Sanaa Abrahams
11A3041

Master’s Degree Thesis

Rhodes University
Department of Philosophy

Title: Understanding of Biological Teleology from a Naturalistic Perspective

Thesis in Partial Fulfilment of Degree

Supervisor: Francis Williamson
f.williamson@ru.ac.za

Date of Submission: 15 February 2019

While it may sound as if ‘order for free’ is a serious challenge to Darwinian evolution, it’s not so much that I want to challenge Darwinism and say that Darwin was wrong. I don’t think he was wrong at all. I have no doubt that natural selection is an overriding, brilliant idea and a major force in evolution, but there are parts of it that Darwin couldn’t have gotten right. One is that if there is order for free — if you have complex systems with powerfully ordered properties — you have to ask a question that evolutionary theories have never asked: Granting that selection is operating all the time, how do we build a theory that combines self-organization of complex systems — that is, this order for free — and natural selection? There’s no body of theory in science that does this.

Stuart Kauffman

Table of Contents

Chapter 1: Teleological Attribution and Mechanism: An Uneasy Union 9

1.1 Classical Teleology 9

1.2 The Problem of Teleology 15

1.3 Kantian Metaphysics 18

1.4 Introducing Mechanistic Reduction 26

Chapter 2: Traditional Etiology and a Normative Definition of Function 33

2.1 The Etiological Theory of Function 38

2.2 The Dispositional Theory of Function 43

Chapter 3: Normativity and Holism 52

3.1 Function and Internal Normativity 54

3.2 The Systems Theory of Function 69

3.3 Holism 76

3.4 A Value Account 90

Chapter 4: Functional Explanations as Causal Explanations 96

4.1 The Definition of Function 96

4.2 Objections 101

Chapter 5: Anti-reductionism and Naturalism 107

5.1 Reductionism versus Anti-reductionism 109

5.2 Against Biological Reductionism 113

5.3 Realisation Physicalism 117

5.4 Ultimate Explanations 121

5.5 Modelling Holism 125

5.6 Biology as Explanation 129

Understanding Biological Teleology from a Naturalistic Perspective

It is a matter of common judgment, evident in our descriptive practices, that organic processes and structures are purposive in character. In our statements about the organs, traits and behavioural strategies of organisms for example, we promptly make use of expressions like “the purpose of”, “the proper function of” and “in order to”.[1] Thus we say that “the purpose of the hypothalamus is to monitor blood oxygen and sugar levels”, “the function of jackrabbits’ ears is to assist in thermoregulation in the desert” and “Peacocks spread their tail feathers in order to attract peahens”. These kinds of expressions usually denote that the statements in which they occur are teleological in nature. That we find it descriptively satisfying to make teleological attributions when thinking about living things is captured by Immanuel Kant in his *Critique of Judgment* by the phrase *subjective* or *perceived* purposiveness.[2] Kant claimed that in its natural laws, with respect to our ability as limited beings to understand biological phenomena – and even potentially regarding the objective explanatory grounds of connection between the parts of biological systems – the natural world appears to us to be bound up inextricably with teleology.[3] Despite the fact that it is far from clear that our use of function-ascription statements is compatible with the ontological commitments of twenty-first century science, it seems that we regard functional explanations as peculiarly satisfactory in the case of living things. As, Francisco Ayala writes, non-teleological explanations simply do not seem capable of conveying the directive organisation of biological systems.[4]

A teleological ontology is regarded with great scepticism in contemporary scientific circles. Teleological explanations of natural phenomena capture the idea of design or goal-directedness in the way the universe is constituted. More than a prospective physical state or end (like the proposed heat death of the universe), teleology is taken to imply purpose in a natural entity, state or process.[5] And since the Enlightenment, the consensus has been that science can make extraordinary progress without needing to concern itself with what a material event is for. While the material cause and the

---

[1] Ernest Nagel, ‘Teleology Revisited’ in *Nature’s Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998), pp. 198 – 199.

[2] Immanuel Kant, *Critique of Judgment* (1790). Trans. by J. H. Bernard, 2nd edition revised (Macmillan, 1914), pp. 140 – 146.

[3] Kant, *Critique of Judgment*, pp. 117- 119.

[4] Francisco J. Ayala, ‘Teleological Explanations in Evolutionary Biology’ in *Nature’s Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).

[5] John Farrell, Why Teleology isn’t Dead (Forbes), accessed via http://www.forbes.com/sites/johnfarrell/2016/06/08/why-teleology-isnt dead/#2e3d48b73d41.

efficient cause have remained crucial to modern science, the classical concepts of final and formal causality are today viewed as irrelevant to physics. Indeed the notion of purpose in the natural world is nebulous and ill-understood, and is often regarded by biologists themselves as a mere rhetorical and pedagogical tool. Because physical explanations which require the genuine influence of formal and final causes are no longer regarded as scientifically legitimate, our strongest descriptive urges in the biological realm are not considered by scientists to undermine the extension of mechanism as a metaphysical position to the life sciences.

Still, philosophers have long since pointed out that teleological expressions in non-biological and biological contexts are importantly asymmetrical with respect to the explanatory role of teleological principles contained therein. Purposive characterisations in non-biological contexts imply only external teleological phenomena. When it comes to inanimate phenomena, mechanistic reduction of teleological concepts can hence easily be achieved. The objectionable form of teleology which is the focus of this thesis exists solely in non-intentionally purposive systems. Thus the problem bequeathed to us from the Enlightenment revolves around the meaning we attribute to the teleological claims we make in biology, given that it is mostly accepted that such statements are not to be taken at face value. There is dissensus surrounding how functions explain, the kinds of entities of which functional explanations can be appropriately asserted, as well the metaphysical presuppositions which an explanatory appeal to function entail.[6] Does description of a teleological phenomenon denote distinct biological information, or are these descriptions in fact identical with processes expressible using standard causal concepts and categories? These are some of the questions which I will be attempting to answer.

To the extent that teleological thinking is metaphysically suspect, many theorists attempt to shift the stigma of functional explanations by reducing function ascriptions, and aim thus to de-legitimise an appeal to teleological causal relations in an analysis of function. The point is to dispel the mystery which envelops the application of function concepts by reformulating biological functional explanations so as to dispense with teleology. My project is to interrogate the success with which teleological explanations have thus been eliminated in the biological sciences, and, over the course of this thesis, I conclude that a kind of teleological causation nevertheless remains the most adequate explanatory ground of natural products. My proposal is that functional explanations are causal explanations for the presence and maintenance of self-reproducing systems. I contend that, insofar as the attribution of function presupposes the valuation of a function-bearing system as a causal necessity for its constituent parts, functional explanation references distinct and irreducible holistic properties.

---

[6] Nagel, ‘Teleology Revisited’, pp. 198 – 213.

Using Kantian metaphysics to frame the discussion, this thesis aims first to explore critically the subject of functional characterisations of biological phenomena, and second, the metaphysical basis of modern science. Its chief contributions to the philosophical function debate reside in proposing novel arguments in justification of what I consider is an improved formulation of an attempted definition of biological function, in which teleological causal powers are explicitly recognised and accommodated in functional explanation. Moreover, this thesis attempts a naturalistic reconstruction of the metaphysical entailments of the real causality of a whole.

To begin with, that it is not possible to conceive of organic phenomena except as possessing ends or goals introduces our primary justifiable basis for thinking according to the teleological principle.[7] Aristotle was of course first to consider life in terms of a hierarchy of capacities in his *De Anima*.[8] But it is Kant who probably provides the discussion which is seminal in articulating the intuition that reference to purpose is essential in describing living beings. According to Kant, we are first led to think of biological entities as having a *telos* because the laws of mechanistic causality strike us as inadequate to the concept of an organised being. [9] And his argument for a conceptual imperative towards functional descriptions is that our cognising of natural products is impossible without us thereby also judging of them to be produced designedly as purposes.[10] To-date, natural function is still regularly adduced, with functional explanations remaining an indelible feature of standard biological practice. Hence Alexander Rosenberg states that a philosophy of science which focuses on elimination rather than justification of functional explanations in biology "must be wrong".[11] Functions have categorical explanatory value for biology. It is this fact which has been widely acknowledged in the philosophy of science. It comprises the basis for an apparent dispute regarding the meaning of functional terminology, and it has ushered in the popularity of *etiological* analyses of function, as well as the subsequent hypotheses which are its reactions. There now exists a plurality of analyses of teleological statements, of which the dominant schools of thought I shall consider are the etiological, *dispositional* and *systems* interpretations.

This thesis seeks to develop the traditional etiological theory of function. While natural selection is key in explaining how and why function bearers exist as designed products, I nevertheless challenge its sufficiency, arguing that function ascriptions cannot be adequately rendered by any standard mechanistic analysis and that an analysis of function which incorporates a non-reducible appeal to a form of teleological causation is necessary for empirical understanding of the entities studied by the life sciences. Departing from prior attempts to derive technical norms from natural selection for teleological

---

[7] Kant, *Critique of Judgment*, p. 127.

[8] See Aristotle, *The Works of Aristotle: De Anima*. Translated by Hugh Lawson-Tancred (Penguin, 1987).

[9] Kant, *Critique of Judgment*, p. 118.

[10] *Ibid.*, pp. 140 – 146.

[11] Cited in Peter Mclaughlin, *What Functions Explain: Functional Explanation and Self-Reproducing Systems* (Cambridge, 2001).

ascription, it introduces a moral valuational component in support of a naturalistic value analysis (in which value has an essential explanatory role). The intended deliverable is an adequate exploration of biological function which follows progressive trends within the scientific community in its view of teleological explanation. My analytic aim is to propose a theoretical definition of biological function, which combines both the principle of natural selection that is so integral to modern biology, and definitive characteristics of life, including, but not limited to, self-organisation. The point of arriving at such a definition is to establish on the most generalist scientific grounds a theoretical argument against scientific reductionism about at least some biological facts.

A theoretical definition in this instance helps us to understand how a function concept is, and should be, used, by taking into consideration the standard explanatory applications of the concept by specialists. The significance of a theoretical definition is hence that it should have sufficient explanatory reach for the gamut of functional phenomena embedded in biological theory.[12] So, deriving a definition by attempting to characterise important examples of function attribution allows us to frame a normative theory which will illuminate certain central distinctions. Still, the scope of such a theoretical definition will be delimited by conceptual analysis, and insofar as the term under analysis is one well understood by the conceptual community of biologists, the criteria for application of the concept will correspond closely with our beliefs about function also. Therefore the definition of function presented in this thesis will – and should – feel familiar. I begin by setting forth my analytic aims in order to indicate the justifications and criticisms which I take to be appropriate to my account. While my argument is heavily concerned with empirical fact, it is less interested in avoiding counter-examples through conceptual refinement.

My secondary goal is to articulate a defence of an anti-reductionism that is compatible with physicalism, in order to suggest how teleological explanations might be rendered coherent within modern science, and thus to provide an explanatory framework through which teleological causation can be understood.

The conclusion that teleological discourse is not ontologically tameable supports the hypothesis that a revised physicalism, able to adjust to holistic or ‘top-down’ causation, is called for. In the final chapter, I undertake a metaphysical defence of my analysis of biological function by arguing, on the basis of an ontological thesis of emergentism, for the superiority of theory anti-reductionism. This is the doctrine that all investigable entities are organised into a hierarchy of autonomous domains and consequently, there is a non-reducible relationship between physics and the special sciences. I claim that while the irreducibility of teleological ascriptions shows that metaphysical holism plays an essential part in scientific explanation, science as it now conceives itself is not able to engage critically the

---

[12] Karen Neander, ‘Function as Selected Effects: The Conceptual Analyst’s Defense’ in Nature’s Purposes, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998), pp. 316 – 317.

relationship between levels of organisation[13] without questioning some of its most fundamental theoretical precepts. But equally, since it is not theoretically parsimonious to conclude that biology is at odds with accepted scientific theory, the notion that functional explanations are basic in a genuine causal sense also raises misgivings about what are the required metaphysical assumptions of a naturalist science, and what indeed is the investigatory reach and viability of the ones we are currently making. While an overhaul of the naturalist paradigm is not my aim, these are pertinent issues towards which this thesis will have to take a stance.

Lastly, biological function presents an important problem for philosophical research. First, the debate between reductionism and anti-reductionism has considerable practical significance about what is the right research programme to be pursued in the sciences.[14] But the seemingly small technical issue of holism also lies at the heart of much larger and variegated disputes in the special sciences – ranging in subject from social formations, economics and mind, to free will and responsibility.[15] Furthermore, from a theoretical point of view, function involves a scientific paradox which to-date remains unresolved. These issues follow and spotlight a broader trend within science in which the dispensability of teleology in science is being challenged. Most famously perhaps, Stuart Kauffman's new paradigm for evolutionary biology challenges scientists to engage recent empirical findings by integrating the concept of biological self-organisation with evolution. Not only does this new body of theory acknowledge directionality in nature, but, as is argued by the palaeontologist Simon Conway Morris, there are fundamental physical characteristics to life at the most basic level which suggest that there is convergence across the spectrum of life towards the evolution of consciousness. Another more radical suggestion is made by Neuroanthropologist Terrence Deacon, according to whom consciousness is not materially embodied. And yet, consciousness as a subject for neuroscience is not extra-physical to the extent that it is materially causally efficacious. This research potentially adds valuable insight to these discussions.[16]

---

[13] Alexander Rosenburg and Daniel W. McShea, *Philosophy of Biology: A Contemporary Introduction* (Routledge, 2008), p. 126.

[14] Philip Kitcher, '1953 and all that: a Tale of Two Sciences' in *Philosophy of Biology: An Anthology*, (eds.) Alexander Rosenburg and Robert Arp (Wiley-Blackwell, 2010), pp. 227 – 228.

[15] Harold Kincaid, Individualism and the Unity of Science: Essays on Reduction, Explanation, and the Special Sciences (Rowman and Littlefield, 1997), pp. 1 – 2.

[16] John Farrell, *Why Teleology isn't Dead* (Forbes), accessed via http://www.forbes.com/sites/johnfarrell/2016/06/08/why-teleology-isnt dead/#2e3d48b73d41.

1. Teleological Attribution and Mechanism: An Uneasy Union

Both laypersons and scientists regularly reference function or purpose in explanations for things, and also accept functional explanations as explanatorily significant and perhaps acceptable responses to questions about the existence, structure, location and even value of entities. And most of the time, when we thus explain a thing by referring to a stable character or effect that it brings about, we do not thereby intend also to imply teleology in either its Aristotelian or modern form.[17] Throughout the social sciences and the biological disciplines especially, function statements are lightly countenanced, even though no biologist today actually thinks that the jackrabbit's ears assist in thermoregulation in the desert because their goal is to realise an essence of jackrabbit-hood, along with its distinctive ears. Therefore a common approach to the explication of ordinary teleological expressions is to view them as misguided statements, based in confused examples, or else to be metaphorical in intent. Indeed many apparent examples of teleological phenomena, involving systems that are intentional artefacts, can be shown to be reliant upon implicit appeal to intentional agency, and are therefore ontologically mundane. Nevertheless, the phenomenon of non-intentional or internal purposiveness is undeniably applicable to living beings. Many biologists in fact believe that functional discourse is essential to describing and explaining a number of important biological phenomena. Why is this so? Why is functional explanation regarded as appropriately adduced of some things, but not of others? What is the relevant categorical distinction here? These are some of the questions I set out to answer in this chapter.

In their accounts of the concept of function, many naturalists attempt to expand the scope of functional analysis by including in the definition of function besides biological purposiveness, univocally, attributions of function (as does Ruth Garrett Millikan) in the case of learned and reasoned behaviours, customs, language and artefacts.[18] Such a general characterisation would focus on those definitional factors which are shared by organic and intentional functions. However there is no reason to suppose that a general classificatory concept would be useful for explicating biological function. In fact, we will see that there are compelling reasons not to pursue this route: a general analysis of function ascriptions gives us too abstract an account and ignores key desiderata on functional analysis in the biological context. I outline these desiderata before integrating them into my critique of major positions in the literature. It must be demonstrated, rather than *prima facie* assumed, that the unique conceptual challenges posed by non-intentional teleological explanations can (as in other instances of putative teleology) be justified from the viewpoint of materialistic determinism.

---

[17] Mclaughlin, *What Functions Explain*.

[18] Ruth Garrett Millikan, 'In Defense of Proper Functions' in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998), p. 296.

In this, first section, I make clear that function ascriptions are objectionable to the extent that they are regarded as causal explanations of some kind for a function bearer in a containing system. And this sort of causal explanatory use of functions is considered to manifest only in non-intentional systems. While it is my intention that this thesis should deepen and extend the concept of what counts as a biological individual displaying non-intentional purposiveness, for now, it is enough to say that non-intentional teleology is paradigmatically exampled by organisms and kin groups of organisms.[19] In this discussion, I will therefore be focusing on non-intentional systems as encountered primarily in biology and I hope to show over its course what concrete functional explanations in this class seek to explain. Let me iterate that the Kantian intuition in terms of which this discussion is hedged is that perceived purposiveness in nature must be explained because it is unavoidable to judge of animate phenomena but as determining themselves to purposive production. So I am beginning from the premise that what Kant called "purposiveness not due to purposeful action" [20] is pre-analytically explanatory of teleological statements in the case of living things, and questioning the proper interpretation of function ascriptions considered as explanatory.

In what follows, I outline the source of scientific unease regarding our common judgments about the purposive character of biological phenomena. Following Peter McLaughlin, I argue that explanatory appeal to function is *prima facie* problematic insofar as it is taken to involve an implicit appeal to holistic causality. Genuine functional explanation can thus be said to include a presupposition which conflicts with mechanistic determinism. I make use of this section to elucidate precisely how the ontological and epistemological commitments entailed by the use of functional concepts to explain organic objects are supposed to be inappropriate, and I go on to suggest that an analysis of biological function must consequently be sought which successfully expresses the content of teleological vocabulary in biology through reductionist explanatory mechanisms, appropriate to the relevant explanatory context. At issue is whether such function statements can be reformulated without appealing to teleological powers, and, if they cannot, whether a theory of biological teleology can be acceptable to science.

1.1 Classical Teleology

Teleology is a component of the classic four causes of being catalogued by Aristotle in his theory of natural philosophy: that includes the material, formal, efficient and final causes. Classical teleology of

---

[19] These are McLaughlin's examples. See Mclaughlin, *What Functions Explain*, p. 115.

[20] Mclaughlin, *What Functions Explain.*

course refers to the study of final causes as well as formal causes, and – following the famous Kantian distinction – there are both external and internal varieties thereof. As I shall argue over the course of this work, internal as well as external teleology are problematic for naturalism, thus rendering functional explanations in biology difficult for modern science to countenance. Typically, the end or goal involved in external teleology is the end intended by an agent external to that which has been purposed or designed in order to achieve this purpose. The achievement of the end then confers a value or good for the external agent. Ascriptions of external teleology in non-biological contexts are on the whole unproblematic because we can explain the perceived purposiveness of machines and other artefacts in terms of the causal efficaciousness of human beings. An artisan and his artefacts demonstrate external teleology insofar as the artisan has definite intentions in acting and anticipates the result of his actions. For instance, it is possible for us to know that the function of a clock is to tell the time since this is an effect or consequence assigned to the clock by its maker. Therefore, external or intentional teleological characterisations in non-biological contexts have genuine explanatory power.[21]

I would suggest that the manner in which putative external teleology has, at least historically, been conceived in biological contexts is similarly straightforward. Kant claims that humans must necessarily conceive of nature as a whole as organised. One reason for this is that it appears to us that everything in the natural world has purposiveness in the manner of an instrument, for it is in some way or another advantageous in relation to other things. Kant’s paradigmatic example is that sandy soil has purposiveness contingent upon the end character of pine trees and so on *ad libitum*. This means that, in order to halt a regress of the relative purposiveness of natural phenomena, eventually there must be a being for which nature is either immediately or indirectly beneficial. This being must itself be a representation of a goal state (or possess intrinsic purposiveness), rather than one further thing serving of others as a means to purposes.[22] Hence the possibility of natural things as externally purposive is only cognisable for Kant on the condition that something exists outside of the natural world and is the origin of its designed production. Though Kant himself thought it an impossible task to prove the existence of an intelligent cause of the world through argument from the appearance of external teleology in nature, there is in theory nothing metaphysically amiss about the notion of an external agent responsible for the world viewed teleologically. Furthermore, if we take seriously the Kantian division of that which can be objectively established and is constitutive of the determinate judgment, from that which is known to be a maxim for the use of reason only, the matter of the objective existence of this Being relates strictly to the ontological grounds of the possibility of relative purposiveness in

---

[21] McLaughlin, *What Functions*, pp. 16 – 17.

[22] Kant, *Critique of Judgment*, pp. 127 – 129.

nature.[23] In principle, our ability to determine an end goal of the whole world has no bearing on whether we must judge of living things as themselves possessing final and formal causality. Therefore neither is the reality of 'theologistic' external teleology of natural phenomena a direct concern of the philosophy of science.

Our immediate focus then is the widespread lay and expert use of functional descriptions as internal teleological explanations. This is a type of teleology, supposed to be prototypically instantiated by organic systems, and which biologists and philosophers alike have found extremely challenging to define. Unlike external teleology, internal teleology does not assume an external agent for the system characterised teleologically, and for this reason, it can be said to denote non-intentional purposiveness. There is indeed agency involved in non-intentional purposiveness, but it is internal in kind. Here the end or goal to be attained belongs to the process or structure itself and the end is a good considered from the perspective of the purposive entity. That entity is also the beneficiary of the good conveyed by the end.[24] And for the moment, unless otherwise stated, I shall be discussing functional attribution only as an internal teleological interpretation of the purposiveness found within biological and social contexts. Relevant natural functions are the common organismic ones we observe, such as that the heart pumps blood in order to circulate it, or that the function of chlorophyll in plants is to enable them to photosynthesise. Although I will not be paying attention to the class, social formations also count as non-intentional entities. Common or basic function attributions such as these express the notion of a "proper function".[25] In the case of biological phenomena, functions belong properly to types of entities and only secondarily to individuals.[26] This means that functional traits are general in that they consistently recur as patterns across individuals in a biological group.[27] Functional explanations seek to explain the problematic function attribution that is made of non-intentional systems. The difficulty that has then perplexed philosophers is what it is exactly that we mean when we ascribe a function in biology. In part, the diversity of extant analyses of functional explanations is due to different concepts of what constitutes a biological function.[28]

Some thinkers, like Larry Wright, insist to define proper function in a way that encompasses the purposiveness exhibited by animate and inanimate nature. Wright argues for a univocal account of biological and non-biological functions, it seems to me, purely on the grounds that natural and

---

[23] Kant, *Critique of Judgment*, pp. 139 – 141.

[24] McLaughlin, *What Functions Explain*, pp. 16 – 17.

[25] Neander, 'Function as Selected Effects' in *Nature's Purposes*, p. 319.

[26] As a side note, if we follow Aristotle, it may be especially suggestive of the anomalousness of biological functions that living organisms, unlike artefacts, do not have idiosyncratic purposes. This would be because living things must by nature reproduce. A reproductive purpose is the acme of the nutritive purpose particular to self-organised and self-maintaining bodies. See Aristotle, *The Works of Aristotle: De Anima*.

[27] McLaughlin, *What Functions Explain*.

[28] Ernest Nagel, 'Functional Explanations in Biology', *The Journal of Philosophy*, 74, 5 (1977) p. 280.

conscious functions “have a profoundly similar ring”.[29] But I think that any such desideratum on an analysis of teleological ascriptions must not be too strong. What may well be indispensible to a more general unifying and ordinary notion of proper function is an account of proper consequence or effect. Specifically, anything to describe of which we are tempted to use teleological language may have manifold consequences, most of which will not delineate the function of that entity. So chlorophyll, for instance, lends to plant life its vibrant green colour. This fact does not, however, entail that the purpose of chlorophyll in plants is to colour them green. Likewise, the use of a clock as a paperweight does not make that end its function. A functional explanation is intended to explain the presence of an item in the structure of which it is part, in terms of one or more *particular* effects that it produces.[30] (When we look shortly at an influential and – I argue, crucial – approach to conceiving function called the *etiological* theory, I hope the relevance of appeal to the right sort of effect in determining a normative notion of proper function will become clearer. Indeed it is this which makes the distinction between function and accidental effect a primary aim of any functional analysis.[31]) But there is no good reason to presuppose identical causality of the origin of biological purposes and consciously arranged ones. On the contrary, it is precisely because judgments of internal teleology about natural objects call for an explication of agency that does not involve intentionality that we know that, despite a univocity in the form of the term “function”, when we speak of inner rather than external purposiveness, the former principle would seem to introduce into nature a distinct variant of functionality or goal-directedness.[32] Explanatory appeal to internal teleological descriptions is to be found only in a particular kind of system encountered in the biological and social sciences.[33]

I want now to give a description of the subject matter with which we are dealing: the perceived phenomenon of non-intentional purposiveness in biology. In general language, we can say that internal teleological explanations suggest a causal relationship in which the recurrent effect engendered by a cause fundamentally contributes to, or is determinative of, the conditions which allow the cause to bring about that effect.[34] For instance, a functional explanation of the item, chlorophyll, in plant systems is that the purpose of the chlorophyll produced in a plant is to abet photosynthesis, on account of the fact that it is in facilitating photosynthesis in the plant – and not in colouring it – that chlorophyll contributes

---

[29] Larry Wright, ‘Functions’ in *Nature’s Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998), pp. 54 – 55.

[30] Nagel, ‘Functional Explanations in Biology’, pp. 280 – 281.

[31] Wright, ‘Functions’, p. 54.

[32] As a side note, if we follow Aristotle, it may be especially suggestive of the anomalousness of biological functions that living organisms, unlike artefacts, do not have idiosyncratic purposes. This would be because living things must by nature reproduce. A reproductive purpose is the acme of the nutritive purpose particular to self-organised and self-maintaining bodies.

[33] McLaughlin, *What Functions Explain.*

[34] Kant, *Critique of Judgment*, p. 121.

to the possibility of the system which enables its very production. The main concept in explicating the sense in which function ascriptions in the natural world are intended as explanatory is thus the concept of the self-reproduction of a system.

All living things are complex, ordered systems. Kauffman sketches an inimitably elegant picture of the systematicity on display in nature: "[t]he thousands of genes regulating one another within a cell; the network of cells and molecules mediating the immune response; the billions of neurons in the neural networks underlying behaviour and learning; the ecosystem webs replete with coevolving species" – all comprise systemic bodies.[35] It is important to clarify that the non-intentional systems of which teleological principles are descriptively adduced do not themselves have functions: systems that are conceived as functional have parts or properties which possess proper functions. For instance, the cells, tissues and organs of organisms have purposes; just like the institutions and cultural practices of social formations are functional.[36] However not just any system has parts with functions. The system of which some or all parts are function bearers must, in some sense, have a goal or end.[37] Kant explains life's distinctive autonomy and purposiveness: we experience organic entities as characterised by an arrangement peculiar to animate nature. Plants and animals are said to differ from inanimate entities in that their individual parts are reciprocally interdependent and are organised within a whole such that the various components together contribute to the maintenance of the system in proper working order. In a functional analysis, the part of a complex biological system is regarded in relation to the causal role it plays in supporting the system as an extant phenomenon. A function bearer is therefore identified as an instrumental structural subsystem by its function in, or for, a given system. McLaughlin's example is that the heart is that which is a means to the end of blood circulation.[38] By definition, teleological statements denote means-end relationships. In the case of a functional explanation, we assume that a system that demonstrates non-intentional teleology, *S*, can have ends or goals, and suppose that the end towards which its function bearers tend either directly is, or are ends contributory of, in all likelihood the survival – and sometimes propagation – of that system.[39]

The paradigm case for function attribution in an explanatory sense thus involves a causal link between a system that is or has a goal-state to the properties of its parts. All functional analyses in biology presuppose a recurrent item whose consequences or effects contribute either to the activities of a system, or to the proper working and maintenance of a system. To iterate Kant's example, when we

---

[35] Stuart Kauffman, 'Antichaos and Adaptation', *Scientific American*, 265, 2 (1991) pp 78 – 84.

[36] McLaughlin, *What Functions Explain.*

[37] *Ibid.*

[38] *Ibid.*

[39] McLaughlin explains that an analysis of biological function strictly differs across biological and sociological context as regards the extent of self-reproduction. Function bearers in biology maintain the supporting system both as an individual token, via growth and regeneration, and as a type, by means of propagation. Social formations only reproduce themselves as tokens; therefore function bearers in sociology contribute to survival. See McLaughlin, *What Functions Explain.*

study the structure of a bird – “the hollowness of its bones, the disposition of its wings for motion and of its tail for steering”[40] – we consider the parts of the bird in terms of their respective roles within the organism as a whole. We look upon the tail as determined by its function for the working of the system. And as systems of which the parts are said to be purposive for the existence and survival of the whole, living things are conceived as self-reproducing systems. Because the parts of a biological body interact with the supporting system in this sense, an identity condition on a self-reproducing system over time is that it renews itself – either as a form of the same individual or as a series of copies or representations of the same type.[41] Insofar as the individual parts also depend on a network of sub-structural units interacting in a certain way, the living being appears to sustain itself (that is: it exhibits homeostasis, which is a self-regulating property of biological systems by which they maintain themselves in a stable condition after being perturbed or injured) and to bring about itself by restoring and replacing its parts. To express the autonomy and directive control such complexly organised bodies exert over their parts, we otherwise say that biological systems can be conceptualised as self-caused.

So far, I have argued that the conceptualisation of systems exhibiting non-intentional functions is different in kind from that of systems that include an appeal to agential intention. While the origin of an intentional artefact is simply a standard efficient cause, our descriptions reflect that a living being is regarded as a candidate for functional explanation. But what is it that makes attributions of internal teleology, thus described, so philosophically problematic? Since I have contended that we ought to discount any basic relationship between our considered theological commitments and perceived purposiveness in nature – for the sake of this discussion at least – we may regard the teleological judging of nature as a system of purposes as independent of theological presuppositions. As I have already claimed of external teleological ascriptions, the concern of the philosopher is not that some theologians look upon the organs or behavioural strategies of organisms as designed to purpose by an intelligent Original Being. Instead, even modern Pre-Darwinian physiologists who had departed from direct external teleological interpretations of the natural world in favour of grounding function in the idea of proximate design to environment by secondary (or efficient) causation, sought to eliminate teleological explanations of the internal variety - - and for good reason.[42] One advantage of separating out organic from conscious purposiveness is that this strategy highlights that we cannot make sense of the former case in the neat manner in which we can the latter. In the case of biological functions and in other instances of teleological ascription where intentions are not casually relevant, this kind of description has been practically difficult to assimilate in a causal explanatory sense to modern science,

---

[40] Kant, *Critique of Judgment*.

[41] McLaughlin, *What Functions Explain.*

[42] Philip Kitcher, ‘Function and Design’ in *Nature’s Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998), pp. 479 – 480.

in a way that is understated by explications of proper function like that propagated by Wright.[43] This is because – unlike agential teleology – non-intentional teleology implies a species of final and formal causation which cannot readily be collapsed into mechanism. The rejection of teleological causation has characterised science at least since the time of Descartes. Consequently, it seems that if functional characterisations require the genuine influence of teleological causes, they cannot be viewed as scientifically legitimate.[44]

In what follows, I want to explain how – and the extent to which – the suggestion of teleology as a causal explanatory ground of living things is supposed to be metaphysically problematic. As we will see, objection to the metaphysical assumptions implicit in teleological explanation, though significant, is not overwhelming; and in fact, rejecting the causal explanatory use of function statements is urged by theoretical parsimony in science, rather than logical necessity. Indeed it is not obvious how (or even if) the causal explanatory use of function statements is reconcilable with mechanistic determinism. But the contention of this chapter is that the primary task of functional analysis must be reducing ascriptions of putative teleology, in a way which, nonetheless, does not compromise their explanatory potential for the distinctive features of non-intentional functional systems.

1.2 The Problem of Teleology

The philosophers of the scientific revolution expressed the fundamental proposition of modern science to be materialism or physicalism as early as the seventeenth century. Although we will see that causal determinism is not exactly identical with mechanism, determinism of the materialistic or mechanistic variety asserts that material events (like processes, states and entities) are caused by, and are hence entirely explicable in terms of, antecedent material conditions. The complex of antecedent material events constitute the efficient cause of the change wrought. In biology, a mechanism can be described as a scheme of causally interrelating parts and processes which engender specific effects. Scientists then supply explanations of natural phenomena by accounting for the mechanisms that could produce them.[45] Thus the problem brought about by expressions of teleology in science is that causal closure of the physical world means that teleological causation would be an explanatory requirement on a material event only if it is underdetermined by antecedent material events.

---

[43] John Bigelow and Robert Pargetter, 'Functions' in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998), pp. 241 – 242.

[44] McLaughlin, *What Functions Explain*, pp. 16 – 17.

[45] *Ibid.*

Final causes comprise one part of Aristotle's teleological causation, the theory behind which had been perfected in the Christian Aristotelian tradition. A final cause is the end of a thing, or the goal for the sake of which it is. So, for example, the final cause of an embryo is the form of the mature organism into which it develops. First Descartes affirmed causal determinism by excluding final causes, understood as the ends of natural entities as they exist as ideals anticipated in the mind of the divine designer or intelligent cause, from our scientific worldview. This of course ushered in the rejection of external teleological interpretations of the natural, and the definitional separation of the study of why nature exists, from the study of the character of nature, to which I have already alluded. Scientific study of the immanent real ends of natural phenomena, as regarded as types, however, continued, insofar as these were considered to be representations of the Original Being's supreme (but ultimately unknowable) purposes. Still, McLaughlin points out that the persistence of internal teleological reflections based in the eighteenth century study of immanent ends did not threaten the deterministic core of science. The attempt to infer the purposes of nature, or physico-theology, gave scope to the thin theological musings of the otherwise thoroughly materialistic empirical study of nature of the time.

A formal cause, on the other hand, is a change or motion initiated by the form of that which is changed. (As we might expect, formal causes can again be construed externally, as blueprints of the divine artisan, or else internally, as real material embodiments of such plans.) When it comes to organic development, as in the case of embryological development, immanent final and formal causes are difficult to distinguish because the goal which guides the process of development is also the goal for the sake of which the change is initiated. But in principle, final and formal causation are separable, and (notwithstanding a waning prospect for real final causes of living things) it is the latter from whence the problem of teleological explanations in biology has been held to stem. Strictly, causal determinism is simply the view that relations of cause and effect thoroughly determine all natural events. It remains important to an adequate understanding of the difficulty occasioned by functional explanations to stress this distinction between causal determinism and mechanism. Determinism is in principle compatible with both mechanism and a holistic alternative; yet the great plausibility of the mechanistic assumption has meant that holism has been rejected by modern science. Unlike mechanism, holism implies an empirically improbable (though not logically impossible) form of downward causal action in which some properties of the whole system determine properties of the parts. And given that determinism is affirmed as part-to-whole causality on empirical grounds, holism is *prima facie* undesirable. The challenge of biological teleology happens because the phenomenon of real formal (quite apart from the possibility of real final) causality is an explanatory invocation of holistic causes. When Kant later qualified causal determinism by the introduction of a part-to-whole determinism postulate (thereby narrowing the concept of determinism to specifically mechanism) it became seen as untenable for formal causes to exist and they, too, were abandoned.[46]

The appeal to formal causality in the context of biology is intended to make deterministic, characteristics or behaviours of an animate system which look to be underdetermined by the internal properties and interactions of its parts. Since organic structures, like all end-directed processes or structure, exhibit phenomenal design, it seems that the relationship between form and function in living things is underdetermined by the mechanistic character of their material components without the aid of a formal cause. It would be an incredible accident if the parts of a functional body simply came together in the right order without a plan of some sort. The two deterministic options available by which then to alleviate underdetermination are mechanism and holism. If reductionistic determinism accepts genuine underdetermination of the system, it can draw on an ideal form and an agent (who brings it about) in order to render underdetermined properties of the whole explicable in terms of the system-independent, material properties and interactions of its constituent parts. The whole postulated may, as explained, be the living thing represented as an idea in the mind of an Original Artificer. This is an initial condition which would ensure complete development of the functional whole by natural laws, and, in this way, mechanism can account for genuine underdetermination while avoiding recourse to internal teleological attribution. According to the holistic alternative, a real end state or the whole – that is, an existing system – is the cause of those features and interactions of the component parts of the containing system which are goal-directed. And if we accept phenomenal underdetermination of living things, they evidently must imply holism. I take it that it is irrelevant whether ideal formal causes are necessarily part of the explanation for the existence of biological phenomena at all, that is, as viewed as ends in the mind of a designer. The point of departure of this thesis is that formal causation is an indispensible part of the description of a biological phenomenon. Although biological theorising is irked by one sort of underdetermination, it is also the case that we can conceive of organisms as fully determined functional entities without recourse to intelligent agency. When we speak of life, the relevant, problematic formal cause at play is of the internal teleological variety. In other words, regarding biological phenomena, the underdetermination at issue is that of the functioning of the whole. To remove the underdetermination, it must therefore be that the properties of the already existing containing system determine the properties and interactions of the parts.

When the formal cause is conceived as material, as is by holism, the whole must temporally precede its parts in order to have the explanatorily appropriate causal influence on them. And this is a deeply counter-intuitive consequence on a causal explanation. Kant's great contribution to the critique

---

[46] Mclaughlin, *What Functions Explain*.

of teleological discourse in biology is that he recognised that the principle of causal determinism, as delimited in its most empirically plausible form of part-to-whole determinism, must emphatically fail of accommodating teleological descriptions before we are justified in even entertaining in science a new kind of causality.[47] So taking function ascriptions as theoretically significant, there is an imperative to reformulate them satisfactorily through reductionistic explanatory mechanisms. But what is the nature of this imperative? And if such a reduction is not in principle possible, what is the metaphysical and epistemological upshot of accepting the reality of holistic causes in science? Accommodating functional explanation is complicated, and not everyone will accept a theoretical presupposition of the neutrality of determinism about mechanism versus holism. Kant is profoundly influential in setting out this post-Enlightenment problem for us.

1.3 Kantian Metaphysics

At times, it can seem that in the writings of Kant, two conflicting claims about causality are expressed. There is first a transcendental conception of causal determinism, presented in his *Critique of Pure Reason*. The principle according to which every material change has some cause is here stated as a constitutive principle of human understanding, or as a necessary condition of general experience, rather than an empirically known fact. We can thus know *a priori* that relations of cause and effect completely determine all events that occur in the world. In the second part of the *Critique of Judgment,* however, Kant's exposition of the possibility of attaining causal knowledge of the world suggests that the causal principle is after all purely regulative, and therefore a subjective maxim, necessary for what he calls the "mechanical explicability" of corporeal nature (and where the mechanism of nature is to be understood as the determination of the world "according to the laws of causality".) Kant is concerned here not with causality as a transcendental condition for conceiving of events in nature, but with the application of the concept of mechanism to experience, and the empirical study of mechanistic causes as regulatively guided or rule-directed reflective activity. The principle of the mechanistic determination of nature is introduced in the *Critique of Judgment* as one kind of principle which we employ in our search for causal explanations. While the principles of the reflective judgment make no *prima facie* determining statements about the material world, they provide regulative maxims for thinking about the causal structure of nature. The implication, then, is that the causal principle is a competitor of the teleological maxim that makes possible reflection upon an organic world that, as we have seen, in its

---

[47] McLaughlin, *What Functions Explain*, pp. 20 – 28.

prima facie functioning resists a smooth mechanistic explanation. Kantian scholars continue to grapple with this dilemma of how it is that the principle whereby every event has a cause is an *a priori* law of the understanding, and which therefore partially enables the sense of our experiences as logically connected; *but* also that we are entitled merely to *assume* that material nature is ordered according to the causal principle.

One interpretation of Kant is that he indeed establishes mechanism to have objective grounds in the character of physical or material nature. And while critics of the interpretation spotlight its failure to explain why the mechanistic principle, and not the causal principle, is claimed to have regulative status, there are credible reasons to suppose that Kant believes that a mechanistic interpretation of the causal principle is a necessary condition of general experience. It is significant that, according to Kant, the possibility of scientific knowledge is contingent upon objective claims about the mechanistic causes of nature. If we cannot know *a priori* that every physical event has an antecedent mechanistic cause, and science is in fact reliant upon mechanistic explanations, scientific knowledge could not be supported for lack of genuine causal explanations. Such a desideratum upon science makes it look as if salvaging knowledge requires that the concept of mechanistic determinism is objectively necessitated by the nature of things.

Alternatively, another analysis of Kant is that the mechanistic maxim is a specific interpretation of the regulative principle, which nevertheless allows us to come to empirical conclusions which have determinative status. Kant's discussion of animate objects leads him to question the mechanistic determination of nature. The suggestion that our experience of purposiveness in living beings may turn out to be mechanistically inexplicable brings to the fore the idea of an entirely different law of causality in order to judge of corporeal nature: that is, a teleological maxim. Our reflections on organisms present as an obstacle to our judging of the objective character of nature as mechanistic. In essence, the *Critique of Judgment* offers a further principle of mechanistic causation. In this case, the mechanistic maxim itself is to be understood as regulative insofar as the principle of mechanism would represent one reading of the general concept of causality by which we think about nature as a whole. Thus we impose a principle that nature is systematically organised under mechanistic laws, cognisable by beings like us; and, as a subjective maxim, the mechanistic principle tells us something about how we are to approach study of the world. Mechanistic determination would be an empirically discoverable fact. Hence the maxim of mechanism is introduced as a specific method which encourages us, *qua* human beings, in interpreting the manner in which material nature is unified. The trouble with this account of Kant, however, is that unlike its rival, it apparently disallows determinate mechanistic explanations for things. The impossibility of knowing that all of material nature falls under mechanistic laws *prima facie* conflicts with our making determining statements in science.

It may be argued that the identification of the causal principle with mechanistic causation is justified on the grounds that it is demanded by the very nature of the causality of the material. Indeed Angela Breitenbach argues for the plausibility of an interpretation of Kant on which conjoining the causal principle to the empirical concept of matter entails that material change must be explained in terms of external causality. Here, external causality refers to influences of attraction and repulsion by which parts of matter act upon one another – in other words – to the forces acting between the simpler components of a complex material whole, or by which two or more wholes interact. Breitenbach is also, however, quick to point out that the maxim of mechanism cannot be justified to human judgment by understanding of the conception of mechanistic causation *a priori* in the same manner in which the causal principle is given, for the reason that the former, as we have seen, has regulative status. One of the strongest motivations for a differentiated account of mechanism comes from the fact that Kant himself acknowledges the transcendental principle of causality to leave underdetermined the character of specific causal laws. So although the principle that every change in nature has a natural cause is a constitutive principle, making an objective claim, we cannot *a priori* rule one way or the other as regards the determination of physical nature by mechanistic principles.

Whatever the various bases on which scholars like Breitenbach and McLaughlin have argued for the regulative status of mechanistic claims, I take the position that it is most reasonable to view the Kantian maxim of mechanism as regulative. We have *a priori* knowledge that nature is governed by transcendental regularities; nevertheless the causal principle does not guarantee the content of empirical laws (the latter being only discoverable to us by experience). Breitenbach's case for the regulative status of what Kant refers to as 'mechanism' in the third *Critique* is that its importance derives from its facilitating a reflective process upon which our causal knowledge of the world depends. Put simply, the knowledge that every change does, in fact, have some cause leaves us none the wiser about particular causal events. We must therefore assume on a reflective basis that everything is systematically connected by mechanistic laws in particular, in order actually to study empirically the causal explanations behind our ordinary experiences of material change. Hence the principle of mechanism is a regulative idea of reason which nonetheless is a necessary condition for the formation of our conceptual schemes; the understanding guides us to employ a causal principle that is objectively valid within the context of material nature; and thence we may judge empirically that causality in any given instance is to be interpreted in terms of mechanistic law - - *but* – significantly – we may not.[48]

---

[48] Angela Breitenbach, 'Kant on Causal Knowledge: Causality, Mechanism and Reflective Judgment' in K. Allen and T. Stoneham (eds.), *Causation and Modern Philosophy* (Routledge, 2011).

Yet is there a residual problem that mechanistic explanations on a regulative interpretation of the maxim will never yield objective assertions, thereby endangering the scientific project? It seems to me that the conviction that science must be dependent on the determination of our experiences by a constitutive mechanistic principle is unjustifiably elided with the necessity for explanation according to the laws of causality in science. The real problem posed to science is that the apparent anomalousness of animate nature has to be accommodated within the explanatory boundaries laid by causal closure of the physical domain, on the supposition that there is no such thing as supernatural causation. The stronger claim that all of material nature must be amenable to mechanistic explanation, however, arises if and only if a conception of natural causality is such that mechanistic determinism is an ontological requirement on the physical causal closure state. So it is only the case that science is jeopardised by the efficacy of causes alternate to those which are mechanistic, if the only kinds of things that can produce physical effects by the causal closure thesis are, in fact, mechanistically constituted. But the non-reductive physicalist holds that genuine efficaciousness of non-mechanistic causes will be respected as long as such effects are preceded by a fully physical history; that is: these causes do not fall outside of the causal framework. The point is that mechanism does not enjoy primary appeal as an ontologically naturalist doctrine if it is not the only viable alternative to nonphysical causation. And since Kant tells us that we cannot *a priori* see the possibility of either mechanism or teleology as a transcendental causal law, the idea that a constitutive mechanistic maxim is a necessary part of a successful theory of science is therefore inappropriate. Interpreting the mechanistic determination of nature as a principle of reflective judgment does not automatically force us onto supernaturalist terrain because it is a mistake to presume that mechanism is a conceptual entailment of physicalism.

The apparent trouble with adopting this interpretive route is how we might justifiably derive genuine mechanistic explanation from a purely regulative principle, and in response to this criticism, a coherent differentiated account of the principles of causality is posed, by, amongst others, Breitenbach. We have seen how it can be that a guiding mechanistic principle for our reflections on nature should yield scientific statements of objective status: application of the maxim of mechanism leads to the formation of objective mechanistic explanations, according to Kant, because it is a requirement of the concept of mechanistic causation that it is objectively valid for the material domain. That is to say, what the maxim does is instruct us to employ a concept, the character of which is such that it necessitates a determining of our natural experiences by mechanistic law. It does *not* require of us to introduce further reflective judgments - - that is, to judge *as if* mechanistic relations do obtain in the context of material nature.

But despite the fact that we can know that everything material is subject to mechanistic causes, we still need to reflect about nature according to a regulative maxim of mechanism. Recall that, insofar as the transcendental principle of causality leaves our knowledge of the specific causal laws of nature underdetermined, in the case of each particular event, we have to find out about the causes empirically. Whatever the specific case, the general principle of causality is not to be identified with the mechanistic principle *ex ante*. So, on its own, a general or overarching causal principle would be insufficient as a causal account of a particular material event because our judgment in the case is actually underdetermined by the *a priori* concept. For Kant, to make an empirical statement about something in the world is to admit that future scientific observation may disprove what we now believe to be the causal laws determining it. Hence, in order to explain our own experiences of material change, we have to undertake empirical analysis. And assuming that nature is systematically ordered by something like the principle of mechanism – that is, a specific natural law that is discoverable by us – is a necessary condition on this.

Why this necessary condition? Kant claims that although the *a priori* general principle of causality ensures that every process is causally determined in some way or another, it is entirely conceivable that natural events are so irregular that we can never gain determinate causal knowledge by empirical means. Thus having empirical knowledge of the world presupposes that we must supply empirical concepts and principles enabling the categorisation of different objects of experience. When once we use such concepts to classify contingent sense perceptions, we make available empirical evidence of causal regularities in nature. The principle of mechanism is one instance of an assumption that is required for empirical investigation of the given world. In assuming this principle of the reflective judgment, we postulate the mechanistic maxim in order to search for specific causal laws under which we can subsume aspects of our experiences. Thus the principle of mechanism is a guideline enabling the empirical task of investigating the causal structure of nature. The application of certain universals unifies our experiences into a systemic whole. And in instructing us to think about nature as ordered by, and therefore intelligible through, mechanistic laws, it leads us to read a mechanistic conceptual scheme into experience. Our empirical judgments can then help us to reflect further on the relationships exemplified between parts of matters, and to find out more about the particular causes of material change in a case. In light of further experience, we may revise our schema. By providing us with the formal structure necessary for the formation of causal explanations, mechanism helps us to conjoin concepts together, test scientific conjectures and determine its own limits as a regulative maxim. What we then have is an assumed causal principle that is susceptible of empirical treatment just because it enables systematic knowledge of natural causes.

So in addition to being dependant on a transcendental causal principle, causal knowledge of the world is therefore also reliant upon a reflective process. The maxim of mechanism goes beyond the *a priori* and constitutive principle of causality in that it presupposes that all material things are possible simply in accordance with a truncated version of the causal principle. Still reflection by reference to a regulative principle of mechanism remains indispensible to objective mechanistic explanation because, although we may fail to possess *a priori* judgments about specific causal laws, it is a practical impossibility to have knowledge of the causes responsible for material change without assuming causal regularities to hold. The mind thus orders representations on the assumption of a mechanistic interpretation of the principle of the unity of the nature, thereby enabling determinate empirical explanations. And in our search for mechanistic explanations, we interpret the causal order of nature in mechanistic terms, thus providing content and scope to the principle of mechanism.

It seems that a good response to the apparently contradictory status of the causal principle is to take Kant exactly at his word: it is both true that all of nature is thoroughly determined by the law of causality, and that the maxim of mechanism acts purely as a heuristic means for research into specific causal laws, because the two principles are different. But despite not being identical with an *a priori* causal principle (indeed any such *prima facie* identification is gratuitous from a naturalist point of view), causal closure is not undermined by the potential for teleological organisation and directedness. There is no reason to preference an interpretation of the mechanistic principle as constitutive in order to prevent nonphysical causation, given that it does not follow from the fact that living things may not obey mechanistic laws that they fall outside of the causal framework. On Breitenbach's interpretation, in the empirical context of material nature, causal change needs to be interpreted in terms of the fundamental powers of matter. Empirical knowledge of the concept of matter, together with the transcendental causal principle, warrants our knowing objectively that every material change has an external cause. Mechanistic laws embody a fairly specific version of the laws of external causality, which interprets a material whole as the product or effect of the causal forces of its parts. Neither does a differentiated account of mechanism make unfortunate sceptics of us: application of the idea of mechanism leads to genuine explanations because it is a concept which accords objective status to mechanistic statements.

So does the fact that mechanism is not a universal law of matter mean that we can employ teleological concepts at whim in natural explanations? Is Kant telling us that – from the standpoint of modern physicalism – we are entitled simply to ascribe teleology to the objective character of nature? In fact, the answer is that it is a little bit more complicated than that. There is a reason, rooted in the conceptual role mechanism plays in the making of empirical claims, which accounts for Kant's statement in the Critique of Judgment that it, "…is of infinite importance to reason not to let the mechanism of nature in its productions be dropped out of sight and be bypassed in its explanations; for without this no insight into the nature of things can be attained."[49]

---

[49] Kant cited in Breitenbach, 'Kant on Causal Knowledge', p. 8.

Despite the regulative status of the maxim of mechanism, we must still begin by assuming that nature is determined by the laws of mechanistic causality. It is because we cannot *a priori* see the possibility of teleology as a constitutive principle of experience that Kant first asserts that – despite our proclivity for teleological discourse – we have no legitimate *prima facie* reason to introduce into science a new kind of causality. Whatever our *a priori* judgments about causal change, Kant seeks to emphasise the appeal the mechanistic maxim as a regulative principle must have for a rational being in order to enjoin us to search for a (distinctively mechanistic variant of) causal explanation. Mechanism has primary appeal as a way to go about achieving scientific insight because it plays an essential part in what it means to have causal knowledge of the world. We have seen that a good exegesis of Kantian metaphysics is that we read the systematic unity of nature into our experiences in order to understand them as coherently connected. That is, we must approach nature as if its causal processes are ordered under specific principles. Mechanism is a regulative idea of reason which aims at an ideal of material unity systematically created through mechanistic causation. Although this conception has not been fully attained (and indeed may not be fully attainable), in our attempt to conceptualise and order our sense impressions, the maxim of mechanism as a regulative principle nevertheless provides us with a guide to make them cohere under a mechanistically-sustained causal unity. By charging us to assume that nature as a whole is determined by mechanism, it brings us to apply mechanistic laws to experience. It is this causal intelligibility of material objects with which science is concerned. And although organisms raise an apparent difficulty for a mechanistic account of the world, mechanistic causation is perforce our basic means of explaining nature. So although we cannot rule out whole-to-part determinism or holism, we ought to attempt to think about living things in mechanistic terms.[50] Mechanism allows for a unified physicalist account, or what we would today talk about in terms of *causal reductionism*.

Philosophers in the present day might describe the attractiveness of a mechanistic form of physicalism in terms of a concern with the meta-scientific study of the major aspects of science and the desirability of a unified body of scientific knowledge. This is the concept of what is called "unity of science"[51] by Paul Oppenheim and Hilary Putnam. In its most tenable form, this hypothesis is reductionist in content: it holds that unity of science can be attained to the extent that scientific disciplines can be ordered into a system of reductive levels, signifying the major potential reductions which constitute necessary steps in the direction of complete physicalist reduction. Each discipline or branch with things of a given level as its universe of discourse is so selected as a reducer of a branch

---

[50] Breitenbach, 'Kant on Causal Knowledge'.

[51] Unity of science has been defined variously; most philosophers today agree that its best understood as entailing language and or theoretical reduction.

with things of the next higher level because these levels present as scientifically legitimate, or as an apparent 'natural order'. The concept of reduction relevant in this thesis will be specified in a later chapter only - - it being superfluous to understanding the theoretical impetus behind the pursuit of an ideal state of science; however, proponents of our moving from a present, fragmented science to an ideal science via some or other cumulative reduction,[52] submit that although there are phenomena at higher levels which clearly cannot at present be explained by the available theoretical predicates characterising lower levels, it is scientifically prudent to endorse the hypothesis. One of the most potent methodological recommendations of the unity of science doctrine is its simplicity. Oppenheim and Putnam argue that the alternatives to which its opponents allude, including Psychism and Neo-Vitalism, are virtual bywords for supernaturalism. These hypotheses attribute to complex entities – in addition to those predicates standardly associated with a given level – radical parts or properties which are not acknowledged by any of the sciences. To begin with, if such postulates make reference to immaterial forces, the introduction of properties to explain the behaviour of living, but not of non-living things, for example, will not offer biological facts which admit of testable proposals. Hence the 'spooky' 'vital forces' which are supposed to animate cells, or the 'group minds' allegedly found at the level of social groups, cannot have meaning in scientific terms. But more to the point, even if we are not in an empirical position to establish conclusively one way or the other as regards the possibility of the integration of scientific knowledge, autonomous theories (in the sense of non-reducible predicates or facts for a given scientific discipline) would seem to have explanatory value if and only if the theoretical apparatus for a potential reducing branch is descriptively insufficient. That is to say: if a working hypothesis of reducibility should prove to be unfruitful. After all, if all of science might in the future indeed be captured by some more fundamental division of science like physics, the sceptic about mechanistic reductionism in biology is potentially suggesting an unnecessary bifurcation of the conceptual system of science by proposing the existence of parts and/or properties over and above those employed in our approach toward inorganic phenomena.

In attempting to characterise the biological – should it make sense of the empirical evidence in a plausible way – we ought to preference mechanistic theory in our descriptions of living beings. Mechanism as a causal framework has to fail to integrate conceptually our experiences of organisms as characterised by a special kind of arrangement, before we can introduce any other causal concept into the interconnected experiential cognition that is afforded by mechanistic law - - not because mechanism offers the only possible naturalist interpretation of a systematic and lawful causal unity, but because, as a principle of causal order in nature, it presents the simplest picture. The epistemic 'ought' here derives

---

[52] Oppenheim and Putnam actually mean by this micro-reduction.

primarily from simplicity. We would need a positive reason to undermine – *not* causal knowledge itself – but an intelligible scheme of regularities which is as efficient as that given by reductionistic determinism. The theoretical apparatuses described across reductive levels are demonstrably unified in terms of part to whole causation. By means of the interactions between parts of matter standing in external causal relation, the causal capacities of more fundamental physical units determine complex things described by science. In the language of the unity of science thesis, we might say that simpler, lower-level attributes or entities are ordered in relation to objects at higher levels as efficient external causes.

My overall intention is to introduce a theoretical definition of biological function, based explicitly on natural selection, which will provide us with an adequate concept of purposiveness for organisms. And preserving the simplest solution to a unified conceptual framework or system for science requires first attempting to explain causal change in animate objects by referring to reductionist principles. Ideally, attributes which are relevant for explaining living beings (such as directive organisation of parts within a whole, along with the capacity of a whole for self-organisation and self-maintenance) should be obtained by developing and extending the theories associated with its more basic elements, so that the causal story involving reduction of a biological whole to the system-independent properties of its parts remains explanatorily sufficient. However, if it is not in principle possible to define entities or attributes as they figure in biology by averting only to the concepts used in describing the (sometimes non-living) objects of more fundamental sciences like physics, it will then be warranted to introduce new concepts into the scientific scheme. So, if, as a matter of basic biological process, none of the biological theories are to be found in the explanations of physical science, or any future correction of one or other of these theories, the principle of causality supports our moving towards a definition of organismal function that is to be understood by means of teleological causation. To avoid a spurious charge of supernaturalism, we would subsequently want to be able to show that the consequence of a failure at the effort towards overall reduction should not be as unacceptable from a physicalist standpoint as is often suggested.

Therefore, this being the case, to begin with, we need to ask how we can make sense of living things in mechanist terms. Is there a way?

1.4 Introducing Mechanistic Reduction

Regarding machines and other functional artefacts, we can easily achieve an uncontroversial reduction of teleological concepts to the laws and theories of the physical sciences. Because teleological characterisations in non-biological contexts imply only *external* teleology, as we have earlier seen, ideal teleological causality in these instances can be assimilated to efficient causality. Both the end of a clock, that is its final cause, and the plan according to which it is made, or its formal cause, exist in the clockmaker's mind as part of the efficient cause of the clock. Mechanism can alleviate the underdetermination of the artefact by its component parts through appeal to a (typically mental) representation of the whole structure. Thus the artisan clockmaker initiates material events that predate and determine the clock.

Although the endeavour in biological theorising is likewise to assimilate formal causation to efficient causation, this is not as easily achieved. Now in recent years – especially with the advance of molecular biology – a mechanistic conception for explanations in biology and the other natural sciences has become standard. Hence a mechanistic understanding of determinism is evident in the practice of these sciences, where separate mechanisms are postulated at the different levels of biological organisation (including organismic, cellular, molecular, biochemical) as a matter of ordinary research practice. Behaviours of biological systems such as photosynthesis and protein biosynthesis – even disease – are commonly explained by biologists through describing a mechanism that can be the causal source for this behaviour.[53] But the challenge presented by teleological ascriptions in biology is that we have been unable similarly to dispense with the teleology of formal causes given that the internal purposive character of the organisation and behaviour of living things is what is held to distinguish them from inanimate phenomena. The paradigm case in biology is a system which is itself the subject of its function bearer's benefit. I have introduced the concept of a living being as a self-reproducing system, and *prima facie*, it remains unresolved if such systems in their inner workings are sufficiently determined by the properties and interactions of more basic material particles.

Kant's celebrated argument is that we cannot think about organised beings in their internally purposive form according to the mechanistic principles of nature as this would demand consideration of "…a material whole as a product of the parts with their powers of combining with one another (as well as of bringing in foreign materials)".[54] According to Kant, a whole that is a purpose is unlike a machine in the self-formative power that it – in its internal possibility – exhibits. This power is self-propagating in nature, by which, as we have seen, is meant that a system in possession thereof retains its identity by continuously reconstituting itself in its own likeness.[55] So this sort of complex system can assimilate inorganic matter to its own structure.[56] The implication is that the basic internal purposiveness of organic bodies presupposes a whole, upon which the organisation and activities of the parts rely, even though there is nothing in the material constituents themselves that possesses the formative capacity of the whole. Physicist Erwin Schrödinger, argues in *What is Life?*, for example, that life is set apart from

---

[53] Johannes Röhl, 'Mechanisms in biomedical ontology', *Journal of Biomedical Semantics,* 3 (2012).

[54] Breitenbach, 'Kant on Causal Knowledge', p. 147.

[55] McLaughlin, *What Functions Explain*, p. 179.

[56] *Ibid*.

other forms of material organisation in that it maintains its entropy by feeding on negative entropy. The general tendency dictated by a basic law of nature, namely, the Second Law of Thermodynamics, is that the entropy in a closed system increases with time, meaning that it descends into disorder; and yet, living things alter their environments the better to increase organisation and meet their needs.[57] How is this appeal to a causally efficacious, real whole to be explained mechanistically? It is not obvious.

To claim complete mechanistic determination of the functioning of biological phenomena, one may perhaps want to introduce into the initial conditions of the origin of the natural world some feature that accounts for the fact that these phenomena are impacted by a containing system that is temporally prior to its material constituents. However this manoeuvre invokes formal causality in the sense of external teleology, allowing once more for an unwelcome intrusion of an external teleological interpretation of final causes. The ends of a divine artificer of the natural world, recall, are considered to be unpalatable by modern science on the supposition that physical systems are sufficiently causally determined. It is furthermore *ad hoc* to presume that completely determining the origin of biological phenomena would resolve underdetermination of the kind that leads to the teleology we see displayed in the maintenance of entropy in living organisms; that is, of the internal functioning of the system.[58] Therefore, unlike in the case of inorganic entities, it appears at least that some functional explanations of organic entities are not reducible to ordinary mechanistically deterministic explanations.

It is a fundament of this thesis that a discussion of function attribution must focus on those uses of functional explanation which are widespread in the scientific community and the metaphysical entailments thereof. It is not possible to revise radically the biological concept of a system whose parts can be function bearers without also unduly delimiting its explanatory scope. A functional statement in biology is explanatory because and insofar as it analyses the structure and role of a sub-structural item in a system that is organised towards a characteristic end. This conception of a biological structure as a genuine self-reproducing system is integral to modern science. And given that the maxim of mechanism guides us to search for reductive explanations of natural products, it must be that organic systems so described are not fully intelligible according to mechanistic laws before we are justified in bringing them under teleological rules.[59]

I have shown that, despite a phenomenal basis for teleological judgment of biological phenomena, our experience of purposiveness in nature alone is not commensurate to a teleological principle as a transcendental condition of the use of our judgment, especially when our empirical knowledge presupposes a mechanistic conception of nature. Before the completion of science, we

---

[57] Erwin Schrodinger, *What is Life?* (First published 1944), accessed via the Stanford Encyclopedia of Philosophy at http://whatislife.stanford.edu/LoCo_files/What-is-Life.pdf.

[58] McLaughlin, *What Functions Explain*, pp. 20 – 28.

[59] Kant, *Critique of Judgment*, p. 118.

would need an insuperable reason to undermine a cohesive system of causal knowledge organised around the laws of mechanism by countenancing teleology as an objective explanatory ground.[60] Since functions are adduced of living systems in a valid explanatory sense, we are thus pushed towards a constructive dilemma: we must be capable of rendering functional explanations in biology in terms of the concept of mechanism; otherwise, either phenomena characterised by such ascriptions, as far as our understanding of them goes, remain causally underdetermined by natural laws and therefore in part physically unintelligible, or else, teleological causality exists. As you might expect, the former option is an unacceptable starting point for scientific investigation of the natural. Indeed it was to resolve the antimony that results after noticing that the purposive character of living things seemed incapable of being understood in terms of mere mechanistic causes that Kant concluded teleological statements in nature to be – not objective assertions – but a heuristic tool for guiding empirical inquiry. The use of function statements would then be a non-causal explanatory fact which stands in for a lacuna in our understanding of the world.[61] And this is not a good epistemic position to be in either.

In the rest of this thesis, I reflect on the some of the ways in which the philosophical problem of perceived teleology in nature has been addressed, and I suggest that the best naturalist account is an etiological thesis improved by the addition of a normative criterion for a function-bearing system as a real and holistic cause of itself. Since my attempt to engage non-intentional, agentless purposiveness constitutes a critical response to the attempt to pursue a reductionist ideal in functional explanation, it is appropriate that I begin with an examination of the best-known mechanistic analyses of function. Most agree that teleological claims in biology both describe and serve to give or to frame explanations, although there is disagreement about what is explained, and how. The major point of variance between authors is whether teleological explanations regard the presence and/or maintenance of a trait in a biological unit, or if teleological claims are explanatory of the role of sub-structural units in bringing about some or other capacity of the biological system. The influential and – I argue, useful – etiological theory assumes the first view, and aims to elucidate teleological attributions through appeal to the evolutionary history that is responsible for a certain trait. But while the etiological, dispositional and systems theories posit different ideas about the point of making teleological claims, the views are unified in their insistence that animate phenomena must ultimately be amenable to mechanistic explanation.

Therefore etiological theorists like Wright and Philip Kitcher stop short of endorsing anti-reductionism in determining functional explanation. The attempt of such an approach is to preserve

---

[60] Breitenbach, ‘Kant on Causal Knowledge’.
[61] Nagel, ‘Functional Explanations in Biology’, pp. 288 – 290.

causal efficaciousness of a biological system upon itself via an appropriate feedback mechanism. Here a reduction to mechanistic explanation is effected through a theoretical device for mediating causality from the appropriate effect of a function bearer within a structure, back to the item itself. Thus a function bearer can be said to be the efficient cause of where and what it is in a manner that nevertheless implies no assumption of holistic causal relations.[62]

Among those who eschew Kantian agnosticism about function ascriptions in favour of attempting to explain them according to the mechanisms of nature, another chief objective has been to re-describe the notion of having a function or being goal-directed such that the analytic renderings of these concepts are well-defined and devoid of the mystery that surrounds formal teleological notions.[63] In the dispositional and systems arguments, functional explanation is given a purely descriptive form of causal analysis. The systems theory in particular aims to express functional explications without using any specifically biological expressions, so that the content of putative teleological explanations can be reformulated as non-teleological causal-mechanistic explanations. Hence the system-property view is a non-causal approach to teleological explanation, which proposes that teleological attribution picks out a system capacity by grouping together the diverse causal mechanisms which perform it. And such effects or services to the realisation of a systemic capacity can be described without formal teleological statements. The ostensible result of thus reducing the claims of functional explanation by separating it out from teleological terminology is that there can be explanations which are similar in structure to those given in the other sciences for organic systems or bodies characterised as purposive.

I go on to weigh up some of the respective advantages and disadvantages of these different views.

The problem my analysis aims to resolve is whether we can in fact conceptualise functional explanation in biology such that teleological notions are eliminated; and, if we cannot – on pain of commitment to supernaturalism – how it is possible to characterise such explanations in the vocabulary of physicalism. I begin by interrogating functional analyses relative to actual usage of teleological language in standard biological practice, in order to expose the definitional shortfalls of mechanistic interpretation in capturing the causal mechanisms involved. Ultimately, I conclude that we cannot dispense with the notion of design as well as a kind of formal (and final) causation in accounting for non-intentional purposiveness. This suggests that, although we are enjoined by the Kantian principle to search as far as possible for

---

[62] McLaughlin, *What Functions Explain*, pp. 6 – 8.

[63] Nagel, 'Teleology Revisited' in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998), p. 213.

mechanistic explanations, we must be aware of the limitations of a mere reduction of biological phenomena.[64]

---

[64] Kant, *Critique of Judgment*, p. 148.

2. Traditional Etiology and a Normative Definition of Function

In this chapter, I explain (what possibly remains) the most prominent attempt to understand function statements from a naturalistic perspective: Wright's etiological analysis. Wright's solution to the problem of functional explanation can be said to the prototype of the etiological or so-called backward-looking position - - although most current etiologists work with some revised version of the original framework. Without a metaphysical trade-off, Wright's etiological account undertakes to explicate the concept of function by adding to the explanans of function ascription a feedback condition by which the existence of the function bearer (type) is explained.

It is true that the exegesis I here present somewhat denatures the characteristic simplicity of the account in appropriating it to a notion of biological *design* by natural selection. When Wright says that he pursues a "consequence etiology",[65] he means that his basic strategy of argument is to seek an explanation of the origin of a function bearer based on its effects. The goal is to deliver a non-evaluative analysis of function attribution such that the analysis is general enough to encompass functions in both artefacts and animate phenomena. As McLaughlin succinctly says of Wright, "The function bearer is said to be where and what it is because of what it does without any reference to any benefit provided to someone by it or to any valuation of its effects from some perspective."[66] However, I do not think that a normative component of biological function as I here introduce it; that is, as non-evaluative normativity, generated by the conditions for natural external purposiveness by specification, is in itself incompatible with the spirit of Wright's work. On an etiological account, to characterise a trait as having a function in explanatory intent is to regard it as instrumental of an end that is normatively distinguished by its having an appropriate etiological relation to that trait. Nevertheless, this understanding of functional analysis as causal etiology does not in itself pursue an essential valuation of a biological function bearer as an end, since (as we will see) natural selection is a non-intentional designer, blindly achieving its goals in the form of reproductively fit individuals. I explicate Wright's etiological thesis in order to extol the merits of its chief contribution, which is just that a functional analysis explains (partially) through specifying how the possession of a functional feature has historically contributed to the presence of that characteristic.

In my critique of the systems theory in the chapter hereafter, I show how my own view departs from traditional etiology, and its general and non-evaluative analysis of function attribution, in support of a deeper, internal normativity of living beings. I explicitly argue against the kind of reductionistic thinking which lends the etiological position to interpretation in terms of discrete design sources. Thus I claim that, to the extent that natural selection can be said to explain organic function, in that the function of a

---

[65] Wright, 'Functions'.

[66] McLaughlin, *What Functions Explain.*

biological trait is relativised to the organisation and predictability of a particular environment or *selective regime,*[67] biological *homology* of functional structures is nonetheless countered by the phenotypic goals directing processes of generation and regeneration of organic characteristics; and therefore a functional analysis will have to make allowance (not only for the role of environmental circumstance in determining function, but also) for the internal organisation and coherence of animate systems, known as they are to arrange their own repetition with a considerable degree of accuracy. Still, the point of the arguments enumerated between the etiological and the dispositional theses which now follow is strictly to introduce into the analysis of function a normative component by means of the reference to natural selection implicit in the former account (which is independent of an evaluation of any benefit conferred by the function on its external producing cause), in order that the explanandum of a functional entity should remain in part external to that to which it belongs. So while we have seen that it is possible to conceive of the origin of a functional token in biology as determined without postulating an external source of design, looking upon natural selection as a formula for generating the external normative conditions for functional analysis enables us to capture those of its elements which remain crucial to understanding animate function as dialogically linked to the environment over ontogenetic and phylogenetic time. I aim to make clearer the advantageousness of this idea of function bearers as (partial) products of natural selection in detailing a definition of function that is adequate to biological theory, because interwoven with the established phenomenon of homology. To this end, I argue that, in contrast with a dispositional view, an etiological account can sustain a normative interpretation of function; this interpretation of functional explanation as referencing an externally determinative process furthermore implies the importance of the many contingent causal factors upon which biological purposes depend.

I want to begin considering some of the most influential attempts to understand biological function from a naturalistic perspective with an important proviso. So far, I have glossed a significant distinction in an analysis of teleological discourse, to which I will now return, in order that we can better identify the problem this discussion seeks to address. As Ernest Nagel argues, there is in fact a broad structural difference between functional and goal-directed explanations. Functions and goals are not actually transposable.[68] An organ like the opposable thumb, for instance, may have the function of assisting the possessor in grasping objects, without having a goal. Also, the end of a goal-directed process can, but does not necessarily, have a function.[69] Much human behaviour will be of this latter sort. In general, we can say that goal ascription belongs to a process, in the case of which, various

---

[67] This is McLaughlin's term. See McLaughlin, *What Functions Explain*.
[68] Nagel, 'Teleology Revisited', pp. 199 – 200.
[69] This is Nagel's example. See Nagel, 'Teleology Revisited'.

antecedent conditions relate to an outcome via one or more causally efficacious regularities. An example used by Nagel is that the human body is goal-directed with respect to the homeostasis of the blood temperature. So given certain effects of the adrenal glands on metabolic rate, and particular facts about moisture and temperature, homeostasis is achieved.[70] And before continuing any further with an analysis of attributions of purposiveness in natural sciences, it has to be said that my interest in such ascriptions extends to functions and not to goals. The distinction between the two sorts of attribution is important since a lot of our idea of goal-directedness in explanations of organic traits or behaviours stems by way of analogy from our own conscious behaviours, customs and language devices. It is not very incredible that, as a matter of brute psychological fact, we might model a concept of non-intentional purposiveness on human intentionality. And while the metaphor may prove apt for explaining abstruse deterministic connections (when there is no other explanatory concept to be had anyway),[71] it is also a misleading model for theoretical scrutiny of internal purposiveness. I take it that when we talk about function as a central explanatory concept in biology, we are describing distinctive properties (such as purposive organisation of organic bodies and the ability to self-organise and self-maintain) which precisely present as metaphysically objectionable.

The reason for my exclusion of goals from a function analysis is that concern with goal-directed processes signifies a line of reasoning employed by philosophers of science to confine the explanatory use of function ascriptions to systems that have clear mechanistic presuppositions and I want to rule this strategy out *ex ante* as inadequate to the character and behaviour typical of organic phenomena. Objecting to the Aristotelian connotations of the notion, some theorists deny that function is directly applicable to systems and instead conceive apparently teleological structures as systems which are intelligible as a result of goal-directed processes.[72] So for instance, functionalism about life is regarded by some as the view that being alive consists in the realisation of a sequence of processes – some (such as information processing and metabolisation) operative within the lifetime of a single individual, and others (like reproduction) over several generations.[73] And when a goal is predicated of a change or activity, how this purposive process is realised can, it seems, be explained in its entirety with reference to antecedent material conditions. Talk of genuine functional explanations for organisms, tissues and cells can then summarily be disposed of. A well-known set of distinctions in the philosophy of biology which achieves such a mechanistic reduction of putative teleology in non-intentional processes is proposed by Ernst Mayr. Mayr distinguishes between teleomatic and teleonomic end-directed processes. Famously, teleomatic processes are those regulated to an end by causal laws and

---

[70] Nagel, 'Functional Explanations in Biology', p. 299.
[71] McLaughlin, *What Functions Explain*.
[72] *Ibid.*, p. 17.
[73] Mark Bedau, *The Nature of Life* (Cambridge, 1996).

contingent boundary conditions. Teleonomic processes owe their goal-directedness to an internal material representation of a goal, in addition to external forces.[74] Nonetheless, it is clear that ascriptions of purposiveness in the biological context resist a reduction to simple activities. An organic system is a material representation of an end itself or a goal state, which we ought not to be tempted to construe in terms of additive causes like processes, for this is to belie the complex nature of non-intentional purposiveness. The failure inherent in modeling organic systems on processes in this way is a continuation of the underestimation of the marked divergence in the principles of internal and external teleology displayed by those desirous of a univocal account of function.

A challenge to a single, simple approach to natural and conscious functions is potentially posed by the developmental systems theory in biology, defended by theorists like Robert Lickliter and Thomas D Berry, and Richard Lewontin. It is straightforward that the function of an artefact like a clock is the accumulated effect of a sequence of mechanistic processes produced by its individual component parts, as well as natural laws concerning the activities of those parts. We can in fact decompose them, tracing back from the capacities of the clock along simple causal mechanisms, that add up, flow-chart style, to the movements of the minute and the hour hands. But a developmental systems theory suggests that there exist reciprocal relationships between the genotype, environment and organism in the development of morphological outcomes.[75] Traditional conceptions of ontogeny[76] and phylogeny[77] in the philosophy of biology typically assign a preontogenetic explanation for development, and regard the organism's stimulative environment as merely supportive. Yet this does not explain the developmental processes whereby a biological trait or characteristic is realised by an individual. Indeed, not only do internal causes and external causes of the phenotype[78] interact during ontogeny, so that the genetic state and environmental sensitivity of the organism are mutually determinative developmental processes, but their effects are expressed and realised through the phenotype produced, as a primary cause of the developing organism itself.[79] So if it is right that multiple changes shape a living thing, and that these are cumulative, non-additive causes, we may require a more nuanced view of organic structures than that proposed by amongst others, the teleomatic/teleonomic distinction of non-intentional processes.

McLaughlin, for example, points out that, in a teleological system, teleonomic processes must finally culminate in (a) teleomatic process/es. In the case of the teleonomic flight of the Warbler to

---

[74] McLaughlin, *What Functions Explain*, p. 28.

[75] Robert Lickliter and Thomas D. Berry, 'The Phylogeny Fallacy: Developmental Psychology's Misapplication of Evolutionary Theory', *Developmental Review,* 10, 190, pp. 348-364.

[76] That, is, the development of individual organisms.

[77] Phylogeny is traditionally taken to refer to the evolutionary history of a biological type.

[78] That is, an organic body's perceptible properties.

[79] Susan Oyama, *Evolution's Eye: A Systems View of the Biology-Culture Divide*, (Duke University Press, 2000).

Africa, its migration is presumably guided by some internal programme; yet given that this part of the Warbler is a representation of a goal state, it cannot itself be teleonomic, under pain of infinite regress. Thus a teleological complex must have a basis in a *teleomatic* process.[80] But if an organic process is proximately determined, or entirely explicable on the basis of external constraints, how can we make allowance for that complex biological interaction, in which the material representation of the end state or internal programme specifies norms of reaction over the environment of the individual organism, creating the boundary conditions which, in turn, alter its genotype? It seems that in a biological context, we must necessarily speak of express functional structures or complexes precisely like an eye, for there are no simple natural non-intentional teleological processes. Thus it is for instance well-known that the eye distinctively exemplifies a structure of great intricacy, resulting from the gradual activity of natural selection upon minor variations, and which is to be found in nearly all animal species. Visual perception is the effect of a body that is instrumentally related to that function. As a function bearer, the eye is said to be constituted for the purpose of tracking light, and its identity condition over time consists in its self-reproduction as such a body.[81] It indeed has activities which are goal- or end-directed in a functional, explanatory sense (thus the purpose of the lens is to focus the beams of light that are received by the retina, and this, in turn, converts light into neural signals which are transmitted to the brain by the optic nerve); nonetheless, these do not act independently or consistently according to general causal laws and/or environmental conditions. Causal pressures – whether exerted by an aquatic or terrestrial light environment, or by changes in the receptor organ that processes visual information (brain) – operate on a temporally prior function bearer (what we have also called the phenotype of the eye) and it mediates changes or motions in the system in order to preserve its identifying end. This partially accounts for the great variety in eye anatomy in the animal kingdom: lenses and retinas are distinct across species and highly adaptive. There is just no prototypical process of sight that can be teleomatic in the manner of a falling stone coming to rest upon impacting the ground.

Hence when we speak purposively about an organic entity, it must be that we are referring to one or more structures rather than processes. It is only of natural systems that we cite functions in an explanatory sense. It is important to stress that this point is independent of whether or not animate nature has teleological grounds of causation. I am here arguing that teleological statements which are functionally prescriptive in form have explanatory potential in biology, while goal-ascribing ones do not. Therefore, if one is going to demonstrate explanatory reduction of apparent non-intentional teleology, one has to account for the causal mechanisms found in complex structures. It is exceedingly attractive to dissect organic purposiveness as the product of simpler means-end relations because descriptions

---

[80] McLaughlin, *What Functions Explain*.
[81] I take it that eyes that change enough to not track light are no longer eyes.

of human intentional and instrumental actions (as opposed to non-intentional functions in human beings) can be understood thus. And simple linear systems indeed take us closer towards explaining function-ascription statements mechanistically. But the intuition this parallel is based upon derives from the use of faulty concepts: we do not arrive at a biological system whose parts can be function bearers by adding together many disparate and externally-directed processes. Function in the biological and social sciences is about teleological attributions in a problematic causal sense, rather than in a hermeneutic sense.[82] What is at issue is not function expression as a placeholder for an as-yet-unknown mechanistic explanation, but as a self-reproducing system deemed to be causally suspect insofar as it is considered as causally responsible for its own parts.

In short, the unit of non-intentional purposiveness for organic phenomena has to be internal teleology. (Kant in fact thought that, given that the parts of an organic structure have reciprocal relative purposiveness to one another, there must be intrinsic purposiveness of the whole, even as the organisation we perceive in the natural world can be taken to suggest purposiveness of the whole of nature.)[83] Therefore the functional character of biological entities is an ineliminable condition on an analysis of teleological judgments in nature, with the result that an account which defines all functional explanations in terms of goals, such as Nagel's *goal-supporting* view of function (and with which I shall therefore not be engaging), is an inadequate route for functional analysis.

Therefore let us return then to the positions introduced thus far which do indeed engage explicitly non-intentional functional systems.

2.1 The Etiological Theory of Function

Given that the Darwinian Revolution is of pivotal significance to modern biology as a lawlike mechanism for producing adaptiveness of organisms, many theorists have sought to account for the explanatory role of function attribution by appealing to the theory of evolution.[84] Indeed many philosophers accept the use of functional explanations in the biological sciences for the sheer reason that natural selection has the potential as a feedback mechanism to legitimise teleological descriptions in classical physicalist terms. Without appealing to a prior whole as an efficient cause of properties of the parts in an organism, natural selection promises to explain why the effect of a functional trait of a particular type can be

---

[82] McLaughlin, *What Functions Explain*.

[83] Kant, *Critique of Judgment*, pp. 128 – 129.

[84] Colin Allen, Marc Bekoff and George Lauder, 'Introduction', in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).

causally responsible for other tokens of the same type.[85] It is in this tradition that Wright aims to give content to function ascriptions.[86] Natural selection is here commandeered to a process which serves as reproductive of a biological function bearer.

In his attempt to reformulate functional analysis, Wright asserts that teleological descriptions are *per se* explanatory; that is to say, they are specifically intended to explain the presence and origin of the function bearer. This claim can be understood as a specification of the scope of Wright's analytic interest in function ascriptions.[87] His analysis of the explanatory role of function ascriptions is based on the argument that it belongs to the nature of function to be explanatory in a substantial causal form. For Wright, attributions of function cannot be explanatory merely in the sense of what a biological feature is good for, because the latter interpretation does not differentiate between a function and an accidental effect. So ascribing a function to something cannot be sufficiently rendered as a statement about the usefulness of the phenomenon under consideration, since that item can issue in multiple useful, and nonetheless peripheral, consequences in the structure to which it belongs. Thus to say that, in beating, the heart muscle functions as a diagnostic aid as this thumping is a good the heart performs for the organism, does not make the quasi-function ascription in the case real. The proper function of the heart is that particular effect which explains its presence within animals, and that is in order to pump blood throughout the body.[88] Wright's proposal is accordingly that functional explanations must be etiological, meaning that they relate to the causal background or genesis of the functional item which they describe. On his account, to say that the function of a trait *T* is effect *e* is thus to say that:

(a) *T* is there because it does *e,* and
(b) *e* is a result of *T*'s being there.[89]

The first clause entails that teleological description is a kind of causal explanation. By including as a necessary element of the analysis of function a stipulation that *T* came to be where it is because it is the causal antecedent to *e,* it thus becomes possible to circumvent the problem that *e* might be an accidental consequence of *T.* Although Wright is also concerned with consciously designed functions, natural selection is the mechanism whereby natural functions can for us satisfy (a), given that the function of a biological trait is the reason it is present in offspring. Biological traits had consequences for the propagation of the genes responsible for them just inasmuch as they brought about certain

---

[85] McLaughlin, *What Functions Explain*, p. 93.
[86] Allen, Bekoff and Lauder, 'Introduction'.
[87] McLaughlin, *What Functions Explain*, pp. 94 – 95.
[88] Wright, 'Functions'. pp. 51 – 66.
[89] *Ibid.*, p. 67.

competitive advantages for parents; hence the presence of a feature, *T,* is ensured in an organism by differential selection for a specific effect, *e,* and that effect is its function.

Still, the main concern of Wright's analysis is to elucidate the function/accident distinction. Since it is still possible for the etiological reason for a natural trait to diverge from the consequence we ought to attribute to it, Wright distinguishes functional explanations from ordinary causal explanations by way of the addition of the second clause (b). He uses the example of oxygen-respiration to make this point, although it might be made of any element that enters into the production in an organic system of an effect which is merely a means to the end to which selection is responsive. So it is absurd to claim that the function of oxygen in the bloodstream is to combine with haemoglobin, even though doing this is exactly why oxygen is present. The proper function of oxygen in the blood is to facilitate oxidation reactions. The second clause supplies a necessary and sufficient condition on a function, according to Wright's analysis. Wright argues that the nature of etiology is such that the appositeness of a functional explanation is determined by the particular history itself. There are multiple etiological reasons for how doing *e* determined that *T* came to be where it is, but only those in which *e* is related in a causally appropriate manner to *T* can be regarded as a functional etiology. This (as squares with our paradigm case for internal teleological attribution in an explanatory sense) will be one in which the consequences of *T*'s being there have a part to play in its own causal history.[90] Of course, to make this explanatory appeal is not fallaciously to invoke backward causality, in which the direct effect of the trait determines the token's existence; rather, as I have said, the second clause reiterates that functional explanation implies a species of holism or downward causation.[91] In this instance, the holism is made consonant with standard causal explanation by appealing to a succession of systems over time, so that the causal control a living system exerts over its own parts is made relative to an individual and the parts of various instantiations of the identical biological type. What Wright describes as the "convoluted forward orientation" of the second clause is here made intelligible by that important distinction between trait and token types in the case of biological phenomena. Given that natural functions belong to types, the causal pattern identified in his analysis is one in which trait types can – in performing a consequence automatically selected as a function in light of its resultant advantage – provide a kind of causal background for the occurrence of an individual trait. Therefore producing energy is the function of oxygen in the bloodstream on evolutionary-etiological grounds, for it is this effect which, by means of natural selection, supplies a reason for the presence of oxygen – and not the fact that oxygen combines readily with haemoglobin.[92]

---

[90] Wright, 'Functions', p. 68 – 72.

[91] McLaughlin, *What Functions Explain*, pp. 26 – 27.

[92] Wright, 'Functions', p. 73.

Lastly, an important feature of Wright's position is that he rejects benefit as part of functional analysis. Although Wright claims that a functional trait *T* must be disposed to perform a particular effect *e*, he does not require that *e* is, or ever has been, good for anything. In his description of the feedback relation, he explicitly avoids appealing to the benefit conferred on a relevant system by a function. Recall that organic purposiveness is supposed to involve a good that is conferred on a structure or system that can legitimately be understood as having interests. Benefit thus incorporates the notion of good into the analysis of function, and Wright's expressed intent is to achieve a formulation of function that is devoid of a valuational component. I have already alluded to his stated reason for this: Wright's pursuit of a univocal account of biological and non-biological functions means that his characterisation of function cannot contain desiderata which do not belong equally to both.[93] Thus the theoretical definition of purposiveness for biological entities asserted on Wright's etiological view is simply that functional tokens occur because they enter into lawlike relationships with certain of their effects.

Wright's norm-free functional analysis thus details a process: a mechanism (natural selection in the case of living things) offers a non-evaluative explanation for how a function bearer can be causally responsible for itself in that this feedback relation accounts for the origin of a functional characteristic purely through its own effects. Thus, in order to have a function, an item *T* of effect *e* must instantiate a type whose tokens were at least at one time causally connected to other tokens of the same type that non-accidentally performed *e*. In other words, a functional trait must have the proper evolutionary history, in which it originates as a reproduction because some tokens of its type were disposed to properties which led to that type being propagated over generations. This account of function in terms of the causal origin of the function bearer is hence strictly a non-evaluative consequence etiology. Thus an etiological view will also inevitably fall prey to the charge that it must – at least at first – disqualify from functionhood newly-appeared propitious traits in biological items (such as are organismic mutations) because such traits will not possess the appropriate etiology. But even if we share the intuition that a functional analysis must accommodate this charge, (and I happen not to) the objection establishes only that the etiological thesis may be implausible as conceptual analysis.[94] As I will later explain, the merit of a stipulative theoretical definition is decided by its scientific prolificacy.[95]

Indeed etiological theories of function have much to recommend their superiority. Throughout this thesis, I seek to defend a causal account of functional explanations foremost in order to meet the desideratum that such explanations should preserve the distinction between proper and accidental

---

[93] It is arguable that Wright's argument that artefacts can have functions without providing an obvious benefit is unsuccessful. See McLaughlin, *What Functions Explain,* pp. 42 – 55.

[94] McLaughlin, *What Functions Explain,* pp. 101 – 102.

[95] See my discussion of a theoretical definition on page 7.

biological consequences or effects. As I go on to argue, to contend that ultimate design to environment by efficient causal factors is the delineating factor in the emergence of functional traits is in effect to set external normative conditions on functional analysis. This means that trait types transmitted by natural selection, or specific phylogenetic histories, can act as function constraints in biology. Selection for a particular variation in successive developmental systems of the same biological type sets some external limits on the ontogenetic possibilities of a functional trait. Furthermore, it can be said that a view of the ultimate condition for teleological ascription as historical in character makes sense of our ordinary tendency to use comparable metaphors to speak of animate and inanimate function (however different these might in fact be).

On the other hand, the view also has distinctive flaws. Earlier I have specifically argued against Wright's univocal approach to function on the grounds that our cognising of biological phenomena requires a distinct judgment of their internal organisation. A dynamic and holistic approach to biological processes to which I have already alluded is the expanded view of heredity and phenotypic development known as developmental systems. And as we have seen, a developmental systems theory suggests that the organism life cycle is the product of a heterogeneous mix of functional and structural complexity: biological individuals construct, and are also influenced by, their development and evolutionary environments,[96] meaning that they are developmental systems which comprise causal complexes rather than series of causal processes. When considering an etiological thesis, we ought therefore to bear in mind that a critique leveled of evolutionary accounts by this theory is that the conception of development implicit therein does not sufficiently allow that a phenotypic trait or character is determined by an entire complex of interacting influences. Although a given phenotype is the result of the co-action of the individual's genotype and the developmental context, so that a genotype has the potential for different developmental pathways, there is a tendency in biology towards ontological prioritisation of historical contingency to the exclusion of other causal factors.[97] This sort of preformationist or predeterminist thinking, illustrative of what Lickliter and Berry term the "phylogeny fallacy",[98] is a conceptual framework for which I hope to make adequate contingency. However, in this thesis, I adopt a variant of the position that function attributions reference an evolutionary etiology as a causal explanation for the function bearer, and I ask that the position be engaged by the reader at this stage with the understanding that preontogenetic factors are never sufficient as causes in ontogeny.

---

[96] Oyama, *Evolution's Eye*.

[97] Lickliter and Berry, 'The Phylogeny Fallacy', pp. 353 – 356.

[98] According to Lickliter and Berry, the phylogeny fallacy occurs when we think about ontogeny and phylogeny as mutually exclusive and exhaustive factors in the construction of phenotypic outcomes. There is a history in biology of dividing aspects of development into the immediate determinants of a given trait or character (such as environmental forces), and those evolutionary factors thought to be responsible for the shaping of the genotype for individual features. In dichotomising developmental explanations thus, the concept of the developmental system holds that aspects of the organism-environment interaction process that produce developmental outcomes will therefore be overlooked.

There will be various conditions, circumstances and interactants which are necessary in addition to genetic information for a phenotypic outcome to come about.

In the next chapter, as I continue in my critique and emendation of prevailing accounts of function, I argue that a critical shortcoming in Wright's explanation stems from such gene-centric assumptions of development, with the result that the account fails to capture significant aspects of practice in the natural sciences, including biological analogy and multiple realisability. But the point I will seek to stress through the etiological thesis is the importance of a certain, external normative component of function despite the absence of a valuational perspective. Naturalistic external normativity for biological functions is in principle generable through a mechanistic non-agential design process like natural selection. And it is this normative condition which supports the distinction between functions and accidents in function bearers.

Thus the etiological approach interprets the explanatory task of teleological attribution as that of specifying how the historical contribution of a function bearer is causally relevant to its own presence. But it is not useful for us further to expound the advantages of the approach before appreciating the "forward-looking" approach to biological teleology against which it contrasts. We turn now, therefore, to the dispositional view.

2.2 The Dispositional Theory of Function

In spite of the substantial support etiological analyses enjoy in the philosophical literature, it is sometimes said that biological usage of function ascriptions in fact more accurately references subsets of capacities entities now perform (otherwise known as dispositional facts). This is the contention of the dispositional position: because functions correspond to an explanation for current adaptive effects or consequences of traits, function statements purportedly cannot present causal explanations for the presence of features in a population.[99] In this section, however, I argue for the greater merit of etiological functional analyses, on the grounds that dispositional theories deprive function of two properties indispensible to its appropriate conceptual extension in biological theory. First, a normative interpretation of function cannot be sustained within a dispositional analysis; and second, the dispositional view fails to accommodate the link between the operation of natural selection and the form of a function bearer.

---

[99] Justin Garson, *The Biological Mind: A Philosophical Introduction* (Routledge, 2015).

Many biologists are concerned that structuring functional explanations in terms of the past effects of phenotypic traits diminishes the capability of natural science to provide precise ascriptions of biological function. Morphologists in particular call attention to the fact that it is exceedingly difficult to evaluate claims about the adaptedness of species in the past, since we cannot have complete knowledge of the environments in which they lived.[100] Indeed some theorists go beyond the empirical objection and argue for the conclusion that a theory of natural function cannot be linked by conceptual necessity to the theory of natural selection, on the grounds that it is otherwise logically impossible for anyone to attribute a purpose to a feature without also understanding Darwin's theory of evolution. And this is obviously untrue. William Harvey correctly announced the function of the heart two hundred years before the publication of *On the Origin of the Species*.[101] Consequently morphologists have advocated for a very different perspective on the purposiveness that is seen in nature -- one which has greater empirical appeal. If we may borrow a distinction first articulated by Mayr, proponents of the forward-looking or dispositional approach in general hold the etiological thesis to be better suited to the concerns of evolutionary biology than those of functional anatomy. Accounts within the dispositional school of thought are aimed at showing that function is an ahistorical concept.

On the whole, such hypotheses attempt to come to terms with function by specifying it relative to those effects a biological trait is disposed to produce that preserve or otherwise contribute to the survival of the living organism in possession thereof. An illustration of this viewpoint is given by Martin Rudwick, who defends an engineering-style analysis of the appearance of the purposiveness that is seen in organic products. In brief, his argument is that we use our understanding of the principles of mechanical engineering to infer the proper function of a biological structure from the causative roles it can possibly play in the maintenance of the living whole.[102] And thus functional analysis is ostensibly in principle separable from evolutionary theory.[103]

However, it is now possible to identify two major advantages of the etiological approach over the competitor dispositional thesis. First, the latter kind of analysis has the unfortunate theoretical implication that something, in order to possess a proper function at all, must not fail in performing it. A backward-looking theory of function has the upper hand when it comes to attributing a function to natural entities which are not (for whatever reason) capable at that time of carrying out their functions. This is because it is not the actual effect of some, one heart, but the pumping of the blood by ancestral

---

[100] Allen, Bekoff and Lauder, 'Introduction', p. 7.

[101] Neander, 'Function as Selected Effects: The Conceptual Analyst's Defense', pp. 321 – 322.

[102] Allen, Bekoff and Lauder, 'Introduction', pp. 6 – 8.

[103] M.J.S. Rudwick, 'The Inference of Function from Structure in Fossils' in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).

hearts that accounts for the proliferation of a certain genotype, and hence accounts for the proper function of the present organ, no matter how injured or malformed it may be.[104] And the reason it is able to do this is because it belongs to the essence of the purposive that it need not fulfill its function in order to possess it.[105] In other words, the characteristic mark of tokens that can be identified under function categories is that there is something that the token is *supposed* to do. It can fail or be defective in some way because it is classified under norms. Although it need not explicitly acknowledge this aspect of functional analysis, an historical position on function is sufficient to the idea of the essential normativity of function. This is a claim tendered by etiological theorists such as Karen Neander and Millikan. Thus any description of function which relies upon morphological criteria alone cannot be satisfactory since there would be no biological purposiveness without our taking it to be a normative phenomenon. Organic function is intimately connected with function types given that an organism's history will set the norms that determine purposiveness. Hence what we mean when we say that "the purpose of the hypothalamus is to monitor blood oxygen and sugar levels" is that we recognise functional norms as applying to a hypothalamus because and only insofar as we expect it (on the basis of the function of its ancestors) to execute these regulatory effects, thereby resulting in ascriptions of functional norms to members of this function category which cannot produce such effects.[106]

And while it remains a challenge to assuage the difficulty of specifying the evolutionary history of an item as a necessary criterion for the diagnosis of function (whatever our analytic aims in interrogating teleological claims), the criticism that a pre-Darwinian physiologist like Harvey would have had to assume the truth of the theory of evolution in order to diagnose the function of the heart is applicable only if one thinks that the notion of the etiological theory as capturing a certain reference class describes a feat of conceptual analysis. Although it is a tendentious claim, given disparity in the literature on the subject, conceptual analysis can roughly be defined as an attempt to capture the criteria of application (whether implied or explicitly entailed) for the use of a common term, or the criteria by reference to which the term has meaning relative to the members of a linguistic community.[107] Some writers on function, including Andrew Woodfield, Wright, Nagel, and John Bigelow and Robert Pargetter, expressly engage the task of conceptual analysis of our common phrases or idioms regarding teleology.[108] But while it does not fall within the scope of this thesis to defend a definitional theory, this objection provides an opportunity for me to be more precise about what I conceive to be the intention of the analysis of teleological ascriptions here presented. The descriptive definition attempted

---

[104] Millikan, 'In Defense of Proper Functions', pp. 296 – 297.

[105] *Ibid.*, pp. 302 – 304.

[106] Neander, 'Function as Selected Effects: The Conceptual Analyst's Defense', pp. 324 – 326.

[107] *Ibid.,* pp. 314 – 315.

[108] Millikan, 'In Defense of Proper Functions', pp. 296 – 297.

by the conceptual analyst is contrasted by Millikan with a theoretical definition. While the former attempts to describe the relationship between usage of the term under analysis and the relevant linguistic community, a theoretical definition aims to explain the relationship between the term and its actual referent, that is, some feature of the world. An example of a theoretical definition is, “Water has the molecular structure HOH”. I am inclined to think that a definition of proper function as a theoretical definition is the appropriate programme to pursue in response to the ubiquity of teleological explanation in biology for the reason that my project extends well beyond the search for linguistic meaning, to an attempt to discover the causal principles involved in functional categories.

Of course the natural question which arises from the goal of accounting for biological teleology is whether we are restricted to a conclusion about the methodological assumptions of biological practice. If all that can be established from an investigation of functional claims is that our cognitive faculties happen to necessitate descriptions of certain natural processes and properties in terms of purpose, design and adaptive function, it may be that a reductionist and mechanistic, rather than an holistic, ideal, is causally adequate to the metaphysics at play here, irrespective of how well-founded is our penchant for teleological thinking. However I am in agreement with Helen Steward that an argument on which biological entities demand functional explanations serves an ontological point, for the reason that the teleological descriptions countenanced by functional biology would be necessary (if indeed they are necessary) to making sense of the story of how a natural thing, exhibiting particular complex morphological and behavioural traits, comes to be, and persists as such.[109] Again, assuming a theory about the nature of theoretical definitions is, in itself, controversial, but I follow Millikan in thinking that a theoretical definition of ‘proper function’ ought to describe that to which the term refers, which explains the use of the term in a successful theory of biological phenomena.[110] Given that conceptual analysis describes simply the criteria of application for proper function that people standardly hold, it may be that theoretical definitions better capture the meaning of the term, although, to an important extent, the search for meaning must necessarily overlap with our understanding of the beliefs modern biologists have about proper functions. At the risk of overstating the distinction between our understanding of the world and the conceptual tools we engage in talking about it, a theoretical definition constructs a picture of the nature of that which we aim to define, and one which is not so vulnerable to shifts in the usage of the terms by which we name it. Thus, in the project of theoretical definition, it is a moot point whether Harvey, without knowing evolutionary theory, possessed the selfsame understanding of ‘proper function’ as we do today. This conclusion does not presume the truth of the etiological thesis – instead

---

[109] Helen Steward, *A Metaphysics for Freedom* (Oxford, 2012).
[110] Millikan, ‘In Defense of Proper Functions’.

it affirms a conception of biological purposiveness which brings together more biological facts under the category of proper function and is therefore more explanatorily productive.

Hence we can move on to the second advantage of etiological over dispositional analyses. Another strong merit of the etiological approach is its capacity for recognition of the role of external design in attributions of function to organic entities. Although the full import of this advantage is discussed only in chapter three, as I explain, dispositional accounts miss out on the normative element of function in part as a result of their stifling the sole prospect for demonstrating a relationship between environmental design and function in an epistemic position from which we cannot presuppose an intelligent origin of nature.

Earlier I mentioned that design, understood in the sense of external teleology, had been banished from the world by the early modern philosophers, who distanced themselves from final causes. Naturalistic determinism rejected speculation on the divine purposes which the appearance of adaptedness or excellence of design in nature so seemed to suggest. And yet, Darwin showed that – in the absence of mind and volition – evolution by natural selection could bring about an ingenious biosphere, in which life forms have proliferated and diversified into a rich abundance of ecological niches.[111] This - - despite it not being a conscious or deliberate matter that organic diversity exploits so many of the opportunities for living on Earth. Dobzhansky defines the evolutionary process in terms of the environment presenting challenges to living species in the form of unoccupied ecological niches. Natural selection initiates a response from environmental inhabitants in that they may accommodate the environmental change by adaptive genetic changes, or they may resist it altogether. But whatever the case, organisms now living are descendants of species successful in their responses. In matters of size, structure, and ways of life, the diversity of the living world is stunning.[112] At the pinnacle of the complexity spectrum are vertebrates, including the human species, which is highly adaptable and can survive in a great many environments; and at its opposite most extreme, there are forms of adaptedness corresponding to the narrowest ecological niches, such as belongs to the overspecialised fungus family *Laboulbeniaceae.*[113] Although the absence of artful intention means that natural selection cannot example genuine Kantian external teleology, evolution can brook something very like external

---

[111] Daniel C. Dennett, *Darwin's Dangerous Idea* (Penguin, 1995).

[112] Theodosius Dobzhansky, 'Nothing in Biology Makes Sense except in the Light of Evolution', The American Biology Teacher, 35, 3 (1973) pp. 125 - 129.

[113] Dobzhansky, 'Nothing in Biology Makes Sense except in the Light of Evolution'.

purposiveness in naturalist terms, since non-conscious selective processes in this case yield entities which are designed to purpose without an appeal to an agent external to the physical world.[114]

Thus it is possible plausibly to attribute particular purposes for which functional traits, as evolutionary products, have been naturalistically created to serve, in that a causal etiology for a function bearer specifies some effective or operational condition which is the deliberate end of its reproduction as an instantiation of its type. Selection for desirable effects explains the origin of a function bearer, that is, why biological parts with certain properties (and not others) have been assembled together in a particular way. And so a *prima facie* uncontroversial external teleological explanation of a kind for a functional body in biology is given in that the final cause (interpreted in the sense of external teleology) for a function bearer is embedded in its environmental context in the form of selective pressure. At this point, we can also say that, in keeping with traditional etiological accounts, a causal interpretation for a function bearer in terms of an end anticipated by a non-intentional artisanal process can be in principle mechanistically achieved; moreover, natural selection does not perceive value in the achievement of its goals and therefore there is no value component attached to such an account *per se.* However, indisputably, the perspective from which natural entities are designed is an historical one. One must begin by looking back to the selective pressures the environment exerts on a biological feature in order to generate the requisite normativity. In large measure, that which specifies the effect of a structure, trait or a behavioural strategy in a biological system as a function simply is the given *environment* to which it has responded and continues to respond. Even though the function of a constituent of an organism might end up making a causal contribution to the survival of the working whole, a purely morphological definition of proper function is nonetheless undesirable since organismal excellence is itself only intelligible relative to the demands of the environment on the Darwinian schema. Now dispositional accounts can typically provide a notion of function freed of teleological discourse because of their exclusive emphasis on the role of a biological feature in ensuring the future continuance of that feature in function attribution - - however in so doing, the explanandum of function in the biological context becomes essentially internal to the organic system, and therefore independent of the crucial organism-environment complex.

This drawback is made evident in an interesting variation on the dispositional approach, found in the writings of morphologists Walter Bock and Gerd von Wahlert. They define a trait's function as "all physical and chemical properties arising from its form … that … do not mention any reference to the

---

[114] See Wright, 'Functions'. Wright has a discussion of whether this can actually be considered external teleology given that natural selection is in fact self-selection. His response is that it belongs to the nature of consequence selection to de-emphasise intentionality.

environment of the organism."[115] Function is singled out from biological role on this account, so that those uses of a structure in the life of the organism that express a relationship to its natural environment are, in this case, stipulated as outside of the ambient of function.[116] If, as Bock and von Walhert do, we are to eliminate all environmental factors from the concept, it is not possible to conceive properly of function as a product of adaptation. To be sure, the biological role of a structure would then be privy to some interrelationship with the environment. But, on their supposition that the function of the wings of the Warbler is flight, and the biological role is to facilitate migration, it is not the morphological unit of the wings – but their use – which is the direct subject of selection forces.[117] I would contend this statement to be obviously untrue: we know it to be a corollary of the theory of evolution that function enters into adaptation for the reason that, as much as structures comprising diverse chemical and physical properties can be selected for the same biological role, we also observe remarkable parity of form in biological role.

Unity is as striking a characteristic of the living world as is diversity. Perhaps the most remarkable evidence of likeness in biological structures or functions is given by the biochemical universals. It is an impressive universal biological similarity that heredity is coded by just four genetic 'letters' in DNA: adenine, guanine, thymine and cytosine. The other substance of heredity, RNA, differs only in that uracil replaces thymine. The evolutionary development of life has occurred by means of the novel sequencing of combinations of just these letters. In addition to the universal DNA-RNA genetic code, the translation process for the synthesising of the sequences of the letters in DNA-RNA into sequences of amino acids in proteins is universal. Molecular studies, comparing the biochemistry of genes between species, moreover reveal that some enzymes and other proteins are quasi-universal, or functionally similar. Despite containing differing sequences of amino acids across a range of living beings, they catalyse similar chemical reactions.[118] These, and other significant biologic uniformities at the level of cellular metabolism, suggest that organic structures have a common source of evolutionary descent and share some basic features. This phenomenon is what is called homology by biologists: homology is a likeness in structure or physiology between the parts of different species of organisms because of evolutionary differentiation from a shared ancestor. Comparative anatomy and embryology provide further compelling examples of the convergence of morphological structures as a result of shared evolutionary pressures. Homologous bones are to be found for instance in the varying forelimbs of humans, bats and deer; these represent modifications of the physiology of a common mammalian

---

[115] Walter J. Bock and Gerd von Wahlert, 'Adaptation and the Form-Function Complex' in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).

[116] Bock and Gerd von Wahlert, 'Adaptation and the Form-Function Complex', pp. 131 – 133.

[117] They seem to imply that function might be influenced via faculty (that is the form and function complex) but there is no discussion of wherein exactly the relationship of function to biological role might consist.

[118] Dobzhansky, 'Nothing in Biology Makes Sense except in the Light of Evolution'.

ancestor. Homologies are also detectable in the external skeletons of otherwise superficially very different arthropods, including lobsters, flies and butterflies.[119] The explanation for this is that the unit upon which natural selection works is the phenotype. That is to say, because the phenotype is what is visible to environmental obstacles, the developmental systems view considers that genic change cannot play an ontologically distinct role in evolution.[120] Evolution is best described as redistribution in the phenotypes of a biological population. And this state contains a significant function component even in the restricted sense of properties attributable to form or type specified by genotype.[121] So it is not a contingent matter that its particular wings enable the Warbler to fly; many of the same aerodynamic properties are observable in the very different wings of insects and bats. Were dispositionalists to be correct, the environment cannot be a source of design in the functional analysis of a Warbler's wing. And this is not the case.

A key reason why organic structures are singular as material systems is because they remain identical to themselves only through characteristic interaction with their environments. Function bearers' structural properties are correlatively concerned with their environments for the reason that system parts in biology are at least partly identifiable with causal role function in the performance of the systemic end of self-reproduction. So given that function bearers are at least in some sense where they are because of what they do, sometimes similar evolutionary solutions will arise in response to like environmental challenges - - despite (rather than purely because of) form. Therefore, the existence of biological homologies shows that one cannot discount the causal history of an organic feature from the explanandum of function ascription, if function is indeed in part designed and therefore a normative characteristic, given that one cannot expunge natural selection from function.

My aim in this section has been to spotlight that – because it is possible on a dispositional account to conceive of the effect of a biological structure as a function without its having been designed to produce that effect – the consequence of such a theory is that it becomes a descriptive matter whether or not a given system part in biology is functional. An etiological account is superior in that, in its own right, it supplies a normative criterion for function attribution. Given that natural selection can be used in a non-problematic way to formulate external teleology, our scientific motivation for adopting a causal etiology as a stipulative definition for function is that it enables us to speak of organic products as 'purposed'. Regarding animate function, historical analysis works better. In the case of the etiological thesis, we say that the effect of a functional token in a biological context is not merely accidental with regard to the

---

[119] Dobzhansky, 'Nothing in Biology Makes Sense except in the Light of Evolution', pp. 128 – 129.

[120] Oyama, *Evolution's Eye*.

[121] *Ibid.*, pp .81 – 84.

origin of the beneficial trait because other tokens of the same type have at some time performed similarly in other such systems; and therefore the function bearer is minimally responsible for its own causal replication. Hence evolutionary history is necessary and sufficient for establishing an external normative condition for ascribing proper function. If a normative element of biological function is indeed to arise naturalistically, it must be through a reconstruction of the causal origin of functional bodies.

3. Normativity and Holism

Up until now I have introduced normativity into the definition of biological function in the form of external purposiveness, without strictly diverging from the classical formulation of the etiological account, which is not incompatible with mechanism. While the attempt to derive norms naturalistically from selection is not unique to my account (Millikan, for example, attempts to do something similar),[122] I go on to claim in chapter three that functional normativity must also be internal, causally necessitous, holistic in its ontological character, and essentially related to value. In what follows, I argue that the etiological theory must be augmented to make allowance for the self-organisation and maintenance of individual integrity exhibited by living things, and consequently, descriptions of biological purposiveness cannot be rendered as explanations purely in terms of mechanistic processes.

In this chapter, I take seriously the empirical viewpoint that the environment is to be regarded as a constructive force in the realisation of phenotypic outcomes. Deriving the normative necessity involved in a functional relation by insisting that the operation of selection is the basis for the attribution of external design in function-bearers is theoretically desirable. And, despite the difficulties occasioned by linking the design of biological entities to phylogenetic determination, I contend that the notion of a phylogenetically derived norm is plausible relative to the *recent past* of a given feature.

Nonetheless, the thrust of the argument of chapter three is that the traditional etiological view fails by taking for granted that intergenerational trait type transmission meets the minimal conditions for biological evolution, when, in fact, serial propagation of traits in living things is always accompanied by selection producing complex systems which are responsible for their own token existence. If replication is taking place but has not yet led to a system the present reproduction of which can be said to be the causal product of its functions, there is no life.[123] Developmental systems theorists demonstrate that an imperative causal factor involved in the realisation of phenotypic outcomes is the individual phenotype. Any system that has a claim upon biological function ascription maintains itself in the present, in developmental and self-regenerating processes which surpass genic causation. My aim is therefore to show that what is needful to integration of contemporary biological development theory and an analysis of function according to an evolutionary account of a trait, is a schema which moves past causal explanation in terms of ultimate determinants (and charging development to genes) to looking at the individual developmental processes whereby a phenotype is actually realised.[124] And, phylogenetic histories, as it will turn out, generate functional norms of necessity (meaning that they establish the kind

---

[122] Millikan, 'In Defense of Proper Functions'.
[123] McLaughlin, *What Functions Explain.*
[124] Lickliter and Berry, 'The Phylogeny Fallacy'.

of necessity identified by an ought-rule), quite apart from the causal norms (or laws entailing that type of necessity expressed by an is-rule)[125] which are necessary to individual ontogeny. Phylogeny does not suffice as a causal explanation for development (and thus, for the ontogeny of form). Rather, the genotype of an organism defines its *norm of reaction*, and the immediate causes or mechanisms responsible for bringing about a particular trait or character are constructed by the token developmental system. It is this systemic component necessary for the development of a living being which has still to be accounted for in an analysis of function.

In the case of organic structures, a function-bearing system seems to demonstrate – not only a particular interdependent and goal-orientated organisation of the parts within the whole – but in addition, a capacity of the whole to bring about certain effects in itself. Whether the system exists at the cellular or group level is immaterial: regardless of the level of complexity, all biological systems have characteristics particular to life that maintain and reproduce the substructures on which they depend. This occurs through a delicate balance of chemical and behavioural exchanges.[126] And while selection can explain function to the extent that functions are supposed to abet typical propagation of organisms, we will see that the causative action involved in a function's contribution to systemic reproduction is an independent phenomenon. So how is the internal organisation of function-bearing systems to be accounted for, given the Kantian injunction towards mechanistic explication? The latter half of the chapter seeks to answer this question.

I hence discuss an account of functional explanation as referring to a function bearer's causal contribution in a complex system, otherwise known as the systems interpretation. The attempt of this view is to analyse a biological trait based on its present propensities, position and internal structure in an organism and it is significant as an illustration of the argument that biological categories can have their origins in structural and embryological factors, rather than phylogenetic explanation.[127] However, ultimately, I contend that the systems theory is unconvincing as an explanation of biological internal coherence – not only in that it overlooks the role of normative necessity in its purely homological conceptualisation of function categories – but also in that it neglects the existence of explanandum at all levels of the biological hierarchy which point to the explanatory significance of top-down properties in natural systems. This suggests that what is missing from an analysis of function explanation is a cause which has the character of an internal norm, and is essentially value-related.

It is in thus framing the etiological thesis in internal normative terms that my account is intended to differ from those of other etiological theorists. My analysis of function cognises the mutual

---

[125] This is a distinction made by Hans Kelsen. See Hans Kelsen, *General Theory of Norms* (Oxford Scholarship Online, 2012).
[126] Kauffman, 'Antichaos and Adaptation'.
[127] McLaughlin, *What Functions Explain.*

dependence and construction of organismic, genetic and environmental factors in individual ontogeny and the role of this constructivist interaction in accounting for the systems of robustly ordered physical properties which we see in nature, thereby combining the principle of natural selection with the powerful self-organisation of complex systems.[128] The fact that an historical definition of biological function must be glossed by holistic analysis if we are actually to understand the causal relations involved will imply that we cannot shy away from an explicit appeal to teleological causation.

3.1 Function and Internal Normativity

But let us begin by dispelling any appearance of question begging as to why one might need or want to appeal to environmental design in examining functional explanations. The previous chapter introduced the idea that function ascriptions reference the favourable consequences by which natural selection has acted to preserve function bearers. We say that function attributions are explanatory of a feedback mechanism involving self-propagating systems, suggesting that a function bearer can supply an upward causal etiology for its own presence. Thus the appeal to an intergenerational mechanism seeks to alleviate the underdetermination of the functioning whole suggested by the appearance of purposive organisation in living things, by asserting a direct relationship of design between biological systems and natural selection.[129] Thus to the extent that the phylogeny of functions can be speculatively determined, causal etiologies show that it is possible to go some way towards explaining natural functional bodies in terms of mechanistic laws, as designed products of the operation of natural selection, non-intentionally selected by the environment for their prolificity. However, apart from the case for homology, why can we not put aside all considerations of external teleology and instead attempt to construe the explanatory structure of function in organic entities morphologically? Earlier, I have expressly pointed out that, in philosophy, ultimate and proximate causation of natural phenomena are often treated of as in theory divorceable. So why should we consider evolutionary factors in construing a *prima facie* proximate functional effect?

Consider that in the biological sciences, there is a history of preserving a conceptual dichotomy of causal explanation into proximate and ultimate causes which dates back to the publication of Mayr's *Cause and Effect in Biology*.[130] The terms became seminal after Mayr argued for distinguishing between ultimate causes, defined as preontogenetic factors operating over phylogenetic time that effect

---

[128] Kauffman, 'Antichaos and Adaptation'.

[129] McLaughlin, *What Functions Explain.*

[130] Ernst Mayr, 'Cause and Effect in Biology', *Science,* 134, 3489 (1961), pp. 1501-1506.

the evolution of a typical genetic programme, and proximate causes of the individual biological token (such as physiology), which are the immediate causes responsible for the expression of its genic information. Although (as I shall again emphasise) we must be wary of falling foul of the phylogeny fallacy, it is certainly still maintained by some, socio-biologists and evolutionary biologists in particular, that there is heuristic value in preserving these terms and decoupling functional and evolutionary biology.[131] In other words, it seems that what is wanted primarily from functional analysis is to capture a means-end relationship within what has been described as a self-reproducing system, in which the function bearer is identified by its instrumental role for the end named by the function in the supporting system. So what prevents our separating out the evolutionary history of a functional trait on the grounds that ultimate determinants are inessential to an analysis of the particular organisation of the function-bearing parts within a biological whole, and therefore, historical causes are inessential to the nature of functional explanation as regards biological phenomena?

But just at the same time, constructing function on the basis of phylogenetic histories gets even more problematic. Even granting the desirability of a theory of function bearers as products of the operation of selection, in what way does saying that a trait has been deferentially selected for by virtue of something that it does actually show that natural selection can provide a normative component of function in the absence of a valuating agent? To worsen the case for a normative theory of function based on ‘natural design’, empirical evidence suggests that the idea that functional tokens are defined by goals or goal-states as revealed by their phylogenies is untenable because biological entities lose form. I go on to show that the fact that, from an evolutionary perspective, there is no distinction between ultimate and proximate causes in biology undermines the supposition that nature can have clear ends.

The trouble begins in that Darwin complicated matters more than Kant could have anticipated. It is not merely that intelligent design is no longer an explanatory requirement on the notion of external purposiveness in Darwin’s wake: the theory of evolution upturned former belief in discrete species. If the term ‘natural design’ (as taken to refer to a selective process whereby biological purposiveness is produced) is regarded in the sense of final causes, it is clear that there is no directly perceivable design in nature. Darwin’s negation of immutable biological forms expelled the immanent ends or purposes of living things as considered in themselves as tokens of types.[132] Alternately, if design is understood as a formal cause or plan of a biological system, neither does inductive evidence support the classical notion of natural purposes in this sense.[133] In the absence of the essences of Aristotle, there is no genuine final cause in an internal sense – the full being and functioning of a living thing as a token of a type is

---

[131] Lickliter and Berry, ‘The Phylogeny Fallacy’, pp. 352 – 353.
[132] Dennett, *Darwin’s Dangerous Idea*.
[133] McLaughlin, *What Functions Explain.*

not the goal for the sake of which it is what it is – for in fact the entity simply *is* and will undergo formal change if need be to safeguard that existence. Indeed, in coming to terms with evolution, there is nothing even in the genotype which can be called sacrosanct. As Darwin claimed, "[D]escent with modification", or genetic mutation, provides the raw material – accident – upon which selective pressures work.[134] And consequently, one might be led to conclude that the only theory of function with which the post-Darwinian biologist is left (if any at all) is thoroughly non-normative.

In other words, Darwin taught that we cannot simply look back to what is species-typical or has conferred survival advantage to see what is biologically 'innate' – that is, what a functional token should be and do: besides being shaped by the phylogenetic constraints laid down by the evolutionary histories of their lineages, individuals in biology are subject to contingencies. The effect of mutations and natural selection upon biological systems is successive minor variants, with the result that the cumulative effect of modifications to development is ultimately enduring change in the phenotypes for biological types.

According to development systems theorists, the use of the proximate/ultimate distinction is still prevalent in biology largely because of the standard assumption that evolution just is change in the genotypes which characterise populations. On the Neo-Darwinian synthesis definition of evolution, allele (or variant gene form) frequencies are emphasised, so that natural selection is taken to transmit a particular code of DNA information or set of genotypes to the present generation. Genetic variants are treated as preontogenetic factors which operated on the ancestors of the individual (ultimate cause), and ontogenesis is then seen as a conduit for realising these messages as phenotypic characteristics (proximate cause). Thus evolutionary explanations typically entail the dichotomisation of developmental explanations. In contrast to this idea that phenotypic variation must be caused by change in the relative frequencies of different genetic variants across generations, the developmental systems perspective stresses that developmental interactants are informational in the sense that they have a marked and distinct impact on ontogenetic processes in the construction of phenotypes. While biological ultimate-based explanations tend to refer to development processes as 'biasing' factors, modifications to development in fact have critical evolutionary relevance. [135] A thoroughgoing interactive constructivism between developmental and evolutionary processes means that developmental causes are evolutionary causes.[136] So although we know that questions about the extent to which phylogenetic change is causally responsible for a feature are related to questions about immediate causation and development in complex environments; it is also the case that in interrogating putative 'internal' causal

---

[134] Cited in Dennett, *Darwin's Dangerous Idea*.

[135] David Haig, 'Proximate and Ultimate Causes: How Come? And What For?', *Biol Philos,* 28, 5 (2013), pp. 781 – 786.

[136] Lickliter and Berry, 'The Phylogeny Fallacy', pp. 357 – 359.

factors for a biological individual, we are speaking about the degree to which species' developmental processes are susceptible to the manifold influences that bring about transgenerational change in a population.[137] Developmental influences are essential to functional biology because phylogenetic and ontogenetic change do not play ontologically distinct evolutionary roles.

In the previous chapter, I introduced the argument that ultimate accounts are supposed to have explanatory utility for function ascriptions through the exposure of function. Recollect that phylogenies provide content for a normative identification of a function bearer, or why a given trait is as it is, insofar as the function of an adapted trait is considered to be whatever it was differentially selected for, and consequently phylogenetic histories are considered to be indicative of evolutionary goals. Partly why we associate teleological thinking in biology with ultimate explanations is because of this ostensible direct and fundamental causal explanatory link (via natural selection) between the history of a function bearer, in the sense of the preontogenetic factors pertinent to embryological development, and its presence. Put simply (if functional explanations are causal) the function of biological trait *T* is what *T* is designed to do, and what *T* is designed to do is that effect which has conferred a survival advantage on tokens of the same type in the past (and where 'design' is to be understood as 'natural design'). However, this is an incomplete gloss on a more complicated model. Evolutionary histories do not represent pristine accounts of survival value which can be used to delineate a finalistic 'What For?' of traits, with its goal-directed overtones reminiscent of Aristotle. While most traits that presently make a positive contribution towards selection will also have been shaped by natural selection in previous generations, phenotypes neither proceed directly as products of, nor are they directed or limited by, ultimate causes, such that evolution consists in the transmission of adapted genetic programmes to future generations.

The point of this line of objection has been to show that the mechanisms behind evolutionary change leading to novel phenotypes can be explained by means of developmental processes: that is, by proximate, rather than ultimate, causes. Even for an approach to functional explanation that centres on history, the fact is that the identity of a biological trait over evolutionary time is not always going to be determined by the propitious effects of its ancestors. No conceptualisation of biological categories in terms of external normative function (or why a trait *T* is where and what it is) is going to be entirely satisfactory, given that the reason for *T*'s identification with a certain effect is not always species-typical in a sense that proceeds from heritable variation. So how is it that capturing a trait's ancestry and phenotype across generations can provide a normative identity criterion on a post-Darwinian account of function? It is not clear that we can use the idea of 'goals of natural selection' to claim that phylogenies reveal functions if ontogenesis comprises phylogenetic change. Species continuity is undermined by

---

[137] Oyama, *Evolution's Eye*.

the fact that biological statements are historical generalisations, which have what McLaughlin call's "spatiotemporally limited" truth-value, and evolutionary accounts for traits can be captured in terms of proximate causes. Over the course of a phylogenetic history, a trait can lose one species form and acquire another.[138] This puts pressure on a principled distinction between the 'How?' (physiological mechanism) and the 'What For?' (evolutionary goal) of a biological token. This is the deeper problem of generating a normative account of function from phylogenetic accounts.

I am first going to address the first criticism, which questions the desirability of a normative account of function, before addressing the challenge of showing how normativity is possible.

To begin, we know that normativity is a *prima facie* established foundation of a theory of function.

Regarding the first objection, we have already seen the argument that we cannot cleave to a dispositional thesis simply on the grounds of empirical palatability, since normativity presents a veritable obstacle for a naturalistic account of functional explanations. The fact that a population which presently inhabit it thrive within an environment which engenders certain selective pressures on group members is not an indicator *simpliciter* that these organisms should exhibit the typical organs, traits and/or behavioural strategies they do – – irrespective of the fact that these effects may be individually determinative of the conditions which allow function bearers to self-reproduce. (This is the structure of analysis exhibited in dispositional analyses in general, in which the causal role of the environment is perhaps implicitly suggested – if, as I have said, it is nevertheless peripheral to the analysis; but the point also applies to purely morphological definitions of function.)[139] Its function could indeed be an effect of a biological body that presently (either directly or indirectly) contributes to the survival and maintenance of the containing body, but it may not do this. A desideratum on function is that it *ought* to do so. In a biological context, (a limited account of) normative function supports a nuanced notion of conditions of stability and health in otherwise phenotypically diverse populations. And for that, an evolutionary perspective which makes *explicit* reference in conceptualising organic purposiveness to the environment as a selective force is needed. Thus a healthy heart is distinguished from a diseased heart if an organ genetically tends in its properties to approximate the norms of an organ the biological presence of which is ultimately due to selection.

And, at the same time, contemporary neo-Darwinism, that is, the Darwinian theory of evolution coupled with the insights of Mendelian genetics,[140] can suggest the possibility of re-establishing a kind of teleological causation as an explanatory ground in biology. So far I have argued that our basis for

---

[138] McLaughlin, *What Functions Explain.*
[139] Kitcher, 'Function and Design', pp. 482 – 492.
[140] See Dennett. That is, DNA based reproduction.

recognising the identification of biological features through their historical function as necessary to the study of our experiences of purposiveness is the *prima facie* appeal of a normative concept of function. In response to the second problem – that of accounting naturalistically for the normative component of biological function – some contemporary theorists are willing to concede 'Darwinised final causes'.[141] This is a term I borrow from evolutionary biologist David Haig, but which I shall independently define as an ultimate cause qualified by temporal and environmental constraints.

There is a restricted sense in which living things can have final causes in an external manner, in that within certain circumscribed conditions, it can be contended that such and such a phenotypic character or trait (*T*) is a purpose or goal of nature relative to environment (*E*) and at a certain time (*t*); this means that it is in principle knowable that *T* was selected by way of the reproductive success of some one or more of its effects (*e*), within *E* in time past[142] *t*. This is an explanation by historical cause and therefore an ultimate one, which shows how an organic body of a certain effect, and not some other, came about. Since we know that phenotypic development is never simply the manifestation of a genetic 'programme' or 'blueprint' about phylogenetic characters, it follows from the adoption of a development systems perspective that evolutionary explanations for functional items will have to be specified relative to environment and time. The concept of the developmental system holds that not all heritable changes in the phenotype originate in genes: heritable variations in reproduction include (in addition to the genotype) the relevant experiential and stimulative aspects of the organism's environment.[143] For an evolutionary explanation, what is therefore needed is continuity of organism-environment complexes by successive life cycles, so that reliable genotype-phenotype correlations are achieved by a succession of development systems, rather than the mere duplication of genes.[144] Hence to speak of a trait or character as being phylogenetically derived is to say that development systems have reconstituted themselves with a substantial degree of stability over a finite period of evolutionary time. A time period constraint upon a functional criterion (as is true of an environmental constraint) is therefore important in charting the development of reliable phenotypic outcomes because transgenerational uniformity of specific phenotypic characteristics implies, first, that phylogenetic characters are derived, in the sense that they are characters acquired by the most recent common ancestor in the phylogeny of the relevant taxa; as well as, second, some consistency in the structured organisation of the *environment* in which development takes place.

---

[141] David Haig, 'Proximate and Ultimate Causes: How Come? And What For?', *Biol Philos,* 28, 5 (2013), pp. 781 – 786.

[142] This would have to be recent past since, as Kitcher says, we have no reason to presuppose that the effect for which a trait was initially selected is the effect for and by which it is maintained.

[143] Lickliter and Berry, 'The Phylogeny Fallacy', pp. 354 – 356.

[144] *Ibid.*, p. 357.

If, in thus speaking teleologically about the structure of biological systems, external final causes or evolutionary goals are interpreted in this qualified Darwinian sense, then (conceding the advantages of a definition of function as a normative rather than a descriptive category) it becomes possible to advance a normative etiological view of biological function in the wake of the neo-Darwinian synthesis. Up till now, my concern has been to establish that biological function is most helpfully characterised as a propensity or effect of a trait in a containing system which explains the recent maintenance of the trait under evolutionary pressure. Thus far, this is an account of functional explanation in terms of mechanistic causes which nevertheless succeeds in appealing to a feedback mechanism in order to satisfy the theoretical desideratum that non-intentional systems are minimally causally responsible for themselves. So there is nothing metaphysically radical about an explanatory appeal to Darwinised final causes *per se*: final causes arise here as a putative means of expressing a basically efficient account of function bearers. A function ascription would hence explain the structural causal interrelations within a biological system by relating the effects of the developmental systems transmitted in reproduction (so the ends in previous generations) to the causal constitution of the present generation, as the limited goals and constraints for the sake of which reproduction is initiated. This is imperative. And – despite empirical criticism – an etiological analysis remains theoretically congruous with a more modern conception of the operation of richly varied and interacting causes in biology - - provided that an historical account delimits how deep are the ancestors in a phylogeny one should invoke in determining function.[145]

Now it is sometimes pointed out of the etiological view that it equivocates on the present-tense versus dispositional character of its analysing propositions. McLaughlin, for instance, argues that it is not appropriate to break down function statements into tenseless disposition statements, with the unavoidable result that an etiological account of functional explanations must equivocate about the tense of at least one of its propositions.[146] Thus an etiological interpretation must imply something like "*T* is there because it recently had and still has a disposition to do *e*." But of course nothing less is to be expected, and the spatiotemporally finite character of the ends of natural selection is reflected in this qualification of the causal etiology for a function bearer by tense. The core etiological idea of function is a causal historical explanation which appeals to dispositions recently favoured by selection, and these adaptations can be expected still to be adaptive.[147] It is possible that old adaptations may cease to be useful; and newly arisen dispositions of traits may contribute to reproductive success without a history

---

[145] McLaughlin, *What Functions Explain.*

[146] *Ibid.,* p. 96.

[147] Peter Godfrey-Smith, 'A Modern History Theory of Functins' in Nature's Purposes, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).

of adaptation; still the latter fail in being functions because they fail in meeting the identity condition on the function bearer. In successive generations, the trait will have changed and attained a new function.

What of the possible implications for a theory of function which follow from control and regulation in biology not being – as was so long assumed – the sole prerogative of phylogenetic relationships?

We are able to deduce from the developmental systems view that continuity between successive biological tokens of common ancestry is not, in fact, due exclusively to similarities in their genetic characteristics, so that biological ultimate causes on their own are not enough to explain the presence of function bearers. This has consequences for a proposal of the explanatory project of function attribution as evolutionary explanation. We have so far seen one analysis of function statements which allows that considerations of phylogenetic or evolutionary history are causally relevant to the origin of function bearers, in order to make the point that natural selection is explanatory of them. However, it is also the case that a contingent mechanism which is essential to reproductive success in biology is self-regulation or self-maintenance through self-regeneration. Chapter one highlighted that functional explanations in biology presuppose that the effects of a function bearer are related as *means* to the end of maintaining a containing system in proper working order. And this feature of self-regulation seems to be constitutive of beneficiary systems of organic functions apart from their self-reproductive powers, facilitated by natural selection. In other words, although developmental systems are at least partially explained as products of natural selection, it is possible to conceive of the causal efficaciousness at work in ordinary biological processes realising and supporting individual phenotypes as grounded apart from this. The trouble for an explanatory account then is that explanation of the latter is not guaranteed by an account of the former.

We can deepen this critique of whether, through reconstruction of the phylogenies of functions, natural selection can actually cover all explanatory features of function ascriptions, by drawing on a line of objection from the *propensity* thesis.[148] On the etiological interpretation of a functional explanation as a causal explanation for the presence of a function bearer, differential reproductive success of probabilistically occurring mutations takes place across generations, meaning that natural selection, as a feedback mechanism, in fact shows that a function bearer, such as a heart, is where and what it is by appealing to what other tokens – ancestral hearts – once did. So natural selection justifies the origin of traits leading to intergenerational organismal benefit: working between generations, it explains why character types which can be effectively bestowed upon descendants are present. Nevertheless, the argument of the propensity view is that it does not actually have causal relevance for how the effects of

---

[148] I have chosen not to examine this. It is similar to my own view but lacks the obvious background of final causes.

a function bearer support present token reproduction. If the vertebrate heart, for example, is currently adaptive for the organism in which it is found, and it is also a biological character which has in the past positively influenced, and continues to positively influence, selection, natural selection will causally account for it, and the heart will hence qualify for function ascription. But if the heart does not support differential reproductive success of the vertebrate body – although the heart might be useful to the organism – that trait cannot then be accounted for by a mechanism of evolution.[149] And whether or not one thinks that an adaptive, acquired character (meaning one which has not been inherited) ought to be classified theoretically as a function, it is undeniable that such a heart would play a vital causal role in biological development and evolution. The heart has a circulatory effect, and blood circulation is good for self-reproduction of the organism. It follows that a process of simple reproduction by continual self-repair (otherwise known as self-regeneration), demanding that a non-intentional system replicates itself by reproducing its constituent parts in a particular order or configuration, along with the composing properties of the constituents, is required to explain how the cause of beneficial effects (function bearer) is causally basic to the existence of the token itself. Although all parties appear happy to concede that this ability to self-maintain through self-regeneration happens to be bound up with natural selection as a product, it also seems to be in principle an aspect of biological fitness independent of impact on intergenerational reproduction.

The argument here is that even on the assumption that it is right that biological functions are effects of a trait which explain the recent presence and/or maintenance of that trait under conditions of differential reproduction, the appeal to natural selection will not explain replication and repair (entailing metabolism) and growth in biological systems. An etiological interpretation explains what a trait used to do that was good for the function bearer; hence demonstrating that such an account can express the phenomenon of biological self-propagation. What it does not do is capture the way in which a trait is supposed in the present to reproduce itself. As McLaughlin points out, when something is serially propagated or replicated across generations, there is transmission, certainly – and perhaps even a type of selection, leading to evolution in populations. But few biologists would consent to describe as living populations which merely reproduce, mutate and evolve. Indeed soft artificial life creations like *Tierra*[150] would be considered to be alive in meeting such minimal conditions for evolution. McLaughlin suggests instead that what differentiates biological evolution from the evolution of replicators like computer programmes and viruses is that the former activity involves selection producing complex systems which preserve their forms as a result of metabolic reproduction.[151] In the case of nonliving replicators, the

---

[149] McLaughlin, *What Functions Explain.*

[150] Rosenberg, 'Reductionism in Biology', pp. 458 – 459.

[151] McLaughlin, *What Functions Explain.*

reproduction of certain dispositions fails to support self-constitution of the substance and form of self-reproducing systems. What is missing from an etiological function is that an organ, trait, or behaviour is also where and what it is – its biological identity over evolutionary time is also – as a causal result of ontogenetic development, and the continued welfare of a containing system that can be a beneficiary of function bearers.

This chapter has stressed that modifications to development enter into ontogenetic construction, entailing that developmental causes, like genetic causes, contribute to complex systems reconstructing themselves in future generations and hence bringing about the conditions for their own further transformation. The construction of organisms involves intergenerational structural conservation by way of consistently arising generations of developmental interactants. These stably repeating life cycles of interacting processes and entities are not innately determined or necessitated by any static material identity – if this means by the continuity of pieces of DNA with determinate functions. Of course gene products are involved in the creation of organic networks and their functions; still these functions are neither specified by simple hereditary transmission of traits, nor do they occur in the absence of causal regulation.[152] Instead, an organism is a recurring complex of internal and external interactants which tracks a network of developmental information generated in contingent construction, and although the organisation of such a system may itself be contingent, it nevertheless has to be accounted for.[153] It follows that although having the right sort of history is a causal precursor of biological function and therefore is necessary as a normative identification for it, a phylogenetic criterion is not going to be sufficient for it. So acknowledging that the welfare of a self-reproducing system implies something more than differential reproductive success, natural selection as a feedback mechanism does not account for every step associated with the origin of a trait beneficial to a self-regulating system. A functional analysis that takes function attribution to be causally explanatory of a function bearer's existence must also introduce a welfare provision which appeals to the current adaptive value of the function bearer.[154] The aim of this provision is to explicate how causal contribution towards a systemic end of nourishment helps to make a function bearer where and what it is. Thus proper biological function must, in addition, correspond to a causal account of a system characterised by metabolic reproduction, in which a token of a trait type can be regarded as contributing to its own reproduction as the same token, in being valuable for an underlying system.

Hence what has been learned from a fuller discussion of ontogenetic causes in biology is that, even after the appeal to external final causes introduced by the mechanism of selection, there remains

---

[152] Oyama, *Evolution's Eye*.

[153] *Ibid.*

[154] McLaughlin, *What Functions Explain.*

evident underdetermination of the origination and development of a function bearer by an etiological function. And this fact brings into question whether an external gloss on the normativity characteristic of biological categories is indeed adequate to an analysis of function attribution. I have argued that, if function ascriptions are to serve as causal explanations of function bearers, an etiological functional explanation must include in its analysis of the causal role of the function bearer, its relation to a system that is (not merely self-propagating, but also) self-reproducing. The internal features that have benefit for, and thus support survival through self-regeneration and general self-reproduction in the non-intentional systems in which they exist, do not arise accidentally, but as a product of phylogenetic *and* ontogenetic influences in biological development.

So what is the most theoretically promising way in which to undertake an adequate naturalistic reconstruction of function attributions – if natural selection fails to provide a formulation which does just this? As we saw in our account of the scientific status of teleological causality, final (and particularly) formal causes are justified to the scientific project as remedial explanatory principles in a theory of motion in living things – if and only if an explanation in terms of efficient causes remains incomplete. In the case of functional analysis of the sort in which we are interested, we know that the phenomenon of non-intentional purposiveness is such that the function of a trait *T* is effect *e* if and only if a function bearer *T* is a cause of *e*, *and* the effect *e* is related as a good to a system that is itself a goal-state of, or possesses as a goal, self-maintenance, and therefore, can be appropriately classed as a beneficiary. How reproductive success comes about in biological phenomena is by means of a feature of the beneficiaries of functions of self-regeneration. What we assume when we ascribe with explanatory intent functions to the parts of a biological system then is that the existence of such a part is in some measure due to its present utility to the characteristic self-reproductive activity of that system, in that this utility leads (via some causal mechanism) to its own reproduction as a function bearer. At every instant, a non-intentional system comprises parts that exist as means to ends – as causes of systemically valuable or beneficial effects – and therefore explanatorily relevant properties of functional traits cite an ontologically prior whole as an identity condition. As a biological category, function bearers include in their description a relation as components of an internal teleological system: it is not only that particular traits which are good for the proliferation of progeny are to be taken structurally as goals from the point of view of selection; in fact, functions are also goods for their respective organisms considered from the perspective of those systems themselves (that is, from the perspective of the distinguishing biological goal of survival). Thus function attributions are also grounded in the self-reproduction of a function bearer as the same token over time *through* contribution to a system whose identity condition is general metabolic reproduction.

In short, by the lights of a fuller analysis of function, any functional explanation references a biological individual which has the character of an end for that function in that the whole is supposed to be causally productive of its own component parts (including the function bearer). This occurs through an instrumental relation between a function bearer and a system distinguished as self-reproducing. Like so, the system is intended to be explanatory of them. And thus – were we to disregard for a moment the imperative imposed by the mechanistic maxim – one way in which to alleviate the underdetermination posed by function attribution being grounded in the contribution of a functional trait to its own token existence (via a beneficiary) is simply by appealing directly to a continually self-repairing, self-replacing and self-reproducing structure in the form of a material whole. This would be the individual phenotype, conceived as a causal constraint on its own parts (to which it is prior), and which is potent as a holistic cause, independent of its phylogenetic origins. The relevant underdetermination would therefore be resolved by identifying the apparent teleology exhibited in the self-maintenance of the organisation that is the biological system, as the product of a genuine internal teleological cause - - which is both final, as its own goal, motivating self-reproduction, and formal, in the sense of a plan, guiding the change.

What is even more interesting is that it is possible to derive the conditions for internal, non-intentional teleology – that is, it is possible to account for the appearance of structures characterised by a goal of nourishment and self-maintenance in living things – from the presence of external normativity - - as a means of ameliorating underdetermination of the general self-reproduction of organismic systems by natural selection. From this perspective, the phylogeny of a developmental system, as an historical description of the past effects through which natural selection has served to maintain a biological individual of particular features, is to be understood as stipulating externally the normative conditions for the organism actively to construct its own developmental and evolutionary environment in ontogeny; hence, relative stability during ontogenesis of a typical individual over a period of evolutionary time is in part attributable to the stability of the development complex that is passed down: that is, to the environment, as well as to genetic factors. In other words, the evolutionary development and history of successive development systems which have reconstituted themselves similarly over generations imposes the governing standards of acceptability and evaluation on the phenotype of a species. The suggestion is that biological individuals displaying non-intentional purposiveness are adaptive products of evolutionary design; thus phylogenesis constrains what will count as the internal *telos* of the certain type of organism of which a biological system is an instance, under fairly particular stated conditions. This means that the *specification* of living things can be conceived of in terms of the direct action of natural selection, as a source of external final causation. To say that a biological systems *S* has as its internal goal the mature organism, both as its own end (final cause), and as the anticipation of this end (formal cause), is hence to say that: given that *S* is a (limited) purpose of nature, the identity of *S*, for a given time and place, is constituted by intergenerational reproduction through a feedback mechanism. This is what is meant by the claim that evolution imposes the teleological causation that is primary to the introduction of internal normativity in a functional analysis of organic phenomena: putative internal organic teleology in the form of immanent real ends of natural phenomena, as regarded as types, is generated here by a contextualised history of the phenotype *S*. As a result, in teleological discourse, a biological individual is identified in delineating a non-intentionally purposive system as an end and prior whole by providing a causal explanation of its origin – rather than in describing its dispositional structure.

But of course, given the mechanistic maxim, our first course should be an attempted reduction of implied holism in an analysis of function. And so this is the objective of the next section in this chapter, in which I review a theory which does not hold function ascriptions to be explanations of the causal origins of function bearers. Rather, such an analysis focuses on instrumental relations by linking the function of a trait to its causal contribution to the overall operation or property of a containing system. First, let us summate this section before judging whether it succeeds.

Chapter two explained and developed the idea that the simplest way in which to account for the causal explanatory use of functions post-Darwin is by justifying teleological statements through the concept of natural selection. Given that natural selection is a process able to generate consequence-etiologies, we identify the function or purpose of a biological trait with those of its effects which have been reproduced as a result of higher heritable fitness.[155] I then began this, first, section of chapter three by calling into question the desirability of such an appeal to an ultimate-cause based description of biological functions as naturally-selected effects, as well as by interrogating the extent to which the dissolution of the distinction in ontological role between phylogenetic and ontogenetic causes renders talking about historical factors as of distinct evolutionary significance to functional biology a non-starter. So, that the presence of specific ontogenetic factors is needed to give rise to, and to sustain, life cycles shows that, at a very basic level, immediate influences on development, including interactants like self-stimulation and the developmental environment, are equally implicated with genetic causes in actively supporting and determining species character. However, in responding to these objections, first, I have argued for an external normative characterisation of function, for which the idea of a function bearer as constituted by a feedback mechanism spanning several generations of tokens of a biological type is essential. And second, a significant contention of this section has been that an external normative element based on

---

[155] Justin Garson, "Function and Teleology" in *A Companion to the Philosophy of Biology*, (eds.) Sahotra Sarkar and Anya Plutynski (Blackwell, 2008), p. 530.

phylogeny can be theoretically sustained in spite of the ways in which the emerging biological individual creates, and is in turn affected by, its developmental and evolutionary environments. Often, complexes of causal interactants recur again and again in the form of species-wide patterns of development, making for the transgenerational continuity of developmental systems that enables theorists to speak of "gene flow".[156]

The notion of natural design, intended to reference the non-accidental lawlike quality of function ascription,[157] is instrumental in introducing a normative, environmentally-correlated concept of biological function, and hence the theory of evolution plays an indispensible role in functional explanation. But the question remains whether higher reproductive success in itself justifies characterising with explanatory intent something as having a function[158] - - specifically in the sense that a functional trait is a means to something else that is itself normatively distinguished as an end, or, that it is instrumental of beneficial effects. And, as it turns out, an appeal to natural selection will not give us the apparently non-intentional functions of organismic structures, traits and behavioural strategies. The fact that the kind of system displaying non-intentional purposiveness is a contingent product of evolution does not show that natural selection serves as a direct causal source underlying ascriptions of organic function. In addition, since function statements in the case of natural phenomena seem to presuppose an element of systemic welfare, the minimal conditions for biological evolution will not be met through a naturalistic explanation of function attribution involving a mere mechanism of differential selection. When it comes to expressly *biological* evolution, the parts of natural systems can only be viewed by the lights of functional analysis as means to the end of biological self-reproduction if the causal role a prospective function bearer plays in self-replication conveys a good from the perspective of the present system itself. Thus irrespective of the fact that a trait is involved in the right sort of way in a process of replication, the heart only has the function of pumping blood because this particular recurrent effect of the organ fundamentally enhances the capacity of the supporting vertebrate body for self-repair and self-maintenance.[159] As a contingent product of evolution, does a system of organisation characterised by a mechanism for self-nourishment still need to be accounted for? I have argued that, in fact, it does. As a result, we know that it is not a sufficient condition on a causal explanation for the origin of a function bearer to cite its being a causal progenitor of its own token presence through differential selection: the identity of a function bearer must necessarily reference the emergence of a structure which is the constitutive beneficiary of that function.

---

[156] Oyama, *Evolution's Eye*, pp. 8 – 9.
[157] McLaughlin, *What Functions Explain.*
[158] *Ibid.*
[159] McLaughlin, *What Functions Explain.*

The main point is that, in attributing functions to its parts, we take the organism to involve non-intentional teleology.[160] And, for all that internal teleological structures are products of evolution, what has still to be explained is how organismic traits get functions categorically in the sense of effects which contribute to the ability of the system as a whole to remain identical to itself over time through self-repair and self-replication. Hence a functional explanation must encompass the self-referential ability of the organism, including the material relations of function bearers to the subject of the benefit conferred. So some feature, supporting the survival of a biological system, and by which such self-reproducing systems contribute each to their own wellbeing, is going to have feature in a functional analysis.

In this section, I have also made the preliminary suggestion that the greater significance of an etiological definition is that an external normative characterisation of function supports the conditions for internal normativity, intended to resolve residual causal underdetermination. Dispositional critics who insist upon thinking about function categories solely in terms of internal structure and position in the organism fail to consider that the causal mechanism underlying an internal teleological organisation cannot be an adventitious causal feature: rather; it must relate in some way to a normative end which is antecedently marked out as a contingent goal for natural selection, since there cannot be a system which is the subject of an end of survival or propagation independent of that system itself possessing reproductive value relative to its environment. Put in another way: it is a theoretical desideratum that an organism, conceived as the recipient of the beneficial effects of its parts, is coincidental with a whole that is characterised as such in an evolutionary context. in ascribing the vertebrate heart a circulatory function, one appeals to its being useful for the performance of a systemic end, survival, which is that which makes the vertebrate what it is. And (granted the notion of natural design) the organism itself, as its own end, is in turn useful from the vantage point of selection. Thus an etiological conception is essential to functional analysis because phylogenetic explanations are productive of normative boundaries for biological entities post Darwin. We'll look at this idea more closely in the next section, when we review the conflicting interpretation that a function ascription explains the contribution made by an organismic trait to systemic operations.

Clearly, the normativity of function has *prima facie* importance. But certainly not everyone has thought so. In order to defend the normative description of function proposed in this discussion, I therefore critique a third and final naturalistic examination of biological function statements, an attempt of which is to rid the notion of function of explanatory power *apropos* the presence of functional entities. This is the systems style variant of functional analysis, independently advocated by philosopher Robert Cummins.

---

[160] McLaughlin, *What Functions Explain.*

I argue that, despite the potential contributions it is poised to make to the debate between etiologists and dispositionalists, Cummins' account shows that the systems view is vulnerable to criticism to the extent that its ahistoricity forbids consideration of a boundary condition or principle of internal constraint on the activities of natural bodies - - without which we cannot make sense of that curious causative character of the individual in its own phenotypic development.

3.2 The Systems Theory of Function

Regardless of what one considers to be the explanatory object of function statements in biology, such explanations assume by definition a two-part instrumental relation: a biological effect *e* is a function of a trait *T* if *T* is a means to *e*, which in turn, is a means to some goal *G* (like survival and/or reproduction). But where we saw the standard etiological view discount – to the detriment of its explanatory project – any relation of a function bearer to a containing or reference system, Cummins' systems theory regards it as essential.[161] Cummins stipulates function as a bipartite relation insofar as a feature *T* has effect *e* as its function if and only if *T* is a means to producing *e*, and *e* is also instrumental to the realisation of a capacity *C* of the containing system. It is also notable that the systems view is not a normative analysis of function statements: it rejects functional explanations as explanations in any robust causal sense. Cummins discards the tendency of thinkers (myself included up to this point) to assume it as obvious somehow that the performance of a function must contribute to a state of an organic system that is in some way its *internal* goal. Biological functions are instrumental relations relative to *some* goals; still, the systems interpretation does not attribute to the complex and hierarchically organised systems it analyses characteristic ends or proper conditions of working order.[162] Rather, a particular operation of a complex system is picked out as an end because of our interest in an analytical account of this capacity of the system itself. But, given my discursive aims at least, the systems theory is significant in that it captures the two-step instrumental relation characteristic of organic systems by analysing function attribution in terms of how simpler sub-systemic capacities are complexly organised so as to bring about particular systemic capacities.[163] In order to help clarify why I think we need to talk about functions in a stronger causal explanatory sense, I therefore regard it as prudent first to take a step back and examine a final and non-normative mechanistic theory of function.

---

[161] McLaughlin, *What Functions Explain,* p.139.

[162] Garson, *The Biological Mind*.

[163] *Ibid.*

I reflect in this section on Cummins' view, considered as the best candidate for explanatory sufficiency as regards the causal role of a functional item in systemic processes. Nevertheless, I conclude that a systems definition of function does not successfully characterise non-intentional teleological relations in the distinct manner in which an adequate conceptualisation of systems displaying such organisation is taken to differ from those which are intentional artefacts. This critique aims to shows that, in order to be able to ascribe biological function, a function must make direct causal appeal to a normative end.

Cummins' argument begins with the idea that it is misguided to work from the premise that a functional explanation is causal in kind, as this is based in two mistaken presuppositions. The first, according to Cummins, is that the purpose of a functional characterisation in science is to elicit an explanation of the presence of an item *T* about which we make teleological statements, when its effect is not, in the context of biological purposiveness at least, causally relevant to the occurrence of that item.[164] The second involves the notion that what it means for a phenotypic trait *T* to perform its function *e* is for *e* to contribute to the preservation of the system which includes it; and ostensibly, functions need do no such thing.[165] It is necessary to my purpose to elucidate an objection to the former criticism shortly (the latter debate, on the other hand, is not likely to bear consensus. I will take it to be erroneous on the grounds that it falls foul of the desideratum that a theory of function should distinguish between proper and accidental effect). But, contends Cummins, these twin ideas lead to the false conclusion that a functional analysis is a causal explanation of the origin of *T*, and that it is one more in particular that consists in an appeal to what *T* does.[166]

Here, as in the standard case of the dispositional thesis of morphologists, the function of *T* is seen in terms of its consequences rather than its antecedent conditions.[167] And its explanandum is a causal contribution to the complex activities of a containing body or system.[168] Cummins claims that what scientists are describing when they explain the effect/s of a feature in the context of a complex system is why that system possesses the capacities to perform various difficult tasks, by appealing to a chain of elementary performances by its constituents. These simpler capacities are then the functions of the parts which bear them. The function of *T* is hence relative to a description of a capacity of the greater system of which it is a component part. (As an aside, there is also some allowance made for the role of the environment on this account, given that a capacity must be defined within an environment.

---

[164] Robert Cummins, 'Functional Analysis' in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998), pp. 172 – 173.

[165] Cummins, 'Functional Analysis', p. 176.

[166] *Ibid.*, pp. 169 – 180.

[167] Nagel, 'Functional Explanations in Biology', pp. 299 – 301.

[168] Neander, 'Function as Selected Effects: The Conceptual Analyst's Defense', pp. 326 – 332.

This affirms the idea that functions are indeed susceptible of adaptation. Be that as it may, Cummins does not think that the environment is explanatory of function. *Eo ipso* the natural world cannot produce purposes.)

Now although I agree with thinkers like Kitcher that the systems thesis raises a significant point about the importance of sub-systemic causal contributions to complex processes in a functional analysis,[169] I contend that the notion of a causal role function does not succeed in effacing a normative account of biological function, generable as has been contended, through the mechanistic non-agential design process of natural selection. It seems to be true that the vertebrate heart has the function of pumping blood partially in virtue of its causal contributions to the objects (for instance, circulation) of the organism. However, notwithstanding the accuracy of Cummins' critique of the central tenets of the etiological thesis, his descriptive account does not work, firstly, because it is not fruitful to suppose that we can conduct a functional analysis of any part of a biological structure apart from some candidate for a normative condition of its capacities and activities, in light of the morphological diversity of natural phenomena. In contrast to homology, there is also *analogy* of biological phenomena, which is a functional similarity of a part based purely upon usage (or what Bock and von Walhert refer to as 'biological role'). The wings of birds and insects, for instance, are adapted in a similar manner. That is to say, they demonstrate dynamic evolutionary development appropriate to their respective, related functions and/or environments; therefore, many of the same aerodynamic properties are observable in these structures - - in spite of their possessing no common ancestral origin at the beginning of evolutionary specialisation. Embracing interspecies miscellany in a description of biological function means recognising that only those containing bodies organised according to an internal or characteristic system-specific purpose, exactly such as survival, will persistently facilitate morphological changes consistent with the capacities appropriate to life and its maintenance relative to a particular environment. To its detriment, the systems thesis takes for granted that activities or behaviours that have arisen as a result of natural selection will mechanistically coalesce into the patterns observable across species of organic systems.[170]

Certainly, it will also be the case that pre-ontogenetic factors programme the particular adaptive structures which comprise living things, along with their various respective capacities in an environment. Thus George Lauder iterates that a common response to the problem of the apparent organisation of natural structures to function is to adopt a mechanistic biochemical approach in relating

---

[169] Kitcher, 'Function and Design', pp. 492 – 494.

[170] Cummins contends that his definition applies uniformly to organic and inorganic entities. Yet his allowance for the role of the environment means that a specifically organic whole, positioned in time, and as mediator of the effects of that environment, becomes crucial to the functional analysis as a normative constraint. See discussion on the distinctiveness of the environment as a selection mechanism.

biological form and propitious effects. This approach would allow us to see lower-level organismal constituents as in direct stasis with an adaptive environment. Nevertheless, the existence of what Lauder calls "intrinsic determinants" of morphological change will not account for developmental constraints on evolution.[171] Emerging empirical research in evolutionary studies shows that there just are limits on the kinds of forms that can be generated during ontogeny, and so there are always limits on the species distribution patterns available for inspection by natural selection.[172] My stated suggestion is that this is because the conditions peculiar to life involve some minimal consistency of form as well as of adaptive environment.

Therefore the deterministic impact of internal goals in organic structures in the acquisition of a particular feature *T* of effect *e* suggests in concert with the work of developmental systems theorists that complex biological interactions are not only expressive of the dialogue between organism and environment in adaptation: as I have already intimated, morphological evolution is also organismically driven, by the goals of an organisational structure within an environment. Moreover, as is pointed out by developmental systems theorists, living things will also tend to replicate some consistent features of developmental environments through constructivist interaction. What is called the developmental and evolutionary "interdependence" or "interpenetration" of organism and environment by Susan Oyama and Lewontin is tantamount to the rejection of an externalist conception of natural selection.[173] While conservative thinkers continue to view the environment as presenting a well-defined range of (potentially infinite) stimulus conditions for organisms to surmount, these theorists insist upon a view of the environment as an organic factor in phenotypic development that is structured and specific to the organism.[174] Hence my argument evinces the significance of a biological relationship between a living thing and its environment in which the whole itself is the locus of causative action in phenotypic outcomes.

It is now clear what are the two main faults of the systems interpretation of function: first, not every complex system that qualifies as a subject for functional analysis by the lights of the account in fact involves genuine biological functions because it is not necessarily aimed at a normative state or end; *and*, it will also be the case that a reductionist approach cannot appropriately be taken to the relationship between form and function in the case of natural systems, since organic bodies are (to gloss an otherwise complex biological statement), in their effects, of necessity organised towards a

---

[171] George V. Lauder, 'Historical Biology and the Problem of Design' in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).

[172] Oyama, *Evolution's Eye*.

[173] *Ibid.*, p. 3 – 14.

[174] Lickliter and Berry, 'The Phylogeny Fallacy', p. 358.

condition that is cumulatively responsive to selection pressures. The first criticism of the account is widespread. Thus Kitcher claims that it is not plausible to attribute a function to a rock formation in virtue of its causal contribution to the widening of a river delta, given that there is no direct connection between the causal analysis here and a source of design.[175] The systems thesis is therefore too generous in its applicability. Of course it is sometimes pointed out that Cummins does not intend for his definition of function to have coterminous scope with the notion of function as *purpose*; nevertheless Millikan articulates the same objection in a complimentary, but possibly more damning, manner. The mismatch between proper function and Cummins' description of the function of an item within a dispositional structure is revelatory of his mistaking an index or mark of purposiveness for having a function. Millikan argues that while possessing the right sort of disposition or being a contributor in a system which admits of functional analysis can be a good indicator of the presence of an underlying functional structure, it might not be since, as a contingent matter of fact, purposiveness may not be accompanied by a normative condition in accordance with which the operative function can fail. Therefore it is not warranted to infer a functional explanation for a function bearer from the presence of a successful functional state so called. The heart that pumps blood indeed functions *as* a circulator in a vertebrate; yet, if it does not pump blood on account of an actual tendency to lead to that goal, then its doing so in the present is neither sufficient nor necessary to determining the heart's function.[176] So sometimes a Cummins-style functional description will be a successful proxy for proper function, but this coincidence is fallible.

Although she does not link it to such an argument, Millikan also points out that any description of organic purposiveness that is a variation on a dispositional theme tacitly draws upon the assumption of 'normal working conditions' for its analysis. Thus, according to the systems theorist, the display of tail feathers in peacocks is a behaviour disposed towards attracting a mate, but it is correlated with success only under 'normal conditions'; in this case, those perhaps consisting in the absence of predatory threats and other non-conducive environmental factors. However Millikan reasons persuasively that there can be no normal conditions for the manifestation of an organism's 'disposition', except by reference to its own history.[177] This argument of course recalls the recurrent trope in the philosophy of biology that situations of biological health and normality exist only in the light of evolutionary trajectories, given that, (post Darwin) there is no standard of fitness for a natural object save its advantageousness to a unit that is adaptive to environmental pressures. The concept of biological normality cannot be a value one *simpliciter*; neither does it make sense for it to be statistical

---

[175] Kitcher, 'Function and Design', pp. 493 – 495.
[176] Millikan, 'In Defense of Proper Functions', pp. 301 – 307.
[177] *Ibid.*, pp. 307 – 310.

in nature, but it must be captured in terms of that which has its immediate grounds in being evolutionarily beneficial. And consequently, the normativity of function which I have discussed has to be preserved by appealing to an antecedently-identifiable goal by way of a backward-looking analysis. This consideration leads us to the next objection to the systems account.

In addition, contra Nagel, it is not simply a matter of preference that we tend in our investigations to focus on the antecedent conditions for the existence of biological traits rather than their effects in the formulation of an account of function.[178] Why ought we to think that in explaining the capacities of a natural system (*S*) by appealing to what a constituent feature *T* does, and its contribution thereto, a functional statement about *T* does not implicitly draw upon a causal historical story involving *S* as a whole and pre-organised biological structure for its intelligibility? It seems to be that the purpose of the heart is to pump blood insofar as it is an organ occupying a certain phenotypic space: that is, it produces an effect that consistently abets an activity (circulation) the structure of which is phylogenetically favoured by the conduciveness of the vertebrate body in which it is found to survival. The point is that function ascriptions cannot be autonomous in the way supposed by systems theorists since an explanation of perceived purposiveness purely in terms of proximate causation is not commensurate with the downward causality exhibited in the development of organic phenomena. Thus even if structures with inner mechanisms or with dispositions successfully exercise effects that facilitate series of systemic capacities, entities exhibiting biological configuration and structure would not arise either on the basis of the different elementary capacities appealed to in such an explanation, or the discrete environmental relations into which they enter, unless there is a corresponding normative condition that accounts for the existence of each systemic component, and which, in this case, means that systems characterised by things like functional mechanisms have been preceded by a particular history. My criticism underscores the necessity for the notion of formal design for function and hence for the assumption of holistic causality in biology. The individual token as cause imposes crucial formal constraints on development and evolutionary transformation of internal organisational properties of the biological structure.[179]

The aim of this section has been to assess whether the systems theory succeeds as a mechanistic reconstruction of functional explanations, given our discussion of another critical determination on a conceptualisation of systems possessing non-intentional functions: specifically, that function attributions are also grounded in the self-reproduction of a functional trait to its own token existence by means of its contribution to a system whose identity condition is general metabolic reproduction. Talk about organic

---

[178] Nagel, 'Functional Explanations in Biology', p. 300.
[179] Lauder, 'Historical Biology and the Problem of Design'.

function presupposes an entity which has the character of an end for those of its components said to possess functions, in that such features are supposed to be beneficial for the maintenance of the non-intentionally purposive system of which they form part. We hence pitted the etiological against the systems interpretation, on account of the fact that Cummins' view includes in its analysis of the causal role of the function bearer, its instrumental relation to a larger system. And indeed, given that Cummins' account avoids relating function attribution and adaptedness in favour of the approach that functional structures can be identified purely in terms of their causal contributions to systems, it might be that a systems-style analysis better models the way in which functional concepts are in fact used in sciences like comparative and functional anatomy. Nonetheless, I conclude that it fails to displace an etiological characterisation.

First, although we know that function essentially involves the repeated arising of systems of contingencies of a very particular and complex organisation, not all such systems do in fact qualify as functional. Functions can only be attributed in the case of systems in which interacting processes and entities are governed at minimum by a norm of production, meaning that there are recurrent conditions which have enabled a certain effect to take place. In these cases, the causal contribution of an item to a complex system happens because of a disposition to produce that effect; entailing that there can be a function present. This re-establishes the desirability of a normative theory of function based on design to a goal, which specifically entails what we have called natural design in the case of biology.

And second and relatedly, it seems that to ascribe to something a function with explanatory intent is necessarily to view it as an end for a function bearer ultimately because of its own instrumental relation to an internal goal, rather than to a mere capacity, of the containing system. In other words, a biological function statement presupposes in addition some sort of normative distinctiveness of the end towards which a function is a means. This is the normativity associated specifically with holistic conservation through top-down organisation of internal and external interactants in a developmental system. I argue that internal goal-direction is suggested by the role of the form of a biological whole in conferring explanatorily relevant properties on its parts, by guiding change and motion in the functioning of the system. Thus I conclude that only a system which possesses as a constitutive goal, or is itself a goal-state of, formal self-reproduction, is a candidate for functional analysis in the case of biology.

Furthermore, it has been stated that a Darwinised final cause is an end which is externally normatively constituted by its causal history. So it is important to notice that insisting that biological function attribution takes place in the context of normative valuation of a complex system is in effect to insist once more on incorporating a causal feedback requirement into the analysis of function. If a functional explanation must be accounted for in terms of the causal contribution of an effect to the characteristic activity of a system, it must be that there is a feedback loop between a function and a function bearer. A function will partially explain the anterograde existence of a functional type because this effect is also causally productive of the eventual replication of the system, along with its individual constituents, in promoting its reproduction. Thus a biological function is, besides, an effect which continues to contribute to the origin of the function bearer.

Hence next, we turn to the matter of what is the best way in which to think about function-bearing systems as entities which are normatively distinguishable.

3.3 Holism

We have just seen that when it comes to an analysis of biological function statements, a causal role approach is just not good enough. In the preceding section, I provided a positive argument for the claim, introduced by Wright and canvassed throughout this work, that a functional explanation is definitionally governed by a kind of technical norm.

Let us recap the claim that biological functions imply an appropriate evolutionary history. From our survey of another attempt to reduce functional claims to ordinary mechanistic explanations (this time, by stipulating them as instrumental relations identifiable through non-normative standards), it becomes apparent that Cummins' systems project fails. It fails in part because design adduced by the operation of selection is indispensible to an analysis of animate function. There is nothing, either in the internal organisation of, or in the selective regime imposed upon, a biological individual which in itself can determine whether a particular outcome of a peacock's tail feathers is its function. And while a principal objective of this chapter has been to convince the reader that the presence of individual developmental factors is ineliminable when to comes to diagnosing function in living things, this is not sufficient to such a diagnosis either. Patterns of effect or behaviour arise in organic structures by different causal means, and it is only the effects of structures of the same type in the past which confer the status of function on the properties of present entities.[180] So first and foremost a function bearer is *supposed* to perform its given function in that that is what features like it in the past have done. Thus we are brought back to the idea that derivations of function on the etiological model fare better than do definitions proposed by variants of the dispositional thesis. An etiological account (if still insufficient) amounts to the requisite explanation of the causal ancestry of a functional effect.

But beyond the necessity for an external normative characterisation of function, the systems view also founders because functional characterisations in biology appeal to a temporally antecedent

---

[180] McLaughlin, *What Functions Explain.*

and causally efficacious real whole. We have seen that the original etiological claim that an explanatory appeal to functions is totally unencumbered by commitment to essential valuation is impugned when it comes to accounting for the characteristic self-reproductive activity of non-intentional systems. In fact, biological function must be interpreted as implying a supporting system as an internal end towards which functions are normatively constituted as means. Consequently, my own view breaks away from the non-evaluative analysis typical of the traditional etiological interpretation, insofar as I take functions specifically in the organic realm to entail the distinctive value of an individual with the capacity for integrity as an organisational system or scheme. A chief purpose of this thesis has been to exhaust mechanistic analyses of how natural functions explain in the hope of finding an adequate one. And certainly it is in principle plausible to argue that the first, external normative component of functions can be uncontroversially mechanistically unaccounted for by an etiological account. Nevertheless, the best contender for a mechanistic analysis of the second (that is, the systems thesis) does not succeed, in light of the apparent internal normative aspect of function-bearing systems.

Although the two principles I have been suggesting as constitutive commitments of functional explanations are in principle distinct, it has to be said that there is a both an empirical and a theoretical relation between self-replicating and self-reproducing systems. A disposition to self-reproduce through self-constitution and self–repair seems to be a fruitage of natural self-replicating systems – presumably, because general self-reproduction will tend as a matter of empirical course to bring about greater differential reproductive success for material structures. But furthermore, it is a theoretical precept that the self-reproductive capacity peculiar to living things can only occur in self-replicating systems, since an organic structure has a form constituted as an internally normative systemic condition owing only to this state's possession of an evolutionary etiology. Yet, be that as it may, we saw in section 3.1 that it is nevertheless wrong to attribute the causal efficacy of a self-reproducing mechanism in bringing about individual token presence to a self-propagating system. An analysis of function claims shows that such causal explanations advert quite primarily to a holistic mechanism as causally productive of functional entities – responsible, as it is, for active self-maintenance and -replacement of supporting systems. And so, second, there is a sense in which a function bearer is also *supposed* to perform its function in virtue of the fact that the components of a non-intentional system are specified in relation to the organisational structure as an internal systemic end. Functional tokens are realised as causes of beneficial effects for a particular system, in that the internal causal relation (governing individual token self-reproduction) which is necessarily operative in functional explanations entails that a function bearer references a normatively distinguished whole as an identity condition. Hence, a preintentional valuational component forms an internal norm on function attribution, such that part of what is actually at play in our ascriptions of function is a real whole that is prior to its parts and is constituted as its own internal *telos*.

So even though the etiological approach claims to reduce successfully all teleological language in reconstructing function attributions, it seems not to do so because of the suggestion of holistic causal relations implicit in the causally explanatory use of such statements. If, moreover, the systems view cannot supply a causal analysis of the workings of non-intentional systems only through mechanistically interpreted physical laws, what theoretical paradigm might best illustrate this crucial instrumental relation? In this section, I take up this question and I suggest the remaining alternative explanatory principle as a response - - that an account of the internal causal structure constitutive of functional explanations is best given by reference to genuine teleological causes.

Thus far, I have argued that a theory of function must include both an assumption of external teleology, in the sense that function attribution is based first on a means-end relation by which a trait is determined by an ultimate cause (or, more exactly, a Darwinised final cause), *and*, an appeal to a principle of the self-organisation of natural systems – the latter of which is of course explanatory of how a functional token is derivative of its own token presence. The question I am now asking is, if it is true that function statements mark out internal as well as external norms, why is it that, though the latter are at least in principle mechanistically explicable, the former are not? Why is it right to conclude that the internal material representation of a goal state governing a function-bearing system resembles a teleological relation (instead of some composite of efficient causal interrelations between sub-systemic entities)? After all, multiple causes – both internal and external to a living thing – participate in bringing about the biological processes underlying the activity of self-reproduction. What reasons then are there for thinking that animate functions are grounded in self-reproducing systems realised through genuine holistic powers of systems, and not accomplished via independent changes in the properties of constituent parts? First, it is important to understand what exactly is general metabolic reproduction or regeneration: in what follows, I contend that biological self-reproduction involves a mechanism of self-repair and self-replacement that is externally normatively constituted by discrete sources, but which, nonetheless, becomes a self-regulating end in a very particular way. The reproduced whole system in biology acts as an internal boundary condition on its parts: it is a causal actor and Darwinian agent in its own right in virtue of the fact that it starts exhibiting the *emergent* property of self-preservation. Second, my aim is to delineate explicitly technical norms in a functional analysis from norms of moral evaluation, the purpose of which is to demonstrate that the assumption of a whole which can be the proper subject of a good is essential to eliminating any lingering vagueness surrounding the application of functional concepts. I hence conclude that it is a necessary condition for having a function that a trait is conceived as subject to internal teleological causes.

The first reason has its basis in the *Critique of Judgment*. It adopts the Kantian description of the apparent holism of the internal instrumental relation characteristic of organic function, and attempts to show, on the basis of our best current biological theory, that there is reason to think that the holistic constraint on function is genuine instead of merely rhetorical.

A minimal feature of teleological discourse we know is that a biological function is (in part) to be described as a direct instrumental relation whereby an effect abets systemic ends. But furthermore, a criticism of the systems view is that, if we do not make the theoretical assumption of an internal end of self-reproduction for a function bearer, the necessary causal effect of the individual phenotype in-transition in limiting the potential of the genome[181] and its environment during ontogenetic construction of a functional trait will not be accounted for. Of course Kant notably argued that looking upon the ground of determination of a living thing as a cause that has unavoidably the representation of a purpose precludes us from understanding that thing as primarily caused by mechanistic principles, since no explanation in terms of efficient processes gives rise to a unified causal ground. The idea is that one cannot deny a unity of causal dependence if there is union of purpose in the cumulative effects of the whole.[182] But while Darwin has been used with *prima facie* success to show that Kant is wrong in the case of how living things come to be subject to external norms, this line of reasoning succeeds as regards internal norms. Why is that?

The first reason it is essential to speak of the form of the individual as a genuine causal factor in the production of non-intentional systems derives just from the nature of biological self-reproduction. Self-reproducing systems are defined by the whole exerted as a material representation of a goal state upon its constituents at multiple levels of biological organisation. And since organic systems are composed of interrelated constituents, such configurations possess distinctive and irreducible causal powers. Let us take a look at this argument in greater detail: If a constitutive feature of a function bearer is that its effects contribute causally to the token reproduction of a complex system, the phenotype of an organism must be an indentifying condition on the form as well as biological role of a functional trait. Hence the form, activity and position of a part of a self-reproducing system is constrained by its role in a preceding inter-dependence of constituent parts, which then means that the system collectively is able to self-replace and self-maintain. No constituent is determined but in relation to the whole and, therefore, the unity of purpose present in the connection of the parts cannot be the product of what Kant calls a “mechanical faculty of motion”.[183] Instead, the individual must be its own producing cause, or formal cause, or else we will lose the concept of a self-organising being.

---

[181] The sum set of genetic material in a cell or organism.

[182] Kant, *Critique of Judgment*, p. 123.

[183] *Ibid.*, pp. 140 – 146.

The suggestion is that a satisfactory explanation for any organic structure requires special appeal to organisational closure as a holistic causal regime.[184] Philosophers today frame this debate using the term *emergence*. Holistic properties, consisting in whole-to-part causation, form an emergent causal order in biological systems, whereby mutually dependent constituents, coordinated around an internal goal of self-reproduction, together realise a closure of constraints upon each other. This is a higher-order self-formative capacity belonging to the complex system, and not to its parts, insofar as it arises *only* through the organised interaction of sub-systemic units. It is a capacity of a normatively distinguished whole which enables the system to bring about certain effects in itself. And while there are legitimate objections which may be marshaled against a thesis of emergentism, I address these in a discussion on holism in chapter 5. The present suggestion is a naturalistic account on which function is governed by a causally efficacious internal representation of a goal state.

We can actually review the holism of function-bearing systems through the example of the interplay between trait type transmission by natural selection, in the form of phylogenetic histories (and which imposes some external limits on the ontogenetic possibilities of a functional trait), and the role of the developmental environment in shaping the fundamental nature of biological phenomena.

While so-called ultimate causes underlying development and phenotypic variation are vital as causal mechanisms, involved in the reproduction of biological systems as normatively established structures, the genotype is not actually the level of primary causal explanation for ontogeny. The phenomenon of phenotypic *plasticity* illustrates that it is the phenotype (although there are many, potentially competing, levels thereof in a single system), rather than the genotype, which takes ontological precedence as a causal interactant and unit of selection. The phenotype thence imposes evolutionary outcomes on its own structure and organisation.

So it is easy to see how the etiological analysis of function echoes the chief tenets of the developmental systems approach. Natural systems, otherwise remarkably congruent in structure and function, exhibit significant interspecies morphological variation, partly because of the role of the consequences of a systemic feature *T* in its own etiology. A teleomatic process like the combining of haemoglobin with oxygen is not to be described as an effect of oxygen's being in the blood *simpliciter*; rather, the precise form of the structural organisation responsible for oxygenation is determined by the morphology-function complex. For, as Kant has argued, the purposiveness of a biological system is closely connected in its self-formative power with the condition of not taking into its form any element

---

[184] Matteo Mossio, Leonardo Bich, and Alvaro Moreno, 'Emergence, Closure and Inter-level Causation in Biological Systems', *Erkenntnis*, 78, 2 (2013) pp. 153 - 178.

that is not already part of its original – albeit underdeveloped – nature.[185] This reiterates the important historicity of biological systems. There is clear correspondence in structure between individuals as well as between the parts in the same individual, attributable to common ancestry. Since negative feedback relations are capable of sustaining self-reproduction of a biological type, a mechanism by which a part of a system is brought causally to bear upon itself (or else upon things continuous with it) is a means by which living beings achieve trans-generational reproduction in addition to intra-generational *persistence* with respect to specific properties.[186] So a manner whereby formal or structural reproduction of natural structures comes about is by virtue of this fact that certain genes succeed in perpetuating themselves: that is, manifest traits succeed as causal progenitors of their own typical presence, through differential proliferation. As we know, when there is reliable replication of the environment and other developmental means across generations – effecting the reconstruction of entire developmental systems – species characteristics and their functions will be reproduced.

Still, the species typical aspects – genetic and otherwise – which successively repeat themselves across related developmental systems do not make up the whole story when it comes to the reproduction and heritability of stable function-bearing systems. While persistence of species characteristics is a product of stable developmental systems, these do not essentially require consistent replication of all participants in systemic interactions. Biological processes can be stable irrespective of deviations in their respective compositions; similarly, stable outcomes can result from different processes.[187] This is the case inasmuch as trans-generational reproduction and intra-generational persistence of natural characters depends upon reliable life cycles, rather than static genotypes or even phenotypes. For instance, there are differences in genotype which are functionally neutral provided that the relation between organismic influences remains regular; entailing that, sometimes, genetic variants will achieve the same evolutionary outcomes in a given environment. A product of a holistic mechanism is corrective and self-regulatory activity achieved through compositional plasticity of just this sort. Hence although formal reproduction of biological structures tied by negative feedback relations is important, we see holistic development of such a material system as its own internal final and formal cause in the way that a living thing reproduces itself through any means necessary, thus in principle independently of any particular causal powers of constituent parts.

Why must biological systems be described as plastic? Justin Garson points out that, by definition, goal-directed systems are systems which necessarily exhibit plasticity and persistence with respect to given activities, and this is achieved through compensatory mechanisms realised across the

---

[185] Mossio, Bich, and Moreno, ‘Emergence, Closure and Inter-level Causation’, pp. 154 – 155.
[186] Garson, “Function and Teleology”.
[187] Oyama, *Evolution’s Eye*.

system parts.[188] It is plausible to conclude from this that the internal variant of the goal-contribution theory of function with which we are concerned must then insist that a biological system is capable of complex self-reproduction, or that it is plastic and persistent regarding self-reproduction. This requires both that the system can reach the same state, that is, a state manifesting the same properties, in different ways, and that it is able to attain and maintain this state unhampered by environmental perturbation. And empirical fact accords with this in that every genotype is indeed associated with multiple potential developmental pathways; hence, a given phenotype can be reproduced by virtue of different genotype-environment correlations.[189] It is also known that organic phenomena display homeostasis: to be exact, they reproduce a constant internal environment by resisting change and persistently seeking the trajectory of a phenotypic state in the face of environmental pressures.

Consequently, despite the counteraction of invariance or species-typicality in populations by the moulding effects of variational processes (including genetic drift and natural selection), biological structures nonetheless develop and reproduce themselves as phenotypes because the individual itself exerts causal influence over the epigenetic pathways active in selection.[190] I have already iterated that the distinctive causal role of the phenotype against the influence of other, genetic and environmental, formative factors leads similar species features to recur independently in nature, thereby fostering the appearance of biological analogues as a reaction to comparable environmental stimuli. Therefore, in incorporating the plasticity criterion associated with goal-directed systems, any theory based in the instrumental relationship of a function bearer to a referring system is predicated upon the explanatory presupposition of the phenotype, which is antecedently identifiable as a contingent goal for selection, and hence legitimate as an end of self-reproduction. An animate body must predate its constituents as a cause if it is to act as a phylogenetic constraint on morphological change.

Note that both of the above discussed factors necessarily enter into delineating living from non-living systems. Earlier we saw that not all systems (this includes negative feedback systems) are biological in character by cause of their not being goal-directed. Correspondingly, not every goal-directed system is living. Function-bearing systems are distinguished not merely in that such systems seek equilibrium states by different mechanisms, but by the persistence of states or properties of such systems which figure prominently in their own reproduction.[191]

Talk of both of these characteristic features of biological systems, namely, being goal-directed, and being related by negative feedback systems, brings us to the second reason in favour of speaking of genuine teleology. In this second argument for the holism of self-reproducing systems, I contend that

---

[188] Garson, “Function and Teleology”, pp. 539 – 541.
[189] Oyama, *Evolution’s Eye*, pp. 45 – 46.
[190] *Ibid.*, pp. 514 – 516.
[191] Garson, “Function and Teleology”.

function attributions are characterised by norms of moral evaluation as well as by norms of production. The former type undermines the possibility of a mechanistic reduction of internal as well as external teleological relations.

The basic argument is as follows: we know that the functions of biological parts are not purely externally grounded in their contribution to their own typical persistence: they are also independently justified by the fact that function bearers are part of an internal teleological system, meaning that such parts are goods for functional systems relative to the systems themselves. And importantly, this internal relationship governing natural systems must be conceived in terms of an irreducible, holistic normative principle underlying a capacity for self-reproduction, for it is not possible to regard an entity as a proper recipient of the good bestowed by the traits it possesses, unless, as a whole, it is a bounded subject which can be said to have (not simply a goal) but a good. Hence function descriptions only make sense in the context of the supposition of a goal-state which has a good of its own. Although a function has to be determined by a technical norm, the attribution of function must besides be grounded in specifically a norm of moral evaluation, which implies the relating system as a beneficiary in its own right.

Notice moreover that the fact that systemic features, said to be functional in the sense of internal teleology, assume moral considerability of the underlying system will prevent the reducing of claims of external teleology also. In this thesis, I have argued for identifying the external purposes of organs, behaviours and so forth with those of their effects by which they self-propagate - - albeit this interpretation requires that we suspend judgment about an intentional beneficiary and source of design for function bearers. It is because functional status of this sort is given by discrete external factors that we may *prima facie* judge of functions which are external *simpliciter* as denoting in principle reductionist causal explanations. However, presently, it becomes obvious that any commitment that my view retains to an etiological hypothesis must be glossed differently than the traditional account, so as to reflect the argument that functional status is essentially related to contribution to system performance.

The point cannot also be put like so: Teleological relations of the external variety perform a similar descriptive purpose in the cases of biological function bearers and simple, inorganic functional products. In both situations, such characterisations serve to distinguish normatively the function bearer. Nevertheless, barring this feature, the analogy breaks down. Functional designation of simple artefacts is totally external. In contrast, McLaughlin explains that the determination of function in a complex system is dramatically constrained by the relations between system parts. For this reason, when it comes to the parts of a complex or even a compound product, purpose is internal in description, and somewhat independent.[192] If we examine a biological complex system, the reason why adaptations have functions is not because they contribute to the performance of some potential function of the organism for the use of an external beneficiary; rather, they are conducive of a trait type in being useful to the organism itself. Although the organic things to which we attribute function in an external sense are evolutionary products, features which have utility for the organism are present to natural selection and are thus inherited if and only if they have also led to increased *systemic* reproductive success. So, given a basic assumption that what has utility relative to the organismal system in which it exists will (most of the time) also promote increased progenation of the organism, we know that etiologically derived traits must recall general systemic welfare.

It is true that, to the extent that a biological function bearer promotes its own reproduction as such a body, its function is a contingent fact derivative of the causal properties of the function bearer. The suitability of a natural feature to a particular effect is just then dependent on the function bearer's being causally related to itself as a means to an end. Still, despite this fact that having a function lies somewhat in external causal factors, the end to which a biological trait is a means is also materially realised through the structure of the supporting system itself.[193] The determination of their functions is dependent on selective processes; even so, organisms have a good of their own (in the form of general systemic regeneration) and the contribution to this good is going to be part of the causal structure for any function-bearing trait. Artefactual function is distinguished from natural function in structure by this quality, that a natural function denotes a means-end relation which necessarily references a containing system. Thus, all things being equal, the function of trait *T* is effect *e* if and only if *e* directly or indirectly maintains the supporting system *S*.

Therefore, if functions are irreducible considering that internal teleological relations involve a moral conception of norms, the modern biologist must also concede that a trait said to have a purpose insofar as it forms part of a putatively external teleological structure, is not efficient in origin on such grounds either. The explanation for its existence as a feature that achieves an evolutionarily successful outcome is still mediated by an internal means-end relation. And hence, to the extent that a teleological description is given as an external function of a biological trait, the causal feedback loop is in some way subject to a moral norm. The implication is that the function attribution here being discussed indirectly references a subject beneficiary of the function bearer's contribution to its own reproductive success. External teleological interpretations of the natural world are consequently also causally irreducible.

Tellingly, a counterexample similar to the first presented against the systems view is also a source of dissatisfaction with Wright's original, non-evaluative formulation of the etiological thesis. The

---

[192] McLaughlin, *What Functions Explain.*
[193] *Ibid.*

well-known counter-example which follows shows clearly that even a functional analysis which restricts itself to attributions of external teleology cannot avoid appealing to moral norms. Thus, just as the rock formation which causally contributes to the widening of a river delta cannot on those grounds alone possess purposiveness; neither can clay crystals which proliferate as a consequence of possessing parts or properties that encourage this tendency to replicate. The criticism is that the simple physical feedback relation constructed in the latter example is also not tantamount to a function, despite the fact that Wright's conditions for function ascription have been met: the crystals are present because they have properties that support replication, and the successor crystals non-accidentally have these properties because their predecessors were disposed on the basis of their properties to do so.[194] Be that as it may, we remain disinclined to say that the function of crystals is to replicate. What is common to both counterexamples is the absence of a normative or valuational component in the account to which it is addressed. Regarding the rock formation, the dispositional structure is not preceded by a particular kind of history underlying its capacity to affect the river. The import of this, we have seen, is that the performance for which something was copied determines what it is supposed to do. There is no precession of rock formations which actually widened river deltas in a manner that aided in reproducing the type. The rock formation is therefore not a functional token, since a norm of production is missing in Cummins' analysis.[195] What is made apparent by the second example, however, is that a technical norm of this kind is not sufficient to introducing the needful valuational factor. An etiology appropriate to technical norms is present; still there is no corresponding function, simply because there is no good that the clay crystals perform for a subject, of the sort that is relevant to the feedback relation in the case.[196] Without a specifically moral element, the mechanisms and/or dispositional structures such as are described by Wright and others do not support inference to a functional explanation. *A fortiori* the rock formation does not have interests which are served by its capacity to widen the river delta.

Wright's attempt to describe a feedback mechanism without referencing a system that is the beneficiary of the function, fails. He is unable actually to cite an instance in which the causal effect of the functional type on the individual token is not mediated by the benefit it provides to a containing system.[197] Doing something or someone good is part of the feedback mechanism (natural selection) by which the effect of a functional character assists in bringing about that character. Consider for example the 'hitchhiking effect' in biology. Wright would have us entertain the idea that it is sometimes possible for a useless trait to be recurrent enough that its occurrence and disposition to produce regularly a certain effect warrant the attribution of function, even though it is only where it is by accident: for

---

[194] This example is cited in McLaughlin, *What Functions Explain.*
[195] McLaughlin, *What Functions Explain,* pp. 105 – 106.
[196] *Ibid.,* p. 99.
[197] *Ibid.,* pp. 93 – 97.

instance, if a gene were contingently coupled to another, useful, gene.[198] But, in point of fact, natural selection is such that, should its gene products turn out to be regularly adaptive, the presence of the functional gene in question is not accidental, because it is not actually hitchhiking. The gene has a function as, by the lights of evolutionary theory, its history of reproductive advantage is sufficient to its having one. Thus functions imply relevant systems which can enjoy the benefit of those functions. The essential element of a feedback condition productive of function which the etiological account ignores is that of the complex whole, of which the function bearer is necessarily part, and to whose welfare the existence of the function bearer is intimately tied. Furthermore, the system level only imposes a morally evaluative norm on phenotypic effects in light of its holistic individual identity.

Natural selection may be a primary causative force in biology, but the normative organisation of self-reproducing systems – and specific goal-orientation towards welfare – is not accounted for by mere technical norms. A phrase borrowed from Kauffman underscores this point well: he writes, "Selection was not compelled to invent the native coherence of ontogeny, or biological development."[199]

I would like to bring this section towards a close by attempting to impart some additional substance to the concept of a biological whole or individual. As naturalists, we suppose that there are no true, agential external final and formal causes in the universe; yet, I have been claiming that there is something like genuine contingent internal, non-intentional teleology. As a penultimate point for consideration, I hence want to offer some remarks concerning whether we can reasonably credit the qualitative complexity of living things in the face of our acknowledgment that life arises from pretty basic macromolecular building blocks via natural processes (and not through the mental representations of a deity). So far, I have presented an empirically-based conceptualisation of a capacity of biological wholes for self-maintenance that is realised through a holistic causal mechanism, and which is only contingently related to natural selection as a product. I now suggest that relatively recent discoveries made using a computerised mathematical approach to the concept of self-organisation[200] gives us reason, based on mathematical formalisation, to think that there is a naturalistic source for biological order, and indeed, that, in the story of life, molecules do not reproduce individually, but by means of webs, comprising "the crystallization of catalytic closure"[201]. This would mean that molecular structures which are "collectively self-reproducing"[202] originate quite ordinarily and spontaneously in nature. Mathematical biology hence lends credence to the idea that vastly complicated and complex systems,

---

[198] McLaughlin, *What Functions Explain*, p. 98.

[199] Kauffman, 'Antichaos and Adaptation'.

[200] Stuart Kauffman, *The Origins of Order: Self-Organization and Selection in Evolution* (Oxford, 1993).

[201] Kauffman, *The Origins of Order.*

[202] *Ibid.*

qua biological individuals, develop from the interaction of different, yet simple, polymers of basic molecule types.

By way of explanation: a new paradigm for evolutionary biology begins in the mathematical models pioneered by Kauffman and others in that these initiated change in biologists' views about order and evolution. Post-Darwinian biologists have typically viewed natural selection as the single source of the systemic order exhibited by all living things. However, it is possible that biological order is spontaneous throughout nature. Newer findings and perspectives from biology, chemistry, physics and mathematics provide support (albeit it of a tentative kind) to the existence of an innate property of self-organisation, possessed by some complex systems. This is what Kauffman calls the phenomenon of *antichaos:* while an often-observed defining property of complex systems is "the randomizing force"[203] of *chaos* at work in disordering their initial conditions, sometimes systems simply 'solidify' into pockets exemplifying a high degree of order. Mathematical models for biological phenomena exhibiting self-organisation allow scientists to understand the features of complex systems and to make predictions which match up to key observed features of life, such as stability, homeostasis and evolvability. Using a computer model of a set of molecular regulatory interactions, Kauffman has shown that there is a high probability that a small number of molecules of even simple properties will produce a network with self-organising characteristics – indeed without the engineering effects of natural selection. Such models of organismal function demonstrate how simple inputs from individual elements in the system can connect to yield the complex, coordinated behaviour of a system which is seen in networks characterised by the maintenance of systemic order. And, taken as an example of a Boolean network[204], the self-regulating network of a genome illustrates how antichaos may direct ontogeny.[205] Indeed, one of Kauffman's chief contentions in *The Origins of Order* is thus that the higher order reflected in naturally occurring systems surfaces through the interaction of selection and spontaneous order. So, although it may be that natural selection is a major propellant of the capacity to evolve and adapt, we may begin to understand it as shaped by the addition of self-organisation to selection.[206]

And finally, even if self-organising biological structures of a qualitatively different and more complicated reproductive character can emerge, when I cite a natural 'whole' or 'individual', to what precisely am I referring? A whole is technically defined in the reductionism/anti-reductionism debate as a "structured

---

[203] Kauffman, 'Antichaos and Adaptation'.
[204] See section 5
[205] Kauffman, 'Antichaos and Adaptation'.
[206] *Ibid.*

organisation of elements"[207]; nevertheless, it remains necessary in the natural sciences to specify the level of organisation at which we take there to be entities that satisfy the determinations of the concept.

One of the central concerns in Darwinian Theory is exactly that of determining what constitutes a *Darwinian actor* for the purposes of evolution; that is, what is an individual in nature upon which causal forces can operate.[208] While radical reductionists such as Richard Dawkins and Daniel Dennett delimit the level of causation to that of the gene, there is some consonance of opinion in contemporary biology that it is actually the organism which is the primary unit of selection, and that the appearance of success or decline at higher levels of aggregation (like demes[209] or species) results from the cumulative effects of natural selection upon lower-level constituents. However, in the place of micro-evolutionary or macro-evolutionary explanations, a notable proposal of the great evolutionary biologist, Stephen Jay Gould, is that evolutionary theory must be opened up in order to accommodate the variety of causal influences which act on separate levels in the hierarchical organisation of natural phenomena. In an argument not atypical of modern sociological thinking, Gould argues against reducing evolutionary theory to a single explanatory principle, for the reason that it is not only genes or organisms which meet Darwin's criteria for the individuality of a unit. Cell lines, demes, species and clades[210] are of the biological entities which can, too, be said to qualify as evolutionary individuals.[211] In the final chapter of this thesis, I turn properly to the concept of reductive levels; yet we may for the moment surmise a definition by means of a somewhat opaque reference to Putnam and Oppenheim's well-known proposal that a part-whole relation connotes that X is part of a whole Y "if X is spatially or temporally contained in Y".[212] So, given that evolutionary action happens on different levels of biological organisation, it is reasonable to conclude that individuality pertains on multiple reductive levels.

The material point is that in describing a biological whole as an interactor and cause, it is feasible to suggest that entities at many levels of the biological hierarchy display the categorical feature of self-reproduction. Insofar as there is heritable or transmissible variation in fitness present at a given level, entities undergo reproduction and multiplication as units of selection.[213] Wholes include biological bodies like genes, chromosomes, organelles, cells, entire organisms, colonies, demes and even whole species. Parts can be macromolecular, or comprise components of a cell, or species, for instance.[214]

---

[207] Paul Oppenheim and Hilary Putnam, 'The Unity of Science as a Working Hypothesis', Minnesota Studies in the Philosophy of Science, 2 (1958) pp. 2 - 36.

[208] Richard York and Brett Clark, The Science and Humanism of Stephen Jay Gould (Monthly Review Press: New York, 2011), p. 101 Gould.

[209] An interbreeding population.

[210] A group of biological species possessing homologous features.

[211] York and Clark, *The Science and Humanism of Stephen Jay Gould*, p. 100.

[212] Oppenheim and Putnam, 'The Unity of Science as a Working Hypothesis'.

[213] Oyama, *Evolution's Eye*, p. 138.

[214] *Ibid.,* p. 138.

This is not to say that causal processes operating at the individual-level are exhausted by changes at and below that level in the absence of involvement by factors operating at levels of organisation above. In Gould's hierarchical theory of selection, there are causal patterns and processes at different levels of the biological hierarchy, and micro-evolution and macro-evolution, although distinct, are linked by feedback mechanisms because of the way in which emergent attributes at higher levels of aggregation drive evolutionary change. As we might expect, the operations of diverse selection forces will interact and sometimes compete.[215] Nonetheless the idea is that, in principle, a biological self-reproducer is always a part of another whole in that its ability to regenerate, and, indeed, to self-replicate, takes place at the very least in the context of a wider ecosystem, and that developmental system will exert causal influence on it.[216]

In sum, over the course of chapter three, I have argued that a passable reconstruction of biological function attribution includes reference to a self-reproducing system, in which the internally purposive relation which is constitutive of a function-bearing system is also characterised as a legitimate teleological structure.

In the wake of Darwin, the re-introduction of a normative functional type can be achieved by appealing to the environment in the restricted role of a non-agential selective power vis-à-vis causally efficacious biological entities. Indeed, that the operation of natural selection is here used to conceive an external normative criterion for function purely by appeal to mechanistically determined physical laws is that element of Wright's analysis for which the account has enduring appeal. On this view, natural design refers to the ineluctable selective goals of nature for the ultimate sake of which a functional system can be said to be brought into being. Thus the account gives explanatory content to the intuition that design is constitutive of function-bearing structures.

Still, etiological accounts specify the conditions for functional type rather than token existence. We saw that the function-bearer of biological practice is regarded as necessarily causally responsible for its own present reproduction, over and above the reproduction of other tokens of the same type. I hence contended that, if function ascriptions are to serve as causal explanations of function bearers, an etiological functional explanation must include in its analysis of the causal role of the function bearer, its relation to a system that is self-reproducing (as well as self-propagating). Given that functional explanation entails a self-referential causal capacity of functional tokens which is nevertheless not entailed by selection, it is necessary to postulate an additional explanatory condition on function attribution. I have moreover argued that a systems definition of function fails to reduce the internal

---

[215] York and Clark, *The Science and Humanism of Stephen Jay Gould*, p. 104.
[216] *Ibid.,* p. 95.

causal relation presupposed by functional explanation through the positing of a mechanism that is causally responsible for the recurrent effect of a trait. Biological theory reveals the failure of analyses of function in terms of present disposition to confront the internal normative organisation of function-bearing systems. This internal causal relation must be understood as normative to the extent that the parts of a non-intentionally purposive system are specified as current contributors to reproductive success *only* in relation to the complex system as a normatively distinguished whole.

Therefore proper function can only be attributed in circumstances in which a biological token is a reproduction of another token, and so can be subject to an external norm in the form of a norm of production. And, a function-bearer must be normatively conceived in relation to a distinct organisational structure which has the character of an internal end for its components. In this final section, I have also suggested that the nonsuccess of the systems thesis in explaining a putative internal teleological structure through the role of a functional token in systemic processes justifies an explanatory appeal to genuine teleology. And I end by tendering two positive reasons to think that, in a functional analysis, the role of function-bearers as contributors to systemic welfare is not reducible. Thus, the conclusion of this chapter is that a causal analysis of a function-bearer presupposes an internal normative component of biological functions. The origin of this normative aspect cannot be reconstructed mechanistically, both because it is associated with holistic conservation in living things, and because it presumes a subject beneficiary of the function bearer's contribution to its own token reproduction. Hence a metaphysical assumption of function ascription is plausibly of a normative relationship between function-bearers and a containing system which is characteristic of a formal cause in an internal sense: A biological system is an internal formal cause on its components owing to the fact that its form is productive in the processes of development, as a whole and material embodiment of a plan, acting as the blueprint guiding ontogenetic change and motion in the system. A causal element possessing a valuational component, and presenting as an immanent final cause, is, too, assumed. As a material whole, the functional system acts as an internal final cause on the reproduction of parts, as its own goal, motivating systemic self-reproduction, and hence as the subject for whose benefit function-bearers presently exist.

Finally, any naturalistic theory of functions must turn to phylogenetic history to account for the origin of biological self-reproduction as well as replication.[217] A biological individual admits of analysis as a teleological explanatory concept, that is, it is a normatively distinguished structure in its own right, just because it is subject to an external technical norm. It is the value involved in such structures towards which our discussion turns in the next section.

---

[217] McLaughlin, *What Functions Explain.*

3.4 A Value Account

Before summarising a function definition, I think it important to make some cursory comments on the kind of value I take there to be involved in function attribution. A final argument for the integrality of value to an analysis of functional explanation also strengthens the case for speaking teleologically about biological systems.

The philosophical literature on function is peppered with the notions of benefit, good or welfare. In fact, that the attribution of function predicates a valuation of the end towards which a function-bearer tends is a given: Remember that identifying something as possessing a function – even with descriptive intent – is to regard it as (either directly or indirectly) instrumental in its consequence/s of a system that is somehow normatively distinguished - - at the very least, in the technical sense that the performance of the effect is prescribed by a norm of self-reproduction. The upshot of this is that, although Wright intends his account to be valueless, actually – even at a very basic level – the attempt to derive functions without value is ineffectual, since value is unavoidably introduced by natural selection. We saw that it looks plausible to suggest that a functional structure as an end participates in something like the value of an external final cause, in that it is a goal of nature in a limited manner, meaning that its typical existence is contingently necessitated by the reproductive success of some one or more of its effects. I have called it a decisive advantage of Wright's account that it derives norms from natural selection to formulate an entirely naturalistic normative aspect of function.

Indeed, if value is thus conceived as an inessential and external feature of an etiological analysis of function, such a value approach to teleological attributions in nature is not novel. A value-centred analysis of biological purposiveness is defended by philosopher Mark Bedau, according to whom there are three grades of evaluative involvement in teleology. Biological teleology supposedly exemplifies the second grade, through natural selection on the basis of non-explanatory value considerations. Bedau thus defends a version of the etiological analysis, in which, the first clause (a trait (*T*) is there because it does effect (*e*)) of the functional explanation, 'The function of *T* (in system (*S*)) is *e*', is augmented by a value modification (*and e* is valuable). What is germane is his claim is that, when there is no value-orientated system in the causal history distinguished by a functional analysis, there is no instance of teleology because value is not an essential part of the causal explanation in natural selection.[218] So while ascribing a Bedau-style value "on the basis of non-explanatory value considerations" to a putative functional trait might still be explanatory in certain respects – for instance,

---

[218] Mark Bedau, 'Where's the Good in Teleology?' in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998), pp. 265 – 266.

functional explanations might then suggest the presence of value associated with compliance with a norm of production perhaps – such value would not be explanatory of why the trait has enjoyed an evolutionary advantage at all.

And certainly, it seems that we can understand this second grade of evaluative evolvement connoted by teleological claims, and – to some extent – even identify it unencumbered by other kinds of value in organic bodies. The standard etiological analysis must allow that the conditions for function ascription have been met if a biological trait produces those effects which, in the past, contributed to its own differential reproduction – even if its effects no longer contribute to the fitness of the supporting system (or have even become injurious to systemic fitness). So, until selection has deprived an organ like the human appendix of its structure or attributes, such that it becomes vestigial, the etiologist must allow that it has a function.[219] The appendix will also then retain the value which such an attribution is said to imply. And indeed, this coincides with some valuation judgments made in biological practice: insofar as an appendix is considered to be an adaptation (meaning strictly that it is a trait produced by natural selection), it is either a good or bad example of its type.

Nevertheless, I have argued over the course of this thesis that the etiological approach does not suffice as a mechanistic reconstruction of functional explanation. In addition, that there is range of goals and values identified by biologists which we would want a theory of function to be able to explain serves independently to reinforce this conclusion. We saw that the causal story told by the etiologist is in truth complicated by the fact that the determination of a trait's external function by selective forces is an event which presupposes an explanatory appeal to a containing system. A phenotypic trait *T* has a function *e* in being conducive of a trait type only on the condition that *e* has also contributed to systemic propagative success. And, it also seems be the case that common scientific judgments of even external value are premised upon valuation of a supporting system in an explanatory sense. For example, it is taken as genuinely explanatory in biology to claim that an organismic part confers survival advantage upon its bearer; or else that it is useful for reproduction, *because* it is good for a recipient organism. Such evaluative descriptions suggest that the value presupposed by function attribution is not restricted in scope to non-explanatory evaluative involvement. The rest of this section furnishes more reasons for thinking that explanatory requirements on the concept of function demand (in addition) a stronger, explanatory sense of valuation of the end toward which a function is constituted as a means.

Naturally, our allusion to an assumed system in function statements brings us to the subject of internal value. Therefore, in the remainder of this section, my intention is to consider some types of statements

---

[219] McLaughlin, *What Functions Explain.*

biologists make which appeal to internal value, in order to iterate that – as well as explain how – value is an essential part of the explanation offered by a function attribution. My proposal is that the role of internal value in functional explanation constitutes a further consideration in support of the explanatory use of teleological concepts in the analysis of biological function. Since these value-statements imply function on the basis of explanatory value considerations, in that the value of the system as a material whole is an ontological commitment of the causal explanation proffered, it appears that some value attributions demand a different kind of causal explanation.

To start with, it is already clear that – to the embarrassment of the standard etiological account – its adherent is committed to claiming that an adaptation which has become maladaptive is functional. Thus the etiologist must hold that a trait which is structurally fixed in a population (though it is no longer good for anything) has a function.[220] However, many of the references to value which are made in the natural sciences reflect that functions are supposed to be more than structurally efficacious: in fact, it is a desideratum on a theoretical concept of proper function that it is regarded as valuable. I have already mentioned attributions of external value in biology. But another kind of value that appears to be bound up with the causality of function independent of our interests and assessments is that a function is *good* as considered from the perspective of the system of which the functional explanation is adduced. Thus, examined in the light of some further value-connoting claims, such as "a function helps to keep the recipient healthy," or "a function serves to keep the recipient alive", the human appendix fails to have a function – not only because it is unassociated with propagative benefit for the organism involved, but also inasmuch as it does not do the organism any present good. These examples specify teleological-type claims which exemplify genuine evaluative involvement. And they suggest that, in order to do the work we expect of it, a function concept has to be formulated to cognise that benefit essentially grounds the attribution of function. Notice that benefit is a necessary feature of the causal explanation: a trait's providing of an accidental benefit to an underlying system is not going to warrant function ascription. Therefore a functional explanation entails a causal relationship that is characterised by the system as a whole, in the role of an evaluative end, being a causal precursor of its parts. In other words, functions explain in part through final causes. Only self-reproducing systems can have 'a good' in this internal sense. A function-bearing system self-reproduces just *because* it is good for it to self-reproduce.

Predictably, the distinctive character of the goal of a natural system brings us to the final type of non-agential value exampled in biology. Biological function can be endowed with the value associated with restoring or maintaining the constitutional integrity of a system. And, as a point of departure for the argument that this value is imperative to function, we can re-visit the systems thesis in consideration of

---

[220] McLaughlin, *What Functions Explain.*

Wright's earlier critique of a usefulness criterion implicit in the formulation of a descriptive analysis. Remember, Wright argues that not everything for which a trait *T* can actually be put to use or which it actually does is its function. It is for this reason that a purely dispositionalist notion of function is unsuccessful. Cummins acknowledges this failing – that is, that want of a causal contribution in a feature would prohibit its having a function according to his thesis – but Neander points us in the direction of the deeper criticism. That is, a causal role is not equivalent to a proper function since *T* can make several causal contributions to complexly achieved processes in a natural system which we would be nonetheless disinclined to call its functions.[221] To use her example, tumours play an exquisite causal role in the pathological process that is cancer in an organism. And yet, tumours do not have proper functions.[222] The trouble is more than that a tumour isn't good for anything. A tumour is not a good owing to the fact that it does not contribute to the self-reproduction of a recipient system. It is, in fact, *deviant*. *A fortiori* this suggests that the causal relationship signified by a functional explanation necessarily encompasses that the form of a system, as a whole, predetermines its parts. Once again, there is essential explanatory involvement of the system *qua* valuation standard. The function of *T* is only an effect *e* which has been conducive to maintaining the containing system in good form. Hence, an analysis of function as causal explanation must, on pain of absurdity, feature a basic evaluative component derivative of formal causation. The problem of errant causal roles constitutes an additional reason why it is desirable that a notion of function should reference a formal causal relationship as a basis for attribution.

Value is a real and irreducible property at play in teleological descriptions because it is explanatorily integral to a causal analysis of function. Tumours do not have functions for the simple reason that they are not good - - neither for the organism that harbours it, nor for its offspring. They actively harm rather than help, specifically in view of the systemic goal of self-reproduction. My conclusion is therefore that the strong value-centred analysis which is conveyed by genuine teleological causes is indispensible to the explicability of biological function claims.

I bring this section to a close by highlighting for the reader that the value account which is here being proposed is wholly naturalistic. My account does not carry connotations of intrinsic value because I take seriously that there is no such thing as a natural essence. The norm of moral evaluation referenced by teleological explanation in this instance is derived from a norm of production. Insofar as organic phenomena do possess normatively distinct goals, a biological system is by nature non-intentionally valuable, so that its final goal is always identical with its formal goal – and this is simply the

---

[221] Neander, 'Function as Selected Effects.

[222] *Ibid.*, p. 328.

reproduction of the system itself. (To be sure, these norms will sometimes compete in the process of organic development. A function is not a good for a recipient which achieves its systemic goal by any means. Formerly we saw that although organic systems are typically plastic, they are also distinguished by the presence of developmentally conserved traits. A biologist might empirically express this rivalrous relationship through the claim that a phenotype is determined not by its genotype, but by the norm of reaction of the organism. The reaction norm of a genotype is a graphical representation of the differences in plasticity correlated with that genotype. Still, this point only serves to underscore that, although connected by a dependence relation, technical and moral norms in living things are distinct.)

Again, the formal goal of a discrete system is given by its etiology, to the extent that any of its parts which is an adaptation will be normatively determined by its particular evolutionary trajectory. It is true that the question remains of how normatively distinguishable parts in turn become a normatively distinguishable system: the fact of external normative determination of functional entities does not explain systemic order – rather, it presupposes it. However, a distinct biological system is just a system set apart by organisational closure. And, as I have already submitted, there is reason to think that self-organisation is naturalistically explained by the phenomenon of spontaneous order.

4. Functional Explanations as Causal Explanations

4.1 The Definition of Function

As I began by stating, my purpose in this thesis is to propose and defend a stipulative definition of biological function which reflects adequate recognition of the empirical phenomena of homology, analogy, multiple realisability, self-organisation, and self-replication displayed by living things. Such a definition should characterise a significant proportion of the variety of applications of function concepts used in the biological sciences. In this penultimate chapter, I therefore turn to summating the results of my analysis as well as to showing what I consider is the logical form of functional explanations.

I take the enduring lesson of Kant's *Critique of Judgment* for a contemporary teleological analysis to be that design is fundamental in conceptualising a functional structure. More than two hundred years on, it still appears legitimate for practising biologists to admit restrictions on the character of functional effects as a distinct category: specifically, function explanations persist as a problem for the biological sciences precisely because the core of their explanatory significance is seen to lie in their providing a causal explanation of a function bearer's existence. While I concede that we might want to adopt aspects of a systems analysis, as well as potentially weaken the conditions on a backward-looking conception of function in consideration of objections raised by the forward-looking approach,[223] I disagree that the multifariousness of biological practice is better accommodated other than by an etiological account.
We can say that competing analyses eventuate in the wrong theoretical results.

The biggest challenges to the view of morphologists are that, first, it becomes an empirical issue whether or not a given entity is functional, and so second and relatedly, the door is left open on individual selectionist explanations of natural purposiveness – despite the *commonality* of structure exhibited by organisms over morphological difference.

On the systems view, it becomes possible to conceive of the effect of a biological token as a function without there being any design whatsoever in the production of that effect, even though there is, concurrently, significant interspecies morphological *particularity*. Pre-ontogenetic factors comprise intrinsic determinants on morphological change in adaptive structures. Thus looking upon the historical contribution of a function bearer as a step in the causal explanation for its typical presence actually

---

[223] Sometimes a trait no longer performs the effect for which it was selected; rather, it is maintained for different beneficial consequences it may bring. However it is then only the case that the presence of *T* was not always explicable in terms of selection for *e*.

explains the intergenerational structural conservation typical of function-bearing systems, and provides a means of conceiving the normative necessity that is essentially involved in function attribution.

The systems view also discounts the design evident in the mediating of the causal influence of functions and systemic processes by the system itself. As we have seen, any account which – in trying to render a functional analysis of a part of a biological structure (whether it is a gene, tissue or indeed, organism) as a discrete Darwinian actor – ignores holistic causes, and thereby, neglects factors that that affect gene expression and phenotypic instantiation in general. So to underscore the empirical fault which we have already been discussing, such an account will be guilty of an error of reasoning Gould terms "bookkeeping".[224] Gene-centric theorists, for instance, who limit all evolutionary explanation to that of the gene, credit a narrow reductionist approach, and in so doing, mistake replicators, or the transmitters of evolutionary information, for interactors themselves. An interactor is a unit of natural selection because it relates to an environment, enabling differential reproduction. But the relationship of genes to the environment is mediated through larger entities like organisms and species: it is the products of these interactions which are selected for or against and therefore facilitate evolutionary outcomes. So although changes in gene frequencies within a population record the results of natural selection, interactors are in effect the sites of primary causal explanation. In eliding phenotypic constraints, the systems view is an extension of the propensity to bookkeep. It fails to identify the actors in the evolutionary mechanism as the relevant units of selection.[225]

Still, I agree that there are some insights to be borrowed from these opposing accounts. Like Kitcher, I think that Cummins' systems thesis is of value to the function debate.[226] Although the systems view does not in fact concern itself with systemic goals, what we perhaps ought to assimilate in Cummins' position is its emphasis on functional capacities or dispositions in the context of a *system.* We saw that even an etiological interpretation of function must include some reference to a system, the welfare of which is at stake.[227] Etiologically derived traits recall systemic welfare, meaning that function bearers will tend to replicate the system as a whole in replicating themselves. The significance of the working order of a containing system in an analysis of function suggests that, to begin with, we should favour what is sometimes described as a *weak* etiological theory. While a strong etiological theory calls attention to the contribution of a trait to the differential survival and reproduction of a distinct phenotype, a weak theory conceives the function of a trait as that effect which, in the past, contributed to its own

---

[224] York and Clark, *The Science and Humanism of Stephen Jay Gould*, p. 106.
[225] *Ibid.,* pp. 105 – 107.
[226] Kitcher, 'Function and Design'.
[227] McLaughlin, *What Functions Explain.*

reproduction *in* contributing to the fitness of its bearer irrespective of whether the phenotype was best adapted to its environment and therefore selected for. [228]

Indeed, if we should so wish, we could admit the contribution of the systems view even further. We might entertain the idea that function should be defined in part relative to its role in facilitating the capacities of a goal-orientated system. The use of such an analysis is that sometimes a trait may increase the reproductive fitness of the organism to which it belongs only indirectly, even though it features prominently in the activities of the larger system.[229] The function of gills in some adult salamanders, for instance, is to enable underwater breathing, albeit aquatic habitation is no longer to their immediate advantage, because gills continue to form part of the explanation of the amphibian's *capacity* to breathe underwater. Moreover, given that it does consider a functional analysis within the context of selection pressures, the systems view is superior to its dispositional rival.

But despite this, I maintain that the systems view is not as cogent a self-supporting examination of functional explanations as is the etiological interpretation. The doubtful differential reproductive value of functional traits is not even a strong criticism of the latter approach: in fact, we should not expect all the causal interactions in a biological system always to be in equilibrium with the environment to which they respond given the dialectical relationship between organism and environment. As I have argued, this interaction is not taken seriously by the systems thesis on account of the environment-centred perspective on evolution it assumes. The point is that a functional structure facilitates processes which are cumulatively rather than discretely organised to the organismal aim of meeting selection pressures. In respect of its reproductive value, it is a necessary and sufficient demand on purposive phenomena in nature that they contribute to systemic aims in this way.

What conceptually separates an etiological analysis from its competitors and curries it favour is that we want teleological statements to be a species of causal explanation for the presence and maintenance of function-bearing systems. Functional analysis is more than a merely metaphorical or heuristic description of a theory designed to explain a straightforward causal disposition.

But most of all, a backward-looking theory can account for the normative character of function statements. And, (to use Neander's terms) it is better for the project of functional analysis as a theoretical examination that we articulate a notion of function which can encompass both *pathological* and *interspecies* diversity.[230] A normative definition helps us to distinguish function from dysfunction in a causal analysis as well as to specify the conditions of health for a functional organ, trait or behaviour

---

[228] Garson, "Function and Teleology".
[229] Allen, Bekoff and Lauder, 'Introduction', pp. 9 – 10.
[230] Neander, 'Function as Selected Effects', pp. 328 – 329.

of which we know the recent evolutionary history and, to a certain extent, anticipate these even when we do not. Here selection is presupposed as the source of design, generating what Kitcher describes as "a hierarchy of ever more specific selection pressures", which are responsible for the general properties of the design of biological functional phenomena, as well as more fine-grained structural and functional transformation.[231]

An etiological interpretation is not without fault, however. The principal shortcoming articulated against the etiological theory in this thesis is that – to the extent to which functions are explained by a negative feedback mechanism – they remain exemplative of external purposiveness only.[232] Natural selection produces characters leading to intergenerational organismal benefit; yet it fails to explain how a function bearer can supply a causal etiology for present trait reproduction. Organic structures are also perceived as natural purposes inasmuch as they behave so as constantly to preserve and replace themselves in contributing to the reproduction of the systems to which they belong. It is for this reason that an etiological explanation must include an analysis of the causal role of the function bearer in the present welfare of the organism.

Now in itself, the fact that function statements presuppose overall continuity of a developmental complex over time does not have precise implications for the causal mechanisms involved in regulating interactants in the system; nevertheless, there are facts about function bearing in a complex of relations which indicate that a self-reproducing system cannot be interpreted purely in terms of discrete design sources. First, a holistic cause is required to alleviate the underdetermination of biological systems made apparent in the unity of purpose presented by a complex of functional phenomena. This causal relation is an autonomous emergent property which is not identical with but prior to the properties of the parts. Thus the existence of biological function bearers is possible only because they are preceded, and surrounded, by a large functional goal-directed structural complexity. Second, a self-reproducing system, *S*, ought to be said to embody internally-motivating interests of the kind that would confer moral distinctness upon it, insofar as it must constitute, not only a benefit – but a recipient of benefit. As McLaughlin contends, function attributions are ultimately founded in this fact that biological organisms have their own good, meaning that they can be the recipients of the value conferred by the effects of their own, or their parent's, function bearers.[233] Therefore, selection as a mechanism of design does not obviate the need for teleological causation in defining function in a biological context; on the contrary, the necessary simplicity and value of the cause of a self-constituting structure entails it.

---

[231] Kitcher, 'Function and Design', pp. 493 – 494.

[232] McLaughlin, *What Functions Explain.*

[233] *Ibid.*, pp. 210 - 212.

At this point, some theorists may want to separate out design from the analysis, arguing that it is contingent to the causal powers involved; however, without it, there is no hope of a normative notion of function, and therefore also, without it, no value internal to the larger system attendant upon a function. The definition of function is necessarily historical because it is only by reference to the contingent goals of evolution that there can be said to be phylogenetic determinants of the functional components unified through the individual phenotype. Natural external design supports the presence of internal norms for phenotypes - - without exhausting a causal account of order in systems. Hence the dearth of intrinsic value in biology is resolved by design adduced by the operation of natural selection: a biological entity has an internal *telos* that arises from its form, the latter being – in a time and place at least – directly normatively constituted by the superior fitness of its phenotypic expression over the fitness of alternatives. It is through the contingent constraints which lie in the external conditions under which trait propagation takes place that the goal-directed activity of a natural system occurs and the system as a whole can act as an environmental mediator, thus normatively constituting itself in its own likeness by way of the environment. There is, to be sure, a suggestion that the part played by biological functions in enabling complex systems to adapt is still not well understood by scientists, as is the way in which natural selection can bring about systems displaying self-organisation. Nevertheless, any descriptive approach to teleological explanations disbars external final causes, normativity, and is therefore mistakenly value-neutral. So do etiological approaches which do not expressly link design to the constitution of a whole with emergent properties.

The importance of its history in explaining a trait's function is well summated by Lauder:

> *The problem of biological design is fundamentally a historical one. Without an understanding of the past history of organisms, there is little hope of effectively analyzing the relationship between form and function and the interaction between organisms and the environment. The past constrains and determines future directions of structural change and organisms carry with them, through the retention of primitive characters, a record of their past history.*[234]

Hence to claim that the function of a trait *T* is effect *e*, it is necessary and close to sufficient[235] that:

(a) *T* (which is a part or trait of *S*) is there because it does *e* (and *e* has in the recent past, and continues in the present to, directly or indirectly, maintain(ed) *S*), and

(b) *e* is a result (via *S*) of *T*'s being there[236].

---

[234] Lauder, 'Historical Biology and the Problem of Design', p. 514.

[235] This is a phrase I take verbatim from Millikan and it reflects that the aim of a theoretical definition is not to provide an analysis free from conceptual exception.

There are two levels on which this definition is to be comprehended. The first is in the case that '*e* has in the recent past directly or indirectly maintained *S*'. In this instance, the definition involves a distinction between trait tokens and types. This means that the formulation is a variant of the standard causal explanation given by an etiological analysis, in which a trait can – in performing an effect selected as a function in light of its resultant advantage – provide a of causal explanation for its typical occurrence, that is, for its presence in the progeny of the bearer.

However, in the case that '*e* continues in the present to directly or indirectly maintain *S*', the analysis represents a fundamentally different kind of causal account (rather than a minimal conceptual refinement to traditional etiology). Here, the analysis cannot be reliant upon token/type substitution, so functional explanation as a causal explanation in this sense entails that a function-bearer has somehow to be genuinely self-caused. The relation between a functional means and a systemic end is induced by internal teleological necessity. By benefiting S, *e* explains why, where and what a phenotypic trait *T* with an effect, *e*, is. *e* is in turn a functional effect of *T* because *e* is causally connected to *T* by *S*. That is, the direct effect of the trait determines the token's existence. And it can only do so insofar as the system precedes its effects. Hence the attribution of function to *e* explains the existence of *T* by means of an explanatory appeal to an ontologically distinct whole *S*, which has the normative character of both a formal and a final cause for the function bearer. *e* is related on causal grounds to *T* through *S* in that, its part, *T,* is both normatively and structurally constrained by the internal *telos* that arises from *S* as a material system, as designed, contingent natural product. The individual system is imperative to this latter formulation. It is a causal interactant which is suggested to impart both a structural and moralistic value to a function-bearing constituent to the extent that the system is normatively constituted towards self-reproduction.

4.2 Objections

Admittedly, there is still some empirical difficulty with the etiological approach. Nonetheless, Lauder quells this objection by arguing that the extent of the trouble might be exaggerated. The criticism that it is rarely available to us to test evolutionary hypotheses is usually levelled of the etiological thesis by the fields of functional morphology. As such, the demand of analysing historical hypotheses by means of unique structures or functions is overstated, since function is regularly defined in these disciplines apart

---

[236] I acknowledge that development requires some proximate conditions, but these are those that are roughly continuous with what the organism's ancestral environments, and can be expected to remain relatively constant over a short time period.

from both the environmental patterns and internal properties that bear upon groups of organisms. But in truth, the upshot of these causal factors is that patterns of morphological production are rarely unique.[237] It is true that assuming analogous etiologies might direct us to attribute proper function when, in fact, there is none; still it is not the object of a theoretical definition to resist all conceivable counter-examples.[238]

There is however a pertinent lingering objection of the etiological analysis yet to be considered. Many philosophers have remained sceptical of the proposal that natural selection can supply causal histories of biological phenomena. Detractors of the etiological view usually present some variant of the argument that it is random mutation which is behind genetic mutation, and hence it is mutation which effects the emergence of naturally occurring structures. Prominent critics Cummins and Nagel therefore insist that, in arguing from a functional effect to the presence of a function bearer, the interjection of a premise involving the operation of selection is premature.[239] Even the sympathetic Kitcher concedes that the tendency for *T* to reproduce *e* may not fully explain the existence of *T* if it is needful to consider the fitness of rival possibilities to the entity, *T*, whose presence is *prima facie* due to selection.[240]

My own opinion is that, before engaging in a debate about the theoretical optimality of functional entities, we ought to take greater cognisance of the Kantian separation of our knowledge of "empirically cognisable nature" (which is considered to be objectively real by Kant) from those concepts which, though perhaps determinative of the use of our cognitive faculties, are logically extraneous to it – that is, the super-sensible.[241] Kant thought that the concept of an original creative cause of nature to explain the purposiveness we perceive therein can in no way be a principle internal to natural science because this would open science in its foundations to the uncertainty which circularity brings. In providing a causal explanation of a purposive body by naming its proper function, it must then be that we are supplying an account of its organisation, rather than the principle of its possibility.[242] Notice that the causal explanation for a trait, *T*, imparted by a functional explanation is not a proffered explanation of why *T* of effect, *e*, came into being *at all*. The former is an explanation of origin limited to available phenotypes and it is formulable by appeal to the evolutionary patterns which non-intentionally produce phenotypic variation and allow for adaptation via the exercise of a function bearer.[243] In fact, whatever the super-sensible ground of a function bearer may be is (to quote Kant) "of no avail for dogmatic

---

[237] Lauder, 'Historical Biology and the Problem of Design', p. 516.
[238] Millikan, 'In Defense of Proper Functions', pp. 298 – 299.
[239] Cummins, 'Functional Analysis', pp. 176 – 179.
[240] Option X is theoretically sub-optimal according to Kitcher because of the possibility of superior mutants not yet arisen.
[241] Kant, *Critique of Judgment*, p. 139.
[242] *Ibid.*, pp. 127 – 132.
[243] Dobzhansky cited in Nagel, 'Functional Explanations in Biology'.

determinations" since it does not belong to its natural explanation.[244] To expect evolutionary theory to impart complete ontological explanations is to make a presumption on the externally purposive references of the natural world, or its potential final purpose for an external agent, to which knowledge the naturalist is not entitled on the basis of observable teleological phenomena. We can explain the existence of an entity according to our judgment of it as a natural purpose, but if we ask if its presence is a *purpose of nature* (with reference to a larger external purpose), we have to look beyond what Kant calls the physico-teleological view of the natural world.[245] And modern biology is just not amenable to supernaturalism in this way. Evolution refers to change in the phenotypes of a population *simpliciter*.[246]

Therefore it is perfectly legitimate to argue for an explanation of the presence of a functional structure by appeal to what it does because the explanatory role of function requisite for evidence of design is one of creative or differential selection. If its existence is to be genuinely initiated by response to selective pressure, it merely needs to be the case that environmental demands can be invoked to explain ultimately and proximately the presence of the functional item which strives in its various expressions to meet it. For without the conditions hospitable to its physiognomic profile, a genotype will as much dissipate by accident as it has arisen by such. All the etiologist need do to accommodate the objection is to weaken the conditions governing function attributions so that a purpose (of *T*) is defined relative to a forward orientated cause (*T* does *e*) that is in effect a cause constrained by the genuine evolutionary possibilities which colour the history of the functional trait in question. Hence the genetic variance that furnishes a natural selective process does not have to originate therein in order for resultant phenotypes to count as designed, even as, in the analogue of the mortal artificer, the causal ground of the substances upon which the clockmaker works is not central to his agency with respect to the final product. In his seminal discussion on evolution propelled by natural selection, Dobzhansky writes: "Natural selection is at one and the same time a blind and a creative process."[247] Blind, because there is an indiscriminate abundance of life forms; and it is creative, in its exploitation of genetic mutations to the almost inexhaustible range of environmental opportunities in the natural world.[248]

Indeed the notion of design in the organisation of biological functional types stands complete as a naturalistic explanation of the presence of functional phenomena since – as Bedau iterates – the etiological thesis as a form of value analysis need not entail that nature gives an explanatory role to value.[249] Again, value plays an inessential role within the explanation supplied by selection because the

---

[244] Nagel, 'Functional Explanations in Biology', p. 140.
[245] Kant, *Critique of Judgment*, pp. 127 – 128.
[246] In the traditional neo-Darwinian framework, evolution is characterised as the distribution of genes in a population. I take an alternative developmental systems approach to evolution in this thesis.
[247] Dobzhansky, 'Nothing in Biology Makes Sense except in the Light of Evolution', p. 126.
[248] *Ibid.,* pp. 126 – 127.
[249] Bedau, 'Where's the Good in Teleology?', p. 284.

predominance of certain traits in a population is not to be explained by their intrinsic goodness, but by their beneficial consequences.[250] Thus natural selection yields restricted causal explanations, given the assumption of certain background conditions, a time period over which a trait is viable under selection for habituation to those conditions, *and*, (as has become clear) certain features of the biological system, which, in turn, limit the natural world with which a structure causally interacts.[251]

It is certainly the case that Kant never foresaw the possibility of a Darwin. He did not rule out the possibility for *any* Understanding – but given that he considered it beyond human powers to cognise the unity and agreement in the organisation of the parts of a natural body without also allowing that the unity is its constituting ground, he thought that "... it is absurd for men to make any such attempt or to hope that another Newton will arise in the future, who shall make comprehensible by us the production of a blade of grass according to natural laws which no design has ordered".[252] But Darwin, to an extent, proved differently. Even if the supreme cause of natural purposes must be sought in the 'hidden' substrate of the world, it seems that – contra Kant – empirically cognisable nature for us can itself generate explanatory grounds for purposive combinations. Hence, in order to maintain our judgments of their designed production, it is not necessary that we judge explicitly the immediate determining ground of goal-orientated biological systems to be an intelligent Being as Original Creator of the world, for a blind mechanism in fact supplies this physical explanation just as well.[253] Natural selection can explain how and why function bearers exist as designed products.

However regarding our objective knowledge of purposive phenomena – as McLaughlin puts it: "Does natural selection as such get [one] all the teleology [one] need[s] for a naturalistic interpretation of functional explanation?"[254] Naturalistic reconstructions of functional statements express confidence that an appeal to natural selection rids an organic structure of the aspect of a different ground of production by locating its determining cause in the mechanism of nature. So for me, this further question asks whether Darwinism reconciles satisfactorily the concept of a biological individual, as a system which remains identical to itself through general metabolic reproduction, with the laws of mechanism, or whether Kant's critique of the modern naturalist indeed cuts deeper – prompting us to declare the impossibility for the determinant judgment of a unification of mechanistic and purposive organisation in observable nature. The fundamental business upon which Darwinism here encroaches then is metaphysical. The challenge posed to naturalism is thus whether the philosophical position of

---

[250] Bedau, 'Where's the Good in Teleology?', pp. 281 – 282.
[251] Kitcher, 'Function and Design', pp. 482 – 485.
[252] Kant, *Critique of Judgment*, p. 142.
[253] *Ibid.*, pp. 141 – 142.
[254] McLaughlin, *What Functions Explain*, p. 103.

mechanism has sufficient metaphysical reach as a probabilistic resource for function attribution. And as Dennett reminds us, the philosophical implications of Darwinism are of great importance. A natural theory inevitably brings with it philosophical prejudices that open – or indeed close – the door on scientific findings.[255]

I have argued that I am a strong proponent of an etiological approach to examining function; yet how my position differs from that of etiological theorists like Kitcher, Wright and Neander is that I argue that biological functional claims unavoidably invoke Aristotle's real side of teleological causation, and I hence insist on its place alongside mechanism in science as a form of causal explanation. Indeed, reflection on the operation of selection gives us more, and not less, reason to insist upon a holistic rather than a reductionist ideal in explanation – and not just in description. Although it is possible to go some way towards explaining functional entities as designed products, non-intentionally selected for their prolificity in terms of blind mechanism, it appears that 'built-in' teleology is still needed to legitimate the biologist's use of a teleological vocabulary. Natural selection in itself does not legitimate function.

Any plausible naturalistic analysis of function must also account for how the internal teleology biological structures appear to instantiate can be made in accordance with mechanistic production. This is the really problematic type of teleological explanation. On this latter score, my conclusion is that one is more or less stuck with a non-reducible appeal to teleological causation. Today, it is clear that Kant is mistaken that the unity of the ground of the combination in natural products of various elements has to be placed in the understanding of a simple substance, rather than in matter, as producing cause. But still he is correct that this cause cannot be an aggregate of many substances external to one another. In truth Kant remains helpful to the problem of conceptualising biological purposiveness naturalistically, even though he suggests at times that the difficulty is one of an insufficiency of understanding, and that therefore (in theory, at least) the teleological principle may dissolve into causal mechanism.[256]

In order to show that the internal causal relation governing self-reproduction in a system can be construed mechanistically, one would have to be able to explain how the normativity associated with the system as an end towards which its function-bearers are specified as contributory of, and beneficial for, can be present in the system parts. And this cannot be done. It is the specific form and character of the system characterised teleologically which restores the unity of its internal principle.[257] Thus functional explanations of biological phenomena only make sense on the metaphysical assumption of a system as a preceding cause. At each moment, it must be that the mature organism is the cause of the properties and interactions of its parts. And this means that we are not compelled to follow Kant in his

---

[255] Dennett, *Darwin's Dangerous Idea*, p. 11.
[256] *Ibid.*, pp. 133 – 134.
[257] Kant, *Critique of Judgment*, pp. 154 – 155.

heuristic simulation of non-intentional teleology, given that there is genuine reason to suppose that our functional knowledge involves more than mere obligation to *think* of the existence of biological entities by means of a purposive principle. There has actually to be in a determinate way a cause which has the representation of a purpose as the explanatory ground of natural products.[258] Functional explanations of organs, traits and behaviours presuppose the self-formative power of the living things of which they are part, through which power their effects are organised and given identity, and which hence mediates the feedback processes which enable functional entities to contribute to their own causal histories.

After considering alternatives, this remains the most viable theory of what functions explain. No description of function will stand in for a causal explanation in terms of teleology. Undeniably, this is an intuitively obvious and (almost) Aristotelian explanation of biological function – and one which flies in the face of accepted materialism.[259] But it is not the reference in teleological statements to value *per se* which is naturalistically problematic.[260] Inner purposiveness is distinguished from the external sort in that good producing processes are an integral part of a real end or normative state, and this is the material whole itself.[261] I do not consider an explanatory appeal to *evaluative* causes is metaphysically costly, inasmuch as I take internal final causes to be derivable from internal formal causes. The trouble is instead that the etiological analysis is successful in reconstructing a productive concept of function only with the sacrifice of admitting that *holistic* causality cannot be ejected from functional explanations. Consequently biologists, and indeed, sociologists, must reconcile themselves to genuine teleology, or else, attempt the dubious task of functional eliminativism.

As we have seen, holistic causes are metaphysically challenging for the reason that the causal explanation for the function bearer preserves a reference to a present effect of that trait, entailing that there is violation of the standard temporal order of causation. If the anti-reductionist is correct that causation can run from the emergent powers of a material biological system downwards, then it looks like mechanistic or reductionistic explanation of organisms is impossible. So, adopting an explanatory strategy which relies upon the emergent character of systems is a substantial metaphysical thesis, which I admit will require further defence. Therefore, in the final chapter which follows, I undertake to argue that while scientific reductionism represents a deeply compelling metaphysics for epistemic agents like us, emergentism in biology is likely to be true. I also attempt to give a description of how a robust physicalism can be coherently combined with the rejection of mechanistic reductionism. Thus, conceding a metaphysical commitment to a cause which is a purpose need not be unduly expensive for the modern naturalist because teleological discourse need not demand commitment to causation which

---

[258] Kant, *Critique of Judgment*, pp. 144 – 145.
[259] McLaughlin, *What Functions Explain*, p. 211.
[260] Bedau, 'Where's the Good in Teleology?', p. 284.
[261] *Ibid.*

is supernatural or *sui generis* in character, for it to be different in kind, or to warrant new explanation. Chapter 5 suggests what a viable theory of anti-reductionism and naturalism might look like.

5. Anti-Reductionism and Naturalism

In the last chapter of this thesis, I take up, and attempt to resolve, the problem posed by the holistic causal relations contained in my suggested formulation of functional explanation. The initial assumption of the discussion below is the premise that value in biology involves a particular kind of welfare which requires no special defence. The value attached to Aristotelian-type final causes is dissimilar from our standard agential conception of value; it has, in fact, nothing to do with human valuation.[262] Welfare interests apply objectively to biological individuals in that something can be good or bad for the individual, depending on whether it benefits it *qua* biological system. So, moralistic value in nature is founded in the identity condition of a biological system, and this lies just in the system's self-renewal as the same individual by means of self-reproduction. This kind of value is a naturalistic property because it can be construed entirely in terms of the characteristic goal of the system, that is, the reproduction of a phenotypic expression of its ancestral genomic structure. Therefore, in defending the metaphysical underpinnings of my analysis, my focus is instead on top-down causation and the impetus behind theoretical resistance to this we find in mainstream philosophy of science.

I began my thesis by arguing that the contention of Kantian metaphysics is that mechanism is not a transcendental causal law, meaning that a constitutive mechanistic maxim is not a necessary part of a successful theory of science. Given the principle of causal determinism and the fundamental powers of matter, the maxim of mechanism is an assumption required for empirical investigation, which allows for unification of our experiences into a schematic whole. So, significant as mechanism is, its claims stem from creating systemic connection and coherence of our empirical concepts, and not from logical necessity. Though it seems that human reason must concede causal determinism *a priori*, holism is another matter altogether. I have also motioned towards the shape which the holism debate assumes today, which is one between proliferation and unification of scientific theory. Thus far, I have argued that the mechanistic imperative is justifiably undermined by an in-principle argument for the irreducibility of biological functional explanations. But is there a positive argument with which to support the physicalist grounds of downward causation? This is where I pick up on the subject again now.

Holism is an approach which brings to the fore questions about the nature of explanation. It is an anti-reductionist position, and therefore it emphasises the autonomy of the diverse types of scientific representation, explanation and methods of study, and the explanations to which they give rise - rather than any contraction of such views. Anti-reductionism itself denies the ultimate desirability of adopting a single scientific theory.[263] And it has found fertile ground in the biological domain especially, where the

---

[262] Mclaughlin, *What Functions Explain*.

[263] Sandra D. Mitchell, *Biological Complexity and Integrative Pluralism* (Cambridge, 2003).

significance of explaining biological phenomena in terms of biological predicates is frequently urged. The arguments favoured by biologists as well as philosophers of science for the autonomy of the separate biological traditions, both from each other and from the so-called fundamental sciences, often turn on the idea that explanations in biology, sometimes even at the genic level, involve an unavoidable and irreducible appeal to the theory of natural selection. Others are based in the claim that there are in principle obstacles to analysing some biological structures into molecular processes. If it is in fact the case that appeal to a higher-level of organisation is necessary to models of organismal function, then it seems that reduction of biological facts is impossible. Given that my concern is the underdetermination of a function-bearing system by its constituents, the latter strategy is clearly the one with which I shall be concerned, arguing for top-down or downward causation (that is, the ability of wholes to causally impact their lower-level parts).

I suggest two theoretical reasons to think that working biologists should continue under an anti-reductionistic assumption: the first concerns emergentism, and is suggested by proximal underdetermination of a living entity by its supervenient base; and the second relates to the role of contingency in biology. My purpose is to argue that the systems studied by the biological sciences exhibit novel causal properties, allowing for generalisations at higher levels which cannot be predicted in terms of the causal properties of parts. Reductionism can describe the laws regulating the parts of a complex structure, but it cannot supply an adequate higher-level explanation because of the central place of interactions among lower-level constituents to its construction and continuance. It follows from the prominent place of emergent properties in higher-level explanation that higher levels of organisation must be described in their own terms.[264]

Furthermore, the metaphysics involved in the thesis that biological concepts and properties comprise a particular kind of irreducible province is naturalistically acceptable, it being case that everything is realised by physical events. This is all that commitment to naturalism on a realisation physicalism model demands. Consequently, anti-reductionism is a viable physicalist position.

But first, I turn the matter of what is reductionism and why it is of issue in the philosophy of science.

5.1 Reductionism versus Anti-reductionism

The reductionism debate relies upon the doctrine that all investigable entities are organised into a hierarchy of scientific domains. Now whether or not there indeed exist objective divides across nature

---

[264] York and Clark, *The Science and Humanism of Stephen Jay Gould*, pp. 99 – 100.

which can be captured empirically, most scientists and philosophers accept the claim that it is useful to analyse the workings of nature in terms of levels of at least relative ontological status, each of which comprises the appropriate province of study for different sciences. So far as the explanation of a single animal is concerned for instance, we might say that there basic facts at the bottom level of the sort which chemistry and physically currently allow, moving up from sub-atomic particles, through to atoms and molecules, to such objects of research by the biological sciences such as cells, tissues and organs, and culminating in the in the top-level system that is the whole organism. Reductionism and anti-reductionism are terms used to refer to various views about the relationship between the branches of scientific knowledge and how we can expect these to develop.

At its core, reductionism involves a methodological claim and an ontological claim. Claims about methodological reduction are epistemic in nature. In the methodological sense, the reductionist contention is that the universe can be understood entirely in terms of the properties and causal capacities of the most fundamental physical particles. The ontological claim is that those things which are a subject for higher-level theories like biology are determined by the entities studied by lower-level theories such as chemistry and physics. While modern views like that suggested by Jaegwon Kim favour a more robust interpretation of reductionism, I follow thinkers like Nagel and Harold Kincaid in the view that reductionism rests fundamentally upon claims about theory reduction, or what is often described as deductive derivation of the laws of a *reduced* theory to a *reducing* theory. Theory reduction is just the idea that the predicates of one scientific discipline can do the explanatory work of all others. In addition, if there are among the statements of the reduced theory expressions which are not included in the statement set of the reducing theory, the reductionist asks us to accept that the content of the reducing theory may be augmented with extra premises, or so-called 'bridge principles', which then connect the vocabulary of the two theories.[265] Kincaid favours this characterisation of reduction on the grounds that there cannot be ontological reduction of a discipline like functional biology, if there is insufficient reason to think that molecular biology can explain at least what is explained by functional biology -- if not more besides.[266] To do so, the reducing theory must be able in principle to capture the basic concepts, categories and generalisations identified by the reduced theory.

In the case of biology, a significant number of scientists weigh in on the side of reductionism - - and not without good cause. To start with, the implicit but still highly pervasive form of physicalism assumed by many scientists is that theories and generalisations at any special-scientific level, well as the explanations into which they enter, are fixed by physical mechanisms, the description of which is ultimately explanatory of them. Much of the source of reductionism's appeal derives from an inductive

---

[265] Kitcher, '1953 and all that: a Tale of Two Sciences', p. 214.

[266] Kitcher, 'Function and Design'.

argument. Usually, reductionist theorists stake their claim on the strength of purported past successes in reducing all of science to physics. Reductionists extrapolate from the intertheoretical relations demonstrated in paradigmatic examples from physics, to the relationship between classical genetics and molecular biology. It is inferred on the basis of similarities between these relationships that the latter is also reductionist in character. And indeed, it must be said that there are major ways in which molecular biology has transformed our understanding of hereditary phenomena.[267] Celebrated achievements of molecular genetics, including recognition of the structure of DNA, accounting for gene replication, transcription and translation as well as the study of gene regulation, have served to answer questions otherwise inadequately resolved by classical geneticists.[268] But despite the dubious status of the history of purported scientific reductions,[269] the success of modern science is regarded as lending factual support to physical monism as a bulwark against supernaturalism. Because unity is regarded as a desirable meta-theoretical goal in science, it has been argued by philosophers like Oppenheim, Putnam and John Dupré that the most viable means of attaining an ideal science is to be had through cumulative micro-reductionism.[270] The reductionist narrative that progress in the biological sciences is attributable to the embrace of a mechanistic worldview is undergirded by its deliberate dissociation of long-standing ties to metaphysical views like vitalism and teleology and the nonmaterial forces which so many of its nineteenth century adherents defended. Still today, when anti-reductionists say that living things are not just complex aggregations of physical things, but that biological facts are distinct in kind from physical facts, biology appears perilously close to courting supernaturalism.

Conversely, amongst anti-reductionists, many of whom are philosophers of science, it is thought that the facts of the special-sciences cannot be completed and corrected by supplementation of more fundamental predicates because they are explanatorily adequate and, indeed, in an important sense, prior. If we consider Watson and Cricks' discovery of the structure and function of DNA for example, attempts by reductionists to provide a criterion for connecting Mendelian or functional genes and macromolecular genes have remained unfruitful. Whatever one's concept of reductionism, it cannot be claimed that classical genetics has been reduced to molecular genetics.[271]

---

[267] Kitcher, '1953 and all that: a Tale of Two Sciences', pp. 222 – 225.

[268] *Ibid.,* p. 213.

[269] There is debate around the success of reductionism in even physics. The reduction of Galileo's law to Newtonian mechanics and of ideal gas laws to the kinetic theory can only be effected if the laws of the reduced theory are deduced from a modified version of the reducing theory, supplemented with the relevant bridge-principles. See Kincaid, Individualism and the Unity of Science.

[270] John Dupré in particular argues persuasively that the proposal of a unity of scientific content thesis represents a more plausible conception of scientific unity than a unity of scientific method thesis. See John Dupré, *Processes of Life: Essays in the Philosophy of Biology* (Oxford, 2012).

[271] Kitcher, '1953 and all that: a Tale of Two Sciences', pp. 214-215.

But furthermore, anti-reductionists have subsequently argued that the requisite link for successful reduction of the biological sciences cannot – as a fundamental precept – be identified, since individuation of types in biology is blind to physical differences. Accordingly, the relationship of functional genes to polynucleotide molecules is through multiple realisation - - a phenomenon towards which I have already intimated. Biological functions are all environmentally propitious effects and so adaptations of similar effects can be structurally diverse, given that the unit of natural selection is effect, rather than molecular structure. This means that a given Mendelian or classical gene cannot be exclusively identified with one single macromolecular gene or, indeed, any finite set of macromolecular genes. For example, Mendelian genes can generally be said to consist in segments of DNA. However, from the molecular standpoint, genes do not share any common structural properties, and are thus not distinguishable; neither as segments of DNA containing specific numbers of nucleotide pairs; nor in terms of the segments of DNA found between the successive codons[272] that initiate and terminate gene transcription. First, while genes come in various sizes, there will always be segments of DNA for any given segment length that are not in fact genes. The second criterion also fails since not all genes are transcribed in mRNA all of the time.[273] But perhaps more significant is the argument that bridge principles for the linking of the vocabulary of classical genetics to that of molecular biology cannot be generated *even if* the reductionist identifies a given Mendelian gene with the disjunction of all the actual ways DNA sequences presently realise it, or have realised it in the past. Were it, for instance, possible to give a molecular specification of the functional haemoglobin gene by enumerating finite genes and disjoining the molecular descriptions of their structures, this disjunction would still not suffice to a macromolecular definition of the haemoglobin gene because there remain indefinitely many possible ways to constitute a haemoglobin protein. So, in other words, even if it were possible to deduce a putative principle of classical genetics by using an enumerative criterion of connectibility, the principle would not be satisfied in every case. Principles must sustain counterfactuals. Since no derivation from supplementary premises – combined with the concepts, categories and generalisations of molecular biology – could be exhaustive of the biological alternatives evolution could produce, it would still not be the case that the functional principle had been reduced.[274] Therefore there are no-bridge principles with respect to Mendelian genes and molecular genes forthcoming.

Anti-reductionists have hence drawn the conclusion that there are impassable obstacles to be found in the theories of the biological sciences (and indeed to any possible future account of these theories) to the kind of identification of higher- with lower-facts (such as those of functional biology, for

---

[272] Triplets of nucleotides that together form a unit of genetic code. See Kitcher, '1953 and all that: a Tale of Two Sciences', p. 216.

[273] Kitcher, '1953 and all that: a Tale of Two Sciences', pp. 216 – 217.

[274] Rosenberg, 'Reductionism in Biology', pp. 551 – 553.

instance, with those of molecular biology) called for by intertheoretical reduction.[275] Most contemporary participants in the reductionist/anti-reductionist debate do not dispute a physicalist thesis, the main tenet of which consists in something like the claim that the most basic things that exist are of the kind which physics and chemistry allow, and that all else is composed thereof. But anti-reductionists diverge from their opponents in that they will deny that a minimal physicalism entails that biological facts just are constituted by physical ones. The positive anti-reductionist hypothesis is that there exist some generalisations at the level of functional biology which can be neither derived from, adequately explained by, further appeal to theories and generalisations outside of functional biology,[276] and that these generalisations are in themselves explanatory.

As I have already claimed, my preferred route for arguing against theory reduction in biology is by appeal to an ontological thesis of 'emergentism', insofar as downward causation can be said to imply causal efficaciousness of the higher-level properties of a complex system over its parts. Indeed I reserve doubts about reductionism's ability to overcome objections marshalled on the basis of multiple realisation, however, as I go on to explain, the greater import of this point to me is that even the most restricted species-specific reductionism fails to accommodate the possibilities raised for structural heterogeneity in animate phenomena, with the result that multiple realisation reveals a holistic causal principle in organic entities. So I am putting this aside for the moment, and turning to considerations in support of a thesis of causal underdetermination of a biological system by its components, such as requires top-down causation for its resolution.

The reductionist programme begins in the mereological premise of a relationship between a structure and its constituent parts of full causal determination of the former by the latter. Thus the Cartesian method of investigation proceeds from the principle that a complex whole, whether it is an organism or a cell, can be explained by analysing the properties of the parts forming it. Higher-levels of organisation are taken to represent an aggregate of the component powers because the assumption implicit in the method is that these are distinct objects which precede their connection with each other. It is this idea from whence stems the theoretical platitude that – in spite of the interaction of its parts – causation in a whole must in the end drain downwards. But although the reductionistic approach has been fundamental to many of the advances of science (like uncovering the properties of atoms) to quote Gould, "... a problem arises when we assume that the world is like the method, separate parts existing in static isolation".[277]

---

[275] Rosenberg, 'Reductionism in Biology', pp. 560 – 566.

[276] *Ibid.*, p. 554.

[277] York and Clark, *The Science and Humanism of Stephen Jay Gould*, p. 95.

I argue that when analysing biological causation, theory reduction cannot in principle succeed, first because emergent powers, arising in complex systems from the non-additive interactions between parts, play an essential explanatory role in systems whose features are the result of multiple causes; and second, for the reason that, given contingent histories, biological systems are evolutionarily explained, not by genetic blueprint in individuals, but at the higher-level, by means of the variability of higher-level features.[278]

5.2 Against Biological Reductionism

The first challenge to reductionism arises from the presence of emergent, higher-level traits in biology.

Roger Sperry famously argued for a universal principle of downward causation on the basis that it is not possible fully to predict or to explain the direction of a molecule unless the complex of which it forms part is known, since, that it is a component of something larger will shape its trajectory. In order better to see why macro-causation cannot be captured by a simple description of the causal properties of parts, consider that the fact that higher-level entities may have causal influence upon their lower-level counterparts purely by means of the individual connections of micro-structural properties is not a sufficient condition for explaining motion in the system of the sort which produces higher-level causal factors.[279] Helen Steward makes a similar point: particular micro-connections can constitute a necessary condition for the existence and causal efficacy of a whole system; nevertheless the existence of these basal conditions, or the arrangement of micro-particles into a system of the sort which produces higher-level causal factors, is not enough to explain why the effect of that configuration, as a whole, occurs at all. There are simply insufficient metaphysical resources to account for the higher-level properties of a thing on grounds of the provision of its instantaneous causal conditions.[280] It is assumed by the reductionist that once a particular complex of lower-level connections is in place, the existence of certain higher-level phenomena is guaranteed by the so-called thesis of supervenience. This is nevertheless a faulty assumption, based in fallaciously extending the causal conditions for immediate sufficiency of a whole, to those which can be considered sufficient as the final or total source of its effects [281] Philosophers often cite the concept of mereological supervenience, that is, an ontological relation in which the micro-structural properties of a system determine its upper-level ones, in order to argue that top-down causation is a non-starter. But if we are to ask how the causally

---

[278] York and Clark, *The Science and Humanism of Stephen Jay Gould,* p. 96.

[279] Sperry cited in Steward, *A Metaphysics for Freedom*.

[280] Steward, *A Metaphysics for Freedom*.

[281] *Ibid.*

proximal lower-level arrangements requisite for complex collective behaviour come about, it is clear that without a story about the higher-level, something is missing.

The conditions which provide for the emergence of biological entities are compositionally and dynamically complex, requiring the concurrence of a great many non-linear, interacting events in a specified time and space.[282] Such intricate configurations do not turn up at random. An account of the causes for proximal sufficiency of a biological structure going to have to explain the existence of the arrangement of physical and chemical processes into the coordination necessary to the total effects of the whole so formed. Hence the appropriate perspective from which to understand the elaboration relevant to the occurrence of higher-level phenomena is, in fact, the higher-level. The kind of causality at work must be one in which an organisation of micro-level units is produced because the material whole creates successive components which contribute to its supervenient base.[283] Sandra Mitchell uses the example of division of labour in social insect colonies to illustrate the essential explanatory role of the system in the ontogenesis of phenotypic characters: specialisation occurs spontaneously as a colony-level property among individuals who harbour mere genetic variation, insofar as they cohabit.[284] Just what is particular to biological structures is that we take them to orchestrate their movements into the patterns necessary for self-reproduction in this manner.

Now while models of self-organisation are used in biological practice to explain how individuals exhibiting simple behaviours can yield macroscopic structures of complex effects, such models are often characterised so as to avoid recourse to internalised complexity. Nevertheless, self-reproduction requires analysis in terms of the biological system as a genuine causal factor in its own ontogenesis. Thus in the strong sense of the whole itself as a prior existent, possessing a directive capacity, the properties of a biological structure cannot be reduced to those of its parts. The objects of functional and population biology create the boundary conditions for aggregate traits, such that lower-level theories cannot be said to have adequate explanatory potential for all things in the universe of biological discourse.

The second reason why theory reduction is unsuccessful arises from evolutionary complexity in biological phenomena. It is a matter of observation that contingent events proliferate as biological intricacy proceeds 'upward' towards animacy and further still toward systems of greater interaction and integration.[285] One easily recognisable reason for this is that evolutionary forces operate across multiple layers of biological organisation in the adaption of phenotypes. And because natural selection responds in different ways to variations, given environmental challenges, and across distinctive

---

[282] Steward, *A Metaphysics for Freedom*.
[283] *Ibid.*
[284] Sandra D. Mitchell, 'Integrative Pluralism', Biology and Philosophy, 17 (2002), pp. 50 – 70.
[285] York and Clark, *The Science and Humanism of Stephen Jay Gould*, p. 96.

phenotypic levels, contingency will have a growing role in higher-levels of complexity. So, if we examine the preontogenetic factors which account for the typical factors of a biological token, variability in phenotypes is significant in understanding how multiple adaptations can be brought to bear on the problems of survival and reproduction in a particular system.[286] The result is that higher-levels of complexity will be less amenable to reduction, given that evolutionary explanations for historically contingent, adaptive responses appeal to evolutionary factors present in interactants at complex levels of organisation.

These considerations show that there exist autonomous levels of biological explanation which reflect levels of organisation, rather than our mere cognitive limitations, given that we would fail to identify causally relevant, higher-level properties by attempting to derive the objects of study for the special sciences using explanatory patterns that deploy more fundamental concepts.

One chief reductionist objection is voiced by Kim, who argues that, if it is right that the physical parts of special tokens behave differently than they would if not constituent of a body, the existence of higher-level states or processes must necessitate violation of lower-level physical laws. However this objection is premature, first because it is not obvious that the laws of physics make no allowance for a change in physicochemical properties following a change of context.[287] Indeed, there is empirical reason to suppose that the physical influences on a molecule in a cell, for instance, as when regarded as distinct from physicochemical ones, initiate different molecular behaviour from that exemplified by molecules not so embedded.

Anti-reductionists sometimes demonstrate the argument for the plausibility of emergent higher-level properties in complex systems using Kauffman’s Boolean network. A Boolean network is a rule-based dynamic system, which models a set of molecular regulatory interactions, such as is found in a genome. Kauffman employs a crude simplification of the ways in which genes control the production of one another as binary variables, and then uses random Boolean networks to examine the behaviour of thousands of these elements when they are conjoined. In a Boolean network, each element responds to signals from others, which act as inputs to it. The model is run under different assumptions about the number of variables as well as the number of connections between these variables, and from this a ‘rule table’ can be calculated. Rule tables mimic the logic and structure of the genomic regulatory system. The dynamic behaviour of each binary element is dictated by a switching rule called a Boolean function. It is possible to compute how many Boolean functions can be assigned to any element in the network. The Boolean function specifies whether an element will be on or off at the next moment in

---

[286] Mitchell, ‘Integrative Pluralism’.

[287] Steward, *A Metaphysics for Freedom.*

response to all of the possible combinations of inputs it can receive from any subset of variables. Given some basic assumptions, the system will then produce various patterns of the state of variables, which can be classed into complex systems of statistically typical behaviours and structure.

To the credit of the anti-reductionist's argument, it turns out that, when the number of inputs per element is two – irrespective of the number of variables or the nature of the rule table governing the interactions in the set – random Boolean networks will exhibit spontaneous collective order. The pattern of dynamic behaviour of such systems undergoes short measurable cycles, showing stability to almost all minimal perturbations. We may say that random networks with two inputs per variable are characterised by homeostasis. They develop what Kauffman calls a "frozen core" of enmeshed elements that is ordered; still their behaviours converge toward the boundary between order and chaos. This intermediary quality means that networks on the edge of chaos have the capacity for complex coordination of activities. Another, third feature of such networks is the flexibility to adapt under the accretion of successive minor variations in the rule table, and to continue to reproduce, despite small changes, a system that is very similar. And as we might expect – given natural selection's bias towards adaptable systems – Kauffman found that genomic regularity systems exhibit a level of organisation comparable to networks on the boundary between order and chaos.

Thus, regarded as models of the genomic systems of plants, animals and bacteria, switching systems with "frozen percolating elements" meet many of the essential properties by which we describe living things in teleological discourse. Boolean networks moreover illustrate that biologically essential properties of organisms arise automatically from a set of simple interacting molecules (a phenomenon otherwise referred to by Kauffman as "order for free").[288] Stability, homeostasis and evolvability are higher-order properties belonging to the ordered set. Therefore, Boolean networks suggest that higher-level emergent properties can indeed be physical in arising from molecules bonded by relations purely of chemical synthesis, underwritten by regulation.[289]

Second, this concern over downward causation seems to emanate from the idea that laws expressible using purely the concepts of the physical sciences sufficiently dictate all things in the universe. As Steward points out, this begs the question of whether physical laws can sufficiently determine the entire set of outcomes, or indeed, the probabilities of all outcomes, in a given situation, when, as it is, there is insufficient theoretical reason to think that physical laws do more than constrain all things. In fact, according to Cartwright, such evidence as we do possess seems to support the claim

---

[288] Kauffman, 'Antichaos and Adaptation'.

[289] Alexander Rosenburg, 'Reductionism in Biology' in A Companion to the Philosophy of Biology, (eds.) Sahotra Sarkar and Anya Plutynski (Blackwell, 2008), p. 124.

that, far from the closed and ideal structure of laws which mechanics suggests to us, such principles as do describe our world may instead be fragmented into domains.[290]

Nevertheless, since naturalist philosophers deny that we must entertain supernatural powers to make sense of the causality of higher-level bodies, it must be that all the motions of larger biological structures upon such things as cells and molecules still fall within the bounds of physical description. The trouble that hence remains for anti-reductionists is that it is exceedingly difficult to explain how the autonomy claimed for the special-sciences is consistent with commitment to physicalism and the denial of extra-physical causality. A great empirical stride has certainly been achieved by Kauffman's models. Yet physicalism has remained notoriously difficult to define and much of the vagueness which vexes the doctrine stems from the problem of in what exactly the determining of higher-level facts by physical facts is supposed to subsist. In what follows, I detail a version of physicalism I take to accommodate downward causation: Andrew Melnyk's realisation physicalism. I will not be giving my reasons for endorsing realisation physicalism and rejecting traditional definitions, since this would take me too far off course (except inasmuch as to state that I think that the proponent of this view, Melnyk, is correct that realisation physicalism avoids many of the objectionable commitments in which its competitors are embroiled).[291] My purpose is the rather narrow one of articulating an anti-reductionist position in physicalist terms, and so what is required is not a defence of realisation physicalism *per se*, but instead an argument for how a coherent formulation of the physicalist thesis might turn out to support that position.

5.3 Realisation Physicalism

Melnyk outlines three accounts of the relationship among the many sciences and their domains, each of which attributes different meaning to the descriptive and metaphysical primacy of physics that is characteristic of the physicalist thesis. The canonical varieties of physicalism Melnyk distinguishes from his own formulation can in general be divided into those which claim that every particular entity and/or property countenanced by physics is identical with some particular physical thing (a view known as token-identity physicalism); and those according to which every fact expressible in the vocabulary of a science supervenes upon physical facts. The latter view, a kind of global supervenience physicalism, is most popular amongst philosophers. Instead, Melnyk's statement of physicalism appeals on empirical

---

[290] Steward, *A Metaphysics for Freedom*.

[291] See Andrew Melnyk, *A Physicalist Manifesto: Thoroughly Modern Materialism* (Cambridge, 2003) for two respective advantages of realisation physicalism.

grounds to the relation of realisation. And in rough terms, it can be expressed as the claim that all tokens, that is, particular objects, events and property instances, are either physical or physically realised, where the notion of realisation is explained by reference to functional types. And (given solely the distribution of physical properties and the laws of physics) a type F is functional when there is some condition C associated with F so that the existence of an F token is guaranteed if there some token, of another type T, which meets the associated condition for F, C. Thus to say that a token x realises a functional token y is to say that x is a token of a type that brings about conditions which give rise to the existence of y. An important proviso, stipulated to ensure that the holding of every instance of the regularity that a y token must be followed by an x token in case of the physical facts, is the assumption that, given contingent physical facts, all actual functional tokens are indeed physically realised.[292] This in effect rules out that the circumstances for physical realisation of biological by physical facts can be more than a matter of natural law.[293]

Melynk contends that physicalism thus expressed is unequivocally reductionist, for the reason that the in-principle derivability from propositions expressing physical facts of, first, every proposition asserting the existence of some, one actual token of the special sciences, and second, in the case of each regularity holding among special scientific tokens, every proposition asserting the holding of an instance of that regularity, amounts to the explainability of special scientific facts by charting physical facts. This he purports to do by arguing on an inductive basis that explainability as derivability suffices to the core mystery-dispelling sense of that term, and is indeed an explanatory model not unlike those frequently provided by scientists. It is pertinent to note that this derivation is not causal in character: all that realisation physicalism asserts is that the existence of every special- or honourary-scientific token is necessitated in the strongest possible sense by physical facts, for the reason that there is something, that is, a token of a physical type T, that is physically circumstanced such that its tokening gives rise to a functional token of type F. So if it happens to be a matter of physical fact that a token of type T obtains, that the appropriate historical and environmental conditions are in place, and that certain physical laws are given, it will be logically true that the conditions have been met for the existence of a token of type F. Hence, given a metaphysically necessary identity: that is, the tokening of F with the tokening of T, it is a metaphysical truth that there is an F token. This case can be readily generalised.[294] Therefore, according to realisation physicalism, the existence of every functional token is in principle derivable from physical facts.[295] The point is that Melnyk takes physicalism to entail commitment to

---

[292] Melnyk, *A Physicalist Manifesto*.

[293] Melnyk argues that a weaker formulation of physicalism cannot be satisfied by supervenience.

[294] Melnyk, *A Physicalist Manifesto*, pp. 88 – 90.

[295] Melnyk goes on to explain that every regularity holding among special- and honourary scientific tokens is derivable from physical facts and necessary truths. An F token exists and is followed by a G token because there is something, that is, a

reductionism on the assumption that derivability from particle physics can amount to an adequate explanation of the biological in the absence of information about causal ancestry.

But while it may be true that not every reductive explanation must be a causal explanation,[296] there is good reason to think that, in the context of biological phenomena, functional explanations must necessarily be causal in character. I argue that far from there being a reason to take an in-principle-derivability-as-explanation thesis as complete, a non-reductive causal explanation of an honourary-scientific or functional type claim is primarily explanatory because, unlike a reductive physical explanation, the former appeals to the relevant sort of facts. Thus, I claim that, even if bridge principles are forthcoming, and the possibility exists for exhibiting the derivation of putative biological laws from explanatory patterns deploying more fundamental concepts, this would nevertheless fail to explain such regularities. And therefore theory reduction would remain unsuccessful.

First, explanations in biology are, by nature, intended as robust answers to "why" questions about the functional status of biological structures, traits or behavioural strategies since identification in biology is primarily in terms of function.[297] And second, as we have seen, the indeterminacy of lower-level physicochemical units suggests that explicability, as far as the existence of such functional states goes, rests on a story involving higher-level causal factors.

Concerning the first desideratum upon explanation of a biological fact, recall Wright's argument that a statement individuating a biological structure must occur via the strong explanatory role we attribute to functional properties. Because a biological identity has to be delineated in separating out proper function from merely accidental effect, the identification of a biological token or a regularity holding amongst biological tokens must reference the evolutionary etiology, or in other words, imply a causal historical explanation for the presence of the token. This means that something can only constitute an explanation for the biological fact it describes if it alludes to an evolutionary-etiological reason for its obtaining.

A fortiori, an explanation of a biological fact is supposed to account for key factors relating to its existence as a configuration exhibiting a certain effect, which are invoked in one or more proposition(s) asserting the holding of an instance of a biological token or an instance of a regularity holding amongst biological tokens. This desideratum is also necessary to suffice to the demands of full explicability in the

---

physical token, that is physically circumstanced such that it necessitates, in the strongest possible physical sense, some other thing that gives rise to a G token.

[296] We can think about inanimate functional phenomena here.

[297] It is sometimes argued that defining biological categories functionally is not theoretically viable as these are in fact often defined in practice relative to internal structural and role in a complex system. Elsewhere, I argue however that functional identification makes for more fruitful theoretical usage of biological categories. Most significantly, structure and causal role contribution are not sufficient as biological identifiers in that they fail to differentiate adequately biological from non-biological systems.

biological context. So if it is right that the very fact of a system of the kind which produces certain higher-level causal factors depends upon an ineliminable assumption of the causally efficacious whole, a derivation from particle physics is not going to be completely explanatory of that fact, if there are no properties at the macromolecular level upon which to base that presupposition.

Consequently, what it is to explain a biological fact is to identify ‘a body of such and such an effect’ by explaining first, “why does it exist as a certain normatively identifiable body?”, as well as to explain its particular instantiation by answering a question something like “why does it efficiently exist as a body at all?”

It is clear that the alleged relationship between realisation physicalism and reductionism is unjustified, since derivation of biological facts based in inference from a physical fact does not meet the requirements upon an explanation as instantiated by a description in functional biology. Just in case one accepts the causal insufficiency of prior physical states in necessitating subsequent ones, the reduction of biological statements by way of explanation in terms of physical concepts, categories and generalisations is unsuccessful on a realisation physicalist formulation of physicalism – and even if one does not – there is reason to think that explanations for functional tokens must provide information about causal ancestry. Thus it does not constitute a satisfying explanation of a heart to state, as Melnyk does, “... there’s a swarm of physical particles there that plays the [heart] role, and all it takes for there to be a [heart] there is that something there should play the [heart] role” (Melnyk, 2003: 100-101). An adequate explanation of a heart is going to have to include both an ultimate explanation (consisting in factors operating over evolutionary time, which account for the typical factors of a biological token) and a proximal explanation, the former of which must occur via specification of the causal background of a heart, and, unless one accepts causal determination in the strictest sense, one which also supplies an immediate reason for the presence of a particular heart by invoking the holistic causal impact of the material heart. Given that physical realisers do not sufficiently cause the special-scientific tokens they realise, they do not, first and foremost, explain them. From this it follows that the in-principle derivability of regularities holding amongst biological tokens cannot amount to the explainability of such regularities purely by appeal to physical facts and necessary truths.

It is clear that the alleged relationship between realisation physicalism and reductionism is unjustified when it comes to the biological sciences, since derivation of biological facts based in inference from a physical fact does not meet the requirements upon an explanation as instantiated by a description in functional biology. Just in case one accepts the causal insufficiency of prior physical states in necessitating subsequent ones, the reduction of biological statements by way of explanation in terms of physical concepts, categories and generalisations is unsuccessful on a realisation physicalist formulation of physicalism – and even if one does not – there is reason to think that explanations for functional tokens must provide information about causal ancestry. Thus it does not constitute a satisfying explanation of a heart to state, as Melnyk does, "... there's a swarm of physical particles there that plays the [heart] role, and all it takes for there to be a [heart] there is that *something* there should play the [heart] role. An adequate explanation of a heart is going to have to include both an ultimate explanation (consisting in factors operating over evolutionary time, which account for the typical factors of a biological token) and a proximal explanation, the former of which must occur via specification of the causal background of a heart, and, unless one accepts causal determination in the strictest sense, one which also supplies an immediate reason for the presence of a particular heart by invoking the holistic causal impact of the material heart. Given that physical realisers do not sufficiently cause the special-scientific tokens they realise, they do not, first and foremost, explain them. From this it follows that the in-principle derivability of regularities holding amongst biological tokens cannot amount to the explainability of such regularities purely by appeal to physical facts and necessary truths.

5.4 Ultimate Explanations

But let us grant that a biological proximal explanation, citing the immediate genetic, phenotypic and environmental determinants for the presence of a particular body, can be provided for in terms of lower-level mechanisms alone. The reductionist can respond that even if an ultimate explanation (consisting in preontogenetic factors, operating over evolutionary time, which account for the typical factors of a biological token) plays an important explanatory role in biology, they are not necessary explanations, and, in fact, more closely resemble biological hypotheses which sustain counterfactuals.

Thus Rosenberg contends that the ultimate explanations provided for by functional biology are inadequate such that they must give way to proximate explanations, and that proximate explanations will in fact be statements of molecular processes. His argument is that an ultimate cytological answer to a question does not qualify as explanatorily complete because a full explanation must specify the determinate links in the causal chain relevant to the historical pattern it captures. So if it is the case that the ultimate explanations of functional biology are representative of what Rosenberg calls a "how-possibly" explanation, that is, an explanation which illuminates the biological pathways active in selection by pointing out counterfactual phenotypes, then a more complete explanation, or "why-necessary" explanation (one which identifies that an explanandum had to have occurred), must be macromolecular in form because the latter kind will specify the genic and biochemical pathway selection process.[298] The reductionist's molecular explanation adds to the historical facts together with the general principles of natural selection,[299] further putative explanatorily indispensible historical details (specifically, the genes determinative of the characteristics of evolutionary ancestors, and which are those genes upon which selection works), in order to fill in the missing links in the causal chain in an adaptational explanation. This reduction supposedly turns a how-possibly explanation of a higher-level biological fact into a why-necessary explanation.[300]

The trouble with this argument is that a macromolecular explanation – however important a part of the causal situation it might capture – cannot be necessary to the sufficiency of a purely functional ultimate explanation because it is only available *ex post* the original functional explanation. This is a fact glibly elided by Rosenberg's account. Even if the functional level is silent on the efficient processes along which natural selection moves to more advantageous adaptational strategies, functional explanations nevertheless identify the appropriate level at which selection for a functional type or phenotype is enacted. So given that biological facts are to be identified in terms of functional or Mendelian units, the efficient causes which undergird adaptational processes cannot denote explanatory regularities, but can only be considered detailed genic and biochemical itineraries of such contingent events as do, as a matter of the stock of functional facts, occur.

For instance, we can consider one of the only plausible contenders for a higher-level law in classical genetics: namely, Mendel's second general law of gene transmission, the aim of which is to determine frequencies for pairs of genes in gametes.[301] But were we to ask why, in a diploid organism producing haploid gametes, genes on nonhomologous chromosomes assort independently, the answer is cytological in nature. At meiosis, like genes on homologous chromosomes line up, and it is then possible for segments of homologous chromosomes to exchange some genetic material in a process called 'recombination'. Genes located in close proximity on the same chromosome will tend to be transmitted through the segregation of alleles into gametes together. But if the genes are on different chromosomes, one member of each recombinant pair goes to each gamete in meiotic division, and the Mendelian prediction is then that the probability of one member of a pair being distributed to a gamete is independent of the fact of transmission of a member of another pair to that gamete. Assuming that there are true general principles in classical genetics, the cytological account is completely adequate to

---

[298] Again, this distinction assumes a conception of phylogeny and ontogeny which can be said to fall prey to the phylogeny fallacy. It draws upon the idea that the field of questions to which proximate and ultimate approaches are suited are mutually exhaustive. I engage Rosenberg's argument without necessarily subscribing to this notion of the study of development.

[299] Rosenberg is fully aware that since a why-necessary ultimate explanation must still involve natural selection, the success of the reductionist account is contingent upon successful reduction of the law of natural selection.

[300] Alexander Rosenburg, 'Reductionism in Biology' in A Companion to the Philosophy of Biology, (eds.) Sahotra Sarkar and Anya Plutynski (Blackwell, 2008), pp. 559 – 561.

[301] This is Phillip Kitcher's example. My own argument is different to, although complimentary of, his.

explaining Mendel's second law. Knowing what chromosomes are made of would not strengthen our understanding of the basic transmission law. This argument complements Kitcher's claim: in potentially adducing a derivation of a putative biological law from principles of chemistry and one or more bridge principles, we obfuscate what is explanatorily relevant in the case by introducing extraneous molecular details.[302]

My argument for the primary explanatory force of the original functional narrative (which in this instance, is that genes on nonhomologous chromosomes are transmitted independently during meiotic division) comes from the fact that a particular sort of process, in which paired entities that enter into a relationship of exchange are separated and one member of each pair is distributed to a new, descendent entity, is identifiable as a distinct, causally relevant kind only from the cytological perspective. In the example given by Kitcher, it is the higher-level, rather than the macromolecular level, at which there exist properties delineated by selective pressures as primarily significant to a pairing and separation process, and therefore it is also the higher-level at which there are grounds for biological regularities (if such there be). A molecular derivation of the narrative would simply express implementation of this process by the distribution of certain genes on nonhomologous chromosomes to gametes. Consequently, the adequate explanation for why genes on nonhomologous chromosomes assort independently is the ultimate one of functional biology, which invokes evolutionary factors.

Now in response to my argument, Rosenberg would purport to cite a supposed regularity pertaining to homologous macromolecules: namely, that the alternative genetic mechanisms available in adaptation share the disjunctive property of causally realising a particular biological trait. But because homologous genes in themselves contain no reason to do such a thing, and thus lack a common physical explanatory factor, the fact that various genetic sequences might just share a disjunctive property is interesting, but it is in no way explanatory of that homology. It is facts about the adaptations clustered into the units that are phenotypic features which may explain any putative biological generalisations. For purposes of proximate explanation, a macromolecular explanation or even the disjunction of macromolecular accounts might be explanatorily invaluable in various ways, but it is not a replacement for the sufficient functional explanation upon which it piggy-backs.[303]

---

[302] Kitcher, '1953 and all that: a Tale of Two Sciences', pp. 218 – 219.

[303] As I have already claimed, such derivations of regularities holding among special- and honourary-scientific tokens from physical facts plus necessary truths as realisation physicalism would provide would not be adequately explanatory if the in-principle derivability of every functional token does not possess such explanatory potential. But what is more, Rosenberg's reason for extending reductionism about nomic special facts to nomic regularities seems to be that a regularity is fully explained if each of its instances are explained. And over and above our *prima facie* reservations about the merits of such reasoning, the argument I here elucidate makes clear how flawed is such a principle, since putative nomic biological regularities possess, in addition, a common explanatory basis in the facts of functional biology, which cannot in principle in itself be explained *ex ante* in terms of physical properties.

When Rosenberg contends that a full why-necessary explanation must avert to the interaction of macromolecules, he is not simply assuming (in addition to something like the thesis that explanations of biological facts become increasingly complete in direct proportion to increasing molecular detail) a biological law at the level of proximate causation which may or may not be reducible:[304] he is committing reductionism to the strong claim that there are in principle explanatory resources present at lower-levels of organisation in a biological entity that enter into law-like regularities, including given mutations or sets of mutations over a specified time and place, all of them identifiable as properties of genes, as well as genic constraints which lay down the specific feedback mechanisms and causal chains involved in adaptations, *and*, the claim that these things are discoverable from the study of macromolecular states, processes, events and/or patterns in isolation.[305] However, we already know that the interaction of molecules renders this implausible. Detailed extrapolation from genes and the proteins they produce must give rise to less, rather than more, explanatory power in that such reductionist explanantia offer a snapshot view of molecular arrangements, and this abstracts away from the combining of molecules in higher-level items.

Yet even if one does not grant the existence of emergent properties, more adequate explanations of biological descriptions cannot be had by appealing to contingent facts of molecular biology because biological events, adaptations and other patterns (such as they can be said to be identifiable properties of macromolecules) come about through the intercourse of phenotypic effects and environment. So it is not simply that functional regularities will turn out to possess highly disunified explanations in physical terms: such an argument shows all the more that further detailing of the causal properties of lower-level parts does not bear upon the adequacy of the explanans, since reductionism gets the direction of primary causal duty wrong. For the same reason, neither can reduction improve predictive precision in the natural sciences. Selection is not “channelled” via genes or genic behaviours in any sense that is importantly explanatory. Thus why-necessary explanations in biology cannot be proximate because putative biological regularities flow from the top downwards.

Therefore adopting realisation physicalism does not support the explanatory potential of in-principle derivability of honourary-scientific or functional type claims.

5.5 Modelling Holism

---

[304] At different levels of biological organisation, different degrees of fitness will be exhibited. This means that, even if one could reduce the general laws of natural selection at the macromolecular level, its effects would be so different as to prevent adducing its outcomes at higher-levels from those at-lower levels.

[305] Alexander Rosenburg, ‘Reductionism in Biology’ in *A Companion to the Philosophy of Biology*, (eds.) Sahotra Sarkar and Anya Plutynski (Blackwell, 2008), pp. 564 – 566.

What I do think realisation physicalism can achieve, is a model which lends credence to a formulation of anti-reductionism on which the autonomous causal efficaciousness of biological tokens is naturalistically realised. The central issue in the literature on downward causation is how it is that something can initiate a movement in itself in a manner that does not amount simply to one of its parts affecting another (such that the outcome is directed merely by the principles governing the constituent parts), and without thereby also allowing that the motion is produced by an immaterial substance.[306] Thus Kim famously argues against the possibility of combining a robust physicalism with the rejection of reductionism by attempting to impale the anti-reductionist on the horns of a destructive dilemma. Kim writes that a corollary of accepting physicalism must be to consider the biological realm either as reducible, or as existing outside of physicalist ontology, for the reason that a higher-level property, in order to qualify as autonomous, must possess true causal efficaciousness. If it does not, then it is reducible, but if it does, it must be epiphenomenal.[307] However, an anti-reductionist reading of realisation physicalism can sit comfortably alongside an alternative analysis of top-down causation – one in which it is possible to understand the concept of biological change as being the result of the self-organising activity of an entity – by re-conceiving the role of lower-level parts in bringing about higher-level motions.

What anti-reductionism can assert is that causal action can be physically realised without being sufficiently mereologically determined. So far as the causal metaphysics is concerned, the explanation for the presence of lower-level processes in a biological structure invokes the material whole as a co-ordinating and constraining body upon microphysical laws and conditions. This means that the causal work of the explanatory factors biologists cite occurs through mereological events. Emergent higher-level characteristics do not impinge upon physical laws as direct causes in that they are realised through the interaction of lower-level physical events. Regarding Mitchell's example of division of labour in social insects, specialisation is a homeostatic response at the colony-level; yet the transmission of information about the needs of the whole colony is accomplished through individual properties and coordination of events: the proportion of workers is adjusted based on individual bees' waiting time for finding an empty cell in the colony[308].

Be that as it may, higher-level properties are indisputably causes; how lower-level physical events like macromolecular genetic structures are orchestrated is by epigenetic factors, in which the

---

[306] Steward, *A Metaphysics for Freedom.*

[307] Jaegwon Kim, 'The Myth of Nonreductive Materialism', *Proceedings and Addresses of the American Philosophical Association*, 63, 3 (1989) pp. 31 - 47.

[308] Mitchell, 'Integrative Pluralism'.

development of the organism complex, that is the organised body of physical tokens as it presents in its totality, is a necessitating condition for particular molecular genic sequences as well as the mechanisms of temporal and spatial control of gene activity and gene expression. Theoretical levels purportedly to be reduced in the special sciences comprise levels of ultimate and proximate determination, relevant to biological systems both as end-specific bodies, and as self-reproducing bodies. So first, the special-sciences have greater explanatory success in that the predicates in terms of which they characterise phenomena pick out causal features pertinent to the identification of biological structures, connections and relationships, and which their more basic scientific counterparts do not illuminate. This entails that there are ineliminable causal explanations which the reductionist cannot supply since a non-reductive causal explanation appeals to the exchange of individuals identifiable as distinct only from the vantage point of higher-level kinds. Second, the ontogenesis of complex effects suggests that the whole in biology imposes a normative condition on the constituent system, and this condition is therefore explanatory. And so describing higher-levels of organisation cites emergent properties. If this is what the reductionist wants to call relational properties,[309] I am happy to concede the term. Relational properties undoubtedly belong to physical realisers of functional tokens, yet we know that they are not mereologically determined: they span multiple organisational levels and appeal to a preceding functional and structural complexity as a determinative condition. Therefore it cannot be that physical facts fix biological facts by reducing them.

Thus the reductionist's destructive dilemma fails. Anti-reductionism requires that a complex entity have autonomous causal powers. And higher-level properties do enjoy independence in that the activity of the whole is not confined to the sum of the discrete activities of functionally significant smaller constituents upon each other. Still, holistic causal control is consistent with realisation physicalism because such causal powers are not realisation independent; they do not form their very own causal world in a way that allows for implausible direct higher- to lower-level causal transactions. Thus to say that a biological fact is realised by physical processes is to claim that it is accompanied by the instantiation of particular, associated conditions, so that when the latter is present, so is the former. At any given instant, given the laws of physics, physical events are sufficient for special events. Therefore, violation of physical law by an epiphenomenal whole does not follow from the premise that biological structures can have autonomous causal efficaciousness.

On this reading of realisation physicalism, the biological domain is distinct; still this picture of autonomy yields a strong enough nomological relation of connectibility between biological and physical

---

[309] Rosenberg and McShea, *Philosophy of Biology: A Contemporary Introduction*, pp. 120 – 124.

predicates to appease reductionist critics. Notice that it remains true on this account that the existence of a higher-level entity supervenes on its basal conditions. The anti-reductionist can concede that, should the micro-structural properties of a system obtain at any given instant, sufficient conditions for the occurrence of the macro-structure will have been met.[310] Thus the supervenience claim is strong enough at the individual level to warrant a commitment to substantive physicalism. But it also remains unaccompanied by a commitment to global supervenience. A realisation physicalism thesis does not fall prey to one of the chief faults of token-identity physicalism in that place is left for the genuine causal relevance of biological events. Functional biological tokens do not act as causes by instantiating physical laws, since their causal actions are not synonymous with any physical properties, meaning that they are not to be identified with physical event kinds. Realisation physicalism implies only local supervenience. So despite the impossibility of inferring biological effects purely from the traction of lower-level causes, it will be the case that biological properties are individually supervenient. And this consequence is not untoward in the case.

A general model of supervenient causation of the form of local supervenience is acceptable (and indeed, preferable in some respects) on a reductionist position, given that a determination relation at the global level is too coarse to accommodate the fact that there are in principle an infinite number of nomologically possible physical states associated with any given biological state. So given that biological tokens are realised by physical tokens belonging to differing physical types, I think it is right that reductionism should not have to entail a blanket requirement of nomological sufficiency of physical facts for explaining special nomic facts. (Notice however, that the idea of dependency at the local level as relative to species is too weak a version of biological-physical connectibility to concede reductionism. Multiple realisability is inconsistent even with species-specific strong connectibility.[311] Despite compositional plasticity of the biological, reductionism must suffice to individual biological structures supervening on individual physical structures, and this it cannot achieve without conceding normative functional states, which are prior to, and determinative of, their physical components.) Conversely, local supervenience of biological facts is consistent with an anti-reductionist realisation physicalism. Realisation physicalism allows for an appropriate relation of causal dependency between biological and physical properties, given that biological properties are themselves relative to a determinate time and place. Biology is necessarily about contingent historical facts and therefore its

---

[310] Steward, *A Metaphysics for Freedom*.

[311] There is not only compositional plasticity of functionally similar structures across species: it is important to note that differences in physical realisation at the higher-levels – of species, genus, family, order, class and phylum – are compounded of variations in physical properties, events or states that occur among the biologic functional kinds found in individuals within a species. There are, in the case of human blood for instance, more than 100 variants of amino acid sequences of haemoglobins as a result of genetic mutation. See Theodosius Dobzhansky, 'Nothing in Biology Makes Sense except in the Light of Evolution', *The American Biology Teacher*, 35, 3 (1973) pp. 125 - 129.

explanatory resources can only have spatiotemporally restricted adequacy. Therefore the explanandum in the reductionist/anti-reductionist debate references functional as well as molecular results, both categories of which are tantamount to products of the general laws of natural selection and contingent environmental conditions.[312]

My conclusion is that theory reduction of the biological sciences fails – not because biological facts are undetermined by physical conditions – indeed higher-levels of biological organisation supervene upon lower-levels; but because biological entities as functional tokens are not sufficiently determined but by reference to the causal efficaciousness of the higher-level. Supervenience is taken by reductionists to entail that there is no irreducibly downward causation on the assumption that the causal efficaciousness of a complex system is grounded in its parts. But what is wrong with this is the assumption attendant upon the supervenience thesis that explanatory mechanisms must work from the bottom upwards. Beginning from the premise of a deterministic metaphysics, the supervenience thesis is in general extended in its formulation such that a single, momentary supervenience base in an object is taken in itself, at every stage, either to maintain itself, or necessitate the next appropriate micro-physical specification of a particular succession, leading to the false supposition that the relationship between the emergent higher-level conditions we observe, and its corresponding lower-level conditions or proximal supervenient base, is constituently sufficient for the existence of that object.[313] However, the evolution of complex effects in biological phenomena suggests that sometimes the assumption of a material whole is required in order to provide for the very physical realisation of the molecular arrangement. Naturally, the capacity of an entity to bring about such peculiar effects in its components will be intertwined with the causal interactions of sub-entities at the lower level, but it does not follow from this that the causal powers of the whole consist in no more than the sum of the causal relationships between its parts. Downward causation in biological systems involves a higher-level system directing the distribution of lower-level events in a manner that is self-regulating.

It is true that our standard idea of causal capacity involves one thing altering the properties of another by directly interacting with it, and of course, the state of affairs envisaged on a holistic account I have sketched is different. However, there is nothing in principle amiss in a naturalistic formulation of holism since it is not in contention with any physics in support of which we now have reason. Although systems of increasing organisational complexity are underdetermined by their basal constituents, it cannot therefore be concluded that top-down control of lower-level processes requires appeal to anything supernatural.

---

[312] Rosenberg, 'Reductionism in Biology', pp. 558 – 559.

[313] Steward, *A Metaphysics for Freedom*.

5.6 Biology as Explanation

A final objection I shall consider levelled of anti-reductionism by, amongst others, Rosenberg, is how it can be that a putative irreducible functional explanation can have explanatory power. Rosenberg argues that, notwithstanding the law of natural selection, there are no true laws in biology and therefore, even if putative functional generalisations are complete and cannot be supplemented or otherwise replaced by non-functional ones, we should neither expect such generalisations to reduce to more fundamental laws, nor to impart explanation.[314] And in the main, biologists do agree that, given environmental contingencies and mutational randomness, the content of classical genetics cannot be identified with any general principles. This is especially problematic in that, lacking an account of the structure of molecular genetics and classical genetics, the relation between these theories is obscured. Indeed, if neither functional biology nor molecular biology supports laws, the critic can go so far as to demand a considered basis upon which putative special- or honourary- nomic facts in the former case are explanatorily preferable to the kind of disjunction of alternative macromolecular processes such as is exampled by the members of a set, each of which implements the haemoglobin protein.

In this section, however, I argue that this objection misses the mark. A key point of this chapter has been to highlight that, although each level in the organisation of matter may fall within the universe of discourse of a different branch of science, an adequate explanation of any investigable phenomenon will require understanding of how the different levels relate to one another. The attempt to unify science through inter-theoretical reduction is hence a wrong-headed approach to the study of evolved complex systems because integrative scientific traditions interrelate and illuminate each other. Pluralism ought hence to be considered as the best contender for a description of modern scientific inquiry.

To start with, we know that higher-level descriptions are justifiably accorded *prima facie* primary explanatory power from the perspective of emergent properties. So there is something explanatory of why there is a very particular kind of configuration at all in the fact that a heart, as an entity, is present in the way that a swarm of particles is not. What is misguided in the reductionist approach is that, in attempting to explain a multilevel phenomenon by a lower-level entity, the presence of the phenotypic

---

[314] Rosenberg, ‘Reductionism in Biology’, pp. 555 – 556.

form, or a representation of that form, is credited only to constitutent parts. This ignores the rest of the interactive complex; when, in fact, biological development always takes place in some stimulative context. Anti-reductionists stress the organisation of nature and the range of interactants present in that context, and moreover that the individual's functional environment must be understood to be structured by the individual and hence to be organism-specific. Indeed this applies across levels of biological organisation: all levels of the organism partake in wider ecological complexes.[315] Traits and characteristics are constructed in individual ontogeny, in which genic conditions interact with organic factors to exert particular effects. Importantly, phenotypic construction is realised through the individual, as a causal factor in its own expression.[316] Therefore, the individual phenotype is of explanatory import because functional types are dependent at the phenotypic level on transactions involving the organism and its environment. A biological token like a heart is partially specified in relation to the extant whole, that is, the heart itself, and its role in facilitating the goals of the system as a whole, which in this case, happens to have the character of a circulator. Accordingly, although nomic biological facts may not enter into biological laws *per se*, for a time at least, the biological whole imposes a normative condition on the constituent system, and this condition is therefore explanatory.

Second, in the biological sciences, functional descriptions are explanatorily superior *ex hypothesi* by virtue of their pertaining to the causal ancestry of the facts biology reports. Self-sustaining systems in which downward causation occurs are necessitated as natural organisation becomes increasingly complex and must become ever more adaptive to shifting environments. Again, it is essentially explanatory of what a heart is that it is instrumentally related to a certain normative function and its identity condition over time consists in its self-reproduction as such a body. A functional description of the heart supplies an evolutionary etiological reason for its presence, in that, as a function bearer, the heart is said to occupy a phenotypic space the effect of which is phylogenetically conducive to an activity, circulation, which directly or indirectly maintains the system in which it is found.

Now undoubtedly, a comprehensive causal explanation cannot be defined in terms of a single level of physical organisation. Kitcher proposes one possible view on the relation between successive theories which augments our understanding of the causal interactants in biological systems and pays tribute to the scientific consensus that molecular biology has enhanced classical genetics. On his account, the breakthroughs of molecular genetics are demonstrative of three different inter-theoretic relations between higher and lower- levels of biological explanation, all of which, however, fall short of inter-theoretic reduction. I gloss this account of inter-theoretic relations for the reader, without doing it justice,

---

[315] Oyama, *Evolution's Eye*, pp. 27 – 35.

[316] Lickliter and Berry, 'The Phylogeny Fallacy', pp. 353 – 358.

in order to impart a sense of how anti-reductionism can capture the spirit behind the reductionist impulse in the biological sciences, particularly amongst its practitioners. First, in replacing a bald assertion about the existence of certain Mendelian genes which are associated with various phenotypes, with a molecular characterisation of the alleles, a molecular derivation can present a theoretical demonstration of those particular presuppositions of classical genetics which are antecedently identified as problematic. Second, molecular genetics has shown that a lower-level theory can provide characterisations of entities belonging to the predicates of a higher-level theory so that, using the molecular account, we are able to make further discriminations in determining the referents of the higher-level predicates. The result is conceptual refinement. Lastly, in some instances, in a process Kitcher calls "explanatory extension", insofar as it is possible that certain premises within the domain of the language of classical genetic theory can be derived from the concepts, categories and generalisations of molecular genetics, molecular genetics can better explain the action of particular genes.[317] Nevertheless, Kitcher is quick to point out that explanatory extension is not tantamount to reduction. The fact that, in certain cases, explanatory extension is made possible by deducing a principle from a further theory does not make the explanations provided by the old theory better. A more elaborate derivation in the language of ultimate predicates is not necessarily relevant to explaining the transmission of genes to gametes in meiosis just because it is relevant to explaining the details of the rearrangements of the molecules, which figures in an explanatory derivation of that distributive process. Moreover, as I have contended, there is reason to think that, in salient respects, biological explanations must flow from the top down; thus explanatory extensions cannot be provided by molecular biology alone. So even if a molecular characterisation would allow us to understand the functional differences between limb-bud alleles for example, the molecular constitution of the mutant allele gives rise to a non-functional protein, causing abnormality of the cell shape; this affects the spatial relations between the cells of the embryo, and hence the geometrical structure of the cells will, in turn, alter the biosynthetic pathways between genes and proteins. Understanding morphological outcomes requires recognition of the dialogue across levels of cellular organisation, here, between cell genomes and cell populations. In most typical cases in which molecular considerations are of explanatory import to development, it is not possible to proceed without recourse to the perspective of the less fundamental level of functional biology.[318] Pluralism calls for a nuanced approach which recognises autonomy of the special sciences.

I have defended the claim that biological explanations cannot be made more adequate by the introduction of non-functional facts or supporting considerations, because natural products are not

---

[317] For examples, see Kitcher, '1953 and all that: a Tale of Two Sciences', pp. 223 – 226.
[318] Kitcher, '1953 and all that: a Tale of Two Sciences', pp. 222 – 229.

primarily explicable by the principles directing their constituent parts, but on their own, immediate, terms.[319]

---

[319] Rosenburg, ‘Reductionism in Biology’, p. 573.

The definition of function I have presented in this thesis does not resolve all of the problems surrounding biological teleology; even so, it shows that the interpretive paradigm of teleology cannot be assimilated to a mechanistic worldview because natural things are necessarily and (in concert with mechanistic law) sufficiently determined by means of teleological causation. Darwin has not displaced the Kantian insight that a teleological principle must occupy the explanatory lacuna left by the mechanistic maxim as an objective principle of natural forms: instead, he has simply filled in more of the materialist's interpretation of teleological systems. Post Darwin, the naturalist has more intellectual resources with which to reconstruct functional explanations.[320] Still, mechanism cannot supplant the need for a different ground of production. And consequently, the mechanism of nature would need to be subordinated to a transcendental principle of purposiveness.

Perhaps one might be concerned that such a metaphysical conclusion forecloses the possibility of the total integration of biology into contemporary scientific theory. However, a more generous handling of physicalism can help us to reclaim material formal and final causes for the natural sciences. On the pattern outlined by realisation physicalism which I have endorsed, biological activity is derivable from the physical interactions of the constituent parts of discrete bodies. The existence of autonomous functional facts need not entail violation of physical laws since holistic ontological structures are physically underwritten by their supervenient bases. The phenomenon of biological function shows only that the physical rules required to explain lower-lever physical behaviour might be more complicated than first appears, and hence we need to broaden and enrich our understanding of physicalist relations.

Although I have argued that whole-to-part determinism is not radically incongruous with naturalism, I am not, however, at pains to deny that scientific recognition of holistic causes is enormously controversial. Nevertheless, its major impact lies in its changing the rules of scientific inquiry. A positive argument for holism does not merely signify that integration of sciences like biology, sociology and psychology is not necessary to their scientific adequacy:[321] the implication is in fact that scientific unification by way of inter-theoretical reduction might at times be disvaluable. The limits of the mechanistic maxim as a regulative principle intimate that we will not necessarily understand biological phenomena any better for scrutinising macromolecular efficient processes because causation can run downward in the case of organismal function. Instead, we should be focusing on a pluralistic approach, which recognises the contributions of the present diversity of theoretical approaches and tries to map out in regular ways the connections between them. So the loss is to the reductionist thesis - - not to the naturalistic understanding of the scientific project. Indeed, one might even claim that unwarranted

---

[320] Rosenberg and McShea, *Philosophy of Biology: A Contemporary Introduction*, pp. 116 - 117.
[321] Kincaid, Individualism and the Unity of Science, p. 2.

assumptions about reductionism are far more likely to court supernaturalism insofar as this lacks a scientific basis.

Holism appears to be a counter-intuitive causal explanation in great measure because we anticipate a mechanistic reduction to follow from a causally determined material event. In the sense of its intuitions at least, science is a true heir of the Enlightenment. The developmental systems approach to natural science problematises such a universal scientific assumption however. The requirements of biological usage stress the necessity for a theory of biological individuals as shaping their own parts. How these organic systems and structures function will not be independent of their environments, but their effects will be formally and finally determined on my account, given their immediately antecedent formative conditions.

Perhaps the extent to which the empirical study of life on Earth has become more sophisticated ought to strengthen the intuition which Kant himself doubted: that the problem of our teleological judgments of nature is a philosophical one and therefore the solution to it will not substantially change with the progression of science and the increase of our knowledge of natural laws.

References

1. Aristotle, *The Works of Aristotle: De Anima*. Translated by Hugh Lawson-Tancred (Penguin, 1987).
2. Colin Allen, Marc Bekoff and George Lauder, 'Introduction', in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).
3. Francisco J. Ayala, 'Teleological Explanations in Evolutionary Biology' in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).
4. Mark Bedau, 'Where's the Good in Teleology?' in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).
5. Mark Bedau, *The Nature of Life* (Cambridge, 1996).
6. John Bigelow and Robert Pargetter, 'Functions' in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).
7. Walter J. Bock and Gerd von Wahlert, 'Adaptation and the Form-Function Complex' in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).
8. Angela Breitenbach, 'Kant on Causal Knowledge: Causality, Mechanism and Reflective Judgment' in K. Allen and T. Stoneham (eds.), *Causation and Modern Philosophy* (Routledge, 2011).
9. Robert Cummins, 'Functional Analysis' in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).
10. Daniel C. Dennett, *Darwin's Dangerous Idea* (Penguin, 1995).
11. Theodosius Dobzhansky, 'Nothing in Biology Makes Sense except in the Light of Evolution', *The American Biology Teacher*, 35, 3 (1973) pp. 125 - 129.
12. John Dupré, *Processes of Life: Essays in the Philosophy of Biology* (Oxford, 2012).
13. John Farrell, *Why Teleology isn't Dead* (Forbes), accessed via http://www.forbes.com/sites/johnfarrell/2016/06/08/why-teleology-isnt dead/#2e3d48b73d41.
14. Edward Feser, 'Teleology: A Shopper's Guide', *Philosophia Christi*, 12, 1 (2010) pp. 142 - 159.
15. J. A. Fodor, 'Special Sciences (Or: The Disunity of Science as a Working Hypothesis', *Synthese*, 28, 2 (1974) pp. 97 - 115.
16. Justin Garson, 'Function and Teleology' in *A Companion to the Philosophy of Biology*, (eds.) Sahotra Sarkar and Anya Plutynski (Blackwell, 2008).
17. Justin Garson, *The Biological Mind: A Philosophical Introduction* (Routledge, 2015).
18. Peter Godfrey-Smith, 'A Modern History Theory of Functins' in *Nature's Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).

19. David Haig, ‘Proximate and Ultimate Causes: How Come? And What For?’, *Biol Philos,* 28, 5 (2013), pp. 781 – 786.
20. Immanuel Kant, *Critique of Judgement* (1790). Trans. by J. H. Bernard, 2nd edition revised (Macmillan, 1914).
21. Stuart Kauffman, ‘Antichaos and Adaptation’, *Scientific American*, 265, 2 (1991) pp 78 – 84.
22. Stuart Kauffman, *The Origins of Order: Self-Organization and Selection in Evolution* (Oxford, 1993).
23. Hans Kelsen, *General Theory of Norms* (Oxford Scholarship Online, 2012).
24. Jaegwon Kim, ‘Making Sense of Emergence’, *Philosophical Studies: An International Journal for Philosophy in the Analytic Tradition*, 95, 1/2 (1999) pp. 3 - 36.
25. Jaegwon Kim, ‘Multiple Realisation and the Metaphysics of Reduction’, *Philosophy and Phenomenological Research*, 52, 1 (1992) pp. 1- 26.
26. Jaegwon Kim, ‘The Myth of Nonreductive Materialism’, Proceedings *and Addresses of the American Philosophical Association*, 63, 3 (1989) pp. 31 - 47.
27. Harold Kincaid, *Individualism and the Unity of Science: Essays on Reduction, Explanation, and the Special Sciences* (Rowman and Littlefield, 1997).
28. Philip Kitcher, ‘Function and Design’ in *Nature’s Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1997).
29. Philip Kitcher, ‘1953 and all that: a Tale of Two Sciences’ in *Philosophy of Biology: An Anthology*, (eds.) Alexander Rosenburg and Robert Arp (Wiley-Blackwell, 2010).
30. George V. Lauder, ‘Historical Biology and the Problem of Design’ in *Nature’s Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).
31. Robert Lickliter and Thomas D. Berry, ‘The Phylogeny Fallacy: Developmental Psychology’s Misapplication of Evolutionary Theory’, *Developmental Review*, 10, 190, pp. 348-364.
32. Ernst Mayr, ‘Cause and Effect in Biology’, *Science,* 134, 3489 (1961), pp. 1501-1506
33. Peter Mclaughlin, *What Functions Explain: Functional Explanation and Self-Reproducing Systems* (Cambridge, 2001).
34. Andrew Melnyk, *A Physicalist Manifesto*: Thoroughly Modern Materialism (Cambridge, 2003).
35. Ruth Garrett Millikan, ‘In Defense of Proper Functions’ in *Nature’s Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).
36. Sandra D. Mitchell, *Biological Complexity and Integrative Pluralism* (Cambridge, 2003).
37. Sandra D. Mitchell, ‘Integrative Pluralism’, *Biology and Philosophy*, 17 (2002), pp. 55-70.
38. Matteo Mossio, Leonardo Bich, and Alvaro Moreno, ‘Emergence, Closure and Inter-level Causation in Biological Systems’, *Erkenntnis*, 78, 2 (2013) pp. 153 - 178.

39. Ernest Nagel, ‘Functional Explanations in Biology’, *The Journal of Philosophy*, 74, 5 (1977) pp. 348-364.
40. Ernest Nagel, ‘Teleology Revisited’ in *Nature’s Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).
41. Karen Neander, ‘Function as Selected Effects: The Conceptual Analyst’s Defense’ in *Nature’s Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).
42. Paul Oppenheim and Hilary Putnam, ‘The Unity of Science as a Working Hypothesis’, *Minnesota Studies in the Philosophy of Science*, 2 (1958) pp. 2 - 36.
43. Susan Oyama, *Evolution’s Eye: A Systems View of the Biology-Culture Divide*, (Duke University Press, 2000).
44. Johannes Röhl, ‘Mechanisms in biomedical ontology’, *Journal of Biomedical Semantics,* 3, 2 (2012).
45. Alexander Rosenburg, ‘Reductionism in Biology’ in *A Companion to the Philosophy of Biology*, (eds.) Sahotra Sarkar and Anya Plutynski (Blackwell, 2008).
46. Alexander Rosenburg and Robert Arp, *Philosophy of Biology: An Anthology* (Wiley-Blackwell, 2010).
47. Alexander Rosenburg and Daniel W. McShea, *Philosophy of Biology: A Contemporary Introduction* (Routledge, 2008).
48. M.J.S. Rudwick, ‘The Inference of Function from Structure in Fossils’ in *Nature’s Purposes,* (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).
49. Jonathan Schaffer, ‘Monism: The Priority of the Whole’, *The Philosophical Review*, 119, 1 (2010) pp. 31 - 76.
50. Erwin Schrodinger, *What is Life?* (First published 1944), accessed via the Stanford Encyclopedia of Philosophy at http://whatislife.stanford.edu/LoCo_files/What-is-Life.pdf.
51. Helen Steward, *A Metaphysics for Freedom* (Oxford, 2012).
52. Larry Wright, ‘Functions’ in *Nature’s Purposes*, (eds.) Colin Allen, Marc Bekoff and George Lauder (MIT Press, 1998).
53. Richard York and Brett Clark, *The Science and Humanism of Stephen Jay Gould* (Monthly Review Press: New York, 2011).