examining an organism, the various capacities of that organism (to digest food and absorb nutrients, to move and articulate, etc.) are oftentimes the functions of the various organ systems (the digestive system, the muscular system, respectively). These “functions of” the various organ or tissue systems provide some specific utility or utilities to the organism that contains them, and the functions of the system are determined, at least partially, by the welfare of the organism that contains them. Contained within these organ and tissue systems, there are individual organs and tissues which have various functions that—given how organ and tissue systems are defined—contribute to the functions of those organ and tissue systems: the digestion of food is made

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[59] K. Moore, L., Dalley, F. Arthur, A. Agur (2010). *Moore's Clinically Oriented Anatomy*. (Philadelphia: Lippincott Williams & Wilkins, 2010): 2–3

possible (partly) by the stomach's functions of acid secretion and peristalsis.[60] The way organs "function in" the organ system contribute to the "function of" that particular system.

The meaning and scope of the term 'system' in these organ and tissue systems has long been studied and the entities defined by the terms are relatively clear: given clearly defined systemic functions, the organs or tissues possessing functions in those systems can be defined. There are other uses of the term 'system' in biology, however, that are not quite so clearly delineated. In 1967, Neils Jerne coined the term "immune system," in an attempt to unify many of the varied (and seemingly incongruous) immunological phenomena that had, up to that point, been observed by scientists. Serum proteins that interacted with foreign antigens, cells that produced antibodies, cytotoxic cells and other cells, proteins and processes were grouped within a single "system." The use of term 'system' may have initially been used in order to draw an analogical or metaphorical relationship to organ systems, but at the time it was disputed as to whether the immune system qualified as a "system" in its established sense.[61] While there are immune organs (like the bursa of Fabricius mentioned in the previous chapter) many of the immune system's entities were single cells and proteins disseminated throughout the blood, lymph and tissue. It might have been argued that the immune system met the requirement of being distinguishable via a functional grouping when it was coined, if the functions of the system were broadly enough defined. Since the coinage of the term, however, developments in the understanding of immunological mechanisms have painted a far more complicated picture of immunity. Rather than serving the function of "the separation of self from non-self," the immune

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[60] Depending on various interpretations the functional accounts that are adopted, these determinations may be based on what traits currently contribute, or what they contributed in the past what contributions explain present flourishing.

[61] Eula Biss, *On Immunity* (New York, Graywolf Press, 2014): 133-134

system has been found to perform other tasks relating to both protection from foreign pathogens and the management and control of 'internal' biological processes. Components of the immune system prune needlessly-proliferating cells within tissues, manage and tend normal flora systems in the GI tract and mucosa, and regulate non-immune cellular responses, in addition to 'hunting' and destroying pathogenic bacteria, viruses, fungi and protozoa.[62] If the components of an immune system were once distinguished by their participation in a single unifying function that no longer seems to be the case, and if the functions of an immune system are only a disjunctive collection of various functions, the contributions of the components of the system may satisfy some of the functions of the immune system, but no component is likely to satisfy all of them. Thus, it becomes less reasonable to expect that there be any single "function of" the containing system to which all of the components contribute to via their "functions in" such a system.

In addition to giving us metaphorical or analogical systems, the twentieth century also introduced another use of the term "system" in biological science.[63] Modern work in enzyme kinetics, genomics, cell biology and numerous other fields have led to a proliferation of systemic analyses of biologic phenomena often lumped under the term "systems biology." This understanding of the term is in some ways less clearly defined than the uses that give rise to the metaphorical/analogical uses of the term, for various disciplines within systems biology examine phenomena that are very broadly defined from a functional standpoint. Interactomics, for example, takes as its subject matter *all* the protein interactions within individual cells, despite the fact that these interactions are responsible for sundry cellular functions.[64] In other systems

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[62] A. I. Tauber, "The Immune System and its Ecology" *Philosophy of Science*, 75(2) (April 2008): 229-232.

[63] D. Mihajlo, R. Mesarović, *Systems Theory and Biology* (Berlin: Springer Belin Heidelberg, 1968): 57-85.

[64] L. Kiemer, G. Cesareni, "Comparative Interactomics: Comparing Apples and Pears?" *Trends in Biotechnology* 25 (10) (2007): 448–454.

biology fields, however, the connection between function and system is exceptionally tight, even tighter than the relationships between organ and tissue systems and their functions: neural coding systems, for example, are generally defined by their participation in the generation of a particular neurological output given specific inputs.

Systems biology does not have an agreed upon definition for itself as a field. There is likewise no agreed upon definition of the objects of the field's inquiry.[65] Rather, the field is understood more in reference to its methods (attempts to measure, categorize, understand and explain biological phenomena through relationships and processes)[66] than its subject matter, and thus it might be said that the definition of the term 'system' has come to be used for any process or relationship among biological entities. This seems to be too vague to correspond with actual practice, however: there is significant discrimination within systems biology about the systems taken into consideration by scientists. Biologists are interested in systems that produce unique and/or important outcomes in living things, especially when these unique and/or important outcomes cannot be understood or explained through more traditionally employed causal-linear methods of scientific analysis.

Despite its vagueness, this use of the term "system" has nonetheless come to have a great deal of influence on the biological lexicon. It is now commonplace to describe any collection of discrete entities that, via interaction with one another, give rise to unique and interesting outcomes as a 'system.' Students learn how energy is produced in cells by studying cellular metabolic systems, they learn about non-specific immune responses by memorizing complement

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[65] C.R. Woose, "A New Biology for a New Century," *Microbiology and Molecular Biology Reviews* 68 (2004): 173-186.

[66] Mihajlo D. Mesarović, Systems Theory and Biology (Berlin: Springer Belin Heidelberg, 1968): 57-85.

systems, and they understand population-level interactions between species in terms of ecological systems. The varied uses are elusive, to a single definition and while the uses of the terms all 'resemble' each other, there are likely no necessary or sufficient conditions that could be found that could encompass every employment of the term in the biological sciences.[67]

In a project that seeks to examine functional ascription within and across various biological systems, however, it is nonetheless important to alleviate vague uses of the term as best as possible. Therefore, the following rough definition of the term "system" will be put forward. While this definition should certainly not be taken to be complete or encompassing, it does incorporate the aspects of the term that were examined above. The various uses of the term will satisfy these four criteria more or less well depending on the individual cases.

A system is to be understood as a biological structure or framework[68] that is composed of:

- Distinct or distinguishable biological entities (be they genes, proteins, cells, organs/tissues, etc.), which relate with one another through
- "influential" interactivity, (interactions between entities that partially or completely determine the various resultant activities or actions of the interactors), which in turn
- give rise to outcomes that would not otherwise occur had the distinct entities not influentially interacted or *could* lead to these types of outcomes, and finally

[67] I suspect that the vagueness of the use of "system" in biology is a reflection of and a response to the vagueness and indeterminacy of the biological discipline as a whole. Requiring clear and distinct definitional criteria for almost any biological term seems to be requiring something that is impossible considering the variety and diversity of the subject matter that falls within the scope of biological science: even seemingly simple terms like "cell" or "organism" often elude definitional clarity. The inability to capture biological diversity with lexical parsimony is, however, a problem best left for another work.

[68] For the purposes of this work, this definition is not intended to encompass ecological systems, although it may well be the case that the formulation could accommodate ecological systems (although how, exactly, the last criteria ought to be understood would require further inquiry). This distinction between a biological system and an ecological system is largely artificial, as the interaction between an organism and its ecological environment takes place both inside and outside of the physical boundaries of the organism itself; furthermore many biological systems possess ecological aspects.

- these outcomes are significant to the behavior, success, capability, welfare or survival of the things that contain them[69]

The tentative definition proposed above attempts to capture the key aspects of the use "system" in the biological sciences, within systems biology as well as in its more formalized anatomical/physiological contexts and its well-established 'metaphorical' contexts. In these cases, the parts' relationships with one another give rise to various outcomes that would not occur otherwise, and these outcomes become the focus of scientific inquiry due to their influence on the welfare of living creatures.

Under this definition, as with the uses of the term previously considered, there are systems within systems within systems: the living creature is a system which contains various constitutive systems, which in turn contain numerous other systems. This picture of living things might be conceived as an exceptionally complicated nesting-doll, for within each large system there are smaller and smaller systemic structures that can be found.[70] The analogy is imperfect, however: an organism contains many different systems, and individual entities within an organism might figure into more than one systemic framework. Bone marrow has a role within the skeletal system of mammals: it generates new bone and degrades old bones. Marrow also plays a vital role in the process of blood generation within the body. The fact that bone plays a role in the hematopoietic system doesn't prevent it from also playing a role in the skeletal system

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[69] Alternatively, this conditional can be stated in the following way: "these outcomes help to explain the behavior, success, capability, welfare or survival of the things that contain them."

[70] Eventually, of course, this systemic regress must stop, for at a small enough level all that is left are atoms and void; however, it's not clear exactly where the regress can be properly understood to terminate. In the previous chapter, Wright examined the function of oxygen in the body; the fact that oxygen seems to have a biological role in certain circumstances suggests that functional ascription seems to proceed down through the atomic level. See Jean Gayon, "Does Oxygen Have a Function, or Where Should the Regress of Functional Ascriptions Stop in Biology?" *Functions: Mechanism and Selection* (Springer Netherlands, 2013): 67-79.

simultaneously.[71] Furthermore, a single "doll" in a nesting doll is a discrete entity; it can be removed from the others and set aside as a self-contained whole. Biological systems, on the other hand, needn't possess this discrete quality: certain biological systems (cells, organs, etc.) may have easily recognizable boundaries, but others (metabolic systems, self-replication systems) might not be so easily distinguishable.

For the purposes of the following analysis, it will be assumed that so long as the system under consideration is specified, the multiplicity of systemic participation by a single entity is not problematic. This assumption is based upon the observation previously mentioned that multiple functions can be specified for singular traits: if a trait is participating in two separate systems it is likely to possess different functions within those two separate systems. Thus the bone marrow may be assigned functions in osteogenesis (bone production) due to its role in the skeletal system, and simultaneously have functions in hematopoiesis. While this complicates the development of a complete functional account even further, for the most part the functional plurality in individual traits will be ignored in the following arguments.

Instead, the following analysis will focus on the various systemic 'levels' of biological analysis that seem to be features of living things. In the following pages, I hope to show that problems arise for etiological accounts of function ascription across various systems, when the systems are contained within other more complex biological systems. As previously mentioned, these "nested" systems are everywhere in the biological sciences: a membrane-bound protein that

[71] Bone marrow also plays a role in the immune system, as will be shown below; hematopoiesis and immunity are systems that share a significant amount of overlap, and it may not ultimately make sense to define them as being separate systems at all. Whether or not (adaptive) immunity a sub-system of hematopoiesis or a truly independent system is an interesting classificatory question, given their significant interaction and the role of each in the 'normal' activity of the other. A principled response to this classificatory question promises to inform and clarify what it means to be a 'system' at all, though unfortunately it cannot be pursued here. See J.P. Monteiro and A. Bonomo "Linking immunity and hematopoiesis by bone marrow T-cell activity," *Brazilian Journal of Medical and Biological Research* 38(10) (Oct 2005): 1475-1486.

binds to a metabolism-stimulating hormone belongs to the cellular system, the tissue and/or organ to which that cell belongs, to the organ system that organ is a member of, and so forth. The remainder of this chapter will be concerned with whether or not etiological functional analyses (specifically the etiological frameworks of Varner and Ruse) can make principled distinctions between the appropriateness of various functional ascriptions across these different levels of systemic analysis.

ETIOLOGICAL ACCOUNTS, "FUNCTION IN" AND "FUNCTION OF"

It has been shown how the etiological accounts influenced by Wright's analysis promise to provide a principled way of articulating the particular functions of a given component within a living system that is not dependent on the "framing" or context of any functional analysis. By anchoring the functions of various traits in the events of the evolutionary past, a clear distinction can be made between appropriate biological functions (those functions that the traits were 'designed to do'), and the non-functional capacities or dispositions of the various traits.

A problem looms for these etiological frameworks, however, and it arises from the fact that the functions of a system and the functions of the components within that system are not always identical to one another. A particular trait can have some function (or provide some benefit) *to* a particular system, but that does not necessarily imply that that the trait's function is a function of (or a benefit of) that system. Yet a careful reading of Varner and Ruse's accounts of functional ascription does not seem to provide any means by which the distinction is to be made. Instead, these etiological accounts of functional ascription seem to assign the functions of the components of a system to the systems that contain them. In order to set up how this occurs, brief examination of a sufficiently complex biological system is required.

Interleukins are small proteins secreted by the cells associated with the immune system, whose main purpose is to send signals between various cells. These molecules send a variety of signals between immune cells that are essential to those cells proper development and operation: they stimulate the development and differentiation of the various cell types, they induce cells to produce particular types of antibodies appropriate for given pathogens, and signal the presence of infections or injuries, among other tasks.[72] These cytokine proteins bind to other proteins, expressed on the outer membranes of immune cells, and this binding of the cytokine to the cell initiates a molecular cascade of interactions through the interior of the cell that ultimately result in the performance of particular cellular activities.

Interleukins are also important in hematopoiesis. All blood (red blood cells, leukocytes, and platelets) begin as hematopoietic stem cells; these cells differentiate based on the chemical signals (or 'growth factors') that they receive throughout their development process. Given the proper chemical signals interacting with the proper receptors on the surface of the stem cells at the proper time, a variety of different cells can be produced. This process takes place throughout the hematopoietic system, a system which includes the bone marrow, the lymph nodes, the liver, and other organs and tissues distributed throughout the body.[73]

One particular interleukin known as IL-7 acts a hematopoietic growth factor for B-cells ('growth factor' being a common term that groups together those biological compounds that lead to cell growth and differentiation). Early on in the process of B-cell production, IL-7 is secreted by the bone marrow's stromal cells and binds with IL-7 specific receptors (which will be referred to from here onward as IL-7R) expressed on the surface of the developing cell commonly known

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[72] Kenneth Murphy, et.al., *Janeway's Immunology* (8th ed) (New York: Garland Science, 2012), 278, 370, 401, 434.

[73] Ralph Hauke, Stefano R. Tarantolo, "Hematopoietic Growth Factors," *Laboratory Medicine* November 2000.

as ‘common lymphoid progenitor’ (which will be referred to as a CLP from here onward). This binding leads to the transcription of certain genes and the production of the structures and features that comprise a B-cell. As development progresses, IL-7 signals continue (along with other growth factors) to maintain the developing cell and to stimulate the continued differentiation of the CLP into an immature pro B-cell, which will eventually differentiate into a mature B-cell.[74]

Given this background, one might begin analyzing the functions of the various components involved in the B-cell’s development. Within Varner’s etiological functional analysis of the process it makes sense (not surprisingly) to ascribe the function of IL-7 binding to IL-7R. This is because (a) humans have IL-7Rs because achieving IL-7 binding was adaptive for our evolutionary ancestors, and (b) IL-7 binding is a consequence of humans’ having IL-7Rs. Likewise, within Ruse’s three-conditional framework, IL-7 binding is the function of IL-7R because (a) humans actually can bind IL-7 by means of IL-7R; (b) binding IL-7R is adaptive for humans; and (c) IL-7R in humans is an adaptation for binding IL-7.[75]

However, there are several distinct systemic analyses under which we can formulate true (or presumably true) statements about the function of IL-7 binding. Recall that these IL-7 receptors are present on the surfaces of CLPs: the CLP is a system that contains IL-7R (the functional trait). Since the function of the trait has a particular causal contribution to the presence

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[74] Kenneth Murphy, et.al., *Janeway’s Immunology* (8th ed) (New York: Garland Science, 2012): 277-278. It should be mentioned that this description is a paraphrase of the current understanding of the role of IL-7, but that this understanding is somewhat tentative. There seem to be variations on IL-7’s effect across various mammalian species, with the effects on hematopoietic growth best understood in mice. See “Biological and clinical implications of interleukin-7 and lymphopoiesis.” Cytokines, Cellular and Molecular Therapy, 5(1): 25-39. For the purposes of what follows, I will assume that the state of the affairs summarized above applies to humans as well as mice.

[75] Or in the clarified formulation of Ruse’s third conditional, IL-7R in humans is the product of a feedback mechanism involving the adaptively beneficial character of IL-7 binding.

and continued persistence of the CLP, the function that was previously (and seemingly appropriately) ascribed to IL-7R can also be attributed to the CLP: under Varner's formulation, (a) humans have CLPs because achieving IL-7 binding was adaptive for human's ancestors and (b) IL-7 binding is a consequence of human's having CLPs.

Given the closeness with which Varner's account mirrors Wright's I am going to assume that, along with Wright, the "because" in condition (a) is translated in "its ordinary, conversational, causal-explanatory sense,"[76] in Varner's account. In certain cases, our normal conversational uses of causal relationships expressed by Wright and Varner's 'because' are transitive: if I cause a traffic accident, and the traffic accident causes a traffic jam, then it would seem reasonable to conclude that I caused a traffic jam.[77] More formally, within the contexts of certain events, our ordinary causal language sometimes permits us to infer that if A causes B, and B causes C, then A has caused (or been a cause) of C.

This does not hold for *every* ordinary language causal expression, however. Imagine a scenario where a boulder begins to roll down the hill towards an unfortunate hiker's head, at which point the hiker ducks to avoid the boulder, and because of this survives.[78] No individual step of the process that lead to the hiker's survival conflicts with our ordinary causal-explanatory understandings of how the word 'because,' yet the causal relations between the boulder rolling

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[76] Larry Wright, "Functions." The Philosophical Review, 82(2) (1973): 156-157.

[77] An alternative phrasing would be that there is a traffic jam because of my actions, due to the fact that (1) there was a traffic accident because of my actions (2) there is a traffic jam because of the traffic accident. This judgment arises from the observation that my actions were followed by a traffic accident, and the traffic accident was followed by a traffic jam, and furthermore that traffic jams often follow traffic accidents. Likewise it might be said, counterfactually, that had the traffic accident not have occurred, the traffic jam might not have occurred; and that, had I acted differently, the accident would not have occurred. More detailed causal mechanisms or analyses might be prescribed, but for now this formulation will hopefully suffice.

[78] Alternatively, the boulder causes the hiker to duck, and the ducking causes the hiker to survive. Ned Hall, "Causation and the Price of Transitivity," *Journal of Philosophy*, 97 (2000): 198–222.

and the hiker's ducking and the hiker's ducking and the hiker's surviving do not seem transitive: the hiker didn't survive because the boulder began to roll down the hill.

Under what conditions the casual claim in a particular biological process can be considered transitive will be examined at greater length in the following chapter. For the moment, however, the question of whether or not IL-7 binding is a causative event will be examined by appealing to the outcomes that arise from counterfactual instances of the functional satisfaction: the outcomes that arise from possessing dysfunctional CLPs. A lack of IL-7 signals to CLPs causes CLP growth to cease, and "knocking out" or inhibiting IL-7 or IL-7R in otherwise normal cells severely inhibits the normal developmental processes of CLPs.[79] This information strongly implies that if IL-7 is not present, than CLPs will not persist and proliferate. Furthermore, genetic mutations that lead to a lack of IL-7R are recognized to cause severe combined immunodeficiency (SCID), a disorder that is characterized by a lack of functional B- and T-Cells, and leaves those with the mutation very susceptible to bacterial, viral and fungal infections. This strongly suggests that the possession of properly configured IL-7Rs (presumably) plays a causal role in the presence and persistence of the organisms that possess them, and by extension, are a cause of the CLPs that the organism contains. People who lack IL-7Rs (or have dysfunctional or mutated IL-7Rs) are unlikely to survive and contribute to the propagation of CLPs.[80] If the people who possess CLPs with effective IL-7Rs pass the traits on to progeny, then it seems reasonable to conclude that the possession of those properly

[79] J.J. Peschon, et al, "Early lymphocyte expansion is severely impaired in interleukin 7 receptor-deficient mice." In *The Journal of Experimental Medicine* (180:5, 1994): 1955.

[80] Gaspar HB, Gilmour KC, Jones AM Severe combined immunodeficiency—molecular pathogenesis and diagnosis. *Archives of Disease in Childhood* (84:169, 2001): 173.

functioning IL-7Rs is a reason why the CLPs (and the organisms that possess them) are currently there.

Under Ruse's formulation of the etiological account, the function of binding IL-7 can be attributed to CLPs, for (a) humans actually bind IL-7 by means of CLPs; (b) binding IL-7 is adaptive for humans; and (c) CLPs in humans are an adaptation for binding IL-7. This final conditional sounds odd upon first reading, and it seems that it is not satisfied in the case of CLP: CLPs are not adaptations specifically meant for IL-7 binding, but are rather adaptations for the production of varied lymphocytes. However, recall that Ruse's use of the word 'adaptation' cannot be interpreted as "being developed for a particular task" without the criteria for functional ascription becoming circular. Rather, to say a trait is an adaptation is to make a claim about its being a result of a particular causal history. Saying something is an adaptation is saying that tokens of the type have, by performing some action, benefited previous organisms that contained prior tokens of that same type, which in turn has had a causal influence on the production of future tokens of that type.[81]. Under this interpretation of the term "adaptation," the CLP does seem to qualify as an adaptation for binding IL-7, for by binding to IL-7, past token CLPs have benefited previous humans (by developing into B-cells) and this binding has had some causal input into the production of present token CLP.

Within both Varner's and Ruse's accounts, this upward progression of functional attributions can continue: a function of the hematopoietic system can be said to bind IL-7, because under Varner's account (a) humans have a hematopoietic system because achieving IL-7 binding contributed to the evolutionary success of their ancestors and (b) IL-7 binding is a

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[81] Peter McLaughlin, *What Functions Explain: Functional Explanations and Self-Reproducing Systems* (New York: Cambridge University Press, 2007): 87.

consequence of human's having a hematopoietic system. As the ascent continues, the normal language causal-explanatory sense of 'because' comes to seem less and less appropriate: the binding of IL-7 was, in the long causal chain of evolutionary history, more and more of a minor influence on the development and persistence of the entire hematopoietic system than it was on the development and persistence of the IL-7 specific receptors (IL-7R) themselves. However, the outcomes surrounding a lack of IL-7 binding suggest that the specific processes of IL-7 binding likely played at least *some* role (or exerted some influence) in the development and persistence of the on current hematopoietic system.[82]

Ruse's account also suffers from this incapacity to draw principled distinctions between the functions possessed by the subsystems within large, complex biological entities and the functions of those entities themselves. Under Ruse's account, one can say that a function of the hematopoietic system is to bind IL-7 because (a) humans actually can bind IL-7 by means of their hematopoietic system, (b) binding IL-7 is adaptive for humans and (c) the hematopoietic system is an adaptation (for binding IL-7).[83] Like the Varner/Wright account, the "by means of" in condition (a) and the "adaptation for" in condition (c) become less and less robust formulations as the ascent progresses: hematopoietic systems are 'adaptations' for producing blood, if the term 'adaption' is taken to mean "changed or developed for a particular purpose." However, if 'adaptation' is taken to mean "the product of a feedback mechanism involving an adaptively beneficial characteristic," the hematopoietic system *does* seem to be an adaptation (or,

[82] Terry Fry and Crystal Mackall, "Interluken-7: From Bench to Clinic," *Blood* 99(11) (2002): 3894-3895.

[83] Interestingly, in cases where the functions of traits are being ascribed to the systems that contain those traits, condition (b) in Ruse's account will remain unchanged regardless of the system specified, for the presumed adaptability of the function of that particular trait remains constant regardless of the systemic level of analysis.

more specifically, a partial adaptation) for the binding of IL-7: if IL-7 binding contributed to the reproduction of tokens of the type this third requirement seems to be satisfied.

THE PROBLEM OF FUNCTIONAL PROLIFERATION IN COMPLEX SYSTEMS

Neither Wright nor Ruse's formulation provides any definite criteria for stating when a particular capacity is no longer a "particular consequence of [the trait's] being where it is which explains why it is there,"[84] nor do the relevant conceptual distinctions of Wright's ancestral argument seem able to properly exclude these functional attributions of particular traits to the systems that contain them, beyond appeals to "conversational, causal-explanatory" meanings of the term "because." "If two or three things that livers do all contribute to the survival of organisms which have livers," he writes, "we must appeal to all three in an evolutionary account of why those organisms have livers…we would have to say that each one was *a* function of the liver."[85] While this is no doubt correct, the problem is that a large, complex system like a liver contains a host of smaller systems (Kupffer cells, biliary trees, etc.) each of which have functions of their own which are "functions in" the liver. It seems reasonable to assume that at least some of these functions (in at least a small way) contribute to the survival and propagation of the organisms that contain them, and thus contribute to the propagation of livers in their present configuration. If the functions of particular traits contribute to the presence of the liver, and the liver contributes to the survival of the organism, the etiological accounts lack the conceptual tools to distinguish between those two or three liver functions that contribute to the survival of an organism (the 'functions of' the liver), and the processes that enable the liver's performance of those functions (the 'functions in' the liver, or the 'functions in') the liver's various subsystems.

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[84] Gary Varner, *In Nature's Interests?: Interests, Animal Rights, and Environmental Ethics*. (New York: Oxford University Press, 2002): 68.

[85] Larry Wright, *Teleological Explanations*, Berkley: University of California Press (1976): 75.

This leads to the dramatic proliferation of functions that can be ascribed to the containing systems, for the functions of any component whose past functioning has contributed to the continued presence and propagation of tokens of the system type can be ascribed to the systems that contain them under standard etiological analyses. This proliferation of functions is made more complicated because, as noted above, various entities (be they specific traits, systems, organs, tissues, etc.) can participate in a variety of biological systems at any given time. This complex systemic nesting leads to an exponential growth in the functions that can be ascribed to such entities if an etiological approach is to be adopted.

Whatever the functions an informed observer would attribute to the hematopoietic system, it seems unlikely that IL-7 binding would be one of them: while the binding of that interleukin is certainly a function of some of the particular cells within that containing system, it seems a bit odd to ascribe that function to the system as a whole. Likewise, while a CLP may function as an IL-7 binder, it hardly seems to be *the* function of the CLP. Naïve consideration of functional ascription resists the assignment of the functions of components of a system to the containing system, even if these components play a causal role in the persistence and propagation of that containing system.

It may very well be the case a formal analysis of functional ascription could lead to functional ascriptions that wouldn't otherwise be made in the absence of the philosophical insight provided by the conceptual investigations. While IL-7 binding isn't a function that an informed observer would ascribe to a hematopoietic system, it nonetheless could end up being determined to be a function of that system when "functions" are properly conceived. If etiological accounts of function are correct analyses is of functional terms, than it very well may lead to new functions being assigned and documented. Nor is it necessarily a problem that entities possess more functions than they were previously thought to: multiple functions are often found in a single biological entity, as Wright noted above in his discussion of livers. Even relatively ‘simple’ traits could come to be understood as having numerous functions.

Despite all of these considerations, this inability of the etiological account to prevent ascriptions of a trait’s functions to its containing system does seem to have some problematic consequences. First and foremost, accepting this consequence of etiological functional analysis opens a gap between our conceptions of biological function and what the philosophical analysis of those conceptions implies. As shown previously, B-cells (to pick a moderately complex system) have a rather long and complex causal lineage, along which there are many traits performing many functions that lead to the presence of the cells in question. The entire list of functions that these traits have quickly proliferates beyond the point of manageability. If these functions are in turn applied to an organ or tissue that contains those cells, along with all of the other cells and *their* various functions, one can quickly see how the accumulation of functions to containing systems quickly expands beyond the point of reasonableness.

Whether or not the ascription of functions to systems needs to be manageable or reasonable is an open question; it could well be that carefully considered etiological accounts might lead to an acceptance of proliferative functions in systems. Yet this is nonetheless a surprising consequence of the philosophical analysis, especially for an analysis that doesn’t seem to deviate dramatically from the functions it ascribes to non-systemic entities. If etiological accounts correspond with functional intuitions in a trait-level analysis (for example, the analysis of IL-7R’s function) but ascribe a large number of seemingly trivial functions to the trait’s containing system (the analysis of CLP function), there seems to be reason to suspect that there is some deficiency in the etiological account that is leading to this functional proliferation at the systemic level. Furthermore, while it is not unprecedented for relatively simple conceptions to lead to cognitively unmanageable outcomes, functional proliferation seems to ascribe inappropriate functions to containing systems as well. While it may be the case that naive intuitions about the functions of systems are simply wrong, and that the etiological accounts of function get them right, it seems warranted to at least suspect that something has gone wrong in the etiological account before rushing to overturn the intuitions that informed observers have about the functions of biological systems.

Furthermore, if it is accepted that functional descriptions are supposed to contain explanatory power, this proliferation of functions also raises concerns about how explanatory successful functional descriptions can in fact be. If every function in a complex system is understood as a partially explanation of the presence and persistence of that system, and the complete list of functions is prohibitively difficult for one to articulate, then it seems mysterious why 'normal,' parsimonious etiological functions are so often seen as explanatorily successful. Oftentimes complex containing systems are explained by referring only to specific functions that they perform: "kidneys remove waste products from the blood" is a functional description that, on the surface, seems to serve as an explanation for why the kidneys are there. Yet if the function of blood filtration is only one reason for the kidneys presence out of thousands of other reasons for their presence, it raises the question why *that* particular functional explanation is seen as successful while lower-level functional explanations are not.

There are various strategies by which proponents of the etiological view can attempt to solve this issue, though each strategy will raise more difficulties when particular cases are considered. As mentioned previously, proponents of the etiological framework might accept the consequences of their analysis. If the philosophical analysis of functional ascription ends up attributing functions to containing systems that dramatically expand on what was previously understood or accepted, then so be it. This acceptance carries with it the problems mentioned above (and many others).

Alternatively, the advocate of the etiological framework can attempt to restrict the ascription of the components of a containing system to that system itself by means of an adjustment of the criteria in the conditional statements: by attempting to restrict the capacities that will qualify for functional ascription, etiological theories may avoid some of the problems of functional proliferation. It seems important to the project that this restriction be implemented without imposing functional restrictions that are merely arbitrary: the modification to the etiological formulations on offer need to make some sort of appeal to the form of functional ascriptions in order to be satisfactory. Fortunately, there is a promising candidate for such a principled distinction that can limit this functional proliferation, and it is best brought to light be considering how systems that contain seemingly contradictory function are commonly understood.

FUNCTIONAL EXPLANATION AND CONTRASTING FUNCTIONS

The DNA replication system is responsible for the copying of DNA from an existing strand; this copying is essential for ensuring the transmission of the genome across generations. In the bacterial species Escherichia coli, the system involves at least 30 different proteins, each playing a different role in the process by which the bacteria's circular chromosome is replicated. There are two particular proteins which perform specific tasks in the replication system: the protein DnaA binds to the specific sequence of DNA that marks the origin of replication on the circular chromosome; upon binding this protein breaks the bonds holding the two DNA strands together and allows for the other replication machinery to "sit down" on the unbound DNA and begin the process of replication. The other protein, Tus, binds to the termination site opposite the origin of replication and terminates the process of replication.[86]

If this synopsis of the DNA replication system within *E. coli* bacteria is correct, it seems that functions for the various proteins described above can be determined. A function of the protein DnaA could be said to be "initiating DNA replication." When considering this functional ascription in light of our two etiological theories, this ascription seems to pass formal muster, for either (a) *E. coli* have DnaA in because the initiation of DNA replication was adaptive for their ancestors and (b) initiating DNA replication is a consequence of *E. coli* having the protein DnaA (if we choose to ascribe functions using Varner's account) or (a) *E. coli* actually initiate DNA replication by means of the DnaA protein, (b) initiating DNA replication is adaptive for *E. coli*, and (c) the DnaA protein is an adaptation for promoting the initiation of DNA replication.

Recalling the argument of the previous section, under etiological accounts the functions of certain components (those components whose past functioning has contributed to the continued presence and propagation of tokens of the type) can be ascribed to the systems that contain them. Since this function of the DnaA seems likely to qualify for ascending ascription according to this argument, the functions of the DnaA protein can also be ascribed to the DNA replication system as a whole, that system being the containing system for the protein. Thus we can say that, according to etiological accounts, *a* function of the DNA replication system is the initiation of DNA replication.

Consider now the other protein mentioned in the description of the DNA replication system in *E. coli*, the Tus protein. According to the two etiological analyses under consideration, the function of the Tus protein is the termination of DNA replication, for under Varner's account

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[86] [86] J. M. Willey, L. M. Sherwood, C. J. Wollverton, *Prescott's Microbiology* (8th. Ed) (New York: McGraw-Hill 2011): 299-303.

(a) *E. coli* have Tus proteins because terminating DNA replication was adaptive for their ancestors and (b) terminating DNA replication is a consequence of *E. coli* having Tus proteins, and under Ruse's account (a) *E. coli* actually terminate DNA replication by means of Tus proteins, (b) terminating DNA replication is adaptive for *E. coli* and (c) Tus proteins in *E. coli* are an adaptation for terminating DNA replication.

Yet attributing this function to the Tus protein presents problems when considering the fact that functions, under etiological interpretations, seem to be ascribed to their containing systems. Like the DnaA protein, the Tus protein seems to qualify as a component of the DNA replication system whose past functioning has contributed to the persistence and propagation of DNA replication systems: yet if both of these functions are attributed to their containing system, the DNA replication system has the functions of (1) initiating DNA replication and (2) terminating DNA replication. The attribution of contradictory functions to the DNA replication system seems a bit odd, even given the tendency of single traits to be legitimately ascribed multiple functions. Naively, we don't associate functions with their contradictories within a particular trait: there are no 'not seeing' functions of the eye, nor are there 'anti-digestive' functions of the stomach.

Furthermore, if etiological functions are supposed to possess explanatory aspects, these aspects are undermined by attributing functions that perform contradictory activities to the very same entity. If a virtue of functional description is its ability to provide explanations for the presence of a particular trait, as Wright and others insist,[87] then giving functional descriptions that seem to contradict one other to the same trait robs the functional descriptions of the trait of a great deal of their explanatory power. If the goal of a functional explanation is to clarify "why X

[87] Larry Wright, "Functions." The Philosophical Review, 82(2) (1973): 64-65.

is present," or "why X is present in the existing organism Y,"[88] an explanation that can utilize two contradictory activities seems that it is *too* explanatorily successful: the presence of the trait is explained under a great deal of variation in the causal processes that brought the trait about.

Imagine a particular social ritual that is supposed to function as both (1) a way to reduce conflict in the community, and (2) a way to facilitate conflict in the community. If these functions are both attributed to this social ritual, no matter what comes about as a result of the performance of the ritual, the continued persistence of the social ritual in the society can always be explained. If the performance of the ritual dissolves the conflict in the community, the dissolution of conflict was a result of the social ritual. Likewise, if the ritual brings about conflict in the community, then the presence of conflict in the community can be explained by the results of the social ritual.

An explanation that can explain *any* outcome seems to be too permissive to explain much of anything at all. While such an encompassing explanation might well explain the presence of the particular ritual (indeed, in the example above the two functions can't help but explain the presence and persistence of the social ritual), it does not do anything to illuminate why *that particular* ritual exists in the manner that it does *rather than something else*. While biological explanations needn't necessarily provide definitive or deductive reasons for the existence or presence of various entities (a certain amount of contingency and accident is part of any historical explanation, and evolutionary explanations seem inherently historical) ascribing

[88] *Ibid;* Whether functional explanations are be capable of explaining the presence of *the organisms* (i.e. the systems which receive the benefits of a trait's functioning) that possess functional systems is a complicated issue that is not agreed upon across etiological accounts of functional explanation; the issue is tangential to this problem in functional explanation and I will therefore attempt to avoid it here. See Peter McLaughlin, *What Functions Explain: Functional Explanations and Self-Reproducing Systems* (New York: Cambridge University Press, 2007): 209-211.

contradictory functions to a single entity seems to dramatically weaken *any* explanatory power that functions have.

CONSIDERATIONS INVOLVING "EMERGENT" FUNCTIONS

This functional contradiction inside the DNA replication system may seem like a one-off case, but it is not a particularly uncommon occurrence in biological systems. Systems that maintain homeostasis through the employment of feedback processes often possess various components (and/or capacities) that act counter to other components (and or capacities) of that same system in order to maintain homeostasis. Picture a simple homeostatic system, like a climate control system that maintains a steady temperature in an environment. This climate control system will contain elements that turn on heating systems, and other elements (or perhaps even the same element) that turns those systems off. Analogously, within a complex biological system like a cell, there will be components of that cell that enable the translation of a particular protein, and other components of that same cell that disable that translation. If these two components' functions are capable of being attributed to their containing cell, the functions of that cell will contain numerous contradictory functions.

One possible solution to this apparent problem might be to argue that the contradictory functions ascribed to these parts are partial or incomplete, and that they are subsumed under broader, more inclusive functional description. An artifact like a light switch, for example, might be said to possess the functions of "turning the light on" and "turning the light off," despite the fact that both of these functions seem immediately contradictory. However, once the mechanism of the light switch is understood, describing its function as "regulating the flow of electrical current in a circuit" seems much more complete and fruitful functional description, and furthermore incorporates the seemingly contradictory functions. Similarly, the imagined social ritual previously mentioned in the previous section could be described as having the function of "managing the conflict within a community," an encompassing functional definition that seems to contain the contradictory ascriptions without itself being contradictory or explanatorily vacuous. The DNA replication system's function could be stated as "copying the genome," or some similar functional descriptor that encompasses the two diverging functions of the organ.

This solution carries with it the implication that there are *levels* of function: the functions of components of a containing system can be stated, but the functions of those components are not functions of the containing system, properly understood. Conversely, containing systems are oftentimes ascribed functions that are not ascribed to any of the components that compose it. While the function of the stomach is understood to be the digestion of food, there is no contained component that system (parietal cells, enteroendocrine cells, epithelial cells, smooth muscle cells, etc.) which could be said to possess the function of 'food digestion.' Likewise, the functions of the various components of the stomach (acid secretion, hormone production, etc.) are not properly "functions of" the stomach, but rather "functions within" that organ.

This may tempt us to proclaim that there are various functional levels within organisms, and that while the complex functions of the stomach might reduce to the functions of the stomach's components, the ascription of stomach-component functions to the stomach itself can be blocked, by virtue of the fact that they're on the wrong functional level. This seems to accord with the use of functional language within the biological sciences: the functional attributions of systems are generally considered as being distinct from the functional ascriptions of the components within those systems. These containing systems often have 'emergent' functions that cannot be attributed to any single component within a system but are the result of the system's components interacting with one another.[89] Likewise, no single component of a climate control system has the function of maintain the temperature of a space, but rather the entire system has that function by virtue of the contributions of the individual components. Oftentimes these very abilities that are most interesting and explanatorily successful functions of complex systems: in the case of the stomach we understand its function to be digestion, and the fact that it functions as a digestive organ explains both the presence and persistence of the organ and describes what we aspects of it are most interesting.

If a means can be found to draw principled distinctions between the various functional levels, not only will functional proliferation be checked but functional language will also be able to preserve its explanatory capacity. Emergent functions that encompass seemingly contradictory functions generally do a satisfying job of explaining the presence of particular traits and systems. The components' functions in that organ can likewise be determined on their own functional "level," likely by appealing to their own historical and/or present contributions to the continued persistence and propagation of the systems that contain them. So perhaps the solution to the problem of functional proliferation within complex systems can be solved by limiting functions to those functions that "emerge" at a certain systemic level.

PROBLEMS FOR "EMERGENT" FUNCTIONS

The restriction of functional ascription to those functions that emerge at a specific level of systemic analysis is promising, yet it does not entirely accord with all of our commonplace assignments of biological functions. In many cases, the emergent functions seem appropriate, but in certain cases such a strict restriction seems to restrict the proper functional ascription to a

[89] Recall that biological systems seem defined, in part, by their ability to give rise to outcomes that would not otherwise occur had the distinct entities not influentially interacted (see pg. 46-47 above).

containing system. An example that was previously considered in the first chapter will demonstrate how a strict restriction of functional ascriptions to emergent functions at specific systemic levels can generate problems in biological contexts.

Hemoglobin a protein that is structured in a specific way such that it binds tightly to atmospheric oxygen when there is a large amount of the compound present, and then releases its hold on the element when the concentration of oxygen drops. The functions of hemoglobin, as they are commonly understood and articulated, are to bind to oxygen and transport the oxygen to tissues. To put these commonly ascribed functions into frameworks of etiological function that have been discussed throughout this chapter, Varner's account will ascribe these functions to hemoglobin because (a) mammals have hemoglobin because binding oxygen and transporting it to tissues were adaptive for their ancestors and (b) the binding of oxygen and transportation of oxygen to tissues is a consequence of their having hemoglobin. Likewise, under Ruse's account (a) humans actually bind oxygen and transport oxygen to tissues by means of hemoglobin, (b) binding oxygen and transporting oxygen to tissues is adaptive for humans and (c) hemoglobin in humans is an adaptation for binding oxygen and transporting oxygen to tissues.

In vertebrates, hemoglobin proteins are present in very great numbers within the cytoplasm of erythrocytes (commonly known as red blood cells): these cells contain little in their interior besides hemoglobin protein: they lack a nucleus (and thus the ability to translate proteins from genetic material), mitochondria (and thus the ability to generate work-performing energy stores), and the cellular organelles and structures responsible for cellular maintenance and repair. Red blood cells seem to be present in the bodies of mammals for the express purpose of binding to atmospheric oxygen in the lungs and then transporting that oxygen to tissues, and articulations of the function of erythrocytes is generally that they function as a means of distributing oxygen throughout the body. These functions can be articulated etiologically in the following way: according to Varner (a) humans have red blood cells because binding oxygen and transporting it to tissues was adaptive for their ancestors and (b) the binding of oxygen and transportation of oxygen to tissues is a consequence of their having red blood cells. Likewise, under Ruse's account (a) humans actually bind oxygen and transport oxygen to tissues by means of red blood cells, (b) binding oxygen and transporting oxygen to tissues is adaptive for humans and (c) red blood cells in humans are an adaptation for binding oxygen and transporting oxygen to tissues.

Nothing seems problematic with either of these formulations in terms of their appropriateness: an informed observer would likely agree that they ascribe the proper functions to both hemoglobin and red blood cells. However, the functions being ascribed to the containing system (the red blood cell) are identical to a component of that cell (hemoglobin): counter to the solution offered in the previous section, no 'emergent' function arises at the cellular level that encompasses the various functions of the components. The case of hemoglobin and red blood cells is one wherein the "function of" the cellular system is identical to a particular "function in" that cellular system. This suggests that the relationship between "functions of" systems and "functions in" systems cannot be distinguished by mere appeal to those functions that emerge at particular levels of systemic consideration.

As far as containing systems are concerned, red blood cells are unique for their *lack* of complexity. Mature red blood cells are often informally thought of as just "bags full of hemoglobin,"[90] and while the containing cell does indeed do more than merely act as a container for the proteins the common understanding of red blood cell functions are that they share *at least* the majority of their functions with hemoglobin. Not only is there significant overlap, but the

[90]Dawn A. Tamarkin, "Red Blood Cells," *Anatomy and Physiology*. http://faculty.stcc.edu/AandP/AP, accessed 19 March 2014.

functions that red blood cells do not share with hemoglobin are often understood as being ancillary to the oxygen-binding and oxygen-transporting functions: the primary (adaptive) benefit conferred to the organism by red blood cells are those relating to oxygen distribution.

CHAPTER 3

THREE SOLUTIONS TO THE PROBLEM OF FUNCTIONAL PROLIFERATION

In this final chapter, three solutions to the problem of functional proliferation put forward in the previous chapter will be considered, each of which will attempt to solve the problem of functional proliferation via a different method. The first solution will examine the nature of how functions bear a causal responsibility for the presence of the traits that possess them, in the hopes that aspects of the casual claims that etiological accounts rely on might prevent proliferation. Causation is a complex and difficult relationship to articulate, and aspects of causation in a complex field like biology complicate the relationship even further. This opens up the possibility that the nuances of the causal relationships between traits, their functions, and the systems that contain them might provide some avenues by which the problem of functional proliferation can be avoided. At the same time, it presents certain problems for how causal relationships ought to be examined. While there are several sophisticated approaches to analyzing causation, this solution will employ a counterfactual approach to causal analysis in order to search for possible solutions to the problem of functional proliferation. The use of a counterfactual approach is admittedly somewhat arbitrary: alternative methods of analyzing causation would almost certain present solutions that will not be considered in this first section. However, a counterfactual analysis does have certain favorable aspects: the analysis can help illuminate the distinctions between causes and background conditions, and raise questions about whether or not components of systems can be understood to be causes of system. Likewise, counterfactual analyses can make use of findings about the absence of systemic components, and their impact on the system's development.

The second solution will re-examine the problem of functional proliferation using one of the accounts examined in chapter one. Millikan's account of proper functions is *not* a conceptual analysis in the form of those offered by Wright, Varner and Ruse, but rather an analysis that relies upon the actual relationships between past tokens of a type and their influence on the presence of the current tokens of the same type. Since this account is freed of the conceptual constraints of the other etiological accounts, it can be held to different standards regarding how well it need conform to our functional concepts. Furthermore, Millikan's nuanced account of proper functions provides tools for solving the problem of functional proliferation that other etiological accounts lack. This technical understanding of functions allows for some of the functions in containing systems to be understood as functions of that system, while being functions of a different sort, and thus less problematic from a proliferative standpoint. However, this solution cannot entirely avoid problems of its own, which will be examined in some detail.

The last solution that will be considered will draw on another account presented in the first chapter: Cummins' analytical account of functional explanation. This solution will frame the problem of functional proliferation in different terms: the problem of functional proliferation will be framed as a problem with the explanatory aspects of the proliferating functions. By identifying this explanatory failure as the fundamental problem of functional proliferation, the solution will attempt to define etiological functions as those functions that provide the best true explanations for the purposes of biological traits and systems given the background context of evolutionary history.

THE CAUSAL SOLUTION

Recall how, in the argument from the previous chapter, many of the problems arising from functional proliferation stemmed from how the "because" in condition (a) of Wright's etiological account was to be interpreted. “X is there because it does Y,” in the phrasing of the conditional, is open to many different interpretations even if one adopts Wright’s “ordinary, conversational, causal-explanatory sense” of the word “because.” As previously stated, certain causal relationships seem to be transitive: if IL-7 binding causes CLP development, and CLP development causes normal immune function, it sometimes appears to be appropriate to say that IL-7 binding is a cause (perhaps not the only cause, but certainly a cause) of normal immune function, and sometimes appears to be inappropriate. The casual relationship between an inattentive drivers’ causing a traffic accident and that traffic accident causing a traffic jam seems to be transitive: in such cases it seems clear that the inattentive driver caused the traffic jam. In other cases this is not nearly so clear: while a boulder’s rolling downhill might cause the hiker to duck, and the ducking causes the hiker to survive, it does not seem to support the transitive conclusion that the boulder’s rolling downhill caused the hiker to survive.

One method of solving the problem of functional proliferation in containing systems is to “block” the assignment of causal responsibility of those functions within a contained system as having responsibility within the containing system. This solution will attempt to develop a notion of a causal relationship between a function and an entity (the Y and the X of Wright’s first conditional) that doesn’t permit transitivity across systemic levels. As mentioned in the introduction, this search for a solution will take place using a counterfactual approach to causal judgments, and will utilize the subjunctive conditionals that such approaches commonly adopt.[91]

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[91] Wright makes a point to note that the causal relationship in his first conditional “X is there because it does Y” is *explanatory*, and thus indifferent to the reasons/causes distinction. Whether or not counterfactual analyses of reasons for the presence of trait are legitimate is an interesting philosophical question: if the sentence “porcupines have quills *because* they protect them from predatory enemies” is true by virtue of the fact that the protection from enemies is the reason for the quills presence, it may or may not follow that had the quills not protected porcupines from predatory enemies, they wouldn’t have quills. Certainly, the force of the subjunctive conditional is less powerful than in more straightforwardly ‘causal’ notions of ‘because,’ but for the analysis that follows, I will assume that counterfactual analyses of purposes are legitimate. Larry Wright, “Functions,” *The Philosophical Review*, 82(2) (1973): 157.

While this will reveal certain possible solutions, this set of solutions certainly will not be exhaustive. It may well be that other approaches to causal analysis can reveal other methods by which this causal relationship can be understood in a non-transitive way, but such an exhaustive analysis is not required in order to reveal some possible solutions to the problems raised in chapter two.

The determination "humans have CLPs because achieving IL-7 binding was adaptive for O's ancestors" was made based on a counterfactual claim (with a basis in observation) that a lack of IL-7 binding (from here forward, IL-7 binding will be referred to as event A) leads to the destruction and/or improper development of CLPs in humans (from here forward, the development of CLPs in humans will be referred to as event B), and that this destruction and/or improper development of CLPs leads to decreased adaptive fitness in the immune function of the organisms in question (from here forward, proper immune function will be known as event C). Yet it may be that this inference happens too quickly; it may be that event A does indeed cause event B, and event B causes event C, and yet the transitive move that asserts A's causal responsibility for C could still not follow.

Counterfactuals are context-dependent statements: one's determinations about the truth or falsehood of particular counterfactual statements will vary based on the circumstances under which they are evaluated. Take, for example, the following two counterfactual statements: "if this object were gold it would be malleable," and "if this object were gold then some gold things would not be malleable."[92] It is not possible for both of these statements to simultaneously be true, for their shared antecedent condition (that the object is made of gold) allows for the

[92] Cei Maslen, "Causes, Contrast, and the Nontransitivity of Causation," In *Causation and Counterfactuals,* eds. J. Collins, N. Hall, and L.A. Paul (Cambridge: MIT Press 2004): 348.

inference of contradictory conclusions that the object is both a malleable object and a member of the hypothetical class of non-malleable gold objects.

The resolution of this seeming contradiction can be achieved by examining the background assumptions that get made when evaluating the truth or falsehood of counterfactual conditional statements. Counterfactual statements can only be evaluated by assuming that certain background conditions obtain: evaluating the malleability of an object relies on some tacit premises about the physical properties of objects, the identity of the object, the nature of physical properties, and so forth. The first counterfactual contains a tacit premise about the physical properties of gold objects, namely that "all gold objects are malleable;" thus the object's malleability would be logically entailed by the counterfactual. The second counterfactual, on the other hand, assumes certain things about the properties of the object, specifically that "this object is not malleable."

Which counterfactual ought to be accepted depends upon what tacit premises one happens to adopt, and this determination will in turn depend upon the context in which the counterfactual is posed. If the counterfactual is posed about an object whose malleability has not been determined, say, or in a context in which malleability is taken to be a law-governed property of material substances rather than an empirically determined trait, the first counterfactual (if this object were made of gold then it would be malleable) might be adopted. On the other hand, if the counterfactual is posed about a manifestly brittle object, and the property of malleability is not taken to be intrinsic to an object's being composed of gold, the second counterfactual might be more suitable.

This context-dependent aspect of counterfactual evaluation is important for the evaluation of the function's relationship to a trait or to that trait's containing system, for the context by which the two counterfactual statements are evaluated are quite different from one another. The argument that A causes B is evaluated based on the counterfactual observations that, in the absence of event A, event B does not to occur, if otherwise normal conditions are satisfied. This is a counterfactual claim that is evaluated within a specific systemic context that contains assumptions about that particular system's entities, interactions, and outcomes. These assumptions relate to the intracellular interactions that govern CLP development: the tacit premises about the interactions that commonly result from configuration changes within proteins, the normal signaling pathways that result from certain protein interactions, the influence of transcription factors on the translation of proteins, and so forth are likely to be involved in the evaluation of the counterfactual conditional of the causal relationship between A and B.[93]

Likewise, the conclusion that B causes C is evaluated based on the counterfactual observations that, in the absence of event B, event C does not occur. *This* counterfactual claim is evaluated within a systemic context that contains background assumptions about that particular system's entities, interactions and outcomes as well. These tacit premises, about cellular interactions within an immune system and the contributions of certain hematopoietic processes to the normal functioning of that large, diffuse, complex system will in turn allow for the evaluation of counterfactuals based on background law-like relationships between these entities. While the higher-level entities that compose a normal immune system certainly seem related to the entities and interactions of the cellular-level systems that make up that immune system, the question of whether these two systemic frameworks neatly integrate with one another is one that deserves to be investigated.

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[93] P. Menzies, "Difference Making in Context," In *Causation and Counterfactuals,* eds. J. Collins, N. Hall, and L.A. Paul, (Cambridge: MIT Press 2004): 156.

Mossio, Bich and Moreno, in their paper "Emergence, Closure and Inter-level Causation" provide reason to believe that a containing system like a hematopoietic system needn't be thought of as being causally dependent on the actions of the entities that make up that system. They argue that the organization of biological systems (and other self-maintaining systems) have a distinctive type of causal organization that influences the transitive relationships normally entailed by a standard counterfactual analysis. This distinctive causal organization arises from the fact that a complex biological system (for example, a cell) is maintained through a mutually-dependent set of constituents, each of which act as "constraints" on (or exert a determining influence on) other constituents within that closed system. Since each constituent is constrained by other constituents, which in turn are themselves constrained by constituents, the attempts to assign the "cause" of the complex biological system to the single constituents in isolation of the relations between them is not warranted. Instead, self-maintaining complex entities possess a "higher-level emergent regime of causation" which possess distinct causal properties and powers.[94]

This higher-level regime of causation, according to Mossio *et al*, can be understood and defended in terms of the causal interactions among the mutually dependent sets of constraints at the specific level of biological inquiry under examination, and need not appeal to the lower-level "causes" of the containing systems. Under this interpretation of emergent causal activity, the containing system can be an adaptation in an organism for performing the emergent functions that it possesses, and need not make any appeal to the intra-systemic processes that are, naively, considered to be responsible for the presence of the containing system: the "biological

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[94] Matteo Mossio, L. Bich, A. Moreno, "Emergence, Closure and Inter-level Causation in Biological Systems. In *Erkenntnis,* 73:2 (2013): 163-176.

emergence [of system-specific properties and traits], accordingly, is logically distinct from nested causation, and one can advocate the former without being committed with the latter."[95]

If one adopts such a view of biological systems, the properties of a hematopoietic system (including the system's functional properties) can be accounted for without making any appeals to the causal factors responsible for the components of that system. Likewise the components of a hematopoietic system like CLPs can have properties that can be understood without appeals to *their* internal components, and so forth. Since the argument for functional proliferation assumes that the several different types of systems have some sort of causal integration, the fact that these "intracellular-type" systems and an "hematopoietic-type" systems fall under distinctive causal regimes provides the opportunity to separate the distinctive systemic levels within an organism and block the ascription of functions to their containing systems. As discussed in chapter two, numerous different uses for the term "system" appear in biological contexts, but this argument for a distinctive causal organization as a property of biological systems allows for the possibility of alleviating the problem of functional proliferation without modifying previous etiological accounts.

Furthermore, this causal disunion in biological contexts allows for the possibility that, even if there are 'local' causal relationships between traits and their containing systems, it might still be the case that this transitivity cannot proceed unchecked. Despite the fact that there is some law-like relationship between events A and B, *and* between events B and C, there would still be reason to doubt the conclusion that A and C have a law-like relationship with one another: "since the description under which B is nomically connected to A need not be the same as that under which it is nomically connected to C, there is no reason to suppose that A and C

[95] *Ibid*, 176.

instantiate under any (law-like) description at all."[96] The fact that causal conditionals can be formulated that involve common events does not mean that the causal relationship is thus transitive; assumptions that causal relationships are logically closed across systematic levels may prove to be unwarranted.

There is another aspect to the context-dependence of counterfactual causal analyses that may help block the ascription of functions to their containing systems. Certain influences on the specific causal history of particular traits may be required for the presence of a certain state of affairs without seeming to have any *meaningful* causal responsibility for that state of affairs. When examining causal influence through counterfactual analysis, many of the conditions that can be framed in true counterfactual conditionals will be nonetheless not be understood to satisfy our normal-language uses of the word "because." Background assumptions, tacit premises, and enabling states of affairs can all have a role in the causal chain that leads to a particular state of affairs without bearing "normal" causal responsibility for that state of affairs.

It seems reasonable to assume that had the earth not been shielded from the intense radiation of the sun by the atmosphere, life on the planet would not have developed in the way that it did. If life had not developed in the way that it actually happened to, it likewise seems warranted to claim that CLPs would not exist in the manner that do. Thus a counterfactual conditional along the lines of "if there hadn't been an atmosphere, there wouldn't be CLPs" seems to be a reasonable claim to make, given the context of occurrence. However, the statement "human beings have CLPs because of the atmosphere" doesn't seem to accord with our normal use of the term "because."

[96] John Dupree, *The Disorder of Things,* (Cambridge: Harvard University Press 1993): 166.

The reason for this disparity between what counterfactual formulations state and our ordinary language causal judgments is that counter-factual conditional determinations of causal responsibility tend to be insensitive to what H. L. A. Hart and A. Honoré dubbed the "context of occurrence."[97] Despite the fact that the presence of an atmosphere (or of the planet earth, or of the universe) have a place in the causal history of a CLP, the causal contribution to the states of affairs that bring about CLPs are not considered to be factors that we normally assert as the causes of CLPs. Sophisticated counterfactual evaluations may posit that the possible world in which the Earth lacks and atmosphere may be inaccessible to the Earth in which CLPs develop, or perhaps that the presence of an atmosphere is a tacit premise under which all causal evaluations of the presence of CLPs are evaluated. However, no counterfactual assignments of causal responsibility will grant that CLPs are present because of the atmosphere, in the normal sense of the word "because."

This divergence between our normal language causal-explanatory use of the word "because" and the evaluation of counterfactual conditionals might likewise be used to block the ascription of functions of a trait to its containing system, for the context shift between intracellular activities and the activities of cellular development might be far enough separated from one another that either the intercellular processes by which A causes B are tacit premises of any evaluation of B's causing C, or that the possible worlds under which A is true or false are far enough removed from the possible worlds of B's causal contributions to C that the casual ascription of A to C is inappropriate. Even if failure of A would have led to failure of C, the counterfactual conditional would not correspond to our ordinary understanding of the term "because."

[97] Peter Menzies, "Counterfactual Theories of Causation." In *The Stanford Encyclopedia of Philosophy* (Spring 2014 Edition), Edward N. Zalta (ed.), http://plato.stanford.edu/archives/spr2014/entries/causation-counterfactual.

This does not seem to be as promising of a solution to the problem as the different causal regimes that are proposed by Mossio *et al*, for ~A (a lack of IL-7 binding) actually occurs (although quite rarely) and seems to exhibit some sort of nomically governed relationship with B, and B in turn with C, that a counterfactual evaluation seems to require. Thus event A does not seem to be the distantly removed tacit premise that, say, the atmosphere seems to be. However, as discussed above, this seemingly straightforward relationship is certainly more complicated than it first appears and it is at least possible for the advocate of the etiological account to assert that event A is far enough removed from the context of the causal relationship between B and C that its causal contribution is divorced from our normal language causal-explanatory account of the word "because."

Regardless of what is argued, this solution to the problem of functional proliferation in the etiological account comes at a price. Naively, a well-defined system like an organism appears to be coherent across its various levels. Organs accomplish their functions by means of particular cellular functions, which in turn accomplish their functions by means of intracellular functional processes. It seems perfectly reasonable to say that the human's immune systems are replenished by sustaining and supporting CLPs, which is done by means of IL-7 signaling (or, more formally, C does B by means of A). This solution suggests that that sort of functional integration across systemic levels is problematic: merely because functional entities are contained within a system (and function within that system), the systemic level of a functioning entity may have a causal regime that is distinct from the containing system. Assuming that the different systemic systems under which the causal ascriptions take place are commensurate with one another, may be unwarranted, according to this view. Moving transitively between causes at distinct systemic levels is instead a sort of causal ‘equivocation,’ which conflates distinct causal regimes with one another.

This solution must also come up with a way to deal with those cases wherein the functions of containing systems seem to be identical to the functions of the traits that contain them. As in the case of hemoglobin and red blood cells, there seem to be containing systems that share functions with particular traits, especially in cases of simple systems. There may be less reason to suppose a distinctive causal regime in relatively simple systems like red blood cells, or perhaps there may be opportunities in such simple systems to articulate a specific interactions between the systemic levels in such a way that the identification of functions between the traits and systems that contain them can be dealt with. Dealing with these sorts of cases, however, does add greater complexity to the already complex causal solution.

THE PROPER FUNCTION SOLUTION

The second solution to this problem of functional proliferation that will be considered involves a reconsideration of what functions are and what our functional conceptions are willing to capture. As seen in chapter one, there is more than one way that the idea of a “function” can be understood and grappled with. The analysis of the second chapter involved a consideration of functional proliferation in conceptual analyses of function; however, there are alternative ways in which functions can be defined. Millikan and other advocates of proper function present a definition of the term ‘function’ that exists independently of (and prior to) our concepts: Millikan’s account grounds functions in the *actual* influence of tokens of traits on the reproductive advantage of a self-replicating system. Although proper functions may imbue our functional claims with their meaning (in a way that a realist account of physical properties might claim that round objects imbue our concept of ‘roundness’ with its meaning), proliferation of functions in conceptual reconstructions of functional ascription are not, ultimately, problematic for this account. Instead, they're the natural outcome of attempting an impossible project: Millikan writes "that 'conceptual analysis,' taken as a search for necessary and sufficient conditions for the applications of terms, or as a search for criteria for application by reference to which a term has the *meaning* it has, is a confused program, a philosophical chimera, a squaring of the circle, the misconceived child of a mistaken view of the nature of language and thought."[98] Instead of viewing the project of functional ascription as a conceptual one, Millikan views it as one that depends entirely on states of affairs out in the world. This functional realism provides tools with which Millikan can attempt to avoid the problems of functional proliferation posed by the conceptual analyses previously considered.

One advantage Millikan's account has over the conceptual analyses of Wright, Varner and Ruse is that the functional ascriptions of her system are under much less pressure to conform to the preconceptions that we have about functional language as it is normally employed. By framing functions as technical relationships between traits and their contributions, the problems of functional proliferation are far less problematic. While it may well be the case that there are far more functions possessed by complex systems than initially thought, the discordance between what functions the system was naively thought to have and what a careful examination of the system actually reveals is to be expected. Since Millikan-style proper functions are manifested independently of concepts, it is not nearly as difficult to think of them as the sort of thing that can be "discovered."

Another means by which Millikan can avoid the proliferation of functions within containing systems is to distinguish between the "direct" proper functions within a system, and

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[98] Ruth Millikan, "In Defense of Proper Functions," *Natures Purposes: Analysis of Function and Design in Biology*, ed. Collin Allen et al. (Cambridge: The MIT Press, 1998): 297.

the derived, adapted and metaphorical functions that are ascribed. Direct proper functions are possessed by those tokens of a type within a specific "reproductive family,"[99] when certain contributions by past tokens of that type have provided some significant contribution to future tokens of that same time. The contributions that are made are the functions of that type, to the extent that they've significantly influenced the presence of the current type: thus the proper function of a heart is the pumping of blood, for (a) past hearts have pumped blood and (b) this past pumping in the ancestors who possessed past hearts (or heart-like structures, in the ancient generations of the reproductive family) actually contributed to the presence of current hearts.[100]

These functions are contrasted with derived proper functions, which are the proper functions of "adapted devices," or biological devices that vary in their performance and/or existence across changing conditions in order to reach some goal or result that does make significant contributions to the propagations of tokens of that type. The fact that the performances of a particular entity vary across environment and/or time, even as the goal or result remains fixed, implies that the proper function of the entity lies beyond the strict contribution to reproduction that that particular entity has. For example, CLPs express IL-7R on their cell surfaces throughout a specific period of development, in order that the cytokine signals from the bone marrow's stromal cells can send the signals preventing apoptosis and triggering lymphocyte generation and differentiation.[101] While the binding of IL-7 on their surfaces *is* a

[99] Millikan defines a reproductive family in part as "any set of similar items produced by members of the same…when it is a direct proper function of the [previous members of the] family to produce such items. Biological traits like hearts, as well as certain basic inherited and imitated behaviors qualify as tokens in a reproductive family. Ruth Garrett Millikan, *Language, Thought, and Other Biological Categories: New Foundations for Realism* (London: MIT Press, 1980): 24-28.

[100] Ruth Millikan, *Language, Thought, and Other Biological Categories: New Foundations for Realism.* (London: MIT Press 1980): 29.

[101] *Ibid*, 40-41.

proper function of CLPs (since that expression has, in the past, made significant contributions to the present token CLPs), that proper function is derived and not direct. The binding of IL-7 on the surface of CLPs does not constitute the contribution provided by that expression of the receptor on the cell: the expression promotes the lymphocyte development and differentiation which is the *direct* proper function of the CLP.

By drawing a distinction between direct proper functions and the “derived” proper functions whose contributions are indirectly in pursuit of the contributions to persistence and propagation, Millikan is able to make a conceptual distinction between the two notions of the term ‘function’ that the conceptual analyses do not make. Whether or not a conceptual analysis could incorporate this distinction between direct and derived functions is an interesting question, and a successful incorporation of this sort of distinction could do a great deal to prevent the proliferation of functions in the manner examined in the previous chapter.

Millikan’s view does give many hostages to fortune, however. One significant issue with this account is whether or not the relationship between self-reproducing systems and the contributions to their reproduction is the sort of relational property that can support the metaphysical weight that it is being forced to bear. Certain relational aspects of the external world seem to be presented in such a way that they do not require significant conceptual mediation in order to be recognized. The causal interaction between a cue ball in motion and a pool ball sitting at rest, for example, seems to present itself in a way that doesn’t rely on conceptual mediation beyond a very basic level. It is one thing to make the case that these interactions and relations can be understood as taking place absent from a conceptual context, but it is another thing to claim that the causal contributions to the reproductions of tokens of a type can be recognized as preceding a conceptual analysis is a more ambitious claim, and one that might not be able to be defended.

Even if these issues can be dealt with, there is still no assurance that contributions to the persistence and proliferation of tokens of a type will be causally ‘well behaved.’ The causal contributions that are responsible for the propagations of tokens might prove difficult to define or pick out, and might be messily related to the actual adaptive advantage they provide. Given a long and complex causal history, it’s far from clear that functions will be the sort of thing they’re normally recognized to be.

An example will make this problem clear: consider a peculiar behavior that is exhibited by the dogbane tiger moth when it detects an ultrasonic sound. This is a behavior, and thus a trait that is more complex than the ones that have been previously considered. However, it is an innate reflex in the insects (rather than a learned behavior), and it is unlikely that tiger moths are the sort of creatures that can act ‘intentionally’ on mental states in the way that more complex animals do, so it seems to be the sort of behavior that can be considered to possess a direct proper function under Millikan’s account.[102]

According to Lee Miller and Annamarie Surlykke, this particular species of moth, using primitive “ears” located across its entire body, is sensitive to sound waves in the ultrasonic spectrum, and upon hearing the ultrasonic pulses used by bats for echolocation will begin to open and close its wings in such a way that a specialized membrane between the insect’s wing and thorax generates a “click” in the same ultrasonic register that the bats use for echolocation.[103]

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[102] Millikan cites a similar example to this one as a behavior in which it “seems so unlikely that the [insect] calculates over any inner representation;” instead, the behavior is reflexive and instinctive. Ruth Garrett Millikan, “Truth Rules, Hoverflies, and the Kripke-Wittgenstein Paradox.” In *The Philosophical Review,* 99(3) (Jul 1990): 331.

[103] Lee Miller and Annamarie Surlykke, “How Some Insects Detect and Avoid Being Eaten by Bats: Tactics and Countertactics of Prey and Predator” In *Bioscience,* 51:7 (2001): 573.

This is a curious behavior: the moths are preyed on by bats, and normally prey attempt to blend into their environments to escape predation, not to actively draw attention to themselves. The fact that the insects do so, and have highly specialized organs that allow them to do so, seems to suggest that the behavior must have *some* sort of adaptive benefit, and furthermore it seems reasonable to suppose that the benefit must be related to the ability to avoid predation.[104] To this extent, one might think that the stimulus-response behavior between the sensation of an ultrasonic noise and the articulation of the clicking membrane as possessing a proper function, assuming that the reproductive families of Millikan system include the moderately complex neurological system that governs the interaction between the stimulated ears and the responding membrane. This behavior, upon initial consideration, seems to contribute to adaptive benefit in a relatively straightforward way.[105]

However, it turns out to be quite difficult to determine how the clicks actually *do* "pick up or react to correlations of various kinds among items in and around them, for example, between their own behaviors and subsequent events."[106] It has been hypothesized that the Dogbane Tiger Moth 'clicks' startle bats, providing the slower insects with an opportunity to escape from the faster predator, in a manner similar to a skunk's spraying gives it an opportunity to flee faster predators. Likewise, it has been suggested that the clicks act as a method by which the moths can "jam" the bat's sonar: since echolocation relies on the differences in the amount of

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[104] Ecologists refer to this phenomenon as 'crypsis,' though the attributes that enable it share little in common beyond their classification. Coloring, behaviors, dispositions, and even biochemical attributes (i.e. phenomenal mimicry) are all examples crypsis.

[105] *Ibid*, 574.

[106] Ruth Garrett Millikan, *Language, Thought, and Other Biological Categories: New Foundations for Realism.* (London: MIT Press, 1980): 27.

time between the emittance of a sound and the sound's return, the broadcasting of a sound by the insect could disorient the bats and cause them to misjudge the location of their prey. Furthermore, the regular clicks, when emitted by a group of moths, could drown out any returning signals reflected off the insects themselves; in this way the individual insects would be difficult to spot in the same way that it is difficult to make out the silhouette of a person at night when they are standing next to (or behind) a very bright light. A *third* hypothesis is that the insects are not attempting to flee the bats at all: as it turns out, bats don't seem to like eating dogbane tiger moths all that much, and will generally eschew them for something more palatable. Thus the moths would not be attempting to evade predation, but rather to broadcast to the predator that they are not the tasty meal that they might otherwise be taken to be. This sort of "warning" is rather common in the natural world: poisonous creatures often have bright coloring to broadcast to predators that they're not to be eaten, and other animals (i.e. rattlesnakes) will broadcast their presence if they are dangerous or unappealing prey.[107]

It is tempting to view these three possible purposes of the insect's clicking behavior as three competing hypotheses, one of which it might be possible to settle on as being correct, and the others incorrect. It could turn out to be that case that through careful examination one might be able to determine that the clicks have a function.

However, there is another possibility, which Miller and Surlykke admit in their description of the behavior: "the startle, interference and warning hypotheses are not mutually exclusive…all three possibilities (startle, interference, and warning) offer selective advantages,"[108] and it may well be the case that all three of the benefits of the behavior

[107] Lee Miller and Annamarie Surlykke, "How Some Insects Detect and Avoid Being Eaten by Bats: Tactics and Countertactics of Prey and Predator" In *Bioscience*, 51:7 (2001): 577-578.

[108] *Ibid.*

contributed to the development of the functional traits responsible for the behavior. It's entirely possible that the moth's clicking serves manifold purposes simultaneously that are only connected to one another: the behavior might confuse the bats, startle them, warn them that the moths are not worth eating, or provide other unacknowledged benefits all at the same time.

This example illustrates how complicated it can be to formulate the function of even a mildly complex biological attribute given a specific evolutionary lineage. The relatively straightforward proper function of an organ like the heart can easily be determined: the proper function of the heart is to pump blood, for blood pumping is the activity of the heart that contributed to the survival and fecundity of those ancestors that possessed those hearts. However, explanations for the persistence and propagation of functional traits that are this clear are not always so easy to come by: even a biological process as straightforward as the neurological responses of an insect seem to elude clear articulation. Certainly the clicking of the moths seems to do (at least) *something* that gives the moths an evolutionary advantage, and thus it makes some sort of causal contribution to its persistence and proliferation. However, articulating what this thing (or these several things) is, and how it brought about the successes that it did, does not seem as straightforward as a method of articulation functions might desire it to be.

Any attempt to appeal to an idealized, perfected causal history that led to the emergence and persistence of the clicking behavior is not guaranteed to reveal a clear causal contribution to the persistence of the behavior over time. Depending on the histories of the predator or prey, and their particular dispositions at particular times, it is entirely possible that no fixed set of contributions could be pinned down to explain the persistence and propagation of the behavior. It may have been that the clicking initially served as a "startle" function for some bats and the "interference" functions for others, and warning for others, all at the same point in history. Likewise, the causes for the persistence of the trait may well vary over time: the cooption of evolutionary traits seems to be quite common, and these changes need not, as Millikan sometimes seems to assume, require a change in the structures of the functional entities themselves.[109]

Despite all of this, the advocate for proper functions may nonetheless contend that the trait can be said to possess a proper function that unifies the competing causes of the clicking behavior: they might say that the function of the clicking reflex is to disrupt bat predation (or to avoid bat predation). This explanatory richness is undermined by the fact that the clicking of dogbane tiger moths has *another* use, unrelated to its role in avoiding predation: male moths use the clicking to signal their presence to female moths, a purposeful behavior undertaken in order to facilitate reproduction.[110] Which role that the clicking initially played in the evolutionary history of the insect is unclear (although there's no reason that it could not have fulfilled both functions from the outset of the development of the trait itself), but even if these historical questions could be sorted out such co-option still further complicates the causal story on which the formulation of proper function relies.

Instead, all that proper functions leave us with is that the function of the behavior is to click at certain times. This may be enough for this solution to rest upon, but it is worth reflecting on where the account of function began and where, after being subjected to the test of proper

[109] Ruth Garrett Millikan, *Language, Thought, and Other Biological Categories: New Foundations for Realism* (London: MIT Press, 1980): 32.

[110] W. E. Conner, "Ultrasound: its role in the courtship of the *arctiid* moth, *Cycnia tenera*," *Experientia* 43:9 (1990): 1029–1031.

functions, it has ended up. Functions described biological entities, explained the entities' presence and articulated what they were there for and why they were there. At the end of Millikan's proper function analysis, the majority of our functional language is reduced to metaphorical allusions that invoke a difficult to determine, often opaque relationship between a trait and its murky contributions to the evolutionary success of a particular organism.

THE EXPLANATORY SOLUTION

One other method of solving the problem of functional proliferation will be examined here. The root of the problem of functional proliferation is that there are too many causal contributions to the presence of a containing system which, because the systems are also efficient causes of that function, can qualify as functions of the system under etiological ascriptions. IL-7 binding contributes to the presence and persistence of CLPs, and since the binding of IL-7 is a result of the CLPs' being present, the contribution of IL-7 binding to the presence of the cells leads to an ascription of a function that seems inappropriate.

If a solution cannot be found in the causal relationship between the traits and the systems that contain them, nor in a reinterpretation of functions themselves, a third solution to the problem can be formulated that arises out of consideration of one of the reasons why the functions ascribed through proliferation seem so inappropriate. This solution will seek to address the problem of functional proliferation as a problem with the explanatory aspects of functional language, and seek to devise a solution to the problem of functional proliferation that attempts to rescue the explanatory aspects of functional description.

Functional descriptions, as discussed in chapter one, are widely acknowledged to have certain explanatory aspects. Both Wright-style etiological analyses and Cummins-style dispositional strategies acknowledged this explanatory aspect of functional description, although the two accounts differ in what they claim functions explain. Wright and the etiologists claim that functions are capable of explaining the *presence* of a trait or system: functions give answers reasons for why certain things exist in the location and configuration that they do.[111] Cummins and Cummins-style analyses view functions as a more versatile sort of explanatory tool: functions, according to this perspective, are capacities and dispositions of traits that figure into a satisfactory analysis of how the components of containing systems give rise to the containing system's capacities and dispositions.[112]

One problem with the proliferative functions within containing systems is that the functions that are ascribed to the containing systems seem to fail to perform the explanatory role that etiologists claim functional language possesses. One of the issues with ascribing the function of IL-7 binding of CLPs is that they fail to provide an explanation for the presence of the containing system in any sort of non-trivial way. If functions are supposed to be a means by which the presence of traits or systems can be explained, the function of IL-7 binding does not seem to shed light on why the CLP is present in a non-trivial way: IL-7 binding may be a reason that CLPs are present, but not the correct sort of reason. Of course CLPs wouldn't exist and persist without IL-7 binding to the receptors on that cell surface at the proper times and places. However, the act of IL-7 binding doesn't shed any light on *why* CLPs are present in a purposive (or perhaps in a goal-directed) sense. Proliferative functions may be conditions that are required for the existence of the cells, and to that end they may provide causal reasons for the existence of the containing system. They are not, however, purposeful reasons.

[111] Larry Wright, "Functions." *The Philosophical Review*, 82(2) (1973): 155.

[112] Robert Cummins, "Functional Analysis," *The Journal of Philosophy*, 72(20) (1975): 759-760.

This is not meant to conflate functions with purposes, or functions with goal-directedness. What is instead being argued is that the various explanations for the presence of a thing can possess different virtues, and that one explanation cannot be substituted for another. Causal explanations for the presence of an entity are not equivalent to non-functional purposive explanations, which in turn are not equivalent to functional explanations. The presence of a traffic officer can be explained by appealing to a causal history that involves the officer's parents, or it can be explained by the conscious desire of the officer to avoid being punished for not performing her duty, and so forth. The explanation for the presence of the officer that invokes the function, however, is a specific sort of explanation that has explanatory virtues these other explanations do not. It provides a unique insight into why the officer is present in the middle of the intersection directing traffic.

As seen in the examination of causal solutions to the problem of functional proliferation, the list of contributions to the existence of a biological entity is a very long list indeed, and many of these contributions will qualify as functions despite the fact that they are "trivial" in an explanatory context. The atmosphere, to borrow a non-functional causal contribution example from the previous section, likely contributed to the existence of the CLP in its current form. However, an explanation of why CLPs are present in organisms is not likely to invoke the presence the atmosphere. While it may well be the case that the atmosphere figures into the causal history of the CLP's presence, the causal contribution of the atmosphere is not likely to have any explanatory relevance to why CLPs are present in their current form. Likewise with functional descriptions, a good number of the functions of traits in that containing system *will* be labeled as "functions of" that containing system under etiological formulations without providing any reasons as to why the containing system is present from a *purposive* aspect.

Furthermore, since a great deal of intra-cellular functions will qualify as functions of the containing cell under etiological formulations, the proliferation of functions in that sort of complex containing system and the possible assignment of apparently contradictory functions to a containing system also weakens the particular explanatory value of the functional description. Recall how the contradictory functions of the DNA replication system seem to explain its presence a bit too well, seeing as how it can be assigned the etiological functions of both initiating and terminating DNA replication: if one of the explanatory goals of etiological functions is to explain the presence of a trait or system, assigning contradictory functions to complex systems permit the explanation of their presence across a wide variety of possible circumstances. Yet if explanations are too broad, they are not of much value: having the functions of initiating and terminating DNA replication seems to provide an explanation that justifies the existence of the containing system across every possible situation (or, at least, across all nearby possible-world situations in which a DNA replication system *could* be present in a manner relevantly similar to the way that it is now).

If the functional proliferation within containing systems is viewed primarily as an explanatory issue, then a solution to the problem can be found in the examination of what, exactly, etiological functions are commonly thought to explain, and which sort of functions end up satisfying this explanatory goal. Wright claimed that functional explanations "concern how the thing with the function *got there*,"[113] while McLaughlin more formally argues that "the appeal to functions…explains the existence and properties of those parts of a self-reproducing system that contribute to the self-reproduction of that system."[114] In a biological context, this

[113] Larry Wright, "Functions." *The Philosophical Review*, 82(2) (1973): 157.

[114] Peter McLaughlin, *What Functions Explain: Functional Explanations and Self-Reproducing Systems* (New York: Cambridge University Press, 2007): 209.

explanatory project is one that will call upon the causal background of mutation and selection, along with the contributions that certain traits to make that the increase selective advantage in that process in order to explain those sorts of traits' persistence and propagation across generations.

Though as the problems of functional proliferation suggest, it might not be all of the *actual* contributions to presence and persistence that are of primary interest from the standpoint of functional ascription, especially when considering a complex system instead of a single entity. Instead, those contributions that shed light on the existence and properties of the containing systems contained within self-reproducing system will be judged to be appropriate function ascriptions. While there may be many causal contributions responsible for the presence of a containing system, and many of these contributions will appear to qualify as functional contributions to the presence of the containing system under the previously considered etiological formulations, only some of these contributions provide insight into the purpose that the containing system has to the presence and persistence of the self-reproducing system.

By placing this particular type of explanatory value at the center of etiological functional ascription instead than actual contributions to the persistence and propagation of traits within self-reproducing systems, the etiological analysis moves closer to Cummins' account of functional explanation: the functions that are ascribed to traits and systems within etiological accounts will have to meet some explanatory threshold in order to be considered legitimate. IL-7 binding can be discounted as a function of CLPs because explanations of how CLPs contribute to the self-reproduction of the systems that contain them (or provide adaptive advantage to the organisms that contain them) will not invoke the CLP's disposition towards IL-7 binding.

How, exactly, etiological accounts are to manage incorporating this explanatory requirement into their formulations is a matter that deserves more consideration than it can be given here. An additional criterion along the lines of “Y explains the existence and properties of X” or “Y is a purposeful reason for the presence of X” seems rather crude, and leaves open many problems about how to separate relevant explanations from those that are less-relevant, how a “purposeful reason” ought to be defined, what it means to explain the existence and properties of a trait, and a litany of others. Likewise, the incorporation of an additional explanatory requirement into existing conditionals faces profound problems about the nature of explanation (especially this strange sort of purposeful reason-giving or explanation of existence and property). Do the explanations need to be correct, or merely succeed in satisfying the curious? It may well be the case that successful explanations are always true explanations, but this is far from a principle that can be assumed without prior argument. What sort of explanations are acceptable? How explicit (or how vague) are they to be?

Furthermore, something important is lost when explanatory requirements are incorporated directly into etiological accounts. One of the virtues of etiological analyses of function is their independence from the context-dependence of dispositional analyses of Cummins-style approaches: functions are ‘anchored’ by the events that have brought about the entities that possess those functions, and not subject to our peculiar explanatory projects. Furthermore, this anchoring and independence from explanatory projects gives etiological functions a special sort of explanatory force that Cummins-style functions do not possess: the functions are arrived at independently, outside of any sort of explanatory project, and they are then ‘brought in’ to certain explanations of existence and property. By inserting any sort of explanatory criterion into etiological analyses, the process of determining the functions of traits becomes much more about a certain explanatory project, and less about an independent investigation into a special sort of property possessed by a trait or system.

Despite these problems, this last solution to the problem of functional proliferation may be a project worth pursuing. The disparities between etiological analyses and dispositional analyses of function have received more attention in recent literature, in part because of how the philosophical distinction between two 'types' of functional language clashes with the apparent unity of our functional language. Everyday functional claims do not come couched in distinctions between Wright-style and Cummins-style functions, and while a pluralistic interpretation of functions can certainly be philosophically justified, it may well be that there are common unifying themes that connect the competing views.

In the paper "Function and Design," Philip Kitcher moves toward such a unification of Wright and Cummins-style analyses by noting that, in evolutionary as well as artifactual contexts, functional ascriptions in either system take place within a shared context:

> "when we attribute functions to entities that make a causal contribution to complex processes [and assign Cummins-style functions], there is, I suggest, always a sources of *design* in the background…selection lurks in the background as the ultimate source of design, generating a hierarchy of ever more specific selections pressures, and the sutures, traits and behaviors of organisms have functions in virtue of their making a causal contribution to responses of those pressures."[115]

Both etiological and dispositional accounts, according to Kitcher, share a common causal-historical structure that help determine the methods under which functions are ascribed. Functions, according to this view, arise from a process of design.

This solution likewise moves towards a unification of etiological and dispositional accounts under a shared structural background, but the background is not design but explanation.

[115] Philip Kitcher, "Function and Design," *Nature's Purposes: Analysis of Function and Design in Biology*, ed. Collin Allen et al. (Cambridge: The MIT Press, 1998): 493-494 (emphasis mine).

Functions, according to this perspective solution, are ultimately-as Cummins insists-a certain sort of explanatory device. According to his dispositional view, outcomes of containing systems that prove too complex for normal explanatory methods can be explained by appealing to the functional descriptions of their composing parts. The etiological view, likewise, would have to meet certain explanatory requirements, though what these functions are seeking to explain will keep the distinct etiological conception of what functions are more or less intact.

Under this sort of etiological-explanatory strategy, the *specific* outcome that is seeking to be explained is the existence and the properties of traits and systems that exist within a self-reproducing system. In many biological contexts, this self-reproducing system can generally be understood, *a la* Wright, to be the organism itself, although this needn't necessarily be the case: if one is interested in explaining the presence of a receptor on a cell surface, for example, it might well be possible to explain the presence of that receptor by only appealing to the receptor's contributions to the persistence and propagation of the cell, and not the receptor's contributions to the normal function of the organism (though these contributions might be implied): based on the functions' ability to explain the propagation of the trait and the success of the organism in the past and/or present. Those dispositions that are possessed by a trait or system that shed light on the persistence and propagation of the self-reproducing system would, under this view, be considered functions.

CONCLUSION

The three solutions put forth in this chapter are merely proposals for how the problem of functional proliferation can be solved, and none has been pursued in full. Whether or not any of the solutions examined can ultimately solve the problems posed in chapter two, it does seem that etiological accounts of function will require some revision or reinterpretation in order to accommodate a more nuanced understanding of functional entities in biology. The alternative to this revision or reinterpretation is accepting that systems oftentimes have a very large number of functions, some of which are contradictory, some of which seem to explain certain aspects of the system that possesses them, some of which do not.

Etiological analyses promise independence from the context-dependence of dispositional analyses: the possibility that functions can be grounded in the events that have brought about the entities that possess them satisfies a deep intuition about the independent existence of function in the biological world from our own intellectual projects. Functions, after all, are the sorts of things that seem to be discoverable; Glick and his colleagues are not credited with formulating a new and interesting explanation for the dispositions of a chicken, but for the discovery of an organ's function. The function was 'out there,' out in the world, waiting to be uncovered. To say that functions are nothing more than an explanatory tool seems to cheapen an aspect of the natural world that is rather special and compelling.

Yet etiological accounts of biological function are not of much use if they cannot deal with the complexity of the biological world, and systems seem to be a part of that complex world. Should the preceding arguments prove to be correct, revision or reinterpretation of the etiological accounts of function in biology ought to be considered.