TELEOLOGICAL EXPLANATION AND THE DARWINIAN ARGUMENT

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Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any other university for a degree.

Abstract

Darwin's development of his theory of descent with modification by natural selection effected a profound transformation of teleological thinking in biology. In what sense, and through which means his theoretical discoveries can be said to have overcome metaphysical teleology and to have initiated and informed current ideas on what scientifically legitimate "teleological" explanation in biology should consist of, is the question investigated by this thesis. Two main claims (which are really two sides of the same coin) are being defended:

In the first place, the contention is that Darwin's efforts to elaborate a theory of evolution that could comply with the requirements of a certain empiricist (*vera causa*) philosophy of science, enabled him to undermine metaphysical teleological explanation in biology. Through having posited natural selection as the empirical causal process responsible for all the wonderful features of living phenomena, Darwin dispensed with the need for appeals to revealed theology's argument from special creation, as well as with appeals to natural theology's argument from design. The collapse of these kinds of metaphysical explanation was an important precondition for the emergence of any properly scientific account of adaptational phenomena, that is to say, of any scientifically legitimate model of "teleological" explanation.

In the second place, the contention is - and this again by virtue of the kind of empirical historical process he envisaged as the cause of adaptations - that Darwin indeed initiated such a new scientifically legitimate model of teleological explanation. Darwin provided teleological explanation, for the first time, with a proper causal basis (natural selection) - a crucial legacy to present-day biology. However, the explication of that model had to wait until well into the present century. It now goes under the name of an *etiological* approach to goals and functions, and is the model which, in my view, not only offers the closest approximation to Darwin's own conceptualisation of the explanation of adaptational phenomena, but which is, moreover, the most fundamental model for both explanatory and historical reasons. Finally, given Darwin's initiating of the latter model, we can now seriously consider altogether discarding the designation "teleological" when speaking of current biological explanation of apparently functional

and goal-directed phenomena.

Abstrak

Darwin se ontwikkeling van sy teorie van evolusie deur natuurlike seleksie het 'n diepgaande transformasie in teleologiese denke in biologie teweeg gebring. Die vraag aan die orde in hierdie tesis het betrekking op die sin waarin, en die wyse waarop, Darwin se teoretiese ontdekkinge metafisiese teleologie oorkom het, en ook kontemporêre idees oor hoe wetenskaplik legitieme "teleologiese" verklaring in biologie daar moet uitsien, geïnisieer en informeer het. Twee hoofaansprake (wat in werklikheid twee kante van dieselfde munt is) word hier verdedig:

Eerstens, word geargumenteer dat Darwin se pogings om 'n teorie van evolusie te ontwikkel wat kon voldoen aan die vereistes van 'n bepaalde empiristiese (*vera causa*) wetenskapsfilosofie, hom daartoe in staat gestel het om metafisiese teleologiese verklaring in biologie te ondermyn. Deur natuurlike seleksie aan te bied as die empiriese kousale proses verantwoordelik vir al die merkwaardige eienskappe van lewende fenomene, kon hy wegdoen met beroepe op openbaringsteologie se argument van besondere skepping, sowel as met beroepe op natuurlike teologie se argument van ontwerp. Die ondergang van hierdie soort metafisiese verklarings was 'n belangrike voorwaarde vir die ontwikkeling van 'n werklik wetenskaplike beskouing van adaptasie-fenomene, dit is, van 'n wetenskaplik legitieme model van "teleologiese" verklaring.

Tweedens, word geargumenteer - en weer eens kragtens die empiriese, historiese proses wat hy voorgestel het as die oorsaak van adaptasies - dat Darwin inderdaad so 'n nuwe en wetenskaplik legitieme model van teleologiese verklaring geïnisieer het. Hy was die eerste om teleologiese verklaring van 'n behoorlik kousale basis (natuurlike seleksie) te voorsien - 'n belangrike erflating aan hedendaagse biologie. Nietemin, die eksplikasie van die model moes wag tot relatief onlangs in die huidige eeu. Dit gaan nou onder die benaming van 'n *etiologiese* beskouing van funksies en doelwitte, en is die model wat na my mening nie net die beste benadering bied van Darwin se eie konseptualisering van die verklaring van adaptasie-fenomene nie, maar wat ook die mees fundamentele model is - vir beide verklarings- en historiese redes. Ten slotte, gegee Darwin se inisiëring van laasgenoemde model, is dit nou moontlik om ernstige oorweging te gee aan die gewensdheid al dan nie van voortgaande gebruik van die

benaming "teleologies" wanneer dit gaan oor hedendaagse biologiese verklaring van skynbaar funksionele en doel-gerigte fenomene.

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1

Introduction

"Teleology is alive and well in the natural sciences". - Many a philosopher will sit upright on hearing this statement pronounced. After all, did teleological thinking not belong to a medieval world-view we have long since rid ourselves of? Did it not form part of those metaphysical ways of thought that were once and for all overthrown as the scientific world-view gained ascendancy during the past few centuries? Is teleology not the direct antithesis of science? Anyone asserting that teleological reasoning - which historically has been an obstacle to the development of what we now know as modern science - forms part of that very science, can therefore not be in his/her right mind.

However, provided the person hearing the above statement is a philosopher of science, s/he may not be all that surprised, but will use the opportunity to point out that the statement as it stands is somewhat misleading and in need of one or two qualifications. In the first place, instead of applying the claim to the natural sciences generally, we should narrow it down to biology alone - in other words, to that natural science dealing with living systems. In the second place, rather than employing the term "teleology" with all its metaphysical baggage, we may do better by inventing other, less ambiguous terms - terms and phrases such as "teleonomy", "goal-directedness", and "explanation in terms of apparent goals and functions" - that will be able to capture the specifically scientific sense the notion has acquired in recent biological reasoning.

The aim of the present thesis is to spell out in precisely what sense "teleology" is today alive and well in biological science, and to show that it was none other than Charles Darwin (1809-1882) in his main work, the *Origin of Species* (1859), who laid the foundations for a new naturalised teleology that was to replace the metaphysical teleology whose reign in biology extended from Aristotle onwards and well into the nineteenth century.

The present introductory chapter will do four things: *Firstly*, a few brief remarks will be made on the history of teleological thinking up to Darwin's day and into the first half of the twentieth century - *teleology* being understood as the explanation or understanding of phenomena in terms of their supposed purposes, goals or functions. *Secondly*, an important current model of teleological explanation will be sketched. *Thirdly*, challenges posed for teleological explanation by the requirements of the deductive-nomological model, as well as by other charges as to its non-scientific nature, will be recorded. *Fourthly*, a more detailed statement of the thesis will be presented, outlining the framework within which Darwin's contribution to a scientifically legitimate model of teleological explanation will be investigated.

Aristotle and since

Our story commences in the third century B.C. with Aristotle's influential treatment of causation. His classification of the latter into four distinct types of causes, namely, the material, formal, efficient and final causes, is chiefly of interest to us here for the identification of the fourth cause - definable as "the cause responsible for the orderly reaching of a preconceived ultimate goal" (Mayr, 1961 [1976:364]). Many centuries later, Darwin himself would also employ the expression "final cause" to convey insights regarding the goals and functions of phenomena. But by then he had rid the term of all the metaphysical associations (such as supernatural purpose, or an active soul inhering in things) it had acquired since Aristotle.

Significantly, Aristotle was a biologist first and foremost. The notion of final causes acquired prominence in his thinking precisely because of his concern with living phenomena - in which goal-directedness seems evident (Mayr, 1961 [1976:364). From the biological domain the idea of final causes was transposed to other phenomena as well. A teleological explanation, whether of a biological or physical or social phenomenon, was to identify the final cause of the phenomenon; it was to "make an event intelligible through ascribing a purpose to it" (Doyal & Harris, 1986:28). But purpose was to be understood in a metaphysical sense: things derived their purpose from their specific nature and from the place they were thought to occupy within the eternal order of the cosmos.

Generally, then, Aristotelians explained the physical behaviour of objects in terms of the

> purposes associated with their material constitution. When they moved purposively and unhindered, they did so 'naturally' and, therefore, no further explanation of their behaviour was required. Similar considerations were said to apply to the celestial world. The apparent circular and uniform notion of the stars around the earth was also explained as 'natural' in this sense. No further explanation was believed to be needed [...] Why does a boy grow into a man? Why does an acorn become an oak? Aristotle and his medieval followers answered with reference to future purpose or 'natural potential'.
>
> (Doyal & Harris, 1986:29).

The ancient idea of a hierarchical, geocentric cosmos in which each and every species, individual and entity had its assigned place and purpose in accordance with their respective fixed natures, was passed on more or less intact to the Middle Ages - the main modification being the replacement of the pagan conception of the universe as having existed from all eternity, with the conception of a time-bound world miraculously created and sustained by a benevolent Christian God whose purposeful designs it reflected. Given the continuities between the ancient and medieval world-views, it proved not too difficult for Thomas Aquinas to merge Aristotelian thought - its non-Christian nature notwithstanding - with medieval Christian thought after Aristotle's works have been rediscovered in the twelfth and thirteenth centuries.

Christian teleology did less well, however, when the Middle Ages was brought to a close by the emergence of modern science during the sixteenth and seventeenth centuries. Geocentrism was replaced by heliocentrism, and profound changes took place in the understanding of nature. Nature's workings were increasingly thought of as similar to those of a machine. Thinking of nature in mechanistic terms entailed viewing it as essentially purposeless matter regulated by universal laws. Corresponding to the new conception of nature were, as John Burrow (1968:16) remarks, new models of inquiry for studying matter, models "which presupposed regular sequences of cause and effect and seemed to leave little or no room for the interpositions of a miracle-working deity". The practice of rendering things and events intelligible through reference to their supposed inherent teleological purposes, was thereby simply pushed to the background by the new kinds of reasoning that were intent on revealing physical regularities in the interest of control over nature. The overriding concern with how things work in terms of the way past events affect or determine present events, and present events affect or determine future ones could not but be alien to the teleological mode of explanation in which the occurrence of present events is accounted for by their relation to future purposes. (Doyal & Harris, 1986:30-31).

Following Descartes' mechanistic philosophy many saw living phenomena not as qualitatively different from those that made up inanimate nature. The former were widely believed to be equally explicable in terms of mechanistic principles. Nonetheless, not all thinkers were in accord on this point. Mayr (1974 [1976:384]) notes that the

> history of the biological sciences from the seventeenth to the nineteenth centuries is characterized by a constant battle between extreme mechanists, who explained everything purely in terms of movements and forces, and their opponents, who often went to the opposite extreme of vitalism.

The rejection by thinkers like Bacon, Descartes, d'Holbach and La Mettrie of vitalism and final causes in biology, was accompanied by the belief that biological terminology should be purged of all teleological language. There could be no talk of purpose even where growth, behaviour and adaptive structures were concerned. (Mayr, 1961 [1976:359]; 1974 [1976:383]). In opposition to such mechanistic materialism, there sometimes developed certain idealist, vitalist and romanticist tendencies in biology - from relatively moderate to extreme - which in different ways hoped to salvage something of the uniqueness of living beings by denying that they could be wholly reduced to, and explained in terms of physico-chemical events. Approaches ranged from positing some kind of purposive metaphysical vital force active in organisms or even in the universe as a whole, to the more modest claim arising from practical study that there is some kind of inexplicable *x* related to the functioning of organisms that we might just as well call a vital force.[1]

On the whole then, one can say that although mechanistic reductionism was not entirely absent from the biological sciences, there had emerged - by the time of the eighteenth and early nineteenth centuries - something like a consensus regarding the

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[1] See the remarks by Mayr (1965 [1976:372-376]) on our having to distinguish between the sober, descriptive vitalists of nineteenth century physiology (the later Johannes Müller and Claude Bernard) and the speculative vitalism of Henri Bergson (élan vital) and Driesch (entelechy). Note also his distinction between the influence of vitalism and *Naturphilosophie*

continuing need of a notion of purpose or design in the understanding of living beings. It was conceded that chemistry and physics could get along without asking what things were *for*. There it was enough to assume that God had created certain impersonal and universal laws which made things behave in certain ways. But the same was not conceded for biology, as here it seemed evident that God specially created all the various organisms, endowing them with the marvellous contrivances they needed for their respective places in his creation. It was thus through Rational Christianity and its concomitant, Natural Theology, that the crisis of traditional religion and teleology (at least in England) were temporarily overcome.[2] But this happened at the

> cost of some of the more miraculous and emotional elements in Christianity. Instead of the goodness of God being the guarantee of the goodness of the creation, it was the latter which became the prime guarantee of the existence and goodness of the God spoken of in revelation. Science and religion seemed to cohabit smoothly in the ordered and harmonious universe revealed by that devout Christian, Sir Isaac Newton.
>
> (Burrow, 1968:18).

However, as the nineteenth century progressed, this smooth cohabitation of science and religion became increasingly imperilled. A growing historical awareness occasioned by new geological and palaeontological discoveries eroded belief in old (biblical) conceptions of the impossibility of species extinction, and of the relative youth of the human race and the earth. Evolutionary ideas have been steadily becoming more prominent since the previous century, culminating in Darwin's breakthrough in 1859, which eventually caused the final rupture in the relation between scientific thinking and religious or metaphysical teleology. In natural selection Darwin found something akin to a blind mechanistic principle, an impersonal mechanism devoid of purpose which could nevertheless account for the apparent design we observe in organic life. With one stroke natural theology was shown to be superfluous. If God existed he was the remote God of deism who merely put everything into motion by providing certain laws and causal processes that then took their due course. None of the well-adapted species populating the world was specially and individually created through his personal care. Not even humankind. That meant that evidence of the wonders of life no longer forced

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(Schelling, Oken, Carus) respectively.

[2] See Burrow (1968:17-18).

one to infer the existence of a benevolent personal creator. Indeed, once one starts concentrating on secondary causes (rather than on direct divine intervention), doubting the necessity and real existence of a First Cause behind it all is not that far off.

With biology now manifestly in the same boat as physics and chemistry, a renewed effort was made to eradicate the use of teleological explanations from the former. The writings of Driesch and Bergson in the early twentieth century represented a last extreme attempt to resurrect a metaphysical teleology from the ashes of vitalism. But the new philosophies of logical positivism and logical empiricism showed no mercy when faced with such speculative endeavours:

> Twentieth-century scientific philosophy arose in a philosophical context dominated by post-Kantian and post-Hegelian German idealism. It was heavily infused with transcendental metaphysics and theology. The early logical positivists and logical empiricists saw it as part of their mission to overcome such influences. As philosophers of science they were eager to expunge from science any contamination by super-empirical factors arising out of these philosophies. One such item was teleology, whether in the form of an appeal to the will of a supernatural being who created and continues to direct the course of nature, or in the form of such empirically inaccessible agencies as entelechies or vital forces.
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> (Salmon, 1990:4).

Things did not improve much for teleological reasoning during the next few decades - from a science-philosophical viewpoint its logical and empirical status continued to be regarded as suspect. This was probably partly the case because the philosophy of biology never really got off the ground until the 1960s or even the 1970s. That meant that the enunciation in 1948 of what later became known as the *deductive-nomological (D-N) model*, by Carl G. Hempel and Paul Oppenheim in their classic article, “Studies in the logic of explanation”, provided the impetus for the basic consensus on the nature of scientific explanation. Also called the *received view*, it attained its peak in the 1960s (Salmon, 1990:3). The immediate aftermath of this model was a further discrediting of teleological explanations because they did not seem to fit the D-N structure. Before elaborating upon the criteria in terms of which the deductive-nomological model measured and rejected teleological explanation, a tentative account of an important current model of teleological explanation will be presented.

A current model

After the logical positivist witch-hunt earlier in the century, and in the face of the rise of the deductive-nomological model, the status of teleological explanations nevertheless began undergoing a slow rehabilitation, so that by 1958 - the year before Hempel's treatment of the issue - Pittendrigh could remark that given the demise of vitalism at the beginning of the century, biologists could again afford to make statements such as "a turtle came ashore to lay her eggs", instead of the non-teleological "she came ashore and laid her eggs" (Mayr, 1974 [1976:384]). All the same, this did not mean that an adequate explication of the notion had yet been provided. Resolving the difficulties was up to the next decade or two.

In Larry Wright's seminal work, *Teleological Explanations*, which appeared in 1976, was provided an important model of teleological explanation which seemed to overcome at least some of the debilitating charges that could be hurled at older forms of teleological reasoning. Moreover, it will be my contention below that a modified version of Wright's model approximates the closest to Darwin's own ideas on teleological explanation. Although it will be the core ideas of Wright's initial etiological analysis of goals and functions that will be the theme of the present section, we shall see in the fourth chapter how this initial model can be supplemented to eliminate its remaining weak points.

But first an important terminological point that is long overdue: I follow David Hull (1974:103) in using *teleological* "in a generic, metaphysically neutral sense to refer to all statements [or explanations] couched in terms of goals, purposes, and functions". The term thus encompasses the metaphysical and the non-metaphysical. It also encompasses goal-directed, functional and purposive relations.[3] We shall see that goal-directed and functional explanations are in important respects similar, but that functional explanations have a broader range in that they apply to things other than behaviour and processes. Drawing upon Wright, that with which these two kinds of teleological explanation are concerned, namely, goal-directedness and functionality, can be characterised as follows:

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[3] *Purposive* could be reserved for cases where conscious human behaviour is the paradigm - that will however not concern us here.

Goal-directedness will be reserved for activities, processes (such as growth), and behaviours that are directed to the achievement of certain ends. "The rabbit is running in order to escape from the dog", can serve as an example of such behaviour. Wright (1976:39) offers the following characterisation of teleological (or what could be called goal-directed or "teleonomical")[4] behaviour:

S does B for the sake of G iff:
(i) B tends to bring about G.
(ii) B occurs because (i.e., is brought about by the fact that) it tends to bring about G.

Functionality in biology, on the other hand, applies to "those situations in which the organization of living creatures is paradigmatic" (Hull, 1974:103). Or, put less vaguely (but also more generally, in that the definition includes the functions of inanimate human artifacts, as well as allowing for goal-directed behaviour to have a function on top of its goal-directedness) by Wright (1976:81):

The function of X is Z iff:
(i) Z is a consequence (result) of X's being there,
(ii) X is there because it does (results in) Z.

Thus, "the heart beats in order to circulate blood" is an example of a statement concerning the heart's function. It is also an instance of a "natural function", that is, a function relating to the structure or behaviour of organisms - as opposed to what Wright calls "conscious functions".[5]

To further clarify the relation between goals and functions, we can say that functions and goals are both *consequences* in causal sequences; but more particularly, a

[4] Mayr's (1974 [1976]) adoption of the term (teleonomy) Pittendrigh introduced in 1958 may be a good idea, because the use of a separate term denoting goal-directed behaviour that is understood in a non-metaphysical sense, may help to prevent a lot of confusion. However, I do not necessarily go along with Mayr's additional specification that the goal-directedness be due to the operation of a program.

[5] Conscious functions are functions we ascribe where human artifacts or intent are involved, e.g., "the function of the newspaper shoved under the door is to block a draft". See Wright (1976:75-76).

function is a consequence of some component (e.g. an organ) of a system (e.g. organism), and likewise, a goal is a consequence of some activity (e.g. behaviour) of a system. Put differently, when something is said to have a function, it means that that something forms an integral and important component in some organismic process or system. The "components" of which functions are consequences need therefore not always be *entities* such as organs; even goal-directed *activities* can be functional when regarded from the perspective of another more encompassing process in which the activity plays a constituent role. Goals, on the other hand, are never the consequences of things, but rather of activities or behaviours. (For instance, the goal of the impala's running away is to escape the lion; the function of such escaping is survival. Again, the function of the heart is the circulation of blood, but the heart has no goal.)[6]

As for the nature of goal-directed and functional explanations, they have in common what Wright has termed a *consequence-etiology*. Both offer an etiology, that is, a causal account of the occurrence or presence of certain behaviours/entities, and do so in terms of the consequences of these types of behaviours/entities. The consequences concern the reaching of certain goals or the fulfilment of certain functions. However, an explanation in terms of a goal or a function is not invalidated by the failure in any particular instance of the behaviour/entity in question to reach its goal or fulfil its function. An "in order to" relation is still present. Failure and malfunction does not take away from the fact that the behaviour occurs or the entity is present for the sake of (that is, because of) the goal/function. How exactly this claim can be justified in a non-metaphysical way by reference to the causal history of the phenomena in question, as well how one can more accurately distinguish between beneficial consequences that are goals/functions and ones that are not, will be the subject of the fourth chapter. As Mitchell (1995:42) comments, Wright himself had not yet taken the trouble to "make explicit the specific characteristics of the historical, causal 'because' which carries the explanatory burden" in his account. It was left to others to show that the key to a solution was to be found in the process of natural selection.

[6] I am drawing here in part upon Wright (1976) and Mitchell (1995:39,42), integrating their perspective with some of Wilson's (1991:137-138) insights.

The D-N challenge and other difficulties

We can now return to where we have left off before the treatment of the etiological view, namely to the temporary consensus on the nature of scientific explanation that was reached due to the rise of the deductive-nomological model. Although Wright's analysis appeared only after the received view was already past its peak - various of its problematic aspects having been exposed; it was (and is) still fashionable to use (revised) D-N requirements as yardstick against which other types of explanation, such as teleological explanation, are measured and compared. It is therefore important to devote some space to its characteristics so that we shall be able to see, in the course of this study, how the etiological model defended here compares with it. But before getting to the specific demands of the D-N model, we shall do well to note three general charges against the scientific legitimacy of teleological explanation that Wright (1976:7-22) thought his model was definitely capable of overcoming. They relate to inverse causality, anthropomorphism, and obstructionism in scientific research respectively.

The first charge holds that in teleological and functional explanations the orthodox order of cause and effect is reversed, that is, the proper chronological event sequence is not respected. That which is really a consequence or result of an event becomes designated the cause of the event. However, this is a faulty accusation, and later we shall see how Darwin's theory provided the answer to objections of this kind. For now, Wright's reply will do:

> The reversal of cause and effect has long been hung like an albatross around the neck of teleology, but it is not clear how this view could have survived even modest scrutiny. No doubt there is implicit in the teleological appreciation of phenomena an essential forward-looking element. But there is nothing in any of the ordinary ascriptions of goals or functions or motives or purposes or aims or drives or needs or intentions which requires us to reverse the normal cause-before-effect sequence. When I explain my going to the store by saying I went 'in order to get some bread,' I do not imply that the actual act of purchase caused my going which preceded it. The purchase of bread was a *goal* of the action, not a cause. Perhaps my *having* of that particular goal could be viewed as a cause of the action; but that of course is something that preceded the action, and hence is not guilty of the egregious time-reversal imputed to teleological accounts of behaviour.
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> (Wright, 1976:10-11).

Teleological explanations are therefore entirely compatible with ordinary physico-chemical causality. On the other hand, that does not mean that we can just as well do away with talk of goals and functions, exchanging these for purely physico-chemical terms. The question is whether such a move will not deny us notions that are of great explanatory value.

The second charge claims that teleological explanations are anthropomorphic, that is, they read human mental attributes into the nature of beings that are not human. But even though the teleological paradigm case may be conscious and intentional human behaviour, and even though teleological explanations of other phenomena may be metaphorical extensions of notions that are paradigmatically human, Wright (1976:12-22) maintains that this need not pose a problem. He bases his case on the role of metaphor in science. The use of metaphors is widespread in science and as long as it is employed cautiously, it promotes insight and is a valuable scientific tool. By using a well-chosen metaphor in a new context attention can be drawn to an important aspect that would otherwise not have been recognised. The same is true of teleology:

> [T]he feature of human teleology which transfers to nonhuman cases is the fact that when we say 'A in order that B,' the relationship between A and B plays a role in bringing about A. It is this being pointed out, rather than intelligence and conscious purpose.
>
> (Wright, 1976:21).

The third charge fears that the acceptance of teleological explanations as legitimate, will obstruct further scientific research. According to Wright (1976:22), this charge is based on a misunderstanding of teleological conceptualisations and the role they play in empirical enquiry. He maintains that they are in fact very similar to the other explanatory concepts found in natural science. Whether this claim of his (or the other two, for that matter) holds water, we shall only be able to evaluate once we have become thoroughly acquainted, in the following chapters, with Darwin's reasoning as well as with the amended etiological model.

That said, we can now return to the D-N model - which for long has claimed to hold the key to genuine scientific explanation in the natural sciences (and elsewhere).

To qualify as a deductive-nomological explanation,[7] an explanation has to fulfil the logical conditions of being a valid deductive argument, containing in an essential fashion at least one general law[8] in its explanans, and possessing an explanans that has empirical content. To the logical conditions is added the empirical condition that the sentences constituting the explanans must be true. (Salmon, 1990:12).

In order to avoid confusion, it is important to note here that the D-N model must be distinguished from another distinct model of scientific reasoning that serves a very different purpose, namely the *hypothetico-deductive* (H-D) model. Though structurally similar, the one (D-N) bears on *scientific explanation* and the other (H-D) on *scientific confirmation*. In other words, in the case of a deductive-nomological explanation we presuppose the truth of the premises (including those asserting scientific laws) as well as that of the conclusion (stating the fact calling for explanation). The logical relation between premises and conclusion is not one entailing proof of the latter by the former, but rather signifies that the former explains the latter by giving sufficient reasons for its occurrence. On the other hand, in the case of the hypothetico-deductive method, the logical structure contains as one of its premises a hypothesis of which the truth needs to be ascertained - the truth of the conclusion once again being assumed.[9] (Salmon, 1990:7). (It will later become evident to what extent Darwin's theory carries elements of both of these models.)

Among the philosophically controversial aspects of the D-N model, four[10] will be of specific interest to us, as it will be important to see whether and to what extent the kind of teleological explanation employed by evolutionary theory since Darwin can be said to

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[7] I shall confine myself to the *informal* conditions of adequacy for D-N explanations, and the mention of certain philosophical assumptions of the model. For a treatment of the more complicated, *formal* explication given by Hempel and Oppenheim, see Salmon (1990:18-23).

[8] A law-sentence being for Hempel and Oppenheim a true sentence, as well as having the properties of universal form, unlimited scope, no designations of particular objects, and containing only purely qualitative predicates (Salmon, 1990:13).

[9] This is however not unproblematic. As Salmon (1990:187, note 4) remarks: "[I]t is an elementary logical fallacy to infer the truth of the premises from the truth of the conclusion of a valid deductive argument. As a matter of fact, neither Hempel nor I considers the traditional hypothetico-deductive schema an adequate characterization of scientific confirmation, but it seems to be so regarded by many people". We shall have to decide below whether we concur with Salmon in this judgement.

deviate from these. Moreover, it will have to be determined whether such deviation will invalidate these explanations - Hempel, for instance, did not consider functional explanations scientifically legitimate, precisely because he could not see how they could be made to conform to the D-N model (or to inductive or statistical models).[11] However, if such deviation is unavoidable, then the question to be asked is whether a case cannot be made for the legitimacy of an alternative model to which it does conform.

The first condition of adequacy advanced by Hempel and Oppenheim entails that all legitimate scientific explanations are arguments. Also known as the *inferential* conception of scientific explanation, this condition has been problematised and rejected by a number of writers. For us the question will be whether teleological explanation since Darwin is inferential in this sense.

The second condition of adequacy raises an additional problem. The *covering law* conception of scientific explanation, that is, the requirement that a scientific explanation must include at least one law in an essential way, has been disputed by many involved in sciences having an irreducibly historical dimension. Among these, of course, is evolutionary biology.

Thirdly, disagreement has also followed in connection with the Hempel-Oppenheim *explanation/prediction symmetry* thesis. This holds that "any correct D-N explanation could serve, in appropriate circumstances, as a scientific prediction; conversely, any deductive scientific prediction could, in appropriate circumstances, serve as a D-N explanation" (Salmon, 1990:24). Whether this applies to evolutionary biology generally, and more specifically to the kind of teleological explanations Darwin inaugurated, is questionable.

Fourthly, the issue concerning the role of *causality* in scientific explanation has been widely debated. Contrary to Hempel's rejection of causality as relevant to scientific explanation, many have maintained that causality does have a role to play. Certainly,

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[10] These have been selected from Salmon's discussion (1990:23-25).
[11] For an exposition, see Salmon (1990:28-31).

Darwin himself was intent on providing us with explanations in terms of truly existing causes.

How the kind of teleological explanation that is the legacy of Darwin, provides its own answers to the issues raised by the D-N model and its conditions, will emerge in the chapters to follow. What these chapters will entail, can now be addressed.

Darwin and teleological thinking

The essential background having been given (that is, a brief history of teleological thinking, a tentative description of the model of teleological explanation adopted here, and an enumeration of some of the chief challenges faced by it), the argument to be developed in this thesis can presently be stated in more detail.

Darwin's discovery of the theory of evolution by natural selection effected a profound transformation of teleological thinking. In what sense, and through which means his theoretical discoveries can be said to have overcome metaphysical teleology and to have initiated and informed current ideas on what scientifically legitimate teleological explanation should consist of, is the question I will investigate here.

The answer I will propose, is, *firstly*, that Darwin's efforts to develop a theory of evolution that could comply with the requirements of a certain empiricist philosophy of science, enabled him to cause the downfall of metaphysical teleology in biology - the collapse of which was an important precondition for the emergence of any properly scientific account of adaptational phenomena, that is to say, of any scientifically legitimate model of teleological explanation. (The former claim is valid regardless of whether that empiricist philosophy of science was actually in all of its aspects compatible with Darwin's ideas, and regardless of whether the authors of that philosophy of science fundamentally disagreed with Darwin's defence of evolution - or transmutation, as it was called then.)

Secondly, and again by virtue of the kind of empirical historical process he envisaged as the cause of adaptations, Darwin initiated such a new scientifically legitimate model of teleological explanation. However, the explication of that model had to wait until well into the present century. It now goes under the name of an *etiological* approach to goals and functions, and is the model which, in my view, offers the closest approximation to Darwin's own conceptualisation. It is moreover my opinion that the etiologial approach is also the most important and fundamental model as regards teleological explanation. The argument will proceed in the following manner:

In the first place (chapter two), I shall state some of the science-philosophical assumptions that inform the present study. That will be followed by an expositional analysis of Darwin's theory of descent with modification by natural selection, in which his main premises and conclusions will be listed, as well as the nature of the inferential links and evidential support elucidated. In addition, it will be shown how Darwin structured his theory of evolution in the *Origin of Species* so as to make it conform to certain science-philosophical ideals that were dominant at the time. Most important in this regard was Darwin's adherence to the *vera causa* doctrine that hailed from Newton, and with which he became acquainted through the work of William Herschel and Charles Lyell.[12]

In the second place (chapter three), it will be argued that Darwin's proposal concerning the process of species formation, namely natural selection, was in direct opposition to the traditional metaphysical teleology (in the form of natural and revealed theology) prevalent in natural historical studies at the time. I shall investigate how Darwin - by having offered natural selection as empirical causal process responsible for adaptation and the origin of species - undermined both the natural theological argument from *design* and the argument from revelation concerning the separate or *special creation* of distinct and immutable species. Two conceptions of divine design will figure prominently, namely that of design as practical adaptation, and that of design as divine order.

In the third place (chapter four), it will be shown that Darwin continued to employ teleological terminology, his anti-metaphysical stance notwithstanding. Thereupon, the etiological approach to goals and functions sketched above will be supplemented, and

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[12] A case will be made that Darwin found his inspiration in Herschel's interpretation of the *vera causa* doctrine, and *not* in the idea of a "consilience of inductions" as advanced by William Whewell.

the choice made for its adoption motivated. Finally, it will be argued that Darwin, partly by virtue of the particular science-philosophical mould in which he had cast his theory, and partly by virtue of the kind of historical process he had offered as cause for adaptation, succeeded in issuing in a non-metaphysical, scientific form of teleological explanation. Teleological explanation was provided, for the first time, with a proper causal basis (natural selection) - a crucial legacy to present-day biology.

2

Natural Selection as *Vera Causa*

The aim of the present chapter is to show that Darwin convincingly argued - by heeding certain science-philosophical ideals - for natural selection as the causal and therefore explanatory principle with regard to the origin of species. Before proceeding to a reconstruction of Darwin's case for evolution by natural selection, and investigating the way in which Darwin drew upon contemporary philosophies of science for the presentation and proof of his theory, a brief preparatory synopsis of his theory will be furnished, followed by a treatment of the science-philosophical ideals considered relevant for the analysis.

I can however not proceed to a treatment of the mentioned issues without first stating some of the philosophical *assumptions* informing the line of argument developed in the present and subsequent chapters. Two issues particularly need to be touched upon - that concerning a philosophical account of scientific theory and explanation, and that concerning the role of natural selection in evolution.

Firstly, as regards an account of the nature of scientific theory and explanation, I probably feel myself closest to what Wesley Salmon describes as the *ontic* conception (in contradistinction to the modal and epistemic conceptions).[1] This entails a realist belief in the possibility of knowledge concerning underlying causal (or other) mechanisms - which knowledge is empirical and explanatory. It therefore means that

> [M]ere subsumption under a law is not sufficient for explanation. There must be, in addition, a suitable causal relation between the explanans and explanandum - at least as long as we

[1] For the distinctions he makes between the three conceptions, see Salmon (1990:118-186). He also subdivides these three conceptions further, so that each can be instantiated in a number of different *versions*. For instance, Hempel and the received view falls under the *inferential* version of the *epistemic* conception of scientific explanation. As for opposition between the different conceptions, I tend to agree with Salmon that they need not always or necessarily be viewed as incompatible, but that in many cases they may be complementary.

steer clear of quantum mechanical phenomena.

(Salmon, 1990:130).

This is very much akin to the kind of outlook Darwin had. His adherence to the *vera causa* doctrine which will be discussed below, placed him in an older empiricist tradition than the positivist one advanced by Auguste Comte. That means that Darwin's preoccupation would have been with issues concerning "existential claims for causation", rather than with positivist questions concerning "universal statements of law" (Hodge, 1987:266). (That is partly why neither the semantic approach, nor the received view, is able to fully do justice to the nature of Darwin's theory.)[2]

An account of the *nature of causation* - necessary though it may seem to the realist outlook presupposed here - can unfortunately not be presented within the confines of this thesis. And in fact, it is in my view quite possible that an adequate account of the nature of causation may forever elude us, and that we may be forced to settle for a somewhat vague intuitive notion of what it is for one thing to be caused by another (others). In any case, Salmon, who sees himself as also working within the ontic category of scientific explanation, argues for a theory of causation in terms of the transmission of marks which hardly strikes one as convincing or noncircular.

The lack of both an invincible justification of realism and an explicit account of causation, need however not be viewed as a measure of the relative worthlessness of these ideas. Not altogether unlike Karl Popper, I have no problem with admitting that a commitment to realism (like a commitment to idealism) cannot but be metaphysical and irrational,[3] and that such a metaphysical realism can only give "some intuitive encouragement, some hope, but no assurance of any kind" (1957 [1979:203]). However, the latter statement should not be taken to mean that realism is of mere emotional and inspirational significance, and have no significant influence on the form a

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[2] See Ereshefsky (1991) for a (to my mind) successful refutation of semantic theorists' claim that the semantic approach to evolutionary theory is able to overcome the difficulties that are inevitably encountered by the received view when the latter is applied to evolutionary theory. See Griffiths (1997) for a sympathetic review of Depew and Weber's interpretation of the history of the Darwinian research tradition in terms of the semantic view of theories.

[3] Popper (1972 [1979:38-44]) himself nevertheless offer some (admittedly inconclusive) arguments for realism. I do not necessarily go along with any of them, or, for that matter, with Popper's entire science-philosophical edifice, although I do find some of his ideas

realist's theories take. On the contrary, realism will require of a scientific theory to identify the real *empirical causes* of the phenomena to be explained. For instance, I will argue below that Darwin's theory of evolution by natural selection succeeded in finding the empirical causal process responsible for the origin and diversification of species. In arguing thus, I shall by implication and to a large extent rule out the applicability of certain other approaches to scientific theory, such as the received view or the semantic view.[4]

Secondly, as regards the role of natural selection in evolution, it must be noted that there is a lively debate about the demarcation of the role of natural selection in the evolutionary process. The issue is about the relationship between natural selection and self-organisation, and which can be said to hold the most weight in evolution. In my view, the principles of self-organisation operating in living complex systems cannot be denied an important role in evolution, but neither can natural selection. Where *exactly* the balance lies, I leave as yet undecided.[5] Darwin himself did not rule out some role for factors other than natural selection in evolution. For the purposes of the present thesis, one needs only to admit that natural selection do carry with it a rather large part of the causal burden.

Descent with modification by natural selection

Darwin's theory of evolution, or, expressed more fully, his theory of descent with modification by natural selection, consisted of two relatively unoriginal ideas - the tree of life and natural selection - combined and applied in an original way.[6]

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useful.

[4] In contrast to the perspective adopted here, the semantic view defines a scientific theory as a "class of abstract models. The theory is true of these models by definition. The theory is not true of any real world systems, because it is not directly *about* any real world system. A theory is *applicable* ro real world systems in virtue of more or less complete isomorphisms that obtain between real world systems and the abstract models which the theory describes" (Griffiths, 1997:421).

[5] See Depew & Weber (1996) for a treatment of seven different conceptions of the relationship between natural selection and self-organisation. See Kauffman (1995) for an emphasis on self-organisation. See Cilliers (1998) for a description of the characteristics of complex systems, as well as for the development of a model of complexity.

[6] The synoptic account presented here is in part a selective summary of Sober (1993:7-14) where more detailed explanations and technical definitions are given, and the difference in

Darwin supposed, in the *first* place, that all forms of terrestrial life are related to each other through common ancestors, that is to say, they are all part of a single branching *tree of life.*[7] The different branches of the tree may be made to represent distinct varieties, species, genera, etc., depending on the amount of detail and the span of time we want to depict. The point at which a branching takes place represents the point in time where two separate forms last shared common ancestors. The notion of a tree of life therefore already entails descent with modification in that we have lineages not only descended from one another, but also having undergone change in the process - change is implied by the fact that, after all, lineages now exist which had not existed at an earlier point in time, and which differs from their ancestral lineages.

But *secondly*, Darwin needed to account for the branchings, he needed to find the reasons for, or causes of, the modification and divergence of species. He did this by claiming that there was chance variation in the fitness of organisms, and that the environment favoured the survival and reproduction of the fitter organisms. (Less fit animals will tend either not to survive or not to reproduce as successfully.) Moreover, as he believed that variation in fitness was heritable, the fitter organisms would not only survive to reproduce, but would also pass on their fitness to their offspring. This sums up the principle of *natural selection* - the principle or causal process which accounts for both microevolution — changes within a single species, and macroevolution — the extinction and emergence of entire species.

Darwin thus made a pattern claim (one genealogical tree) and a process claim (natural selection as the cause of the diversity among the tree's life forms). The originality of his contribution did not lie in the idea of evolution, or in the idea of natural selection, but in the idea that evolution or "descent with modification" happens *by means of* natural selection.

We should not forget though, that Alfred Russel Wallace also succeeded in hitting upon this same combination of ideas at almost the same time, and nearly forestalled Darwin in its public presentation. Darwin distinguished himself however, by, among others, the

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theories between Darwin and Lamarck is pointed out.

[7] See Darwin's diagram and discussion in *The Origin of Species* (1859 [1968:159-169, 332-334]).

extensive evidential support he marshalled for his theory. He thereby meant not only to persuade readers of his theory's scientific respectability, but also of its scientific superiority. But more on that later.

The short preliminary sketch just offered of Darwin's theory will be filled out in due time. For now, however, it provides us with enough background to be able to anticipate as we go along the strategic moves Darwin made in arguing for his theory. In the next section we will take a look at the thinkers whose ideas influenced the strategy and structure of Darwin's argument.

Herschel, Lyell and Whewell

Already from the earliest versions of his theory of descent with modification by natural selection, Darwin consciously elaborated his theory in terms of certain contemporary ideals for scientific endeavour. In this regard the philosophies of science advocated by the two most influential and prominent philosophers of science in the England of the 1830s - *John F.W. Herschel* (1792-1871) and *William Whewell* (1794-1866) - immediately offer themselves as candidates. Darwin personally knew, and read the works of both these figures. Moreover, the great geologist, *Charles Lyell* (1797-1875), whose work embodied much the same science-philosophical views Herschel propounded, had a powerful formative influence on Darwin's thinking.

In what follows it will be my contention that it was upon Herschel's interpretation of the *vera causa* doctrine, rather than upon Whewell's consilience of inductions, that Darwin drew when he constructed his theory. However, after the event, when having to defend his theory, he sometimes also made use of Whewell's idea of a consilience of inductions. In arguing thus, I concur with the views of Jonathan Hodge (e.g. 1989), rather than with those of Michael Ruse (e.g. 1975, 1979) - who makes room for both Herschel's *verae causae* and Whewell's consilience in Darwin's construction of his theory; or with those of Wilson (1991) - whose philosophical commitments causes him to veer entirely towards the side of a consilience of inductions. All the same, despite some crucial differences, Herschel and Whewell's philosophies overlapped in many respects, and Darwin would have received many of the same ideas from both.

Already during his undergraduate years, Darwin became acquainted with Whewell, attending some of the same lectures and scientific meetings; and with Herschel he would some years later share much the same social circles. In addition, Darwin belonged to the Geological Society, as did Herschel and Whewell - Whewell having been its president in 1837 and 1838 when Darwin served on its council. Whewell also in many ways supported and encouraged Darwin, at least in the years after his return from the *Beagle* voyage when the future estrangement over Darwin's evolutionist theories had not yet clouded their shared scientific horizon. (Ruse, 1975:165).

Darwin first read Herschel's *Preliminary Discourse on the Study of Natural Philosophy* in 1831 and then again in 1838.[8] He also at some stage read Herschel's *Astronomy*. Among the works of Whewell he definitely did read, was the latter's address to the British Association, his *Bridgewater Treatise* (in 1838 and 1840), and his *History of the Inductive Sciences* (in 1838). (Ruse, 1975:164-6). However, there is no indication that Darwin had read Whewell's *Philosophy of the Inductive Sciences*, which appeared in 1840, by the time he wrote his *Sketch* in 1842. And it was only in his *Philosophy* that Whewell for the first time explicitly articulated his view on the consilience of inductions. Thus, in the crucial years during which Darwin conceptualised his theory and its fundamental structure, it was the *vera causa* ideal as presented in the work of Herschel and Lyell that was foremost in his mind. (Hodge, 1989:171,172).

It is important to note that philosophy of science in England was dominated by invocations of mainly two thinkers - Bacon and Newton.[9] As both Herschel and Whewell took seriously their adoption of Newtonian astronomy as paradigm for their respective

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[8] Herschel, together with Alexander von Humboldt, served as a major source of inspiration to the young Darwin's developing scientific mind. This is acknowledged as follows by Darwin in his *Autobiography* (first published in 1887, five years after his death): "During my last year at Cambridge I read with care and profound interest Humboldt's *Personal Narrative*. This work and Sir J. Herschel's *Introduction to the Study of Natural Philosophy* stirred up in me a burning zeal to add even the most humble contribution to the noble structure of Natural Science. No one or a dozen other books influenced me nearly as much as these two" (Darwin, 1958:67-68).

[9] Routine accusations by scientists of each other not adhering to the basic rules of science as advocated by Bacon and Newton, frequently entered into scientific disputes. Attempts to present one's own work as possessing scientific legitimacy by appealing to the authority of these two figures, at times reflected superficial understanding and a desire to be fashionable. Ruse (1979:56) mentions a "Granville Penn (1822), who wrote a massive work showing that nothing in geology refutes a most literal reading of Genesis, [invoking] three authorities in his support — Moses, Bacon, and Newton"!

philosophies, they could not but agree on many points.[10] Darwin himself had no problem with the conviction of his two mentors that Newtonian astronomy was the model science to be emulated by other fields, and was quite enthusiastic about working towards the transformation of biology into a Newtonian science (Ruse, 1975:166).

Herschel's philosophical system can be characterised as a kind of middle position between empiricism and apriorism, whereas Whewell, having acquired a greater familiarity with Kant than his colleagues, developed a neo-Kantian rationalist stance. Their respective notions of what the process of induction should consist of are of especial importance, as it would be Herschel's and not Whewell's that would influence Darwin when he set about formulating his theories.

Though explicit mention is not made of Locke, Berkeley and Hume in Herschel's *Discourse*, the work is clearly building on empiricist precepts partly enunciated by them. The great Francis Bacon however, is not similarly neglected in the discussion, and Herschel develops some of the former's ideas. In the *Discourse* Herschel championed, among other things, induction as the proper and desired method to be employed in the practice of science. (Kockelmans, 1968:29).

For Herschel, there were two main types of laws - *empirical laws* and *fundamental* (causal) *laws*. The former *describe* empirical regularities but do not explain them - Kepler's laws, for instance. The latter's task, on the other hand, is to *explain* why the regularities exist by referring to what *caused* them, and these laws must preferably be formulated in quantitative terms - Newton's laws of motion and gravitation being held up here as the paradigm example. The combinations of known causes serving to explain phenomena, are what Herschel called *verae causae*, or true causes. He was however all but clear and consistent when it came to what he meant by the concept cause. At times he inclined towards an understanding of causes in terms of force. (Ruse, 1975:161; Ruse, 1979:57; Partridge, 1966:xxix,xxxiii,xxxvii,xxxix).

Whewell concurred with Herschel on the distinction between empirical and causal laws, which in his own terminology was rendered by "formal" and "physical science", and

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[10] They were moreover friends and read and critiqued each other's work.

"phenomenal" and "causal" components of theories. But where they did differ was on the *vera causa* doctrine - in this regard making their respective empiricist and rationalist colours apparent, as we shall see below. (Ruse, 1979:58).

According to Whewell's system, the human mind is furnished with a potentiality for producing conceptions and laws regarding the natural world. These have a predefined form, and are latently present in our minds, ready to become operative upon the first stimuli provided by experience (Partridge, 1966:xviii). Whewell believed that science could provide us with knowledge that is mind-imposed and has a status akin to logical necessity. As a Kantian rationalist he would thus find it essential to reason *to* experience when it came to determining the *verae causae* of phenomena, rather than *from* experience as Herschel insisted. (Ruse, 1979:58).

For Herschel the criterion something had to meet in order to qualify as the *vera causa* of a phenomenon, was as follows: Where we are confronted with two very similar phenomena, and the cause of one of them is known to us in an obvious way, then it becomes clear that the other must have been produced by an analogous cause, though this latter cause might not have been obvious in itself (Herschel, 1830 [1966:149]). Says Herschel furthermore:

> (141.) Whenever, therefore, any phenomenon presents itself for explanation, we naturally seek, in the first instance, to refer it to some one or other of those real causes which experience has shown to exist, and to be efficacious in producing similar phenomena. In this attempt our probability of success will, of course, mainly depend, 1st, On the number and variety of causes experience has placed at our disposal; 2ndly, On our habit of applying them to the explanation of natural phenomena; and, 3rdly, On the number of analogous phenomena we can collect, which have either been explained, or which admit of explanation by some one or other of those causes, and the closeness of their analogy with that in question.
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> (Herschel, 1830, [1966:148]).

The *vera causa* ideal that served as motivation for both Herschel and Lyell, received its canonical explication from the eighteenth century Scottish moral and natural philosopher, Thomas Reid, who gave a new interpretation of Newton's first rule of philosophising. The latter held that

> Hyp. I We ought to admit no more causes of natural things, than such as are both true and sufficient to explain their appearances.
>
> (Quoted in Hodge, 1977:239).

Central to the Reidian interpretation of this rule was the distinction between "true, known, real or existing" causes on the one hand, and "hypothetical, imaginary, unknown, conjectural or supposed" causes on the other. This contrast was exemplified by Newton's gravitational force and Descartes' vortices of subtle matter respectively. But it was not in their *competence* to cause the effects in question (- the planets' orbiting the sun) that the superiority of the one over the other resided. Both would have been sufficient or adequate to bring about the phenomena we want to account for, and therefore had equal status in that respect. (Hodge, 1989:169). The difference comes in when we consider the evidence for the *existence* of each:

> For the gravitational force there is independent evidence (from tides, for instance, and falling bodies on earth) for its existence; it is evidenced by facts other than the planetary orbits it is to explain; whereas for the existence of the Cartesian vortices there is no evidence except those orbits. The gravitational force, unlike the vortices, is therefore both a true, known, real or existing cause as well as a sufficient, adequate or competent cause. It meets, then, the requirement that one is not allowed to suppose, or infer, that one's explanatory cause exists merely because it is adequate to explain what it is to explain. Truth, existence and reality, on the one hand, and sufficiency, adequacy or competence, on the other, are independent considerations and their evidential demands must both be met for a cause to meet the constraints of the *vera causa* ideal.
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> (Hodge, 1989:169).

In other words, we cannot allow our judgement on the adequacy of a cause to decide the issue regarding its existence. That issue can only be decided through our possession of direct and independent observational evidence of its activity in nature, that is to say, from facts different from those we want it to explain. (Hodge, 1987:236).

Unlike Lyell, who would find a welcome ally in Herschel when it came to the *vera causa* doctrine, Whewell, though not rejecting the idea of *verae causae* as such, objected to the empiricist content given them by Herschel. Instead of reasoning in an analogical manner from known experience to that which is unknown — which would imply ruling out any search for new causes that we may not be familiar with as yet, we should rather interpret *verae causae* in terms of a "consilience of inductions" (Ruse, 1979:58). This notion of his basically entails that where a comparison of two or more theories developed independently in different fields of science, shows them both pointing towards a cause of a very similar nature, that cause can be considered a *vera causa*. In other words, where two or more theories dealing with different kinds of phenomena overlap, they can be interpreted as confirming each other, and we are justified in accepting the cause they indicate, as a true one. Whewell formulates it as follows in one of his aphorisms:

> *The Consilience of Inductions* takes place when an Induction, obtained from one class of facts, coincides with an Induction, obtained from another different class. This Consilience is a test of the truth of the Theory in which it occurs.
>
> (Whewell, 1847:469, Vol. 2).

Whewell presented his consilience of inductions as a better alternative to the old Reidian *vera causa* ideal for scientific theories. He did not go along with the latter's presupposition that the truth or existence of an explanatory cause can be separated from its adequacy. The demand that the existence of any cause introduced by a theory be demonstrated by direct, independent evidence, was viewed by Whewell as posing unnecessary and crippling restrictions for scientific theories. Evidence of such a nature is often unattainable, and lack of it should not count against a theory. For we are already justified in inferring the probable existence of the explanatory cause in question if we can show that it possesses evident explanatory adequacy with regard to numerous distinct classes of facts. Nothing more than this is required for establishing the inductive credentials of a theory. Whewell believed that the new wave theory of light, for one, was an instance of a theory not conforming to the old *vera causa* ideal,[11] but that it was good science all the same, and that instead of doing away with the theory as illegitimate, we should reject the outdated ideal. (Hodge, 1989:171-172).

As already mentioned, Darwin also, and perhaps more significantly, learned of the *vera*

[11] The wave theory was not legitimate in the *vera causa* sense because no direct independent evidence could be found for the existence of light waves; the theory was nevertheless very successful in that it could account for diverse groups of optical facts

causa ideal from Charles Lyell. While on the *Beagle* (December 1831 to October 1836), Darwin read with great interest Lyell's three-volume *Principles of Geology* (1830, 1832, 1833), and immediately became enamoured of Lyell's views on the gradual elevation and subsidence of land masses. Throughout the voyage Darwin enthusiastically tried to observe geological phenomena through Lyell's eyes, and on his return the two forged a life-long friendship - Lyell appreciating his young disciple's efforts to prove his geological theory. The friendship was strong enough to outlast, in later years, Darwin's deep disappointment at Lyell's failure to fully underwrite his (Darwin's) own theory on the origin of species. Important though, is that Darwin learned through Lyell's example what it would mean to apply the *vera causa* ideal to natural historical studies, and how critical it is to amass as much evidence as possible for your claims, thereby building a cumulative case that would be difficult to resist.

It was Lyell then, who appropriated the *vera causa* ideal - coming as it does from a tradition in the philosophy of physics - for geology. Lyell badly wanted to transform geology - which was on the brink of becoming a field known for its philosophical promiscuity, being amenable to religious scepticism, materialism, and speculative excess - into a respectable science that would rise above conflicts of a metaphysical nature. He wanted to show that geology need not rest on shaky foundations or imply atheism. Geology could be practised in accordance with the kind of rules of reasoning evidenced by Newton's *Principia Mathematica* (1687). (Secord, 1997:xi,xiv,xvi).

Labelled uniformitarianism by Whewell (in opposition to Whewell's own catastrophism), Lyell held the view that the causes of change at present operating in the earth's surface, are the same in degree and kind, or in intensity and efficacy, as those that operated in the past long before the human period, and the same as those that will operate in the distant future - hence the subtitle of his work: *Being an Attempt to Explain the Former Changes of the Earth's Surface, by Reference to Causes Now in Operation*. Just like Newtonian physical astronomy could appeal to the same kind of causes accessible to, and knowable by the human mind here on earth when accounting for celestial phenomena, so geology can appeal to the same kind of causes accessible (at least in principle) to direct observation by the human mind in the present, to account

(Hodge, 1989:171).

for past and future events on the earth's surface. (Ruse, 1979:40; Hodge, 1987:237).

Given his dissent from the catastrophist viewpoint towards which most British geologists in the 1820s inclined, Lyell did not believe that the world's prehistory had been characterised by calm periods and great upheavals that no longer operate in the present; nor did he believe in the added teleological and metaphysical idea that the world manifests direction or progression. Instead, his thought can be said to advocate - apart from the uniformitarianism (and actualism) referred to above - a steady-state view of the earth. That means that the earth at all times displayed the same cycle of gradual eruption and decay, and that both the organic and inorganic spheres were devoid of any progressive development. (Ruse, 1979:40). We shall later see, especially in the next chapter, in what sense Darwin can be said to have appropriated Lyell's ideas on the inorganic sphere, but rejected his ideas concerning the organic sphere.

Having now sketched some of the main ideas advocated by Herschel, Lyell and Whewell, the ground is prepared for an analysis of the argument for evolution by natural selection as advanced by their pupil, Charles Darwin.

Darwin's argument

According to Michael Ruse (1975:166-7), Darwin managed already in his preliminary elaborations of his theory - in the *Sketch* of 1842 and the *Essay* of 1844 - to incorporate the two main characteristics of theory-construction to be drawn from the Herschel-Whewell philosophy of science, namely, the hypothetico-deductive model and the employment of one cardinal cause or principle to account for a broad and diverse range of appearances. However, as Ruse (1975:168) himself admits, "many of the inferences in Darwin's theory taken as a whole were far from being rigorously deductive." All the same, Ruse (1971) tried his best to force what he regarded as the essential aspects of Darwin's argument, into deductive form - with some awkward consequences - as will become clear below.

I hope to take a more fruitful approach in the following attempt to shed light on the nature of Darwin's argument for evolution by natural selection. In this regard extensive use will be made of the insights of Fred Wilson and Jonathan Hodge. (Ruse's important work will however not be neglected). Few could probably surpass Fred Wilson's (1991) exceedingly clear and detailed reconstruction of Darwin's arguments in terms of its individual premises and conclusions. However, Jonathan Hodge's (1989, 1992) illuminating analysis of the general construction of the *Origin* in terms of the *vera causa* doctrine, brings us nearer to the way Darwin conceptualised his own argument.

Darwin does not, of course, systematically list and number premises, conclusions and subarguments, but rather piles up evidence, examples and arguments in a not particularly tidy manner. It is therefore not surprising that some confusion and misinterpretation concerning the structure of his "one long argument" - as he himself called it - are to be found among friends and foes alike. So there is some truth in Michael Ruse's complaint that

> [...] the major cause of the trouble is Darwin himself. He omits premises, he repeats premises (sometimes in slightly different forms), he has two or three arguments going at the same time, and he jumbles the order of premises and conclusions. He fights a not altogether successful battle against an illicit anthropomorphism which keeps intruding into what he writes.
>
> (Ruse, 1971:313).

Unfortunately though, despite his careful enumeration of all the factors that could lead an interpreter astray, Ruse then becomes ensnared in some traps of his own. I fully agree with Wilson's verdict that Ruse adopts a "rather odd" position with regard to the structure of the *Origin* (Wilson, 1991:182). The oddness of Ruse's position can be seen in the remarks with which he concludes the above (quoted) passage:

> [Darwin] spends a great deal of effort arguing first to something which he calls 'the struggle for existence', which he defines in an extremely slap-dash way, and which he claims is necessary for the proof of statements of natural selection. Not only does he not need to argue for the struggle for existence to get natural selection, but once having supposedly proved the existence of the struggle, he does not always use it in his proof of natural selection. Finally, Darwin offers us two different varieties of natural selection, and it is quite possible that they are logically distinct. All in all, I shall argue that Darwin gives us the, perhaps not uncommon, picture of a great inventor who is not very sure of how to present and defend the child which he has fathered.

(Ruse, 1971:313-314).

To claim that Darwin could have done without the idea of a struggle for existence as premiss in his argument for the existence of natural selection, is odd indeed. Without going into the details of Ruse's analysis and showing up its flaws,[12] we can note that its failure is due to a lack of attention to the explanatory aspects Darwin intended his theory to have. More specifically, instead of realising that natural selection functions as an *explanatory* and *causal principle* precisely because it entails a struggle for existence, Ruse has dropped the struggle for existence right out of the bargain and interpreted natural selection as merely referring to the *fact* it was actually supposed to explain, namely, the fact that organisms with favourable variations have a better *chance* of surviving and reproducing than organisms with injurious ones (or alternatively, the fact that there is an *actual* preservation of those with favourable variations and an *actual* rejection of those with injurious ones). Consequently, in order to get his reconstruction to make (explanatory) sense, Ruse has to try and bring back surreptitiously the explanatory, causal principle he has just discarded. So what he does is to make an implicit appeal to the struggle for existence by simply citing an example (industrial melanism in moths) in which it operates - without, of course, recognising that he has just appealed to the forces of natural selection in the form of the struggle for existence.[13]

Ruse does not trouble to take seriously Darwin's claim that the existence of natural selection follows from the presence of a struggle for existence. But through such neglect Darwin's conceptualisation of natural selection as signifying a causal process and causal mechanisms is forfeited, and thereby also its explanatory power. Wilson (1991:210) is correct in asserting that the main reason for Ruse's inadequate analysis is his wish to show that Darwin's argument is straightforwardly deductive in form - which it is not.

Wilson, who works within a positivist empiricist philosophy of science that incorporates some Kuhnian insights, propounds an alternative view. In his opinion the overall structure of Darwin's argument is not deductive - which is not to deny that deductive

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[12] That has already been done superbly by Wilson (1991:209-217).

relationships sometimes do play an important role in his argument as far as transmitting evidential support is concerned. However, the overall form Darwin's argument takes is rather

> *to introduce certain imperfect regularities and then to move to less imperfect regularities which explain the more imperfect.* The evidence supporting the more imperfect generality will also tend to support the less imperfect law that is later introduced as entailing and explaining the more imperfect. But Darwin also typically introduces other evidence that independently supports the less imperfect law. The structure of Darwin's case is not simply deductive, as Ruse suggests, but is a marshalling of inductive support to justify asserting ever-more-embracing unifying abstractive laws.
>
> (Wilson, 1991:217).

Wilson (1991) in fact wants to reconcile Darwin's theory with a positivist account of explanation (traditionally entailing an insistence on the D-N model of explanation and the requirement that theories be cast as axiomatic[14] systems), which latter has often mistakenly been thought to reject Darwin's theory on account of its lack of process laws. To avoid that dilemma, Wilson insists that the positivist account does make room for another type of law, to wit, "abstractive generic" laws that are "gappy" and "imperfect" when it comes to the explanation of individual facts and events, but which are nevertheless crucial in the guiding of research and the unification of knowledge.

It should be noted that whereas Ruse bases his analysis on the *Origin*, Wilson, in addition, concentrates on Darwin's first (much briefer, and less cluttered by forms of evidential support) public case for natural selection as presented in a paper (together with Wallace) in 1858 - the year before the publication of the more lengthy *Origin*.

We can now attend to the detail of Wilson's construal of the Darwinian argument. After citing passages from the mentioned paper, *On the tendency of species to form varieties*, as textual evidence, Wilson (1991:173-174) identifies three regularities crucial

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[13] See Wilson (1991:213-216).

[14] So far, attempts to produce an axiomatisation of evolutionary theory have not been particularly successful. It has only been axiomatised in part, and not as a whole. Ruse provided an axiomatic sketch of population genetics, and Williams provided an axiomatisation of selection theory. Such partial and incomplete axiomatisation proves problematic. Cf. Ereshefsky (1991:71) and Wilson (1990:117-122).

to Darwin's argument. But before presenting these and the other premises, it is necessary to keep in mind that any reconstruction of an argument takes some liberty in reformulating and rearranging the original ideas, and that Wilson's particular kind of positivist agenda does of course force him to search for formulations that satisfy certain requirements. The important thing is not to stray too far away from the way in which the argument was originally presented. That was Ruse's mistake when he chose to ignore Darwin's insistence on the importance of the struggle for existence. That said, let we now turn to Wilson's reformulation of what can be considered the first three premises:

(T_1) For any species of organism in its normal environment, offspring are (on the whole) more numerous than their parents.

(T_2) For any species of organism in its normal environment, the food supply (on the average) is constant.

Darwin makes the further assumption that

(T_3) For any species of organism in its normal environment, a constant food supply can support (on the average) only a constant number of individuals, and the greater the food supply the greater this number is.

The passages from which Wilson draws for the identification of the above premises, concerns an idea Darwin got from his reading of Malthus's *Essay on the Principle of Population*, namely that the increase of population tends to be geometrical whereas food resources, where they can be artificially increased - as in the case of humans - can only increase at an arithmetical rate, that is to say, the population would tend to rapidly outrun its food supply. Except, of course, if population growth is checked by something like moral restraint. But Darwin's point is that neither artificial food increase nor moral restraint is available to species other than humankind.

It follows then, from (T_2) and the first half of (T_3) that

(T_4) For any species of organism in its normal environment, the number of individuals is (on the average) constant.

Furthermore, from (T_1) and (T_4) we can deduce that

(T_5) For any species of organism in its normal environment, fewer individuals survive than are born.

At this point Wilson (1991:174) adds a central Darwinian assumption he formulated earlier in his book (Wilson, 1991:158), namely

(G) Organisms are, on the whole, goal-directed towards the overriding goals of survival and reproduction.

By using (G) and (T_5), we get

(T_6) For any species of organism in its normal environment, there are individuals born that, in spite of their strivings, do not attain the goals (viz., survival and reproduction) the achieving of which is the function of their behaviour.

(Wilson, 1991:174).

In T_6 is entailed the idea of a struggle for existence - which was meant by Darwin to include both a struggle for survival and for reproduction.[15] Wilson submits that the term "strivings" employed in T_6 is a slightly anthropomorphic way of making the point that goal-directed behaviour is plastic as well as persistent.[16] The obvious question now is

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[15] Darwin knew that the phrase "struggle for existence" was somewhat problematic and he insisted that his use of it was intended to be metaphorical. Rather than speaking of a plant as struggling against the drought, he said, it would be more correct to speak of its dependence on moisture. But the phrase was worth retaining as a general term denoting all of organisms' dependencies on and competitions with each other and the elements. By way of illustration, one of his examples of the several senses of the struggle can be cited: "The missletoe is dependent on the apple and a few other trees, but can only in a far-fetched sense be said to struggle with these trees, for if too many of these parasites grow on the same tree, it will languish and die. But several seedling missletoes, growing close together on the same branch, may more truly be said to struggle with each other. As the missletoe is disseminated by birds, its existence depends on birds; and it may metaphorically be said to struggle with other fruit-bearing plants, in order to tempt birds to devour and thus disseminate its seeds rather than those of other plants. In these several senses, which pass into each other, I use for convenience sake the general term of struggle for existence" (Darwin, 1859 [1968:116]).

[16] A system's behaviour is *plastic* when the goal of the behaviour can be reached through utilising alternative pathways or starting from various initial positions. It is *persistent* when "the system is maintained in its goal-directed behaviour as a result of changes occurring in the system that compensate for any disturbances taking place (provided that these are not too great) either within or external to the system, disturbances which, were there no compensating changes elsewhere, would prevent the realization of the goal." (Wilson,

what could the factors frustrating the mentioned strivings consist of? In this regard Darwin speaks of *checks* on the survival and reproduction of organisms. What he has in mind are things like rabbits being eaten by foxes if they cannot run fast enough, or dogs dying if they catch rabies, or an organism being prevented from surviving or reproducing by some environmental factor that prevents one of its needs being fulfilled.[17] (Wilson, 1991:177). All the latter are specific and imperfect laws from which one needs to generalise to what Wilson (1991:179) calls an abstractive law - capturing the idea Darwin that tries to convey by means of metaphor and example. So we have:

(T_7) For any species *S* of organism in its normal environment, there are forces *f* in that environment such that, for any member *s* of *S*, that the forces *f* act on *s* is sufficient for *s* not to achieve its goals of survival and reproduction, and, moreover, for any member *s* of *S*, if *s* does not achieve its goals, then one or more of the mentioned forces has acted on *s*.

The struggle for existence acquires a more complete expression in (T_7) than it did in (T_6), because of the existence of environmental forces against which organisms struggle in their strivings being asserted. At this stage another crucial aspect of Darwin's theory needs to be brought into play, namely that concerning the heritability of characteristics that are variations:

(H") For any specific organism, there are small variations, and there is a physiological-chemical-embryological mechanism such that these variations are heritable from parents to offspring to the *n*th generation, for any *n*, and also such that no variation could be other than slight and almost imperceptible.

(T_8) For any species *S*, and for any *s* in *S*, there are characteristics *f* of *s* such that these *f* are variations in *s* with respect to *S* and such that these *f* are heritable.

(Wilson, 1991:194,195).

Unfortunately for Darwin, the heredity problematic remained something of an unsolved mystery which would continue to haunt him and which prevented him from judging his

1991:142-143).

[17] See Darwin's mention (1859 [1968:119-120]) of his experiments with plants on small plots

theory complete. Accepting as he did, Herschel and Whewell's dichotomy between empirical/phenomenal and fundamental/causal laws, he sorely felt the need for a theory of heredity that would effectively deal with the causes underlying the facts of variation. He could not rest content with statements asserting nothing more than that variation in fact occurs, in other words, statements of the form we have in (T_8). He wanted to identify the physiological-chemical-embryological mechanism referred to in (H″) - which might require of one to postulate a theory involving invisible entities and unseen causes.[18]

Darwin did subsequently try his hand at such a theory - but without much success. Even among his supporters "pangenesis", as he called it, carried little weight, and today it stands entirely discredited. That he himself was not too sure about the theory's credentials, is shown by the fact that he never reworked the later editions of the *Origin* to include this particular development in his thought.[19] Rather than making it easy for opponents to detract from the argument in the *Origin* by offering them an easy target in the form of a possibly erroneous theory of heredity, he chose to keep it separate, introducing it in 1868 in his *Variation of Animals and Plants under Domestication*. (Ruse, 1975:179-180; 1979:212-213).

Of course, had Darwin but been familiar with the work done by Gregor Mendel on particulate inheritance in the 1860s, the missing link would have instantly supplied itself. But Darwin had to make do with what was regarded by nearly all of his contemporaries as the most plausible theory on the subject - the theory holding that inheritance proceeded by means of *blending*. That meant that if both parents did not happen to possess exactly the same characteristic, then the result would be a blend of the two characteristics, something in-between. But the idea of blending inheritance did pose problems that asked for solutions - phenomena like atavism and what is nowadays known as dominant (vs. recessive) genes, were not readily explicable on the idea of

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of turf and his observations as to the checks operating on them.

[18] Cf. Ruse (1975:179).

[19] In the *Origin* he observed that: "The laws governing inheritance are quite unknown; no one can say why the same peculiarity in different individuals of the same species, and in individuals of different species, is sometimes inherited and sometimes not so; why the child often reverts in certain characters to its grandfather or grandmother or other much more remote ancestor; why a peculiarity is often transmitted from one sex to both sexes, or to one sex alone, more commonly but not exclusively to the like sex" (Darwin, 1859

blending. Moreover, blending inheritance appeared to run counter to Darwin's belief that a new characteristic could be passed on almost indefinitely from one generation to the next and remain relatively unchanged in the process. For if blending were to obtain in each generation, then any new characteristic originally possessed by an organism, would quickly be lost during succeeding generations.[20]

To overcome the blending theory's inadequacies, Darwin supplemented it with a causal hypothesis that incorporated a particulate aspect. To be sure, he accepted that at the phenomenal level we usually observe a blending of characteristics, but suggested that at the causal level things proceeded in a more particulate way. Pangenesis entailed that small "gemmules" were being released by the body cells, which then accumulated and combined in the sexual organs to form sex cells. As parents' gemmules normally do not fuse (except in hybrids), but merely mingles, they could be passed on intact to following generations, and even lie dormant and unexpressed during some generations, only to resurface in later ones. Darwin was however unable to explain how the gemmules got to the sex organs, and his hypothesis in addition suffered badly from attacks on the Lamarckian element (i.e. inheritance of acquired characteristics) he assimilated into his theory.[21] But his failure to present us with the correct mechanism for heredity need not invalidate his claims to the effect that there exist variations, that they are mostly slight or small ones, and that they are heritable. It also does not undermine his next important assumption, to wit, that these slight heritable variations sometimes differ in *fitness*:

(T_9) For any species *S*, there are individuals *s* in *S*, and characteristics *f* which are heritable variations of *s* with respect to *S*, and *S* which are *f* are more fit than *S* which are not *f*.

(Wilson, 1991:196).

Fitness, it must be noted, is a probabilistic concept, and for one variety to be more fit than another means that it is more probable for its members to survive and reproduce than for the members of the less fit variety. It therefore does not mean that each and

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[1968:76]).

[20] Cf. Ruse (1979:209-213).

[21] Ibid.

every fitter member will survive and reproduce, but rather that certain statistical laws apply to the varieties. We can then infer that

(T_{10}) It will on the whole be reasonable to expect, with respect to any species *S*, that if there are individuals *s* in *S* and characteristic *f* of *s* such that these *f* are heritable variations in *s* with respect to *S* and such that *S* which are *f* are more fit in their normal environment than *S* which are not *f*, then, in the long run, all *S* will be *f*.

(Wilson, 1991:196-197).

Of course, without a "long run" there is no point in (T_{10}), and Darwin therefore has to assume that

(T_{11}) The world has existed as an organically habitable place for a very long time.

We have now been enabled to reasonably expect the occurrence of certain events, more specifically we can reasonably expect that given a very great time-span, new variations and even new species will emerge. But this says no more than that we possess a statistical law, and knowledge of probable outcomes is not the same as providing an explanation of these outcomes. To get an explanation we need reference to causes, in this case, to the forces of natural selection. These forces have already been described in (T_7) as having the power to prevent organisms from reaching their goals of survival and reproduction, but at that stage we could not connect these forces to fitness or to the emergence of new species, as we still lacked the needed theses on heritability (H″) & (T_8), varying fitness (T_9), and probable outcomes(T_{10}). Having formulated the latter, we are now ready to move on to Darwin's Principle of Natural Selection, that is, we can now state that varying fitness is conferred on organisms as a result of the existence of forces that act differentially, or have different effects, on different characteristics possessed by different organisms (Wilson, 1991:201):

(T_{12}) For any species *S*, if there are individuals *s* in *S* and characteristics *f* which are inheritable variations of *s* with respect to *S*, and *S* which are *f* are more fit in their normal environment than *S* which are not *f*, then there are g_1 and g_2 such that g_1 are the forces of natural selection with respect to *S* which are *f* and g_2

are the forces of natural selection with respect to *S* which are not *f* and $g_1 \neq g_2$.
(Wilson, 1991:197-198).

In (T_{12}) then, the existence of laws is stated. These lawful relations said to hold between organisms and their environments concern both the different fit-making characteristics of organisms and the factors operating in the struggle for existence, that is, the forces of natural selection preventing organisms from achieving survival and reproduction. (Wilson, 1991:198). Fitness and natural selection are shown to be inextricably linked. There can be no fit-making characteristic without there also being present a relevant force of natural selection with regard to which it is fit-making, and there can be no acting forces of natural selection without there being differing fit-making characteristics - after all, if all organisms in the same environment share the same characteristics, then there can be no systematic differentially acting forces of natural selection. Who survives and reproduces would be solely a matter of chance.

By means of (T_{12}), a certain outcome, say the emergence of a specific variety or species, as predicted by (T_{10}), can be causally explained. Naturally, (T_{12}) can only be invoked *ex post facto*, because the processes involved are of such complexity that it is simply impracticable to attempt gaining detailed knowledge of the laws at work in a given environment. This does of course mean that biology cannot attain to the ideal of scientific explanation upheld in physics, namely process knowledge. (Wilson, 1991:198-199).

The principle of natural selection as asserted in (T_{12}) must be supplemented by an additional thesis if we are to render the account of Darwin's argument for evolution by natural selection complete. The thesis would have to amount to the claim that all species, not just some variations or some species, had been descended from earlier species, and that this had been the result of natural selection. In short, the Principle of the Origin of Species by Natural Selection has to be introduced:

(T_{13}) For any species S_0, there is an earlier existing species S_1 such that all members of S_0 are biological descendants of S_1, and such that there is a characteristic *f* which is had by members of S_0 and not by all members of S_1; and there is a time at which *f* appeared as a variation in S_1, and such that organisms which are S_1 and f were more fit than organisms which are S_1 and not f, and such that there were forces of natural selection g_1 and g_2 such that g_1 acted with respect to organisms that were S_1 and f, and g_2 acted with respect to organisms that were S_1 and not f, and $g_1 \neq g_2$.

(Wilson, 1991:231).

Natural selection's acting on variants is hereby presented as the sufficient and necessary condition for the origin of species. (Wilson, 1991:231). By way of recapitulation, it is worth giving in full Wilson's summary of his reconstruction of Darwin's argument:

> Recall some of the crucial inferences by which Darwin arrived at his theory. There are more offspring than parents (T_1); food supply is constant (T_2) and can support only a constant population (T_3); hence, population is constant (T_4), and fewer survive than are born (T_5); but organisms are goal-directed towards survival and reproduction (G); so in spite of their strivings many organisms do not survive and reproduce (T_6); acting in this struggle to prevent survival and reproduction are forces such as (F); hence, generalizing, there is a struggle for existence (T_7) between the organisms striving to survive and reproduce and the "checks" or forces of "natural selection" tending to prevent the achieving of those goals; however, there are heritable variations (T_8), and some of these make their bearers more fit, give them a better chance to survive and reproduce (T_9); moreover, where individuals with a certain variation are more fit, we may expect in the long run that this character will spread throughout the population (T_{10}); moreover, what explains the statistical law that one character makes for greater fitness than another and explains the actual survival of the fit and the spread of the fit-making characteristic are the differential workings of the forces of natural selection on the fit and the less fit (T_{12}); there is, of course, plenty of time available (T_{11}); and it seems reasonable to think that present species have, on the whole, been brought about by natural selection operating on minute heritable variations (T_{13}).
>
> (Wilson, 1991:250-251).

In order to better appreciate Darwin's conceptualisation of natural selection as a causal process, Wilson's reconstruction can now be supplemented by Hodge's *vera causa* analysis of Darwin's theory. In the process of presenting the latter, reference will be made to Wilson's insights and reconstruction insofar as it is deemed relevant and applicable. However, this will not necessarily imply respecting Wilson's entire science-philosophical framework, and he may well disagree with the purposes for which, or the way in which some of his analyses will be appropriated here.

The schema (see below) Hodge (1989:168) offers of the *Origin* makes clear how the work owes it structure to a systematic treatment of the considerations that would be essential to the proving of natural selection as *vera causa*. A multi-layered structure can be discerned, each layer possessing its own set of divisions.

<table>
<tr><td>Part I

Variation and selection under domestication</td><td rowspan="4">Chapter I

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Existence case</td><td rowspan="4">Division One

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The structure of the *Origin of Species* (Hodge, 1989:168).

Beginning with probably the most noticeable of the book's layers, we find a division into three main *Parts*. The *first* part (chapter one) treats the principles of variation and selection under domestication; the *second* part (chapters two to eight) treats these same principles as they occur in nature; the *third* part (chapters nine to thirteen) demonstrates the explanatory power of the theory of natural selection with regard to different groups of facts concerning species. (Hodge, 1989:167).

Almost, but not wholly, coinciding with the three part structure, is another layer consisting of three distinct considerations or evidential *Cases*.[22] These may be more difficult to identify in the *Origin* itself, but as Hodge (1989:167) points out, by turning to Darwin's *Sketch* (1842) and *Essay* (1844) it becomes clear that this was an articulation he found crucial to his argument - the reason being its direct bearing on the *vera causa* ideal, which required of one to argue persuasively not only for a cause's existence, but also for its adequacy and responsibility for producing the phenomena in question.

Darwin's *first* case thus argues for the *existence* of natural selection as causal process in the world, and comprises the *Origin*'s first part as well as two chapters of the second part. It involves questions concerning the occurrence and prevalence of the cause (natural selection) - whether it exists at all, and if it does, how widespread is it and what are the units (e.g. organisms, colonies, species) among which it occurs?

In his argument for the existence of natural selection, Darwin reasons by *analogy*. He presents his readers (in the first chapter of the *Origin*) with something familiar, something of which they cannot doubt the existence, namely, the occurrence of distinct varieties of domesticated species due to the artificial selection practised by breeders. Thus we have before us familiar phenomena accounted for by a familiar causal process. Darwin imparts to his readers knowledge gleaned from studying breeding practices, in particular, that it was possible to produce a number of widely different breeds of, for instance, the domestic pigeon, all of which may have descended from the same wild species (e.g. the rock-pigeon), by the simple practice of selecting, and breeding from only those individuals possessing some or other quality pleasing to the human eye or useful from the point of view of some human purpose. Also, a change in human interests or criteria will naturally affect which domestic varieties are perpetuated or modified and which not.

Then (in the second chapter of the *Origin*) Darwin confronts his readers with the reality of variation in nature, and takes the opportunity to point out that naturalists more often than not find it difficult to determine which one of a group of closely related varieties is supposed to be the true species and which mere varieties of the former. This dilemma

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[22] I take as point of departure the treatment of the three cases by Hodge (1977:239-244; 1987:234,237-238; 1989:167-170; 1992:462-463).

provides him with evidence for the claim that all supposedly true species are in fact nothing but strongly-marked, well-defined and permanent varieties, and that conversely, all varieties are incipient species (Darwin, 1859 [1969:110,111]).

Darwin's next move is predictable. How does it come, after all, that there are varieties in nature and that some are more widespread and dominant than others, in the event attaining the rank of species? If the prevalence of different domestic varieties can be accounted for by the process of artificial selection, does it not then become possible that natural variation can be accounted for by an analogous process? Not analogous in the sense of another kind of Selector being present, say Nature personified, choosing which variations should be perpetuated and which not - Darwin was quite clear about that not being his meaning.[23] Rather, in both contexts there is variation - in the form of domestic and natural varieties respectively; in both contexts there are conditions affecting the survival and reproduction of the varieties - human interests and environmental conditions respectively; and in both contexts the varieties possess characteristics causally relevant to their survival and reproduction - characteristics relevant to human interests and to success in the struggle for existence respectively. All of the former taken together, as we know, boil down to artificial selection; but then, by analogy, all of the latter taken together must also boil down to a process of selection - natural selection that is; in other words, a process of selection, but one from which human orchestration is absent.

Wilson (1991:236-238) rightly emphasises that an *inductive leap* is being made here by Darwin. He is generalising from specific domestic cases (involving breeding with pigeons, cattle and sheep) he is familiar with, not only to all domestic kinds, but to all kinds everywhere and always - under domestication and in nature. Also, although citing the specific domestic cases do provide *direct* and persuasive support for an inductive generalisation concerning the way *domestic* kinds are produced and modified through selection, it only provides *indirect* support for a generalisation concerning *wild* kinds. But this partial and inadequate support Darwin furnished by means of analogy for the

[23] Darwin denied the existence of purposeful forces in nature, and remarked in later editions of the *Origin*: "It has been said that I speak of natural selection as an active power or Deity ... [and] it is difficult to avoid personifying the word Nature; but I mean by Nature, only the aggregate action and product of many natural laws, and by laws the sequence of events as

existence of natural selection was unavoidable as he did not have direct evidence of selection in the wild,[24] direct experimental evidence not having been available at the time and by its nature hard to come by - not least because speciation events can only be identified with hindsight, after they have already taken place, and the fossil record being too imperfect (transitional types being absent) to yield unambiguous evidence in favour of his claims. But Darwin's inconclusive evidence did not imply that natural selection most probably did not exist. Rather, it constituted a challenge or research task to find direct evidence for its existence - a challenge that has since been met, though not in Darwin's own time.

There was another important motivation for making much of such an analogy - it perfectly fitted the kind of reasoning Herschel's *vera causa* ideal prescribed. Recall what Herschel described as the best way in which to arrive at certainty concerning whether something can really qualify as a *vera causa*: When wanting to determine the *vera causa* of a certain set of phenomena, the search will be greatly facilitated if we take our lead from a stock of phenomena the *vera causa* of which is already known to us through direct experience, and which are similar enough to the set of phenomena under investigation to be classed together with them. According to Herschel, the similar nature of the phenomena, and our knowledge of the *vera causa* responsible for some of them, entitles us to draw the conclusion - and one that is almost undeniably certain at that - that the investigated phenomena are produced by an analogous cause.

This tenet of Herschel was actually instrumental in Darwin's initial realisation that the results of artificial selection, far from presenting a case hostile to his evolutionary theory - as was the commonly held view at the time[25] - could be made to work dramatically in its favour. Because here he had two sets of analogous phenomena - domestic and natural - and the cause of the former was known to us through direct perception, in fact, we ourselves were its author. And, following Herschel,

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ascertained by us" (quoted in Ruse, 1971:330).

[24] See in this regard Wilson (1991:234-239,282).

[25] Artificial selection was thought to testify against the truth of evolutionary theories, because it was believed that artificial selection could achieve only limited variation from the original wild type (and not new species), and that moreover, since it was an unnatural process, domestic varieties would quickly revert to the wild type once turned loose again - evidence of this was available. Needless to say, Darwin's theory would show that none of these objections held water, or in any case, that his views could adequately account for these

that meant he had definite proof of an analogous causal process, that is, a selection process, in nature. If there is domestic selection, well then, given wild variation and the struggle for existence, there must also be natural selection. And if the former is a *vera causa*, then so is the latter.[26] Darwin felt triumphant.

Darwin's case for the existence of natural selection thus relied for (indirect inductive) support on the analogy with artificial selection, because of the then absence of direct experiential evidence for it, and because of Darwin's acquaintance with Herschel's *vera causa* doctrine. But something more still has to be said about the *deductive* dimension of the case.[27] Forgetting for a moment about artificial selection, and reflecting upon the reconstruction above, it is clear that Darwin's argument proceeded through deducing from certain imperfect regularities (such as superfecundity (T_1), and constant food supply (T_2)) other imperfect regularities (such as the struggle for existence (T_6), and natural selection (T_{12})). The imperfect regularities articulated in the premises, constitute assumptions in need of inductive support, but once presumed established or verified as true, we can also accept the other imperfect regularities that follow deductively from them, as true.

Wherever he was capable of it, Darwin indeed tried to provide independent inductive support for his premises,[28] and these then, via the argument's *consequence* relation (the movement from premises to conclusion) rendered the conclusions acceptable or established in the same degree. Remarks Hodge in this regard:

> Darwin does not claim to establish the existence of natural selection by mere inspection of

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phenomena without compromising the power of natural selection.

[26] In advancing this interpretation I am following Ruse (1975:174-176), rather than Wilson (1991:288-289), who disputes - wrongly in my opinion - that Darwin thought the analogy with artificial selection helped him establish natural selection as *vera causa*.

[27] The following remarks largely draw upon Wilson (1991:269-280).

[28] For instance, concerning superfecundity (T_1), he makes mention of a range of calculations and examples, e.g. "There is no exception to the rule that every organic being naturally increases at so high a rate, that if not destroyed, the earth would soon be covered by the progeny of a single pair. [...] Linnaeus has calculated that if an annual plant produced only two seeds - and there is no plant so unproductive as this - and their seedlings next year produced two, and so on, then in twenty years there would be a million plants"; and "cases could be given of introduced plants which have become common throughout whole islands in a period of less than ten years. Several plants now most numerous over the wide plains of La Plata, clothing square leagues of surface almost to the exclusion of all other plants, have been introduced from Europe; and there are plants which now range in India, as I hear from Dr Falconer, from Cape Comorin to the Himalaya, which have been imported

nature; that this process is going on in the wild is not given from experiential acquaintance with its presence there. However, his view is that its existence there is a reasonable conclusion from various premises, concerning heredity, geological change and superfecundity, that are either already accepted or are evidenced observationally.

(Hodge, 1989:170).

But Darwin also, and this is probably in part the reason for his argumentative structure being so confusing, tried to provide independent inductive support for at least some of his conclusions (such as (T_4) and (T_6)). That, of course, would have reinforced their plausibility as it showed that they could be established in other ways than through deductive dependence on premises that may well turn out to have insufficient support or be false. Providing independent empirical support for conclusions that have to perform as premises in subsequent arguments, also prevents these latter arguments from being undermined due to the possible unsoundness of the subarguments that deductively established their premises.

But we now come to an additional and more controversial aspect of Darwin's reasoning, namely, its hypothetico-deductive aspect. The independent inductive support received by the (sub-) conclusions is meant to also transfer back to the premises via the *converse-consequence* relation. In other words, should the premises not in themselves be strongly enough established by induction, they can still obtain support from their deductive consequence being confirmed. The premises thus function as hypotheses drawing support from the independent confirmation of the imperfect regularity deductively predicted by them. We will return to the hypothetico-deductive element in Darwin's reasoning below.

This concludes our discussion of the ways in which Darwin made his case for the existence of natural selection and brings us to his next case.

The *second* case comprises the remainder of the second part of the *Origin*, and argues for the *competence* of natural selection to give rise, through adaptation, to new species, genera, orders, etc. The relevant questions here relate to the consequences and

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from America since its discovery" (Darwin, 1859 [1968:117, 118]).

adequacy of natural selection as causal process. In other words, what are the kinds, amount and rates of change it is sufficient to produce? And what are the possible and actual consequences it brings about?

The competence case also invokes artificial selection but as a somewhat contrasting analogy. Humankind can achieve amazing new varieties and races through selection choices not always even consciously made, but nature can do much more. To Darwin natural selection appeared a lot more competent than domestic selection when it came to the production of new species. Its being a more powerful causal process could be ascribed to three factors: Nature had "incomparably longer time at her disposal" (Darwin, 1859 [1968:132]) - that much was made quite clear by contemporary developments in geology; she acted on all characters of an organism, including those not observed and thus neglected by humans in their selection efforts, and she did so far more rigorously and consistently:

> Man can act only on external and visible characters: nature cares nothing for appearances, except in so far as they may be useful to any being. She can act on every internal organ, on every shade of constitutional difference, on the whole machinery of life. [...] Every selected character is fully exercised by her; and the being is placed under well-suited conditions of life. Man keeps the natives of many climates in the same country; he seldom exercises each selected character in some peculiar and fitting manner; he feeds a long and a short beaked pigeon on the same food; he does not exercise a long-backed or long-legged quadruped in any peculiar manner; he exposes sheep with long and short wool to the same climate. He does not allow the most vigorous males to struggle for the females. He does not rigidly destroy all inferior animals, but protects during each varying season, as far as lies in his power, all his productions.
>
> (Darwin, 1859 [1968:132-133]).

Darwin's anthropomorphic language when speaking of nature notwithstanding, we can see what he is driving at concerning the differences between domestic breeding practices and the selection processes in nature. Because natural selection rigorously works on all characters over much longer periods of time, it will tend to produce greater results, that is, new species, and not just new varieties, as is the case with the more short-lived and superficial or appearance-focused practices of domestic selection.

It is in the fourth and fifth chapters - "Natural selection" and "Laws of variation" - that Darwin tries to establish the competence of natural selection to steadily accumulate over many generations the slightest new differences, should these be beneficial to the individual organisms possessing them, thereby eventually giving rise to great modifications of structure and to new species, genera and orders. Darwin's adherence to the *vera causa* doctrine accounts for his resoluteness about natural selection being a slow process operating on small, often imperceptible modifications in structure which only in the very long run become visible in the form of new varieties and species. Just like Lyell with regard to geological change, so Darwin with regard to the origins of species, refused to appeal to causes that were not operating in the present and not in principle accessible to human observation. As catastrophes, great upheavals and sudden acts of species creation have not been witnessed by us, they for all intents and purposes cannot be invoked to explain geological features or the emergence of species. We should rather search for signs of causes that are extremely slow-operating, causes that are working and have been working since time immemorial at the same intensity to produce all the natural phenomena, including the various species, we are familiar with.[29]

After noting what natural selection can and cannot do, illustrating its action through examples and experiments, describing circumstances favourable to its operation, providing an exposition of his notion of an irregularly branched tree of life, reserving some role for forces other than natural selection, discussing the variability and correlation of heritable characters, etc., Darwin proceeds to the treatment of various difficulties encountered by his theory - as regards its competence, that is. Chapters six, seven and eight thus seek to foil, in anticipation, attacks on his theory to the effect that natural selection would not be able to account for certain phenomena, or, which is the same, would not be competent to produce them - this include, for example, very sophisticated or peculiar organs, structures, habits and instincts (such as the eye, flying squirrels and slave-making ants). These chapters also contest the claims that the absence of transitional types in the fossil record, and the well-known fact of the sterility of first crosses and hybrids, invalidate his theory.

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[29] See, for instance, Darwin (1859 [1968:142]).

But now, if one has demonstrated that natural selection exists and that it is competent or sufficient for the production of species, and moreover, that it is the *only* existing competent cause, then it follows that it is also the *necessary* or *responsible* cause. And this was in essence Darwin's view, although he tended to allow a subordinate role for Lamarckian use and disuse. (Wilson, 1991:231,243-244; Hodge, 1987:259).

The *third* case of the *Origin* (coinciding with the third part) constitutes Darwin's argument for the *responsibility* of natural selection for past and present species productions. It is concerned with questions about past achievement - we want to know what natural selection has actually done, for how much of past evolution was it actually responsible and which things can we explain by showing that it resulted from natural selection. Thus, for example, where the second case could be seen as merely arguing that natural selection is a process capable of producing (at least some) new species, the third case would argue that natural selection was in *actual fact* responsible for the production of *all* the extinct species found in the fossil record as well as *all* extant species - this amounts to the claim Wilson has formulated as (T_{13}).

Darwin starts off the case for the responsibility of natural selection by taking up again the palaeontological difficulty that was treated in a more cursory way (amongst other difficulties) in the sixth chapter. He now devotes the entire chapter nine, and in fact, chapter ten, to the nature of the geological record - this is of course not surprising, seeing that the latter constitutes the chief objection to the responsibility of natural selection for the production of all species. For, after all, without there being recorded signs of the myriad intermediate varieties his theory asserts to have existed, his claim as to the responsibility of natural selection must be declared null and void. Darwin therefore assembles al the favourable geological facts he can lay his hands on to overcome this grave objection. He then follows this up, in chapters eleven to thirteen, with facts from a variety of other fields - biogeographical, morphological and embryological - also favouring the responsibility of natural selection, before closing with his recapitulation and conclusion (chapter fourteen). We will give more attention to the case for the responsibility of natural selection in a moment when dealing with the two divisions of the *Origin*.

Lastly then, an additional layer of the *Origin* can be made out in the form of two

Divisions. Like the three case structure its presence is due to the *vera causa* ideal. The *first* division encompasses the existence and competence cases, and concerns the establishment of natural selection's *vera causa* credentials - namely, that natural selection is a cause that exists and one that is sufficient for bringing about certain results. The *second* division, encompassing the responsibility case, is concerned with the corroboration of the theory as the best current explanation for the origins of species. (Hodge, 1989:168).

As will have become clear in the above discussion of the first two cases, Hodge (1977:242) is quite correct in observing that in the first division of the *Origin* Darwin twice makes an appeal to the fact of variation under domestication: Firstly, in arguing for the *existence* of a natural selection of hereditary variations in the wild, Darwin refers us to the familiar tendency of changed conditions to indirectly bring about hereditary variation in domestic species by presumably affecting - as he thought at the time - the reproductive system itself; and to the familiar fact that these hereditary variations can be accumulated through selective breeding. Secondly, in arguing for natural selection's *competence* to cause new species, Darwin refers us to the recognised power of domestic selection to cause new varieties, and to the reasons why the selective breeding taking place in the wild as a result of the struggle for existence will have more notable consequences, namely, the production of new species. Having made all the use he could of the known process of artificial selection in his efforts to prove the existence and competence of natural selection, in other words, to establish it as a *vera causa principle*, Darwin now moves on to the responsibility case - which is also the second division of the *Origin*.

It is in the second division of the *Origin* that we detect a pattern of argument seemingly in accord with Whewell's consilience notion. As we hinted at above, Darwin's case for the responsibility of natural selection relied on a demonstration of its being able to account for diverse classes of facts ranging from geology to embryology. But it should be noted that the *vera causa* ideal, like Whewell's consilience of inductions, equally demanded that the cause or mechanism a theory appeals to, be able to account for different sets of phenomena.[30] However, unlike Whewell, *vera causa* adherents like

[30] Ruse (1975:161-162,163) also acknowledges this.

Herschel, Lyell, and following them, Darwin, did not regard this as sufficient. Rather, in addition, the existence of the cause had to be independently evidenced. (Hodge, 1989:172).

Darwin therefore heeded all the demands of the *vera causa* ideal, and inasmuch as he did that, he also happened to come close, in part of the *Origin*, to Whewell's idea of theory confirmation. This seeming approximation of part of the *Origin* to Whewell's ideal meant that Darwin could later, when he found it convenient, also use the Whewellian position in justifying his theory. Although Darwin in the first place wished his theory to be seen as *vera causa* legitimate, he sometimes did fall back to a position claiming that, even if his theory did not achieve full *vera causa* credentials, it still could not be easily dismissed, as other reputable theories such as the wave theory of light did not conform to the ideal either. (Hodge, 1989:171-172).

The responsibility case in the *Origin*, then, proceeded by an enumeration of many kinds of facts regarding extinct and extant species, and contended that we can best explain all of these diverse facts (that is, they can be most intelligibly connected under unifying laws), if we assume that natural selection was the cause responsible for the production and adaptive diversification of these species from remote common ancestors (Hodge, 1987:238). All the facts in question can be shown to follow from the theory and be explained by it, and this can be done in a way superior to attempts based on other theories. In demonstrating the explanatory superiority of the theory of evolution by natural selection over its rivals, the theory also receive its confirmation. This point, of course, brings us back to the hypothetico-deductive method, or the issue concerning the transfer of evidential support via the converse-consequence relation. The question is whether and when such confirmation can be considered legitimate, because, as has been remarked in the introductory chapter, logically it does not seem to constitute a valid relation. However, without going into the whole problematic of the logic of confirmation, it can be stated that this is not a problem peculiar to Darwin's theory. Wilson (1991:272), following Brody, suggests that as long as the premises are explanatory - as they are in Darwin's case - we can allow as legitimate the conveying of empirical support via the converse-consequence relation. Says Hodge (1987:263) in this regard:

> Insistence on some such link between explanation and confirmation has been a commonplace for centuries, and is not distinctive of biology, much less evolutionary biology.

These brief remarks do not claim to have solved the problem of confirmation, but only to have pointed out that Darwin's claim as to the responsibility of the cause he found in natural selection for species production and its accompanying phenomena, could not be rejected merely on account of his method of confirmation, as whatever its relative merits, this method is common to physics as well.

In concluding this chapter, one or two things still need to be said about the implications of conceptualising natural selection as a causal *process*. Darwin's modelling his theory on the *vera causa* ideal hailing from Newton, did not mean that natural selection was conceptualised as possessing a law intrinsic to its formulation in the way that Newtonian gravitation theory had its own force law. That was and is simply not possible given the fact that the workings of natural selection consist of complex causal interactions between hereditary materials and environmental conditions. As a complex causal process, there is subsumed under natural selection too many different cases of causal bias to make possible their unification under a law:

> Natural selection has no equivalent law because its very existence requires, causally, processes of reproduction, heredity, and variation; and while these processes may be and were presumed to be conforming to laws of their own, they cannot exist and conform to those laws in an empty universe void of complex interactions between what is changed and the conditions determining how it is changed.
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> (Hodge, 1987:249).

We can however, as Wilson puts it, have imperfect regularities that makes "implicit existential claims about other relevant factors" (Wilson, 1991:165), or, which is the same, as Hodge puts it, have well-confirmed generalisations concerning the way natural selection works "in specified ranges of conditions and with genetic systems of specified properties" (Hodge, 1987:262). What we cannot have, is the ideal of process knowledge - knowing all the variables and the laws to which they conform in such detail that we are able to predict exactly what the future states will look like. But this does not take away from the fact that we have in natural selection a causal process to which we can appeal when giving explanations, albeit *ex post facto*, of evolutionary phenomena.

Part of the problem is that the classical idea of causation in the physical sciences has been closely connected with that of prediction. A theory's capacity for prediction was thought to be proportional to its capacity for accurate description and causal explanation (recall the D-N model). However, as Mayr points out, a biologist would never have made such a claim. The ability to give relatively precise descriptions and good causal explanations of biological phenomena does not entail the ability to reliably predict their future course. This is mainly due to the complexity of the phenomena.[31] In this respect biology has thus taught us that explanation and prediction is independent - the latter does not necessarily follow upon the former. (Mayr, 1961 [1976:366-367]).

The absence, in this chapter, of an explicit treatment of *adaptation* in terms of Darwin's theory, will have been noted. However, that will form the subject of the next two chapters, where, among others, Darwin's account of species production through adaptive diversification will have to be contrasted with what constituted its main rival, namely, the natural theological account advanced by William Paley and others. The present chapter merely intended to describe what could be considered the main ideas and inferential links of Darwin's theory, as well as elucidate Darwin's construction of his theory in terms of the *vera causa* ideal, that is, point out his arguments for the existence, competence and responsibility of natural selection as a causal process in the world.

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[31] Mayr (1961 [1976:368-369]) actually identifies four (somewhat overlapping) reasons for the indeterminacy or difficulty of prediction we encounter in biology: the randomness of an event with respect to the significance of the event; the uniqueness of all entities at the higher levels of biological integration; the extreme complexity of organic systems; and the emergence of new qualities at higher levels of integration.

3

Natural Selection versus Divine Design

Science and religion: A harmony lost

As pointed out in the first chapter, the growing readiness in the nineteenth century to let empirical experience have the final say, and to find purely natural, mechanistic explanations for all phenomena, including those of life, was the kind of approach that spelt the end of the perfect harmony between science and religion as upheld by the Newtonian paradigm. This break did not take effect immediately, however, and many ingenious attempts at reconciling the two were devised. But the spell of natural philosophy and natural theology was thereby broken, and it would henceforth become impossible to practise them in anything but a greatly watered-down version which lacked the kind of psychological appeal needed as impetus for ultimately carrying on with such forms of reasoning. Equally important, the continuation of a literal interpretation of Biblical events such as creation and the deluge was now out of the question. In no insignificant sense people's understanding of their world and themselves was transformed. Especially as far as relations in the sphere of life were concerned, a static world-view in which everything was relatively certain, secure and immutable - because reflective of divine purpose and divine plan - was being replaced by a dynamic one in which blind change and conflict prevailed.

In what follows the role played by Darwin in many of these developments must be traced. For the purposes of this study, it will take the form of an investigation into how Darwin - by having offered natural selection as causal process responsible for adaptation and the origin of species - undermined the metaphysical teleology underlying both the natural theological argument from *design* and the argument from revelation concerning the separate or *special creation* of distinct and immutable species.

Of course, natural theology and revealed theology, for all their presumed independence, were actually joined at the root. For the argument from design as it was conceptualised at the time, was only able to reinforce revealed theology because it was in the first place covertly informed by the same notions and assumptions. Indeed, the argument from design would not have made sense without the fundamental assumption that whichever signs of design we may happen upon could not but refer to the presence of a personal creator that individually created, at some stage in history, each of these designed forms, in other words, it could not but refer to the creator of revealed theology. Actually, this interdependence had been exposed and invalidated by David Hume in his *Dialogues concerning Natural Religion* (1779), where he argued that from a given effect we can infer, at most, and nothing more than, the existence of a cause capable of having such an effect. But this means that

> the appearances of nature do not entitle us to affirm the existence of *one* God rather than many, since the world is full of diversity; nor of a wholly *good* God, since there is evil as well as good in the world; nor, for the same reason, of a perfectly *wise* God or an unlimitedly *powerful* one.
>
> (Hick, 1990:26).

Thus we cannot infer from design in the world the existence of the divine Designer preached by the Judaic-Christian tradition. However, few took much notice of Hume's argument, and natural theology carried on more or less as before.

The interdependence of natural theology and revealed theology means that an attempt at treating Darwin's undermining of the two under separate headings, can only be partly successful: the issues will inevitably intertwine and overlap, especially as Darwin himself does not really keep them apart. In effect, the invalidation of the natural theological argument from design already goes quite some way towards the invalidation of the scriptural account of creation, and vice versa. However, in the discussion below we will try to keep the issues separate to the extent the subject matter allows. But first a few more comments need to be made on the world-view that informed both these forms of argument.

Before Darwin, argues Daniel Dennett (1995:64-65), the distinction between order and design was blurred. We had a hierarchical top-down world-view that could be described as a "Cosmic Pyramid" and presented thus:

God

M i n d

D e s i g n

O r d e r

C h a o s

N o t h i n g

God formed order out of chaotic matter, and endowed some of the ordered matter with design, and made minds for some of the designed beings - being himself the first Mind on which all else depends. But the steps labelled Order and Design respectively, were not kept apart from each other in any rigorous or consistent manner. There was no need for such a definite separation, as both were gifts from God, results of his creative intentions, and thence imbued with divine purpose. Order, that is to say, pattern or regularity, as for instance displayed in the solar system, could in principle be distinguished from Design, which is Order exploited for a purpose, such as is displayed in artifacts. Whereas the solar system has no apparent purpose, a designed entity like the eye has a purpose - it is *for* seeing. But this distinction was of no great consequence because the universe in its entirety was an artifact of God, and all its entities in their natural states were in any case directed towards the ends God devised for each.

Came Darwin's theory of evolution by natural selection, however, and the focus zoomed in on the divide between Order and Design. Previously, God - a metaphysical principle - was the necessary hypothesis for the formation of Design from Order. God was the "*final* final cause", the "*for-which* to end all *for-whiches*" (Dennet, 1995:24). But Darwin demonstrated how a purely natural, causal process could take the place of God in accounting for the progression from the Order step to the Design step. Dramatises Dennett (1995:65):

> Give me Order, [Darwin] says, and time, and I will give you Design. Let me start with regularity - the mere purposeless, mindless, pointless regularity of physics - and I will show you a process that eventually will yield products that exhibit not just regularity but purposive design.

Darwin thus destabilised the timeless Cosmic Pyramid by striking right at its middle, entering there a historical causal process, the consequence of which was a dislocation of the God-head right at the top. Indeed, it now became evident how a top-down approach to explaining the world, could be replaced by a bottom-up approach. Nothing now prevented anybody from extending the kind of causal process Darwin provided for the Order-Design transition to the other steps as well. If there was an empirical way for accounting for the former transition, then there might equally well be empirical ways for accounting for the Chaos-Order transition, and for the Design-Mind transition. And, as for God at the top, well there seemed to be no need for that any longer. Moreover, with God and the Cosmic Pyramid, went also the metaphysical teleology intrinsic to these notions, that is, the belief that everything has supernatural purpose and meaning.

As implied above, the Cosmic Pyramid view of the world was still common to both natural and revealed theology in early nineteenth century England. Discrediting the former was thus synonymous with an attack on the latter. Darwin was, for the most part, far too careful and fearful of controversy to do this openly and in explicit terms. He did not disavow belief in a Creator. However, people would not have been fooled as to the far-reaching implications of his theory - controversial precedents (Lamarck and Chambers) had already alerted them to these. We will now turn to a more detailed discussion of the issues, first with regard to the doctrine of special creation within revealed theology, and then with regard to the natural theological argument from design.

Revelation relativised: The problem of special creation

It was a work of William Paley that functioned as the standard text for British revealed theology in the first half of the nineteenth century. *Evidences of Christianity* (1794) focused on the miracles witnessed by the twelve apostles and presented them as proof that Jesus Christ was the Son of God. But German "higher criticism", together with its British offshoots, slowly started to erode British belief in revealed religion from 1830 onwards. The former attempted to interpret the Bible more and more by reference to natural terms and less as a testimony to supernatural events. As scientific knowledge increased in Britain, it became harder to find an easy reconciliation between science and religion when the two conflicted. Early nineteenth century geology and palaeontology had revealed a much older age of the earth and of life than the mere six thousand years or so that Bible readers assumed, and already before Darwin's advent on the scene, it came to be accepted that the interpretation of Genesis had to take on a more flexible form than previous literal renditions would allow.

This was acknowledged even by religious conservatives such as William Buckland, Adam Sedgwick and William Whewell, who were prepared to go quite some way towards accommodating science's claims within their religious perspective. For them a kind of reconciliation between the Bible and science was achieved by conceding authority to science for whatever happened before the advent of humankind, thus allowing science to promote the idea of a prehistory consisting of vast geological epochs. The Bible took precedence from the creation of humankind onwards. As for the six days of the Genesis account of creation, these could have been six long periods, or alternatively, the Beginning could have been separated from the succeeding six days of special creation by a long time-span. But what was *not* negotiable, was the fact that humankind was created last as the crown of creation, that this happened not too long ago, and that some kind of cosmological progression preceded it. (Ruse, 1979:67-69). Moreover, evolution had no place within this narrative. If there were signs of organic progression in the fossil record, this was to be ascribed to the chronological order of God's creative acts, not to an evolutionary process that would have entailed the unacceptable idea of a genealogical connectedness of widely distinct life forms. After all, one could compromise Revelation only so far, and not any further.

The defense of the miraculous creation of species was to a large extent inspired by fear of jeopardising humanity's status - who was presumed to be created in the image of God and destined to lord it over the rest of creation. Apart from contradicting Revelation, evolution would have erased the fundamental division between human nature and animal nature. To prevent this, the special and separate creation of distinct species had to be upheld, and amongst most religious conservatives this doctrine was synonymous with God in his providence having designed each species to be uniquely adapted to the place it was to fill in the economy of nature.

In the *Origin*, Darwin casts this doctrine of special creation in the role of chief rival to his theory of evolution by natural selection - repeatedly extolling the many explanatory virtues of his own theory while exposing the lack of any in the case of his rival. Naturally, if, as his rival insists, each species was fixed, and expressive of some immutable essence bestowed by God, then his theory would be defeated, because fundamental changes in structure and habit would be impossible, and that means ruling out that one species could give rise to another - whether the proposed causal mechanism be natural selection or any other, such as the inheritance of acquired characteristics. Darwin's efforts at refuting special creation and disparaging its advocates are thus understandable. It drew little attention at the time, however, and for two reasons:

In the first place, there were more controversial precedents, to wit, Lamarck's *Philosophie Zoologique* (1809) in France, and Chambers's *Vestiges of the Natural History of Creation* (1844) in Britain. We will take a closer look at them in the next section, but for the moment it will suffice to say that both advanced evolutionary theories, and neither of them evaded the issue of human descent as was the case with Darwin (at least initially). In England Chambers functioned as a kind of Victorian Lamarck who weathered the first and worst storms raging over evolution, thereby preparing the way for a quieter reception for Darwin.

In the second place, religious conservatives had more serious internal threats to deal with. The critical winds blowing from Germany had sown seeds which were suddenly bearing fruit. The *Origin* was scarcely published, when, in February 1860, there appeared *Essays and Reviews*, written by seven liberal Anglicans, which swept away most of the controversy that would have reached Darwin. Among others, they challenged literal belief in miracles, pointed out the historical development of religious thought, and emphasised the importance of reason in interpreting Scripture. (Ruse, 1979:239-240). The debates occasioned by these and other similar challenges did more than Darwin to undermine belief in the literal truth of the Bible. And by weakening dogmatic religion they aided Darwin's case for the rejection of the doctrine of the special creation of fixed species.

The fact that Darwin did not effect such a huge public outcry, and that there were evolutionary as well as religious works that seemed to have created more of an uproar, could fool one into thinking that Darwin's contribution was not necessary for the downfall of metaphysical teleology. That would however be mistaken. Unorthodox as the two above-mentioned developments may have been, they had no intention of extricating themselves from a teleology based on divine direction and god-given purpose. It was Darwin who, by virtue of the kind of causal process he proposed, broke with metaphysical teleology. But before returning to this point, we should discuss in greater detail the way in which Darwin deals with special creation in the *Origin*.

In his *Origin of Species* Darwin carefully steered clear of a number of controversial and sensitive issues, one of which was the origin of life.[1] Though arguing throughout against the doctrine of the separate creation of immutable species, he refrained from speculating on the first steps leading to the emergence of life as such. In the course of treating other subjects, he now and again makes a passing remark concerning this demarcation between what he considers to be the object of his investigations, and what he is content to leave out of the discussion. For instance, starting his chapter on instinct, he states:

> I must premise, that I have nothing to do with the origin of the primary mental powers, *any more than I have with that of life itself*. We are concerned only with the diversities of instinct and of the other mental qualities of animals within the same class.
>
> (Darwin, 1859 [1968:234], my italics).[2]

But what Darwin was prepared to address in no uncertain terms was the way in which new species develop from the varieties of old species. And whatever may have happened during the beginning stages of life, he is adamant that it did not include the separate or special creation of *immutable* species (or even genera, families and orders)

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[1] Contemporary evolutionary theory does of course not practice a similar abstention. The question as to the origin of life itself is indeed the big remaining question, but there is no dearth of theories claiming to have found the answer. The debate presently revolves around two main alternatives - the one insisting that it was a case of *replicators* (naked genes) first, and the other asserting that the *metabolism* or cell should receive that honour. For a discussion of the rivals, see Fry (1995). Among the adherents of the replicator-first thesis, are Dawkins (1976) and Eigen (1972). Among the adherents of the cell-first thesis, are Cairns-Smith (1985) and Kauffman (1995).

[2] Another example can be found in the foregoing chapter treating of difficulties encountered by his theory, among others that of the existence of very complex and sophisticated organs like the eye: "How a nerve comes to be sensitive to light, *hardly concerns us more than how life itself originated*, but I may remark that several facts make me suspect that any sensitive nerve may be rendered sensitive to light, and likewise to those coarser vibrations

the likes of which have continued existing down to the present day. For if that were to be the case, evolution would have been an impossible and nonsensical idea.

The whole *Origin* is intent on showing that natural selection, the struggle for existence and descent with modification is far superior to the doctrine of special creation when it comes to the explanation of present and past facts (about e.g. adaptation). To this end the two modes of explanation is compared each time a train of reasoning dealing with the one or other aspect of theory is brought to a close, and of course, special creation is found wanting without fail. Already early in the *Origin*, in his Introduction, Darwin puts his cards on the table:

> Although much remains obscure, and will long remain obscure, I can entertain no doubt, after the most deliberate study of which I am capable, that the view which most naturalists entertain, and which I formerly entertained - namely, that each species has been independently created - is erroneous. I am fully convinced that species are not immutable; but that those belonging to what are called the same genera are lineal descendants of some other and generally extinct species, in the same manner as the acknowledged varieties of any one species are the descendants of that species. Furthermore, I am convinced that Natural Selection has been the main but not exclusive means of modification.
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> (Darwin, 1859 [1968:69]).

From this point onwards follows chapter after chapter of careful marshalling of the facts, of spelling out implications, providing interpretations and anticipating difficulties and objections. But be the subject variation, adaptation, classification, geographical distribution, anomalous structures and habits, complex organs or extraordinary instincts, sterility in hybrids or the imperfection of the fossil record, invariably a return is made to the idea of special creation, and its inadequacy as principle of scientific explanation pointed out. Thus, Darwin's objection to special creation, as opposed to his own theory, is that it does not provide us with a coherent theoretical framework consisting of empirical laws and true causes, which could be applied to the whole diverse range of living phenomena in order to explain them, thereby not only rendering them intelligible in a systematic and materialist manner, but also rendering them to some degree predictable. All the special creation thesis offers us, instead, is the

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of the air which produce sound" (Darwin, 1859 [1968:217, my italics]).

repeated assertion that things are the way they are because their Creator wished them to be that way. Such a "restatement of the fact" is then further embellished (where adaptation is not evident, as in the case of rudimentary organs) by reference to additional, rather vague and unscientific principles such as "created for beauty in the eyes of man, or for mere variety"; and, "created 'for the sake of symmetry,' or in order 'to complete the scheme of nature'" (Darwin, 1859 [1968:227,430]), in other words, by appealing to the kind of metaphysical notions entirely at odds with the utilitarian approach Darwin has adopted.

From Darwin's point of view, the presence of a certain feature in a species can generally be explained by reference to its being *useful* to the individual members of the species in their struggle for existence, or to its having been useful to their ancestors (Darwin, 1859 [1968:228]). And, of course, in the struggle for existence there is really no use for displaying symmetry or beauty in the eyes of man. The only consideration is whether particular features are aiding survival and reproduction or not. If there are symmetry and beauty to be perceived from the human point of view, then these do not reflect metaphysical and absolute qualities, but rather the values upon which human evaluation is based. Also, the laws of heredity, reversion and the correlation of growth may cause the presence of some features that are not now useful to the individuals possessing them, but still for Darwin these useless features can hardly be attributed to creation in accordance with metaphysical considerations. He is convinced that they are the by-products of purely empirical causal processes in principle knowable by science. In addition, a feature that is positively injurious to its possessors will not persist or become widespread. Rather paradoxically, Darwin here invokes Paley in support of his utilitarian thesis:

> Natural selection will never produce in a being anything injurious to itself, for natural selection acts solely by and for the good of each. No organ will be formed, as Paley has remarked, for the purpose of causing pain or for doing an injury to its possessor. If a fair balance be struck between the good and evil caused by each part, each will be found on the whole advantageous. After the lapse of time, under changing conditions of life, if any part comes to be injurious, it will be modified; or if it be not so, the being will become extinct, as myriads have become extinct.
>
> (Darwin, 1859 [1968:229]).

Darwin is here cleverly implying that the same utilitarian qualities Paley[3] sees embodied in God's creative acts, can be seen to be operative in the workings of natural selection. Natural selection effects the same results Paley thinks God had, namely, the forming of useful parts, and the excluding of injurious ones. But that is where all resemblance ends. Evolution by natural selection is quite a different kind of causal process from divine creative acts. The one is extremely time-consuming, the other sudden; the one is empirical and mechanistic, the other miraculous; the one is impersonal, the other has recourse to a supernatural agent; the one is probabilistic, the other ensues by divine plan and predetermination; the one is devoid of purpose and direction, the other directed towards a god-given end; the one entails a struggle for existence, the other harmonious balance in nature; the one implies the absence of fixed essences for species, the other underwrites its presence.

As the *Origin* proceeds, and the body of facts and arguments presented to the reader grows larger, Darwin's confidence also increases and his rejection of the opposition becomes phrased in stronger terms. By the time he reaches his "Recapitulation and Conclusion", he does not refrain from letting of steam against what he regards as the stupidity and inconsistency of those naturalists who are quite prepared to make room for the fact that a very great number of species had been the products of variation, but who nevertheless flinch from following the reasoning through to its logical conclusion that *all* species are mutable, preferring instead to hold on to the special creation and immutability of at least *some* species. Moreover, what vexes Darwin greatly, is that the particular species fastened upon as the supposedly specially created ones, depend on arbitrary choice, because there is nothing whatsoever that distinguishes them from the other "non-created" species as better candidates for created status. He thus chides these authors for admitting variation as a *vera causa* in some cases, and rejecting it in others without motivating their choices. After having exposed this intellectual dishonesty, calling it a "curious illustration of the blindness of preconceived opinion", he launches a series of rhetorical questions at them, intended to ridicule their explanatory

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[3] In the 1830s there was actually a Cambridge reaction (consisting of, among others, Sedgwick and Whewell) against Paley, Tooke and Mill who where regarded as exponents of a Lockean sensationalist and materialist epistemology which neglected the metaphysical elements of knowledge and the spirituality of the human mind. In particular, as regards ethics, Paley's *Principles of Moral and Political Philosophy* was attacked for its utilitarian system. (Yeo, 1979:499-500).

model to a still greater degree:

> These authors seem no more startled at a miraculous act of creation than at an ordinary birth. But do they really believe that at innumerable periods in the earth's history certain elemental atoms have been commanded suddenly to flash into living tissues? Do they believe that at each supposed act of creation one individual or many were produced? Were all the infinitely numerous kinds of animals and plants created as eggs or seeds, or as full grown? and in the case of mammals, were they created bearing the false marks of nourishment from the mother's womb? Although naturalists very properly demand a full explanation of every difficulty from those who believe in the mutability of species, on their own side they ignore the whole subject of the first appearance of species in what they consider reverent silence.
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> (Darwin, 1859 [1968:454]).

It should be noted that by the time Darwin produced his theory, there had emerged not only a more accurate picture of the immense age of the earth, but also the disconcerting fact concerning different geological strata with successive and distinct fossil fauna. If one wanted to hold on to fixed essences for at least the most diverse species, and wanted to maintain the Genesis idea of special creation, well then you had to opt for successive acts of creation separated from each other by vast amounts of time. And with each dramatic new discovery, another such event had to be postulated. Someone like the distinguished zoologist and opponent of evolution, Louis Agassiz, was in the end forced to suppose "50 or 80 total extinctions of life and an equal number of new creations". This meant the untenable increase of appeal to divine intervention at the same time as scientific knowledge was making rapid progress. People could not help starting to recognise the ridiculousness of such a state of affairs. (Mayr, 1971 [1976:281-282]). In the above passage Darwin makes the most of this realisation, and hints that what naturalists consider "reverent silence" is nothing but unscientific dogmatism.

To Darwin a deist conception - if any at all - of the Creator's role in the world, seemed to accord much better with the facts. And in the light of the above dilemma, among others, many other people also felt moved towards some form of deism. Rather than having God embody his will in the world through innumerable individual acts of species creation, one had to conceive of him as putting into motion a lawful world of which the emergence of species would be only secondary consequences. In order not to alienate his opponents unduly, Darwin couches this alternative in language that would hopefully make it appear more acceptable to the opposition:

> To my mind it accords better with what we know of the laws impressed on matter by the Creator, that the production and extinction of the past and present inhabitants of the world should have been due to secondary causes, like those determining the birth and death of the individual. When I view all beings not as special creations, but as the lineal descendants of some few beings which lived long before the first bed of the Silurian system was deposited, they seem to me to become much ennobled.
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> (Darwin, 1859 [1968:458]).

This brings us to the end of our cursory discussion of the issue of special creation. A lot more can be said on this subject, but the main reasons for Darwin's denouncement of successive creative acts have been made clear. Some of the issues touched upon above will be encountered again in the next section.

Natural theology undermined: The argument from design

Natural theology had its formidable enemies before Darwin came along. For one, David Hume had in 1779 already subjected the argument from design to a devastating critique. But as mentioned above, this did not attract much attention, and natural theology was still alive and well in the early nineteenth century. The purposiveness thought to be so obviously present everywhere in the universe, continued to vouchsafe the existence of a benign God who imbued his creation with divine purpose. Nonetheless, Paley's *Natural Theology* (1802) was deemed outdated by 1830, and the *Bridgewater Treatises* were commissioned to illustrate in a more scientifically up to date way how the wisdom and goodness of God were manifested in creation.[4]

[4] Commissioned by the eighth Earl of Bridgewater, the eight official treatises were the following: Thomas Chalmers' *On the power, wisdom, and goodness of God as manifested in the adaption of external nature to the moral and intellectual constitution of man* (1830); John Kidd's *On the adaption of external nature to the physical condition of man* (1833); William Whewell's *Astronomy and general physics considered with reference to natural theology* (1833); Charles Bell's *The hand: its mechanism and vital endowments, as evincing design* (1833); Peter Mark Roget's *On animal and vegetable physiology considered with reference to natural theology* (1836); William Buckland's *Geology and minerology considered with reference to natural theology* (1836); William Kirby's *On the history, habits and instincts of animals* (1835); William Prout's *Chemistry, meteorology, and*

Not surprisingly, two conceptions of design - not necessarily mutually exclusive - were at work in nineteenth century natural theology. Reference has already been made to the fact that Darwin and others inclined towards deism. But deism tended to entail a certain concept of design, one emphasising divine *order* in the universe, although the reverse need not have been true, that is, this particular concept of design need not always have been associated with deism. Recall the Cosmic Pyramid described above, and the fact that the distinction between Order and Design was blurred before Darwin, because everything was in any case thought of as created or designed by God. Now, the orthodox teleological notion in the sense of final causes concentrated on the demonstration of practical purpose in all features of organisms. Such purposeful features can be thought of as design proper - belonging to the Design step of the Cosmic Pyramid. But towards 1850 a shift started occurring in teleological thinking so that practical adaptation in organisms was less emphasised, and the notion of order in the organic world as evidence of design - or more properly said, of Order - brought to the foreground. Many began thinking of "law, order, symmetry and harmony as the grandest principles of Divine creation", rather than practical adaptation (Yeo, 1979:507). Of course, the former conception had long been applied to the physical universe - its order having been beautifully articulated by Newton. But the emphasis was now on order in the organic world as well - which idea was perfectly compatible with a deism conceptualising God as akin to a grand engineer or supreme law-maker who created an orderly lawful universe that was then left alone to produce through its own laws and forces an orderly organic world. (Of course, note again, this emphasis on organic order was also perfectly compatible with miraculous origins.) Order in the organic world was evinced by the divine Unity of Plan visible in all organisms, that is to say, by the structural homologies found between the most diverse types of organisms.

We shall see below how Darwin disputed both the idea that divine design could be read off practical adaptation, and the idea that it could be proved by organic order.

William Paley's *Natural Theology* strongly reflected the conception of divine design as

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the function of digestion considered with reference to natural theology (1834). To these Charles Babbage added his own unofficial and fragmentary *Ninth Bridgewater Treatise* (1837).

organismic adaptation. Darwin was thoroughly acquainted with Paley's work - the three years spent at Cambridge ensured at least that much.[5] But as student he would have been the last to anticipate the kind of use to which he would later put the arguments he so admired then. It is no coincidence that the *Origin* repeatedly echoes Paleyan arguments and examples - only to draw, time and again, diametrically opposite conclusions. Darwin wanted to illustrate that the evidence of purposeful design in organisms that Paley and others thought provided irrefutable proof of the Deity's miraculous acts, could just as well, and more plausibly, provide proof of adaptation through a purely natural process - natural selection. Darwin therefore strenuously denied Paley's confident assertion that:

> The marks of *design* are too strong to be got over. Design must have had a designer. That designer must have been a person. That person is God.
>
> (Paley, 1802:473).

In nature, the "marks of design" are to be seen wherever means are adapted to ends, that is, wherever we find organic structures formed in such a way as to be evidently directed to the attainment of certain purposes, for instance, the eye is obviously for seeing, the ear obviously for hearing, and so on. For Paley (to use his favourite example), the eye was like a telescope, only much superior in intricacy and ingenuity of mechanism. But we know that mechanisms like the telescope are a product of human intelligence, therefore superior mechanisms like the eye must be the product of a much superior intelligence, which could only be God. In Paley's view, the immense diversity of organisms were all perfectly adapted to their respective environments, and only God in his great wisdom could have been responsible for this feat. Of course, here and there were to be found some deviations and imperfections, but that was inevitable and only concerned the features of some individuals, never a species as a whole. The majority of the members of any species were perfectly adapted to their environments, which

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[5] Says Darwin (1887 [1958:59]) in his *Autobiography*: "In order to pass the B.A. examination, it was, also, necessary to get up Paley's *Evidences of Christianity*, and his *Moral Philosophy*. This was done in a thorough manner, and I am convinced that I could have written out the whole of the *Evidences* with perfect correctness, but not of course in the clear language of Paley. The logic of this book and as I may add of his *Natural Theology* gave me as much delight as did Euclid. The careful study of these works, without attempting to learn any part by rote, was the only part of the Academical Course which, as I then felt and as I still believe, was of the least use to me in the education of my mind. I did not at that time trouble myself about Paley's premises; and taking these on trust I was

attested to God's perfect wisdom.

Darwin not only contested the claim that supernatural design could be read off organisms' adaptive features, but also the claim that every species was an instance of perfect adaptation. One of Darwin's numerous counterexamples, namely, how to account for the fact that we often find organisms with habits, instincts or features that are at odds with their physical structure, will suffice as illustration.

Striking at the heart of the argument from design, Darwin enumerates cases of animals whose structures do not at all seem to be perfectly adapted to the kind of lives they lead or the kind of environments they find themselves in, but who nevertheless manage to survive, reproduce and even thrive. Put differently, he is saying that because organisms often carry in their structures the marks of other lifestyles suitable to environments different from those they *actually* inhabit, they evidently do not manifest perfect adaptation. But on the view that each species has been created once and for all to be adapted (in body and life style) to its special place in nature which it was to fill until the end of time, it must, according to Darwin, be surprising that one meets with animals "having habits and structure not at all in agreement" (1859 [1968:216]). Of course, one could opt for an easy way out of the dilemma, claiming that "in these cases it has pleased the Creator to cause a being of one type to take the place of one of another type", but in Darwin's opinion this is a wholly unsatisfactory argument, and he remarks that it seems to be "only restating the fact in dignified language" (1859 [1968:217]). Instead, a more scientifically plausible account can be given by appealing to the way in which natural selection works, namely, by acting on what is already there, and preserving any chance variations in instinct (or structure) should these be favourable to the organisms in question in their specific contexts, even when at variance with the functions their structures were previously perfectly adapted to fulfil:

> He who believes in the struggle for existence and in the principle of natural selection, will acknowledge that every organic being is constantly endeavouring to increase in numbers; and that if any one being vary ever so little, either in habits or structure, and thus gain an advantage over some other inhabitant of the country, it will seize on the place of that inhabitant, however different it may be from its own place. Hence it will cause him no

charmed and convinced by the long line of argumentation."

surprise that there should be geese and frigate-birds with webbed feet, either living on the dry land or most rarely alighting on the water; that there should be long-toed corncrakes living in meadows instead of swamps; that there should be woodpeckers where not a tree grows; that there should be diving thrushes, and petrels with the habits of auks.

(Darwin, 1859 [1968:217]).

From the theory of evolution by natural selection it follows that the anomalous structures of some species and varieties are not unsolvable mysteries or signs of a capricious creator, but can be ascribed to *previous* lifestyles and environments, that is, to the lifestyles and environments of ancestors. The substitution, for a personal designer, of an impersonal selection process which (regardless of past adaptations) preserves new chance variations that are heritable and currently beneficial, thus renders normal and likely phenomena that would seem strange upon the design account. Also, the selection account constitutes a more scientific, that is, empirical, explanation of apparent design than the divine design alternative, which by its very nature must appeal to a super-empirical, and thus unscientific principle.

In a sense, arguments like those of Paley already prepared their own downfall by advancing quite some way towards a mechanistic interpretation of nature and its workings. Paley commences *Natural Theology* with his famous watch analogy, thereby setting the scene for the arguments in the rest of the work, which invariably goes out from the supposition that the existence (and attributes) of God can best be proven by demonstrating how much alike the works of nature are to sophisticated human artifacts, that is, mechanisms.[6]

Thus, by, for instance, likening the eye to a telescope, or more generally, living organs to sophisticated mechanical instruments; casting them as mere superior machines that

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[6] Paley is aware of the fact that some may find problematic his claims concerning the mechanistic nature of organisms. He therefore tries to weaken such objections by remarks such as the following: "I have sometimes wondered, why we are not struck with mechanism in animal bodies, as readily and as strongly as we are struck with it, at first sight, in a watch or a mill. One reason of the difference may be, that animal bodies are, in a great measure, made up of soft, flabby, substances, such as muscles and membranes; whereas we have been accustomed to trace mechanism in sharp lines, in the configuration of hard materials, in the moulding, chiseling, and filing into shapes, such articles as metals or wood. There is something therefore of habit in the case: but it is sufficiently evident, that there can be no proper reason for any distinction of the sort. Mechanism may be displayed in the one kind of substance, as well as in the other" (Paley, 1802:157-158).

surpass watches and telescopes only in their degree of intricacy and design, and not in them displaying any substantively different qualities, the door towards a wholly mechanistic and materialist - and thence godless - conception of the world, was pushed ajar. Because if then, as Paley was happy to contend, organs and organisms were nothing but mechanisms of which we, as yet, just do not know all the complicated workings (due to the superior intelligence of their Designer), but which were in principle wholly amenable to an explication in mechanistic terms, then the next step - positing a law-like mechanical process put into motion by God as a secondary cause through which he chose to produce his mechanisms - suddenly sounded less far-fetched. After all, he did keep the planets in their orbits by similar intermediate means. It was such an inclination towards deism - inspired by the Industrial Revolution and the notion of God as "supreme industrialist" (Ruse, 1979:86) - which prepared the conditions for a purely secular evolutionary account of life and its ramifications. For once allowance has been made for a productive causal process intermediate between God and his creatures, the question might start occurring as to this process's possible autonomy, and as to the possible irrelevance or non-existence of the supposed First Cause behind the secondary causes.

Significantly, the French naturalist Georges Buffon (1707-1788) - who is mentioned by Darwin (1859 [1969:53-4]) in his historical sketch[7] as "the first author who in modern times has treated [the origin of species] in a scientific spirit" - already expressed the view that deism honoured God to a greater degree than a conception which believed him to be directly involved in the minute details of his creation:

> Who gives the grandest idea of the supreme Being, he who sees him create the universe, arrange every existence, and found Nature upon invariable and perpetual laws; or he who inquires after him, and discovers him conducting and superintending a republic of bees, and deeply engaged about the manner of folding the wings of a beetle?
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> (Buffon, quoted in Greene, 1959:140-41).

This view continued to gain in credibility and was accepted by many in Darwin's day, not least by figures who influenced him greatly, such as Lyell, who were not averse to

[7] The historical sketch was only added by Darwin to later editions of the *Origin*.

the idea of God creating the organic world by natural law. Underwriting the idea of secondary causes did nevertheless not entail the abandonment of a metaphysical teleology, and in fact, Darwin's two most immediate and important predecessors as concerns evolutionist theory, namely, Lamarck in France and Chambers in England, saw no contradiction in holding on to divine providence.

More attention will be given to the issue of secondary causes when we deal below with the theories of Lamarck and Chambers. But first the notions of a Natural System and a Unity of Type in nature, need to be elucidated. Although in themselves these notions did not exclude miraculous origins and immutable species, and indeed were initially closely associated with such ideas, they at the same time espoused the notion of design as order, and thereby helped prepare the way for a deist interpretation of nature.

In dealing with the Natural System, or what Darwin also calls "the grand fact in natural history", namely that living beings can be arranged in a scheme consisting of groups subordinate to groups (species, genera, families, etc.) - expressive of their degrees of resemblance, he needs once again to dispel the belief that this signifies the existence of a Creator who made every being so as to accord with his fixed and eternal Plan.

The Natural System was the important legacy to biology of the great Swedish systematist and founder of the modern system of classification, Carl Linnaeus (1707-1778), foremost in whose mind were scientific ambitions largely inspired by the kind of metaphysical teleology described above. In his *System of Nature* (1735) Linnaeus provided a classificatory system in which each known plant and animal found its proper place. Implicit in this project was the belief that nature possessed a god-given fixed underlying pattern that we can come to know through our rational efforts. The ostensibly chaotic multitude of beings we observe in nature, actually form part of an *oeconomia*, or a system of means and ends rationally adjusted to each other so that the balance in nature is ensured, and no species ever destroyed (Greene, 1959:131-33).

Just as Adam had been ordained to name all the creatures upon the newly created earth, so - for Linnaeus - it was the duty of science to name, classify and describe all of nature, and through such knowledge glorify God. But in order to achieve this goal the correct method had to be employed - not an artificial method that assign names in an arbitrary manner and according to human convenience, but the *natural* method of classification, which heeds all the natural relationships among organisms, and give each a name expressive of its place in this system of relationships. This was a momentous undertaking, requiring of the naturalist to take cognisance of every characteristic of every species so that accurate classification into genera, orders, etc., could be made through the identification of ever more basic resemblances. Every resemblance or relationship had to be taken into account, for God would not have created things that possessed no meaning. Linnaeus thus dedicated a great part of his life to the uncovering of the natural system - which was supposed to mirror the plan of creation; but the magnitude of the work forced him to settle, in the mean time, for something more practical: he opted for a preliminary classification based on resemblances with regard to a single characteristic. This *artificial system* was to serve as a temporary, rough outline subject to modification whenever new evidence presented itself. But it proved so successful that people subsequently forgot about Linnaeus's wish as to what the real system should consist of. (Bowler, 1989:64-65; Greene, 1959:132-33).[8]

Linnaeus's belief that the orderly pattern of resemblances we discern in nature bespoke the existence of a rational creator in whose mind the original and timeless plan of creation was contained, was still prevalent and powerful enough in Darwin's own time for him to experience it as a pernicious belief that obscured the real cause (*vera causa*) of the different degrees of similarities between organisms. It was an obstacle to his theory, because it denied the possibility of fundamental change, it denied that some forms of life could over time give rise to radically different forms. He accordingly felt no scruples at declaring it a rather vague and worthless idea:

> [M]any naturalists think that something more [than mere resemblance] is meant by the Natural System; they believe that it reveals the plan of the Creator; but unless it be specified whether order in time or space, or what else is meant by the plan of the Creator, it seems to me that nothing is thus added to our knowledge.
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> (Darwin, 1859 [1968:399]).

However, Darwin's refusal to admit that the existence of the natural system can without

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[8] See also Merz (1965:221), Nordenskïold (1929:213,217-18), Sloan (1990:306).

further ado be ascribed to the Creator's Plan, does not mean that he wants to make a case for the opposite extreme: In other words, neither does he want to claim that all the similarities and affinities observed among living beings and reflected in the natural system, signify nothing but the brute fact of mere resemblance. To make such a claim would be to give up the search for a cause of this salient fact of nature. But on the contrary, Darwin feels he had found the cause. Thus, instead of "some unknown plan of creation" on the one hand, or mere likeness on the other, Darwin accounts for the possibility of a classificatory system in terms of common descent:

> I believe that something more [than mere resemblance] is included; and that propinquity of descent, - the only known cause of the similarity of organic beings, - is the bond, hidden as it is by various degrees of modification, which is partially revealed to us by our classifications.
> (Darwin, 1859 [1968:399]).

True natural classification, for Darwin, is always *genealogical*, and the ranking of forms under distinct genera, families and orders thus signifies the varying degrees of modification each has undergone since branching from a common progenitor (Darwin, 1859 [1968:404]).

Unity of descent also explains another closely related fact, namely, the Unity of Plan. The latter refers to more than the fact that life forms can be arranged in a system according to the different degrees of resemblances among them. It refers to the fact that even those forms (in a group such as the vertebrates), who differ from each other in a most extreme manner, still manifest one and the same fundamental *archetype*.

In Britain this view was propounded by the comparative anatomist Richard Owen, who drew upon the morphological theories of the French palaeontologist Etienne Geoffroy Saint-Hilaire - synthesising these with the ideas of Saint-Hilaire's opponent, the French comparative anatomist, Georges Cuvier, who underwrote the traditional teleological focus on the adaptive nature of organisms and denied Saint-Hilaire's claim regarding the unity of plan among organisms. From the transcendentalist Saint-Hilaire (and/or from the transcendental elements in the thought of the German embryologist, Karl Ernst von Baer), Owen got his Neo-Platonic idea of an ideal archetype existing in the divine mind, and realised in all organisms from the same group. But he supplemented this morphological notion with the functionalism of Cuvier, stressing that the amount of adaptive modification - which increases from primitive to higher organisms- accounted for degree of divergence from the archetype. Owen was however not an evolutionist, although he, like others at the time, liked to believe that organic origins arose through the workings of natural law. All the same, the unity of plan discernible in organisms was to be ascribed to God's sense of order; in any case, adaptational needs could not explain it, because some organic structures, although present in diverse organisms, did not serve an adaptative purpose in all of them. But yes, in many instances it was clear that the general plan had indeed been modified in the interest of the special needs of particular organisms. In this way, Owen succeeded in reconciling the orthodox notion of design as adaptation with the notion of design as order and symmetry. (Ruse, 1979:12-14,96,116-125; Yeo, 1979:507-508).

Darwin knew about these theories and repeatedly referred to the authors in his *Origin*. He also knew that he had found a better way than Owen to account for (and reconcile) both the unity of plan and adaptation. To be sure, Owen's ideal archetype need not be ascribed to the Creator's Plan. Rather, such structural homologies find their real and unmysterious cause in the unity of descent. Furthermore, adaptation has little to do with god-given final causes, and everything with evolution by natural selection. Says Darwin (1859 [1968:233]):[9]

> It is generally acknowledged that all organic beings have been formed on two great laws - Unity of Type, and the Conditions of Existence. By unity of type is meant that fundamental agreement in structure, which we see in organic beings of the same class, and which is quite independent of their habits of life. On my theory, unity of type is explained by unity of descent. The expression of conditions of existence, so often insisted upon by the illustrious Cuvier, is fully embraced by the principle of natural selection. For natural selection acts by either now adapting the varying parts of each being to its organic and inorganic conditions of life; or by having adapted them during long-past periods of time: the adaptations being aided in some cases by use and disuse, being slightly affected by the direct action of the external conditions of life, and being in all cases subjected to the several laws of growth. Hence, in fact, the law of the Conditions of Existence is the higher law; as it includes, through the inheritance of former adaptations, that of Unity of Type.

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[9] See also Darwin (1859 [1968:415-419]).

Here Darwin is stripping two important biological notions of their metaphysical garb. He reduces them to contingent historical conditions and processes. By proposing evolution by natural selection as explanation of resemblance and adaptation, Darwin does away with the need to account for these striking phenomena in supernatural terms. Divine design, whether understood as adaptation or order, was a superfluous notion, one which hindered the search for the true causes shaping the features of organisms.

There were, of course, evolutionary theories other than Darwin's available - especially those of Lamarck and Chambers - which would have been able to claim that they could explain resemblance and adaptation in a way not altogether dissimilar from his. However, as with Linnaeus, Paley and the others, metaphysical notions of design were still part and parcel of their approaches. But they were significant in that they provided these notions with a historical dimension. It is important to look at them in a little more detail, in order to point out where exactly Darwin's road departed from theirs with regard to the nature of teleological explanation.

In 1809, the year of Darwin's birth, a work appeared that would fifty years hence be lumped together with his own *Origin*, and which would much to his annoyance, subject him to the same kind of ridicule the earlier work attracted. This troublesome precursor was none other than the *Zoological Philosophy* (*Philosophie Zoologique*) of Jean-Baptiste Lamarck (1744-1829), in which was put forward a version of evolutionary theory.[10] But even more annoying was his British predecessor, Robert Chambers (1802-1871): The title Janet Browne chose for the chapter in her biography of Darwin that deals with the role Chambers came to fulfil in relation to Darwin's theory, is exceedingly apt: *Forestalled but Forewarned*.[11] The sudden appearance of Chambers's *Vestiges of the natural history of creation* in October 1844, published anonymously, was a dismal event in Darwin's life. During all the years which he secretly laboured over his comprehensive thesis on transmutation, and during which he had come to claim this problematic as his sole intellectual property, someone else, also in secret, had been doing the same, and indeed, had now forestalled him in the publishing of a work. At the

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[10] The following treatment of Lamarck is largely based on Greene (1959:155-6) and Bowler (1989:82-88).
[11] See Browne (1996:457-72).

time he felt convinced that the speculative and amateurish *Vestiges* had in advance seriously damaged any scientific case for transmutation which might follow. The scene had been set in a certain way, and he would have had to do his utmost to avoid being seen as another Chambers or Lamarck with all the unscientific airs that surrounded them.

Chambers and Lamarck's theories were similar in many respects, and I will sketch the core ideas of both before indicating where Darwin's insights superseded theirs.

Beginning with Lamarck, we find a concept of nature corresponding closely to that of Buffon. Nature was to be studied and understood without recourse to any explanations based on divine intervention. God created nature as a self-sufficient system consisting of laws and forces that regulate all the motions of matter. As for life - Lamarck found the organisation of ordinary matter quite sufficient to account for the phenomenon of life; there was no need for inventing a special kind of organic matter, or for appealing to some non-material principle that would infuse matter with life. (Greene, 1959:143,155).

Lamarck came to accept the immutability of species less as a result of the fossil record, than as of facts gathered from comparative anatomy. But he did recognise continuous geological change during the earth's history, and because he was not willing to believe that any form of life could become extinct, it seemed only reasonable to believe that organisms survived by changing together with their environmental conditions. And they change to such an extent that one species can give rise to another, indeed, Lamarck did not really think there was such a thing as separate species; as far as he was concerned they all imperceptibly shaded into each other, and all the missing intermediate forms will be discovered in due time. (Greene, 1959:158,162; Bowler, 1989:86,88).

Lamarck's theory of the origin of life held that the simplest lower life forms are continuously produced in nature by means of spontaneous generation. Humid conditions offer an especially favourable environment for these processes. Once these primitive life forms have originated, all others successively evolve from them, forming a gradual series of increasingly complex organisms who possess an increasing number of specialised organs. The formation of these new organs results, according to

Lamarck, from needs experienced by organisms in relation to their changing environment. The attempt to meet a need takes place through a movement of fluids within the body to the parts that must act to bring about the desired end. If the necessary organ does not exist at that location in the body, and the need persists, an organ is developed gradually through the movement of the fluids, and then grows through continued use; it can also wither through disuse. This constitutes his principle of use and disuse, which together with his belief in the inheritance of acquired characteristics, accounted for evolution. (Bowler, 1989:84,86).

The fact that lower organisms are still in existence all around us, was not perceived by Lamarck as a refutation of his belief that a process of complexification has taken, and is still taking place. Less developed organisms currently existing can be accounted for quite easily - they arose very recently, and find themselves at an early stage in a line of development that will eventually also produce humankind - just as previous ones did. In other words, several similar lines of development originated at different points in time as a result of the continuous spontaneous generation of the lowest organisms, and each of these separate lines are presently progressing through the different successive stages - some having already reached more advanced stages and others still caught up in the earlier, less complex ones. (He did however allow for some branching to take place, and accordingly, for branches that are dead ends which do not lead to humankind.) (Bowler, 1989:85; Greene, 1989:162-163).

The acceptance of such an evolutionary hypothesis naturally affected Lamarck's research interests. And, as is evident in the following statement, it stands - as was the case with Buffon - in marked contrast to that of Linnaeus:

> The object of the study of animals is not only to know the different races and to distinguish among them by fixing their particular characters, but it is also to discover the origin of the faculties which they exercise, the causes which give rise to life and sustain it, and finally the causes of the remarkable progression which they exhibit in their organization and in the number as well as in the development of their faculties.
>
> (Lamarck, quoted in Greene, 1959:159).

But unlike Buffon, Lamarck was not yet ready to appreciate the influence of randomness and permanent extinction on the process of life. This can be attributed to his desire for a certain direction in the evolutionary process: life had to be constantly moving towards greater complexity and perfection. It was in this respect that Lamarck did not succeed in escaping from teleological thinking. Though he did recognise that things could sometimes go wrong and that accidental causes could produce irregular varieties that violated the progressive line of development, he did not think that such deviations were powerful and lasting enough to undermine the overall progress. His tendency to be ambiguous about the causes of evolution stems from this commitment to progressive development. He probably sensed to some extent that adaption to new and changing conditions does not in itself guarantee a movement to greater complexity. Consequently, he sometimes speaks in a vague manner of "the cause which tends incessantly to complicate organization", thereby apparently abandoning the project to explain evolution solely in terms of material causes. Thus, although Lamarck was instrumental in conceptualising the realisation of nature's plan as a dynamic process rather than as the kind of static embodiment Linnaeus had in mind, he still thought of nature as possessing some kind of necessary "plan" of development, and regarded certain structures as more fundamental than the supposedly irregular varieties.

Another sign of the persistence of an illegitimate form of teleological explanation in his theory, is his emphasis on "felt needs as a positive agency in organic transformation". In saying that a certain organ developed because a felt need helped to bring it about, entails that a kind of psychological, intentional, or purposeful factor is brought into play, thereby denying that organic change can be explained in a completely mechanistic manner. In this regard Greene aptly remarks:

> [I]t was not until Charles Darwin combined Lamarck's emphasis on the effort of living creatures to survive amid changing conditions of life with Buffon's idea of random variation and the extinction of the least fit that the traditional view of nature felt the full impact of the mechanistic concept.
>
> (Greene, 1959:166).

Chambers, on the other hand, felt that there was room for a work that would be a synthesis of the latest scientific knowledge - comprehending everything from the nebula to man. In contrast to Lamarck, he does zoom in on the fossil record, providing us with a discussion - spanning several chapters - of the different geological strata of the earth, and the fossils correlating with each of them. Such a review of the fossil record from the lowest strata to the most recent presents us, in Chambers's opinion, with some glaringly obvious facts:

> In pursuing the progress of the development of both plants and animals upon the globe, we have seen an advance in both cases, along the line leading to the higher forms of organization. Amongst plants, we have first sea-weeds, afterwards land-plants; and amongst these the simpler (cellular and cryptogamic) before the complex. In the department of zoology, we see zoophytes, radiata, mollusca, articulata, existing for ages before there were any higher forms. The first step forward gives fishes, the humblest class of the vertebrata; and, moreover, the earliest fishes partake of the character of the next lowest sub-kingdom, the articulata. Afterwards come land animals, of which the first are reptiles, universally allowed to be the next type in advance from fishes, and to be connected with these by the links of an insensible gradation. From reptiles we advance to birds, and thence to mammalia, which are commenced by marsupalia, acknowledgedly low forms in their class. That there is thus a progress of some kind, the most superficial glance at the geological history is sufficient to convince us.
>
> (Chambers, 1844 [1969:148-9]).

The view formulated in this passage would not in itself have been problematic for a nineteenth century reader. In fact, Chambers's contemporaries would have been happy to agree with him that there was progression in the fossil record, that the simplest forms emerged first, and that step by step increasingly complex organisms made their appearance, each representing a certain, successively greater degree of complexity within a graded scale of being. After all, this corresponded with the account given in Scripture that God gradually prepared the earth for the Crown of Creation - mankind. But Chambers (1844 [1969:149-50]) pursued the argument one step further, describing in some detail how "we see everywhere throughout the geological history, strong traces of a parallel advance of the physical conditions and the organic forms." This would in itself also not have been perceived as in any way outrageous. It was perfectly clear for all to see that beings were adapted to their surroundings - which was to be expected, since the Creator designed each of them to live in harmony with the circumstances within which he placed them. But Chambers was driving at something more, namely that it is changes in physical circumstances that *cause* changes in the species inhabiting the earth. He actually approached a formulation of the principle of natural selection, unfortunately remaining vague when it came to specifying exactly how the mechanism operates. What was important, was that he saw the emergence of new species and of life generally, not as a miraculous intervention but as a law-like process. As for the origin of life on earth, Chambers (1844 [1969:204-5]) thought it nothing but a natural "*chemico-electric operation, by which germinal vesicles were produced*". Moreover, species were genetically related and new ones were naturally produced from older ones:

> I suggest, then, as an hypothesis already countenanced by much that is ascertained, and likely to be further sanctioned by much that remains to be known, that the first step was *an advance under favour of peculiar conditions, from the simplest forms of being, to the next more complicated, and this through the medium of the ordinary process of generation.*
>
> (Chambers, 1969 [1844:205]).

By this Chambers basically meant that one species (e.g. a goose) can as a result of certain favourable conditions produce another more advanced species (e.g. an ornithorynchus) as offspring. Adverse conditions, on the other hand, could cause a retrogression - the production of a less advanced species as offspring. As part of the evidence for such highly controversial claims Chambers (1969:212-22) appealed to embryological phenomena: Physiologists have determined that each animal, when an embryo, passes through stages that successively resemble all the lesser species that, in the progressive scale of being, precede the species of the animal in question. A human embryo, for example, first resembles a fish, then a reptile, a bird and the lower mammalia, before attaining its own proper form. Therefore, should certain conditions cause the period of gestation to be shorter or longer than would be normal for a certain species, and cause the embryo to be born at the wrong stage of development, the result would be offspring that belong to a different species from that of the parents.

In order to give a theoretical justification for his belief in such extraordinary events, Chambers (1969:206-11) drew from Charles Babbage's argument regarding the workings of natural law. In the *Ninth Bridgewater Treatise* Babbage argued that unexpected and seemingly miraculous events could and do take place, events that would appear to violate ordinary natural laws, but which thereby are in actual fact obeying higher laws of which we are ignorant. He believed that this could be demonstrated through the way a certain kind of calculating machine operates. After patiently observing the machine for some time, it would appear to provide us with a series of numbers, each succeeding the other in a regular and predictable manner, e.g. 1,2,3,4,5..... But induction is never foolproof, and it so happens that the machine, at reaching 100 000 001, suddenly switches to the instantiation of a different numerical series. After some time another switch occurs. This process can carry on ad infinitum without us ever being able to predict when or whether another switch will occur. It does however not mean that the process is not law-like; in fact, the entire process is a necessary consequence of the mechanical structure of the machine - of which we have no knowledge.

Chambers (1969:210-11,219-20) found that the state of affairs described by Babbage must apply to the development of species as well. It would explain why we rarely if ever see instances where one species give birth to another - these being extremely rare and unpredictable (but nevertheless law-like) events, of which it is quite possible that none had occurred during the historical era known to humans, or if they had, it must have been in obscure locations under special conditions - where, for all we know, these events are still occurring. It is here that Darwin would succeed in articulating a more credible alternative involving gradual change. Even Lamarck had more of an appreciation for the gradualness of change than Chambers did, though the mechanism he had in mind - the inheritance of acquired characteristics - was almost equally dubious.

Chambers of course knew about Lamarck's theory, but was not inclined to give him much credit - the one reason being that it was the fashion of the day to ridicule Lamarck, and the other being his rejection of Lamarck's idea that all the living forms imperceptibly shade into each other. For all his evolutionary ideas Chambers did not give up a belief in a plan of being that was of divine origin and entailed definite and eternal distinctions among the various species. Although Lamarck did not give up the idea of life progressing again and again along certain relatively fixed paths - each time realising more or less the same sequence of organic forms, he did dispute the idea of radical breaks between species believed to have fixed essences. For Chambers this was unacceptable - indeed, for him "the whole plan of being [was] as symmetrical as the plan of a house, or the laying out of an old-fashioned garden", which "must needs have been devised and arranged for beforehand" by the Deity (Chambers, 1844 [1969:232]).

All the same, the kind of process Chambers suggested was at work in the realisation of the divine plan in nature, namely species giving rise to one another through reproduction, was hardly orthodox. And he knew he had to address which was probably the greatest objection to his theory: that it would mean the ruin of humankind's special status in creation. If our ancestral roots hark back to the primates, then the first members of the human race could no longer be thought of as called into being by a special act of God who have created us in his own image. We were not of heavenly origin, but rooted in the animal world. This was sacrilege, but Chambers tried hard to make his views appear otherwise:

> But the idea that any of the lower animals have been concerned in any way with the origin of man - is not this degrading? Degrading is a term, expressive of a notion of the human mind, and the human mind is liable to prejudices which prevent its notions from being invariably correct. [...] It has pleased Providence to arrange that one species should give birth to another, until the second highest gave birth to man, who is the very highest: be it so, it is our part to admire and to submit. [...] For it may be asked, if He, as appears, has chosen to employ inferior organisms as a generative medium for the production of higher ones, even including ourselves, what right have we, his humble creatures, to find fault? There is, also, in this prejudice, an element of unkindliness towards the lower animals, which is utterly out of place. These creatures are all of them part products of the Almighty Conception, as well as ourselves. All of them display wondrous evidences of his wisdom and benevolence. All of them have had assigned to them by their Great Father a part in the drama of the organic world, as well as ourselves. Why should they be held in such contempt? Let us regard them in a proper spirit, [...] and we shall be altogether at a loss to see how there should be any degradation in the idea of our race having been genealogically connected with them.
>
> (Chambers, 1844 [1969:233-5]).

Chambers (1969:275-6) also dared to speculate that the present human race with all its imperfections might not be the real crown of creation, that for all we know, a superior species, a "nobler type of humanity" may still develop which will fulfil the "dreams of the purest spirits of the present race".

Chambers became the person to make evolution a fashionable topic for discussion in Britain,[12] though not yet scientifically respectable. Apart from the reviews in journals that either praised the *Vestiges* for making the doctrines of transmutation accessible to ordinary workmen and the like, or condemned it as an atheistic subversion of science and religion, critical pamphlets and books appeared in due course. The range of critical reactions made sure to tackle and thoroughly demolish each and every aspect of Chambers's views - the scientific, philosophical and religious.[13] This was not too difficult as his book with all its errors and naiveties provided an easy target.

For Darwin, the reactions to *Vestiges* served as a due warning that if he wanted to advance unorthodox theories he had better do it in the most orthodox way possible, making sure that at least his means and methods were above critique. When his turn came - and that had to wait until things had entirely calmed down - he would make sure that he steered clear of all metaphysical or religious controversies and considerations in his *Origin*. He would confine himself to the scientific matters at hand and not let himself out on issues he did not pretend to know anything about. And he would utter almost not a word on the status or descent of the species he himself belonged to - that would have to wait until much, much later. Moreover, he would apply himself with renewed fervour to the meticulous gathering of hard and detailed scientific evidence for his theories. In this regard, Herschel's critique of the *Vestiges* must have made a deep impression on him.

Herschel, in his Presidential address to the British Association for the Advancement of Science in 1845, launched his attack at the kind of causal mechanism Chambers employed to account for the formation of new species, namely the length of gestation of an embryo. Though Herschel himself believed organic origins to be natural, he had no intention of letting Chambers get away with the claim that a phenomenon such as gestation length was on a par with the Newtonian law of gravitation. As far as he was concerned, Chambers had done nothing more than present us with a phenomenal law

[12] See Browne (1996:462-4) for examples of people ranging from politicians to literary figures known to have read and discussed the *Vestiges*, as well as for examples of favourable and antagonistic reviews in journals.
[13] See Ruse (1979:106-116).

or description of change. Nowhere did he offer anything even approaching a *vera causa* for the origin of species, and thus his theory could not be credited with being good Newtonian science. (Ruse, 1979:109-12). Darwin would now be more determined than ever to demonstrate the *vera causa* credentials of his theory. Exactly how he did this have been the subject of the previous chapter.

It was in the kind of causal process Darwin proposed for evolution, and in the way he argued for it, that he surpassed Lamarck and Chambers. Natural selection was a purely mechanistic process lacking any built-in direction or purposive force. In this it contrasted with Lamarck's causal mechanism (the principle of use and disuse combined with the inheritance of acquired characteristics) which was supposed to bring about, through organisms' own efforts, increased complexity and perfection. It also contrasted with Chambers's higher or divine "law of creation" which ensured that events (species productions) occurred which took the life process forward along the developmental line - which had to be thought of as progressing from the primitive to the higher forms. Thus, although both Lamarck and Chambers tried to give purely natural explanations of evolution, doing away with miraculous special creation, they could not get themselves to a point where metaphysical teleology was completely left behind. Both were still committed to divine design as Order - God created a law-bound universe, which laws were moreover progressive by nature, giving rise to ever more perfect and well-adapted organisms. A divinely preordained pattern was being realised in creation. Bowler (1989:146) describes Chambers's position as follows:

> Surely God could build such a preordained pattern [the kind Babbage proposed] into the universe which could change the normal laws of nature from time to time in a way that would *appear* miraculous to the casual observer. Chambers's series of transmutations was ideally suited to such an interpretation; the individual acts fitted together to give a rational pattern. By adapting Babbage's position, Chambers turned God into the Great Programmer, who has built the law of progression into the universe where it can unfold through a series of changes to the normal law of like reproduction. The scientist is helpless to investigate the *cause* of such changes; he can see the overall pattern and call it the "law of progression," but he cannot understand the programming mechanism itself.

However, it is hardly science when one, in order to account for certain phenomena, postulates a teleological law which can in no way be empirically investigated or verified:

Even if someone does observe one of these rare events where one species give birth to another, it would be difficult to subject the observation to intersubjective testing - given the very elusive nature of these events. Moreover, even if we observe a number of these events, we can never come to know the law at work, because it is in any case beyond human grasp. Darwin wanted to do better than that. His Lyellian beliefs were directly opposed to Chambers's solution.

Whether Charles Lyell[14] liked it or not, Darwin applied nearly all he learned from Lyell's uniformitarianism and *vera causa* commitments concerning the inorganic world, to the organic world as well. If one had to confine oneself to the search for past geological causes similar in nature and intensity to those causes one knows from observation to exist today, then one also had to search for past speciation causes that could in principle be observed by us today if only we investigate closely enough. Lyell thus did not allow for any violent geological cataclysms - whether miraculous (the Flood) or not - in order to account for present geological features such as mountains, etc. But much as he wanted a natural law-bound explanation not only for geological phenomena, but also for species origins, Lyell recoiled from a full-blown application of his geological doctrine to the organic sphere or to human history. He did believe, in accordance with his steady-statism, in the continuing occurrence, even today, of multiple species extinctions and creations. But definitely not in evolution and mutable species,[15] and he remained vague as to what the natural mechanisms or laws for species creation would consist of. Not the normal known laws, in any case; it would probably have had to be some peculiar laws - almost in the line of Babbage's conception of higher laws; and the appearance of humankind was one case in which divine intervention was probably required. Lyell would therefore remain ambivalent and torn between his scientific principles and religious feelings.

It was Darwin who had no scruples at making the process of life subject to Lyell's ideas of uniformity and actuality, thereby in principle ruling out Chambers's almost miraculous species productions. Lyell's steady-statism was somewhat problematic, because the idea of reversibility entailed by the latter did not sit well with the irreversibility of the

[14] See Secord (1997), Ruse (1979), Greene (1982).
[15] At least not until much later, and only with a great deal of emotional distress.

genealogical tree of life (the tree cannot be retraced or repeated, and a particular species can never emerge twice). Such irreversibility was the one aspect of Darwin's theory that obviously contradicted the traditional mechanistic Newtonian paradigm. After all, life was a very complex affair, and there were too many variables, interconnections and causal links at play to make it even remotely plausible that exactly the same conditions could apply more than once.

The mechanistic and materialist nature of Darwin's theory can be seen in its two main aspects, first, chance variation in organisms' characteristics, and second, natural selection as the weeding out of unfit varieties and the preservation of fit ones. This claim can be motivated as follows:

Firstly, as for chance variation, each organism is born with a set of traits not altogether the same as that of either of its parents; the difference between parents and offspring can be of varying degrees, but there are definite limits to it - for instance, Chambers's dramatic changes are out of the question. The production of these variations always happens by chance. It is important, though, to understand in precisely what sense "chance" is meant here. It means "unplanned, unintended, or undesigned", but not "uncaused" (Hodge, 1987:243). The chance variations were still the effects of lawful, mechanical causes - but they were hidden, in any case Darwin admitted he did not have knowledge of them (recall his statement concerning heredity in the previous chapter). (Beatty, 1987:229). In other words, as far as Darwin was concerned, it was reasonable to believe that the chance variations were physically (and not divinely) caused, and we are justified in searching for these physical causes. The variations themselves were thus *not* the result of a stochastic process. They are only chance events from the perspective of their causal relevance to survival and reproduction. I shall further elaborate this point below.

Secondly, we know from what has been said in the previous chapter that natural selection cannot take place when there is no variation in fitness, that is, not just any variation will do - for there are variations that are neutral with regard to fitness. Rather, there must be variations in traits such that these variations confer differential adaptive benefits on the organisms possessing them. Such adaptively beneficial traits will determine fitness, that is, it will determine the chances on success the organisms in question will respectively have with regard to survival and reproduction. Which variations will generally be the most successful in surviving and reproducing, is not a matter of chance. Natural selection may be a probabilistic process in that the fittest will only on average (and not in each and every case) be the most successful, but that does not take away from the fact that it is a deterministic process. It is deterministic in that certain traits are causally relevant to success. In Hodge's terms, natural selection is a "differential reproduction of hereditary variants" that is "nonfortuitous" because "causal relevance is present", or again, hereditary variants' "physical property differences are sources of causal bias giving them different chances of survival and reproduction". To say this, is to assert that natural selection is a causal process, and not a case of the mere correlation of phenomena. (Hodge, 1987:251,233).[16]

Natural selection may be deterministic, but there is no question of divine preordination in its workings, nor any other kind of "prevision" or "provision". (In any case, its probabilistic character also seems to preclude that.) It is wholly materialist in its determinism: All its results can be explained by the causal interactions between empirical environmental conditions and the material organisation of organisms. (Hodge, 1987:242).[17]

To sum up the role of chance in evolution by natural selection, we can say that it is

> a matter of chance as to what variations are arising in the conditions the species is now living in, but it is not a matter of chance as to which are most successful in surviving to reproduce.
>
> (Hodge, 1987:244).

We are now in a better position to clarify the sense in which variants can be said to be chance productions. As mentioned above, successful hereditary variants are caused in Darwin's view, not by some "vital or divine agency" who calls them forth, but by natural causes. These causes "act blindly with regard to their consequences" - consequences in terms of survival and reproduction, that is. (Beatty, 1987:229). There is no guarantee

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[16] Of course, some detailed account of causation is imperative if one wants to properly motivate these claims, but that is a task that is beyond the scope of the present thesis.

[17] See Daniel Dennet's *Darwin's dangerous idea: Evolution and the meanings of life* (1995) for a wholly mechanistic account of natural selection as an algorithmic process.

that there will arise, in a given environment, any variations of adaptive benefit to the organisms inhabiting that environment. There will be variations, to be sure, but the degree to which they turn out to be adaptive will not be the *cause* of their having arisen in the first place. Of this much Darwin was convinced, despite his ignorance of what we know today as the genetic phenomena of recombination and mutation. This was an important conviction, because it ruled out all possibility of divine design - at least in the way divine design was understood at the time. The world did manifest order and lawfulness, but not the kind of order and lawfulness that would necessarily lead to progressive organic development. Darwin (1859 [1968:318-319], my italics) clearly stated:

> *I believe in no fixed law of development*, causing all the inhabitants of a country to change abruptly, or simultaneously, or to an equal degree. The process of modification must be extremely slow. The variability of each species is quite independent of that of all others. Whether such variability be taken advantage of by natural selection, and whether the variations be accumulated to a greater or lesser amount, thus causing a greater or lesser amount of modification in the varying species, depends on many complex contingencies, - on the variability being of a beneficial nature, on the power of intercrossing, on the rate of breeding, on the slowly changing physical conditions of the country, and more especially on the nature of the other inhabitants with which the varying species comes into competition. Hence it is by no means surprising that one species should retain the same identical form much longer than others; or, if changing, that it should change less.[18]

Variation is random or fortuitous in the sense that it does not occur *because* of its benefit to the organisms involved. (In fact, we now know that most mutations which have any significant effect are harmful.) Rather, a variation arises regardless of whether it is beneficial or deleterious to the organism. Once a variant exists, however, natural selection will in general[19] and in a nonfortuitous way cause its demise or retention/reproduction depending on its fitness-reducing or fitness-enhancing properties. To articulate this fact in current terminology: The events at the microscopic

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[18] Darwin (1859 [1968:348], my italics) later reiterated: "I believe, as was remarked in the last chapter, in no law of *necessary* development".

[19] "In general", because natural selection is a probabilistic process, and there are "complex contingencies" at work as Darwin himself realised. It is therefore quite possible that the fittest new variant, as yet consisting of only one or a few individuals, might be killed by unexpected rockfalls and the like, without ever having had the opportunity to reproduce. That would also be instances of chance events, or "absolute coincidences" in Monod's

level at which recombination and mutation take place, are not guided by the considerations relevant to the survival and reproduction of organisms in the macroscopic world. Jaques Monod, in his *Chance and necessity: An essay on the natural philosophy of modern biology*, formulates the insight as follows:

> "[W]hat may be called 'absolute coincidences', [are] those which result from the intersection of two totally independent chains of events. [...] Now, between the occurrences that can provoke or permit an error in the *replication* of the genetic message and its functional consequences there is also complete independence. The functional effect depends upon the structure, on the actual role of the modified proteien, on the interactions it ensures, on the reactions it catalyses — all things which have nothing to do with the mutational event itself nor with its immediate or remote causes, regardless of the nature, whether deterministic or not, of those 'causes'".
>
> (Monod, 1972:111).

> "[B]etween the determination, however complete, of a mutation in DNA and the determination of its functional effects on the plane of proteien interaction, one could [...] see nothing but an 'absolute coincidence'".
>
> (Monod, 1972:112).

Simply put: Different kinds of laws determine microscopic events (mutation/recombination of genes) and macroscopic events (natural selection of organisms) respectively. But the products of microscopic events (the resulting mutant genes and the new combinations of genes) do have effects on the macroscopic world, in this context, on the kinds of organisms formed. However, as the type of causal relations at microscopic level differs from the type of causal relations at macroscopic level, it is not the same causal process ruling across both levels. The microscopic event was not subject to the macroscopic laws and causes, and it can therefore be considered a chance event or coincidence from the macroscopic perspective. New adaptive traits are exactly the kind of chance events Monod had it about. This is because they are the occasional consequences of genetic mutation/recombination. (We will give more attention to the defining of the notions of adaptiveness and adaptation in the next chapter).

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sense of two independent chains of events coinciding. See below.

It is true, however, that despite the wholly mechanistic and materialist way in which Darwin conceptualised the process of natural selection, he was himself sometimes tempted to discern some progress in evolution - progress in the sense of increasing organisation and better adaptedness in organisms. But he did not think of progress as reflective of divine direction and design - his final stand on the latter was a confessed agnosticism.[20] Rather, for him progress followed purely from the mechanistic way in which natural selection worked:

> There has been much discussion whether recent forms are more highly developed than ancient. I will not here enter on this subject, for naturalists have not as yet defined to each other's satisfaction what is meant by high and low forms. But in one particular sense the more recent forms must, on my theory, be higher than the more ancient; for each new species is formed by having had some advantage in the struggle for life over other and preceding forms. If under a nearly similar climate, the eocene inhabitants of one quarter of the world were put into competition with the existing inhabitants of the same or some other quarter, the eocene fauna or flora would certainly be beaten and exterminated; as would a secondary fauna by an eocene, and a paleozoic fauna by a secondary fauna. I do not doubt that this process of improvement has affected in a marked and sensible manner the organisation of the more recent and victorious forms of life, in comparison with the ancient and beaten forms; but I can see no way of testing this sort of progress.
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> (Darwin, 1859 [1968:336-337]).

We see here that Darwin does not think of natural selection as possessing some inherent teleological force directed towards perfection. And as we saw above, there is for him no necessary law of development, compelling life to successively take on specific higher forms. Rather, it is a purely mechanical and materialist sifting process by which the successful is preserved, that is responsible for the emergence of increasingly improved forms. But note that improvement is still a relative concept here - Darwin carefully specifies that comparisons can only be made between past and present inhabitants of nearly similar climates. The most recent and advanced tropical organism would never be able to compete with an ancient inhabitant of an icy climate if both were placed in icy conditions.

[20] Cf. Flew (1984:52-54).

But Darwin does try to close the *Origin* with an outlook that sounds more optimistic than is warranted by the theory of strife and competition he has just expounded. Notions such as "nobility", "progress", "perfection", "exalted object", "grandeur", "forms most beautiful and most wonderful",[21] are smuggled in here at the end of the *Origin* to soften and mask the harsh materialism and utilitarianism lying at the core of his approach. After all that has gone before, however, these phrases do strike one as little more than somewhat unconvincing rhetoric aimed at swaying apprehensive readers.

Interestingly enough though, nineteenth century religious reactions which assimilated Darwin's theory into their own frameworks, simply disregarded the fact that the *Origin* opposed necessary development. They did not grasp the fundamental character of the process as a materialistic one proceeding through a combination of chance and mechanical necessity. Darwin's views were interpreted as being much in the same vein as the developmental views of Chambers and Lamarck. At the time there were only a few who refused to have anything to do with Darwin's theory, and who continued to cling to a literal view of the Bible and design. At the other extreme, a few Calvinists adopted Darwin's entire approach, precisely because it did *not* guarantee progress and thus coincided with the Christian belief in the fallenness of humankind. But most theologians and biologists sought some kind of compromise in the form of a theistic evolutionism according to which the process was supernaturally guided, either in its entirety or at least in the final stages leading to humankind. But this solution became discredited in science because it precluded a wholly natural explanation of things. From a religious point of view, natural selection began to be seen as too selfish and severe a process to be an instrument of God. Consequently, from the sides of both science and religion the Lamarckian inheritance of acquired characteristics started to look like a better mechanism. These and other options were explored and although evolution continued to be popular, belief in Darwin's selection mechanism dwindled and disappeared towards the end of the century. It was only resurrected and its honour restored some few decades into the twentieth century when the Modern Synthesis was developed. (Bowler, 1989:219-221,246).

The temporary eclipse of Darwinism was largely due to its unsettling implications for

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[21] See Darwin (1859 [1968:459-60]).

traditional notions of divine design. It was by accounting in a radically different way for the phenomenon of apparent purpose and order in living beings that Darwin pulled the rug out from under natural theological interpretations of the world. He showed that nowhere was it needed to call in divine intention in order to give a coherent and plausible explanation of the phenomenon of life and its wonders. Actually an absolute lack of intention was quite compatible with the emergence of well-adapted organisms. By proposing a blind, unguided process as the cause of all natural wonders, Darwin effected a transformation in our conception of nature and ourselves. God was pushed out of creation as an unnecessary hypothesis, and we were left shorn of the last vestiges of an animalistic attitude towards nature. The divine direction previously to be seen everywhere, evaporated. It was inevitable that it would take some time before such an outlook with all its implications would become widely accepted and influential. Indeed, we are still in the process of coming to terms with Darwin.

In the next chapter, we shall see how Darwin did not do away with all forms of teleological explanation when he eradicated metaphysical teleology from his thought, but how, instead, he presented us with the means to transform teleological explanation into a thoroughly scientific undertaking.

4

Natural Selection and Teleological Explanation

This chapter will start with a brief illustration of Darwin's continuing use of teleological language in spite of his having divested biology of the metaphysical notions of divine design and supernatural significance. In what follows an etiological approach to goals and functions will be adopted as a scientifically legitimate way in which to explain the apparently functional and goal-directed character of biological phenomena. Finally, it will be argued that Darwin, through having argued for natural selection as the *vera causa* of adaptation, provided us with a historical empirical causal process which for the first time, and in a theoretically coherent way, made possible scientific teleological explanation in biology.

Darwin's language

Darwin may have left behind metaphysical teleology, but he did not leave behind talk of functions, ends, purposes and contrivances. He felt no scruples at using teleological language to describe the workings of biological phenomena, for instance telling his readers how an organ "originally *constructed for one purpose*", may later become converted into an organ serving a "wholly *different purpose*"; pointing out how an organ "has been modified but not perfected for *its present purpose*"; and how, in very distinct species, the same "*function*" can be fulfilled by similar organs as a result of natural selection having hit upon the same invention for both species (Darwin, 1859 [1968:220,230,223], my italics]).

In fact, Darwin still employed the Aristotelian expression, "final cause", in the *Origin*[1] and elsewhere. Lennox marks that Darwin's *Species Notebooks*, for example, are consistent with regard to the meaning they attribute to this expression, that is, 'final cause' refers throughout to that which things (organs/instincts/behaviours) are *for*.

[1] Cf. Darwin (1859 [1968:242,416,426]).

> In contexts where the central question being considered is 'What is *S* for?', Darwin refers to the answer to the question as stating the 'Final Cause' of *S*. By contrast, when he thinks it is reasonable to suppose that the fact in question is not for anything, he denies that it has a 'Final Cause'.
>
> (Lennox, 1993:410-411).

Statements as to the goal-directedness of organisms' behaviour also abound in Darwin's text: Males struggling with each other "*for possession* of the females"; plants excreting a sweet juice "apparently *for the sake of eliminating* something injurious from their sap"; larger ground-feeding birds only taking flight "*to escape* danger"; and pollen-devouring insects "visiting flowers *for the sake of collecting* pollen" (Darwin, 1859 [1968:136,139,176,140], my italics).

The question arising here regards the legitimacy of Darwin's continuing use of terminology that seemingly contradicts the very nature of his enterprise - after all, what place do goals and functions have in a process where all intention is absent, where chance and mechanistic cause-effect sequences combine to give a purely materialist account of biological phenomena? Does talk of goals and functions not smack of metaphysics and fallacious reasoning all over again? In the next section I will propose the adoption of an etiological approach to teleological explanation which will justify the continuing use in biology of such terminology. However, rendering these terms science-friendly will entail understanding them in a way somewhat different from what we are wont to. In fact, we may start wondering whether "teleological", "goals" and "functions" are still appropriate terms to use, but in the current absence of anything more neutral, we seem to be stuck with these terms, at least for the present.

An etiological approach to goals and functions

Generally, the ascription of goals and functions to phenomena are meant to be *explanatory*, that is to say, when we succeed in ascribing a goal or a function to a phenomenon or event, we feel that it has been explained - depending, of course, on how accurate or sufficient we judge the ascription to be. For example, by saying that the function of the piece of paper in the book is to mark the place where I last stopped reading, I explain not only why the piece of paper is in the book, but also why it is located between those two pages specifically. In this example, however, we have to do with an agent (me), who *intentionally* placed the piece of paper in the book so that it would fulfil the function of place-marker I *intended* it to. (Whether it did so successfully or not does not affect the point being made here.) In such cases where conscious agents are the source of functions and goals, it may be appropriate to speak of the function or goal being represented as an idea in the mind of the agent, which representation can then be regarded as the *proximate cause* of the events or acts in question.[2] But the identification of such a proximate cause in the form of an intention, does of course not rule out a more detailed physico-chemical explanation of what is going on both in the "mind" of the actor and as regards the ensuing actions or states of affairs. However, given the impractical (and mostly unnecessary) nature of such detailed investigations, we are usually content to leave it at the simple ascription of a goal or function - finding that a quite satisfactory form of explanation.

In the case of by far the majority of biological phenomena, there are no mind-possessing actors whose intentions can account for the existence of functional and goal-directed phenomena. And besides, in the previous chapter the divine mind has been relieved of that all-encompassing burden. But we nonetheless still have trouble banishing the impression of design from our thoughts when we scrutinise living complex systems - where functionality and goal-directedness seem to be the rule rather than the exception. Darwin himself never ceased to wonder at the ostensible design so abundantly manifested in living phenomena. How then, are we to account for such a state of affairs, given that intentional design - whether divine or otherwise - can no longer be accepted as a scientifically acceptable solution? To answer this question, a slight detour is in order for the elucidation of certain distinctions within the discipline of biology, distinctions such as that between proximate and ultimate causes, which will prove to be relevant to the answer developed below.

Biology can be seen as a science encompassing two fields that differ considerably in "method, *Fragestellung*, and basic concepts" (Mayr, 1961 [1976:360]). It does not direct its attention exclusively to the answering of so-called *what*-questions - questions aimed

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[2] Cf. Mitchell (1995:41).

at establishing and describing states of affairs (as will be the case in a purely descriptive structural biology). Two other types of questions, namely *how*-questions and *why*-questions, are each found to correspond to a separate domain of biological enquiry. What could be termed *functional biology* concentrates on problems relating to how things operate or function - the main technique being the experiment, and the ideal being an approximation to the simplicity and elimination or control of all variables that characterise physical and chemical experiments (Mayr, 1961 [1976:360]; 1974 [1976:398]).

Why-questions, in contrast, are absent from the physical sciences, but essential to the science Darwin put on firm foundations, namely *evolutionary biology*. But "why?" should here be understood in the sense of a historical "how come?", not in the sense of a finalistic "what for?". It refers to the fact that all biological phenomena are historical, that is, spatially and temporally determined, constituted as links in an "evolutionary chain of changing forms, none of which has any permanent validity" (Delbrück quoted in Mayr, 1961 [1976:360-361]). Evolutionary biology wants to determine the causes or pathway by which organisms' characteristics have been effected. Put differently, it occupies itself with the selective significance of different phenotypical aspects. (Mayr, 1961 [1976:360-361]; 1974 [1976:398-399]).

However, the difference between functional and evolutionary biology extends further than their distinct *Fragestellungs*. The kinds of causation searched for in answer to the respective questions, are of a fundamentally different nature. When we are looking for the set of immediate causes of a phenomenon, say migration, our investigation falls in the domain of functional biology and we can speak of *proximate* causes (in this case certain physiological changes in response to external stimuli). But when we want to know the *ultimate* historical causes (in this case certain genetic and ecological conditions) of the phenomenon, our investigation veers toward evolutionary biology. (Mayr, 1961 [1976:362-363]). As Mayr also formulates it:

> [P]roximate causes govern the responses of the individual (and its organs) to immediate factors of the environment, while ultimate causes are responsible for the evolution of the particular DNA program of information with which every individual of every species is endowed.

(Mayr, 1961 [1976:363]).

It is this notion of the *ultimate causes* of biological phenomena that concerns the present study. Darwin supplied the theoretical means with which, for the first time, the origination of the structures and features of distinct species could be explained in a scientifically satisfactory manner. In the workings of natural selection he has provided the chief ultimate causes determining the form organisms' features take in their normal environments. God was no longer needed as the ultimate cause of these; instead, a historical empirical process took his place. However, Darwin did not pretend to have found in natural selection the ultimate cause of life itself. How the first living system arose, was a mystery to him and he did not claim to have found the answer to that, although he did believe it was also due to some or other law-bound process. But once the first, or possibly even a few primitive and extremely simple living systems made their appearance, Darwin is confident that natural selection was then capable of taking over and through driving an evolutionary process, could account for just about everything that subsequently ensued, that is, for all subsequent variation, modification, complexification, speciation, and so on. But now, how does this notion of the workings of natural selection being the ultimate causes of organismic features, relate to the explanation of these same features in terms of goals and functions? How does natural selection pertain to the issue of the legitimacy of teleological explanation? To show the connection between natural selection and goals and functions, I will now outline an etiological approach to teleological explanation.

Upon an etiological approach to explanation, "to explain why something occurs is to describe the causal history which led to the event - i.e. to give its etiology" (Mitchell, 1995:41). For our purposes that means that the occurrence of certain organs and behaviours will have to be explained by reference to their causal histories. Describing these causal histories will involve showing how the organs/behaviours in question had brought about, in the past, certain consequences which were responsible for the perpetuation, through many generations, of these same organs/behaviours. That is what a consequence-etiology is all about. Comments Salmon (1990:111-112):

> The basic idea of a consequence-etiology is as ingenious as it is simple. A particular bit of behavior B occurs because B has been *causally efficacious in the past* in achieving a goal G.

> A cat, hunting for prey, is clearly engaged in goal-directed behavior. It stalks in a typically catlike way because such stalking has resulted in the procurement of food. It is not caused by the future catching of this particular mouse, for (among other problems) in this instance he may not succeed in catching his prey. But such behavior has worked often enough to have conferred an evolutionary advantage on the members of the species. [...] Roughly speaking, the causal efficacy of B in bringing about G in the past is, itself, an indispensable part of the cause of the occurrence of B on this occasion. It is a consequence-etiology because the consequences of doing B are a crucial part of the etiology of the doing of B.

In other words, at some time in the past and quite fortuitously, a certain behaviour/entity occurred which happened to have had advantageous consequences. And it is because it happened to have had these advantageous consequences that it recurred and acquired a relative degree of fixity, enabling us to make statements involving goals and functions. Indeed, through having had certain advantageous consequences in the past, the organs/behaviours came to be functional or goal-directed, that is, they now appear to us to serve specific functions and goals. The mechanisms at work in selecting and preserving behaviours/entities with advantageous consequences are articulated by evolutionary theory - we will return to this below.

Not all causal sequences render consequences functions. The same goes for goals. It is obvious that not just any consequence qualifies as a function or goal: An organ or behaviour can have, at any one time, many detrimental and beneficial consequences without all or even most of these being functions/goals of the organ/behaviour. One should beware, in this respect, of the "fallacy of functionalism", which entails "taking the fact that a consequence is beneficial as sufficient to accounting for why the practice [or feature or activity] exists" (Mitchell, 1995:43). In order to distinguish between the relevant and irrelevant consequences, some criterion should therefore be formulated. But before making clear how natural selection can be utilised to help solve the problem of a relevant criterion, the teleological character of goals and functions demands more attention.

It is precisely the fact that they are identified as *consequences* of the items whose presence they must explain, that makes for the *teleological* character of goals and functions. It is also the reason some regard explanation in terms of goals and functions as problematic. Observes Mitchell (1995:50):

> The classic puzzle regarding functions [and goals, we might add] is how the consequence of a trait [behavioural or otherwise] could explain why the trait is, in fact, present.

In the introductory chapter it has been remarked that one of the objections to teleological explanation is that it seems to present consequences as causes - it reverses the standard cause-effect sequence. Present actions and states of affairs are being explained by future ones. Such a mode of explanation would of course not only mean violating the linear conception of time, but also signify a return to an illegitimate or unscientific form of thinking, one that matches the defeated metaphysical teleology in regarding biological phenomena as possessing some kind of surplus-value transcending their empirical aspect: That is to say, biological phenomena would be viewed as infused with a purposiveness that is not compatible with ordinary mechanistic explanations. It would require positing an additional direction-giving force or principle for which no independent empirical evidence can be produced. As suggested earlier on, this particular critique should not be accepted as a definite refutation of the validity of teleological explanation. But apart from a few brief comments at the beginning of this study, I have not yet elaborated an adequate alternative interpretation of teleological explanation.

To begin with, we should take care to remember that when we speak of the teleological character of biological phenomena it in fact denotes nothing more than *ostensible* functionality and goal-directedness - at least in all cases where conscious intention is not the source of the functions/goals. The heart is not really *directed* towards the realisation of a certain future consequence (blood circulation); but it does happen to have that vital consequence in organisms presently, just as it happened to have had it for many ages. And even where some degree of conscious intention may be present (e.g. in some behavioural activities), it still is never the case that the *future* determines present states of affairs or activities. Recall the passage from Wright (1976:10-11) I quoted in the introductory chapter, in which he presents the example of one's going to the store in order to buy bread - the actual (future) purchase of the bread was not the cause of one's going there, but rather the goal:

> Perhaps my *having* of that particular goal could be viewed as a cause of the action; but that

> of course is something that preceded the action, and hence is not guilty of the egregious time-reversal imputed to teleological accounts of behaviour.

At this point we may seriously pose the question as to whether the term *teleological* is really appropriate, and not a possible misnomer. Should we at all speak of *teleological* explanation, given all the problematic and metaphysical baggage this term is saddled with? Because it does appear to inevitably carry in its very core the assumption of the future determining the present. And even if that were not the case, there is evidence that the use of one and the same term for both a form of metaphysical or invalid explanation, and for a form of properly scientific explanation, has all the potential for creating confusion. In this respect Ghiselin (1994) was enraged by Lennox's (1993) rather misplaced criticism of himself. In his article titled "Darwin *was* a teleologist", Lennox claims that Ghiselin is departing from faulty assumptions when the latter asserts that in any "non-trivial sense" of the word teleology, Darwin got "rid of teleology and [replaced] it with a new way of thinking about adaptation..." (Ghiselin quoted in Lennox, 1993:409). In Lennox's view, Ghiselin is wrong in equating *teleological* explanation exclusively with explanations making an "appeal to divine design or an internal vital force". Instead, Ghiselin should see that the notion teleology encompasses both that old metaphysical form of explanation *and* Darwin's new non-metaphysical "selection-based teleology". Both are teleological, only, the metaphysical version is scientifically *il*legitimate, and Darwin's version is scientifically legitimate. But it remains a case of one form of teleology having been replaced by another form of teleology, and not of an eradication of all teleology. Concludes Lennox (1993:418):

> By carefully examining Darwin's actual use of teleological explanation, one finds an explanatory structure which is at once irreducibly teleological, and at the same time unlike any of the standard forms of teleology in the nineteenth century. Indeed, it is only rather recently that there is a model of teleological explanation to which Darwin's reasoning conforms.

Ghiselin (1994) reacts to Lennox with an indignation that is in my mind justified. He regards Lennox's criticisms as being in essence a quibbling about words as well as being manifestly oblivious to the epistemological issue at hand. Whereas Lennox wants to continue using the word "teleology", namely, as an overarching term denoting not only the old metaphysical explanations in terms of design, but also Darwinian scientific explanations of biological phenomena, Ghiselin rather prefers to reserve "teleology" for *all illegitimate* or invalid forms of explanation in terms of goals and functions - which include not only the old metaphysical forms but also non-metaphysical but fallacious forms. What Lennox did, was little more than to denounce Ghiselin for not employing teleology as an overarching term like he himself does, moreover pretending that he is thereby arguing some significant point. But Ghiselin (1994:490) points out that an important epistemological point is being missed when terms such as *teleology* and *teleological* continue to be used as descriptive of present-day biological explanation:

> When Lennox [...] asserts that "most biologists and philosophers of science acknowledge the apparent value of identifying various features of living things in terms of goals, ends, functions, design and so on" I am appalled. We acknowledge the value of identifying the real significance of features that have *apparent* goals, *apparent* ends, *apparent* design and the like. In ordinary discourse, design without a designer is a contradiction in terms. No competent teacher of biology would want to blur such an important distinction by calling two such fundamentally different things by the same name, given the immense amount of effort that has to be invested in teaching students not to think teleologically. [...]
>
> Lennox's suggestion that once we have got rid of Design or internal vital forces we have an innocuous form of "teleology" is not the sort of thesis that a properly educated biologist would accept. He completely misses the epistemological problem that working scientists must face when actually doing research on matters of adaptive significance. Contrary to what he claims, one does not have to believe that the world actually was created by some Intelligent Being, if one is to behave as if the world had the properties that He would have endowed it with. Neither does one have to use the word "final cause" to behave as if such things actually existed. One can merely behave as uneducated persons generally do, and not even question the assumption that life has purpose. Teleology may be treated as an ineffable mystery, or perhaps as something that has to be invoked upon epistemological grounds. Or, as so often happens, one can attribute powers to selection that God might have, but natural selection does not.

Biological explanations in terms of goals, functions and the like, need thus not be traditionally metaphysical in order to be illegitimate. In fact, the moment one starts assuming that biological features or processes really, in an objective sense, possess goals and functions, you are making yourself guilty of an illegitimate form of explanation, and are liable to commit gross errors in reasoning, that is, to see functionality and goal-directedness (or to use less loaded terms: features that are causally relevant to survival and reproduction) where there are none. Ghiselin (1994:490) offers us a notorious example of such illegitimate reasoning in "the notion that organisms have certain properties 'for the good of the species'". According to this notion, the individual species member is thought of as serving the perpetuation of the species as a whole through possessing certain features that does not necessarily benefit itself as individual organism, but instead aid fellow species members and thereby the species itself in its struggle with other species. In other words, it is not the individual organism, but the species that is the unit of selection.[3] This kind of reasoning is also teleological and fallacious in much the same way as older teleological thinking. It likewise assumes that things evolve to serve some greater whole, only in this case no divine plan is invoked but rather the notion of the species to which individual members are subordinate or dependent upon. This then, is teleology, and to my mind Ghiselin is correct in insisting that current biological explanation should rather not be lumped together under the same term. It would be better to invent other terminology so as to prevent confusion.

In some sense Lennox cannot be blamed for his wayward remarks, because unfortunately it is true that many biologists and philosophers of science are not always as careful as they should be when writing about explanation in terms of *apparent* goals and *apparent* functions. For reasons to do with the economy of expression, they more often than not neglect to insert the all-important *apparent*, and moreover, like Lennox, many continue to employ *teleological* as a term descriptive of the kind of explanation they occupy themselves with. But unlike Lennox, they will probably all stick to the adjectival form (teleological), and refrain from going as far as employing the related but

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[3] The issue concerning the *unit(s) of selection* is a whole problematic of its own to which evolutionists have adopted different viewpoints. The question turns on whether the gene, the individual organism, or the group is the unit being selected. Put differently: does adaptation take place to benefit genes, organisms or groups? (The species is not considered an option.) Darwin argued for the individual organism. Genic selectionism is exemplified by e.g. the work of Richard Dawkins. See his *The selfish gene* (1976). Elliott Sober (1993:88-118) presents a discussion of the problematic that succeeds in showing how genic selectionists sometimes fail to appreciate the complexity of the forces at play. He argues that we are dealing with a complex process in which selection takes place at all these levels. Genic selection may account for some traits, but not for others. The same is true of organismic selection and group selection. This viewpoint also entails that the interests of the different objects need not be identical: An organism's interests can conflict with those of its genes, and a group's interests can conflict with those of its individual members. It does seem to me however, that organismic selection will always be the primary selection process, with genic selection second, and group selection only occurring

more loaded noun forms (teleology and teleologist) when speaking of biological explanation since Darwin. Such has also been the practice in this study, not so much because I think it advisable to continue use of the adjective, but because the authors upon which I draw still employ the term, and for reasons of continuity and intelligibility I followed suit. Also, an adequate new term has yet to be introduced - one which will encompass both scientific explanations in terms of apparent functions *and* scientific explanations in terms of apparent goals.

Ghiselin (1994:489-490) suggests that instead of "teleology" and "teleological" we use the terms Pittendrigh coined, namely, *teleonomy* and *teleonomic*, but unfortunately it seems not to have caught on, and where it did, as in the case of Mayr, it does not necessarily assume the kind of general or comprehensive meaning we need it to. That is to say, it is not necessarily employed to denote both goal-directed *and* functional explanation. Mayr, for one, in the end seems to restrict "teleonomic" to goal-directed processes and behaviours alone, in other words, the term ceases to apply to functions as well. He observes that one can hardly say that the eye of a sleeping person is goal-directed at anything, even though it is a well-adapted system. According to him, we probably ought to make

> a terminological distinction between functional properties of systems and strict goal directedness, that is, teleonomy of behavioral or other processes. However, since one will be using so-called teleological language in both cases, one might subsume both categories under teleology.
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> (Mayr, 1974 [1976:396]).

Mayr thus falls back on teleology as the comprehensive term. Therefore, anybody who wants to follow Mayr in his use of "teleonomy" for goal-directedness, but not in his continuing use of the problematic "teleology" (or "teleological" explanation) as comprehensive category, will still be left without an appropriate general term to replace the former. I will not attempt the formulation of a proposal concerning new terminology, but I do concern it an issue in need of some serious thought and a new consensus.

For now we will have to make do with much of the old terminology in the form of "as-if"

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under special conditions.

statements that are carefully qualified, because there does seem to be an indispensable role for what Wilson (1991:136) calls a "working hypothesis of *ostensible* design", in attempts to explain biological phenomena. Drawing upon others (e.g. Broad and Goudge), Wilson describes organisms as complex systems with parts arranged, acting and interacting in particular ways, and which display ostensible design or purpose when the following conditions apply, namely

> if (a) the parts and their actions are such as might have been expected *if* the system had been constructed by an intelligent being to fulfil a certain purpose that he or she had in mind, and if (b) when systems of this sort are further investigated under guidance of this hypothesis, hitherto-unnoticed parts, arrangements among parts, and processes of interaction are discovered, and these are found to accord with the hypothesis.
>
> (Wilson, 1991:132).

We seem to be moving into dangerous territory with formulations such as the above. That is why it is imperative to always keep their "as-if" character and possible points of disanalogy foremost in our minds. Where the hypothesis of ostensible design - or what Stephen J. Gould would call the "engineer's criterion of good design" - comes in handy, is in its enabling us to devise "optimality models" that generate possible explanations for particular biological phenomena. With optimality models we proceed upon the supposition that "certain specified morphological features or behavioural patterns causally explain why certain characteristics or traits serve the [ostensible] goal of survival and reproduction". We then try to determine what specific combination of morphological and behavioural variables will maximise the fitness of the type of organism in question, that is, what combination (keeping in mind, of course, the anatomical, physiological and other limits of the specific species) will give it the greatest chance of surviving and reproducing given the conditions in its normal environment. The combination fastened upon - which is taken to constitute "optimal design" - is then compared with the state of affairs in nature to see to which extent there is correspondence. Where it does obtain to a considerable extent, we are justified in inferring that we have achieved a reasonably good understanding of the biological phenomena under investigation.[4]

[4] I am drawing here upon Wilson (1991:134-136).

However, is the idea of optimal design not reminiscent of the metaphysical belief in perfect adaptation by divine design? Do optimality methods of analysis not come dangerously close to the unjustified assumption that there is *always* a function or goal to be found for each and every feature or activity? Even Darwin denied that such a pan-adaptationist approach could apply. The risks accompanying optimality models cannot be disowned, but these are outweighed by the advantages of gaining fruitful hypotheses for guiding further research. Also, although the point made by the previous chapter, was that Darwin had rid us of the notion of a metaphysical designer or force, the point was not that he thereby also undermined all ideas of order, regularity or apparent "design" in nature. Recall Dennett's (1995:65) remark that Darwin, having been given Order, proceeded to show how Design could emerge through a purely mechanical process. But this does entail the supposition that there is, in fact, at least some order, regularity and "design" in nature which our scientific theories can attempt to capture. That then, is indeed a core metaphysical assumption from which science, at least in its more realist mode, cannot escape.

As we have seen above, the hypothesis of ostensible design relies heavily on the analogy with the human ability to make things that could meet certain ends we have in mind. What we should do is to carefully note all possible limitations of the analogy between, on the one hand, human intelligence and the technological artefacts it produces, and on the other hand, natural selection and the adaptations it brings about. In agreement with a number of other authors, Wilson (1991:136-137) identifies "problem-solving capacities" as the crucial characteristic human intelligence and natural selection have in common. Where the solutions humans devise to their problems take the form of various artefacts and practices, the solutions natural selection hit upon or preserve concern the survival and reproduction of organisms and take the form of adaptational features and behaviours. But because the disanalogies between the two types of processes should be kept out of the hypotheses concerning the products of natural selection, we need a "running commentary" that alerts us to "those features of the form of [human problem-solving] processes that are to be ignored in the generation of hypotheses".[5]

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[5] Human problem-solving processes form, of course, part and parcel of human *culture* - which is itself subject to change. Whether, to what extent, and in exactly what sense cultural change can be said to fit the Darwinian evolutionary paradigm, is the subject of a

To recap, the foregoing paragraphs have been concerned with the illumination of a vitally important point, namely, that talk of goals, functions or design in biology are not to be taken literally, that is, we are not to take biological features, processes or activities as *in actual fact directed* towards the achievement of certain effects or consequences. But this realisation does not force us to do away with all such terminology, for the latter has proved to be of indispensable heuristic and explanatory value. Moreover, there is a definite sense in which specific function and goal ascriptions can be said to be accurate or inaccurate, and this is determined by empirical evidence - as we shall shortly see. However, the nature of the whole enterprise does demand of us to be careful in our inferences and language use. In this regard I am for instance not convinced that we need to carry on using the term "design", as in optimal *design* and ostensible *design*. In most caces the latter can be replaced by less loaded, and more accurate terms, such as "adaptation.

The next step in the development of an etiological approach to goals and functions, is

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whole different debate with which the present thesis is not concerned. An interesting move was made by Richard Dawkins (1976), when he concluded his *The selfish gene* with the coining of a new term: *meme*. "Meme" was intended as an analogous term to "gene", and signifies the idea of a cultural unit of transmission. Like the gene, it is a replicator, though a more recent arrival on the evolutionary scene, and its survival value likewise depends on the qualities of longevity, fecundity and copying-fidelity. See Delius's (1989) article, "Of mind memes and brain bugs, a natural history of culture", as an example of an author who takes his lead from Dawkins. However, there are many problems with the meme or replicator interpretation of culture, and a better alternative may be the suggestion by Harms (1996) in his "Cultural evolution and the variable phenotype", that culture be subsumed under phenotypic variability rather than it being interpreted as a separate and autonomous form of evolution.

Related to the question of cultural evolution is the question concerning the evolution of scientific knowledge, which question has become the focus of what is now called *evolutionary epistemology*. Karl Popper, for instance, contended that the growth of scientific knowledge proceeds through much the same kind of process of selection (or error-elimination) as that to which the evolution of the tree of life is subject. He characterised scientific growth as a problem-solving process that proceeds "from old problems to new problems, by means of conjectures and refutations" (Popper, 1961 [1979:258]). According to him, humans have advanced beyond other organisms in their ability to devise solutions in the form of theories, which latter then have to bear the brunt of selection forces, thereby sparing the inventors that fate. Says Popper (1961 [1979:261]): "[W]hile animal knowledge and pre-scientific knowledge grow mainly through the elimination of those holding the unfit hypotheses, scientific criticism often make our theories perish in our stead, eliminating our mistaken beliefs before such beliefs lead to our own elimination". Although there is some merit in Popper's ideas, he does not always get his biology right, and apart from that, I do find his idea of an evolving "*largely autonomous* third world of objective knowledge" (Popper, 1968 [1979:111]) a bit odd. He might nevertheless be able to find some support among meme theorists.

to bring in clearer relief the criterion for distinguishing between consequences that qualify as goals or functions, and consequences that do not. As will become evident, the criterion relates to their causal mechanisms - that of which they are the consequences or effects.

Sandra Mitchell (1995:42) advances two necessary and jointly sufficient conditions for the qualification of a consequence as a goal or a function: Firstly, the feature or behaviour of which it is a consequence must have been selected over alternative features or behaviours due to this particular consequence it has, and secondly, the production or reproduction of the feature or behaviour must be a direct result of that selection process to which it was subject. (Mitchell, 1995:42). It means that in order to identify goals or functions we have to appeal to a causal history in the form of a selection process. The causal history at issue with regard to natural items, is the history of natural selection:

> For an etiological functional relationship to occur, a selection background like natural selection must operate. The selected consequence of an item must furthermore be causally responsible for its replication and, hence, its current presence. Evidence only of a selection background or selection *of* an item will be insufficient to justify ascription of a function. The feature explained, like larger size in male primates, must have been selected *for* the functional consequence, say success in male/male competition, and, secondly, it must have been produced or reproduced as a direct result of that selection process, in this case by genetic transmission.
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> (Mitchell, 1995:42).

Mitchell makes her point with regard to functions, but the passage could be easily rephrased to apply to goal-directed relationships as well. The important insight to be gained here is that in natural selection we have been provided with a causal process and history that provides the means for making sense of, and legitimising teleological explanations in a non-metaphysical way. Natural selection is a causal process that is amenable to empirical investigation, that is, evidence can be gathered concerning the conditions and consequences of natural selection. The conditions and consequences (goals/functions) being, of course, those that are relevant to survival and reproduction.

Important to note concerning Mitchell's two conditions, is that the first condition alone will not do as criterion, because that would for instance allow a one-time accidentally beneficial consequence to qualify as goal or function - which clearly is not what we have in mind with these terms, for all general explanatory value is then lost. To prevent such inappropriate ascriptions one also needs to be presented with evidence that the feature or behaviour in question generally gives rise to this consequence in such a way that the feature or behaviour is reproduced in following generations *because of* its possessing this superior consequence which confers a fitness advantage on the possessors (organisms), thereby causing them to be favoured by natural selection.

But what does *fitness* mean, and what does it mean to say that natural selection favours the fitter organisms? The important point to grasp, is that fitness is a relative concept. We *can* give a general theoretical definition of fitness, but the moment we wish to give a more detailed description of what a fit organism would look like, we are forced to give a number of descriptions, each of which can only have validity relative to a specific kind of environment. But in its most general sense, fitness can be defined as high viability (the probability of reaching adulthood) and/or high fertility (degree of reproductive success). The greater an organism's probability of survival and/or the greater its expected number of offspring, the greater the fitness of the organism. Important is, that biologists are not so much interested in the fitness of single organisms as in the fitnesses of their traits. That means that organisms who share a specific trait may still differ in their respective (overall) fitnesses. Naturally, if natural selection is to take place, organisms will have to differ in traits determining their viability and fertility. In the absence of differences in traits determining fitness, the process of natural selection can per definition not take place. (Sober, 1993:81).[6]

Whether a specific trait enhances an organism's viability and fertility depends very much on its environment. Not only the physical properties of an organism, but also the environment with which it interacts, determines its fitness. An organism (e.g. a dolphin) may be fit when it finds itself in a certain kind of environment (e.g. an ocean), but given

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[6] Where there *is* variation in fitness within a population, natural selection acts to increase the frequency of fitter traits and to decrease the frequency of less fit traits. When one and the same trait influences both viability and fertility, and influences them in different ways, a conflict will develop between the two types of selection. Some sort of trade-off between the importance of high viability and the importance of high fertility in the environment in question will result, and this will determine how strongly the specific trait will be selected for

a very different environment (e.g. a desert), it may suddenly become radically unfit. That is why we always speak of organisms' *normal* environments - the environments in which they have evolved and to which they have become adapted, the ones with respect to which they are fit. However, fitness is not necessarily the same as having a lot of adaptations. In the present study we are very much concerned with adaptations, because features or behaviours that are functional or goal-directed in the sense explicated above, are adaptations, but that is not the same as currently being a fit trait. To clarify this point the next few lines will be devoted to some brief comments on the concept of adaptation and its derivatives.

When we talk about a trait as an *adaptation*,[7] we refer to its history — we are making a claim about why it originally evolved. A trait is an adaptation for performing a certain task when ancestrally there was selection for it to perform this task, because in doing so it conferred a fitness advantage at that time. This is not to say anything about whether a trait is presently *adaptive*: Adaptation must not be confused with current utility. An adaptation may have no present use, indeed, it may even be maladaptive. On the other hand, an adaptation may be useful/adaptive (confer a fitness advantage) now, but not necessarily because of the initial reasons for its evolution, that is, a trait which evolved for one reason, can subsequently be co-opted to perform a very different task. Of interest here is that features and behaviours with functions or goals need not presently confer fitness; however, for a feature or behaviour to have a function or goal, that is, for it to be an adaptation, it must have conferred fitness at some time in the past, for otherwise it would not have been perpetuated.

With regard to the *process* of adaptation a further distinction has to be made — that between ontogenetic- and phylogenetic adaptation. The former has it about changes made within an individual organism's lifetime, such as when an organism learns something and thereupon changes its behaviour in a way beneficial to itself. Phylogenetic adaptation, on the other hand, entails the modification of the composition of a population through natural selection. In this case changes do no not take place within the life of an individual, because it is not the individual who is adapting.

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or against (Sober, 1993:57-9).

[7] I base my discussion of adaptation in the following two paragraphs on Sober (1993:82-6).

Nevertheless, individual organisms benefit from phylogenetic adaptation by having the evolving trait genetically transmitted to them across generations. Evolutionary theory is concerned with the latter kind of adaptation.

Ontogenetic adaptations, or any characteristics acquired through an organism's own efforts during its lifetime, are not heritable, that is, it cannot be passed on genetically to its offspring.[8] The present study's interest thus lies with functional or goal-directed traits or behaviours that are *phylogenetic* adaptations, and not ontogenetic adaptations. Given that the selection process applying is that of natural selection, and that the relevant production and reproduction processes can therefore only refer to those involving mal/adaptations that are heritable traits of organisms, ontogenetic adaptations - not being heritable - cannot qualify.

Upon the etiological approach, explaining phylogenetic adaptations, that is, explaining the presence of particular phenotypical (i.e. morphological, physiological and behavioural) traits by reference to their goals or functions, requires the specification of a causal background, that is to say, a selection background, as well as a narrative account of the relevant role the consequences in question played in the causal history of which the traits are the result. Put differently, in answering the question as to why a specific trait is there, attention is drawn to a consequence it had in the past, a consequence which causally contributed to the perpetuation of the trait. This is the same as offering a narrative account of how the trait evolved by natural selection.[9]

The point is to demonstrate that the trait had a beneficial consequence which conferred a fitness advantage upon organisms in the past who possessed the trait. Being fitter than those who did not possess it, they produced more offspring to whom the trait naturally got passed on, and who in turn was aided by the trait's beneficial

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[8] Lamarckism (the idea that it is possible to inherit *acquired* characteristics) would have to presume that information about the acquired characteristic could in some way travel from the revised body part (somatic-line cells) to the eggs or sperm (germ-line cells). No evidence has been found for the existence of such communication. Moreover, even if the information could reach the DNA, it is not all that likely that the DNA would be able to code for the new characteristic. See Dennett (1995:117,321-2). Note however, that although inheritance of acquired characteristics should be ruled out, this does not prevent the *capacity to acquire certain characteristics* from being heritable. See Dennett (1995:77-80,323).

[9] Cf. Mitchell (1995:44,51).

consequence.

Functions and goals then, refer to past consequences, rather than to future consequences towards which the present is drawn. This focus on past consequences rather than future ones when we explain the presence of a particular trait in a species, does of course not contradict the fact that the trait's presence in an organism now, is indispensable for its survival or reproduction at this moment and in the future. An organ like the heart is having consequences all the time, and without these consequences the organism would die. That is the way things have evolved. And it is because we have knowledge of the consequences traits have had in past organisms, that we are able to predict with relative certainty what consequences they will have in present organisms, as well as what will be the consequences if the trait is absent or abnormal.

It has been made clear now that ascriptions of goals and functions are a shorthand for statements regarding the causal histories of traits. A succinct way in which to convey the fact that a trait's past consequences were instrumental in the preservation and perpetuation of the trait, is to say that the consequence of the trait's consequence is the reproduction of the trait. At this point the time has come to spell out how Darwin prepared the foundations for a scientifically legitimate etiological view of goals and functions.

Darwin and the etiological view

From all the foregoing one should have been able to realise that there would have been no properly scientific account of functions and goals in biology without *natural selection*. In this study I have opted for the etiological view as an example of a scientifically legitimate account of goals and functions. There are also other views available, such as the dispositional account propounded by Bigelow and Pargetter. But the different views need not be thought of as conflicting, and can be viewed as supplements to each other, each playing a role in a distinct explanatory project.[10] And notwithstanding differences

[10] See Mitchell's (1995:47-51) assessment of the dispositional account argued for by Bigelow and Pargetter. In their view biological function should be "forward-looking", rather than "backward-looking" as in the etiological view; a dispositional analysis of functions is therefore required. They draw on the analogy with biological fitness - which notion was rescued from its explanatory failures through being given a dispositional interpretation.

in the details of various analyses of functionality and goal-directedness, contemporary biology operates within the Darwinian paradigm, which means that natural selection and its related concepts, such as fitness and adaptation, will inform whatever accounts of teleological explanation people may come up with in biology.[11] My choice of the etiological view for the purposes of the present study is not wholly arbitrary or opportunistic, though. Apart from it having become more or less consensus among philosophers of evolutionary biology, there is, in my view, a sense in which it can be regarded as the most essential account, both for explanatory and for historical reasons.

In the first place, the etiological account is more fundamental as regards explanatory status, because it is concerned with the ultimate evolutionary causes of traits. By referring to a trait's causal history, the trait's presence is explained, that is, we get to know the answer to the original question as to *why* the trait exists. The dispositional account, in contrast, is concerned with how an existing trait confers a fitness advantage on its possessor, thereby helping to explain why the organism is faring as it does in the struggle for existence that constitutes natural selection. On the etiological account, a function or a goal is a "consequence which has played a certain role in [a trait's] causal history", while on the dispositional account, a function or goal is a trait's "disposition to have a certain consequence" (Mitchell, 1995:51).[12] In my opinion, although I do not deny an explanatory role for the dispositional account in biology, I find it to be little more than a derivation of, or an extrapolation from the etiological view. The dispositional view is too narrowly focused on the present performance of traits to be of use in explaining how traits evolve over the long term and come to have functions and goals in the first place. The etiological account, on the other hand, already in a sense incorporates the dispositional account in its causal histories by illustrating how a trait's having had a

However, in my opinion Mitchell convincingly shows that their criticism of the etiological view is suspect, and that the analogy with fitness applies only to a limited extent. See also Salmon (1990:114).

[11] The *causal role* analysis of function, which focuses on capacities, has in the mean time come to my attention. Amundson & Lauder (1994) argue that this analysis, developed in psychology by Cummins, may even be more appropriate to evolutionary biology than the etiological (selected effect) view. Anatomy especially, according to them, may gain from causal role analysis as it is mostly difficult and irrelevant to demonstrate selective histories for functional traits. The causal role account is thus not historically defined. In my view, it is related to Bigelow and Pargetter's account and thus suffers from much the same problems as the dispositional account. See below.

[12] I am drawing in this paragraph, in part, on Mitchell's (1995) formulations and insights, but unlike her, I do argue that the etiological view is more fundamental.

certain consequence - or, if you like, a trait's having had a disposition to have a certain consequence - was instrumental in the reproduction of the trait itself. That the trait through its consequence must have conferred a fitness advantage at some stage goes without saying, and on the etiological view arguments to that effect will make up the causal history of the trait. Citing Mitchell's (1995:51) example will help further clarifying the difference between the two views:

> What function explains on the dispositional view is why a large male primate reproduces more successfully than a small one. What function explains on the etiological view is why male primates are large.

Now, in my opinion, the dispositional view would not be possible, or at least convincing, if not backed up by the etiological view. Without any regard for causal histories we are liable to make mistaken claims about present goals and functions.[13] Unlike Bigelow and Pargetter I do think that a causal history of adaptation is imperative if we are to ascribe goals or functions to a trait. The dispositional account will allow the sudden chance production of a trait with beneficial consequences to be called functional or goal-directed, without there having been time to observe whether there is any selection for the trait. Such an ahistorical focus on a trait's current utility in a system strips the terminology of a lot of its explanatory force.

Moreover, from the historical point of view of Darwin's breakthrough in the nineteenth century, the dispositional account seems almost to amount to a denial of the significance of his efforts to found biological explanation on a new scientific basis. A dispositional account of goals and functions would have been of little use in an effort to defeat a metaphysical teleology. It is not only the fact that talk of "dispositions to have certain consequences" sounds strangely familiar - jargon which would not have caused a pre-Darwinian biologist restless nights, for it comes so comfortably close to talk of inherent purpose, and even reminds of Lamarck's ideas concerning use and disuse and the role of organisms' own exertions. It is also the fact that a dispositional account of goals and functions *does not account for the presence of traits with goals and functions*; it does not account for the existence of adaptations, which means that no scientific explanation is being offered of these phenomena, and there is nothing to rival metaphysical accounts that appeal to special creation and divine design as explanatory principles.

Darwin expressly wanted and needed to make an etiological point. He needed to do more than show that organisms are in actual fact adapted to their environments - which is really what the dispositional view boils down to, and which is also what Paley and the authors of the *Bridgewater Treatises* knew so well and built their arguments on. To defeat the latter Darwin needed to show *why* organisms are adapted to their environments; he needed to produce an alternative and materialist account, one appealing to empirical causes and mechanistic processes, but also one which brought history into the bargain.

Darwin had to find a kind of causal process that would render superfluous and inappropriate all claims about miraculous origins, god-given adaptations, divine interventions and divine guidance in the biological sphere. It was in Lyell's uniformitarian geology that he found an important lead: If you wanted to build your science on solid foundations, then you had to depart from respectable science-philosophical principles - principles that would in advance rule out the possibility of appeal to strange events (such as miraculous cataclysms) not amenable to sound scientific investigation. For Lyell the injunction to search for past geological causes of the same kind and intensity as present causes, was not so much informed by beliefs concerning the nature of empirical reality, as by science-philosophical and methodological considerations:

> Practitioners, Lyell argued, should carry out their investigations under the assumption that causes now visible around us (volcanoes, rivers, tidal currents, earthquakes, storms) are of the same kind that have acted in the past, and have done so with the same degree of intensity as in the present. In the *Principles*, uniformity was not a theory about the actual history of nature, but a policy for securing the philosophical foundations of geology: Lyell aimed to define, as he said in a letter, the "principles of reasoning in the science".
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> (Secord, 1997:ix).

Darwin made sure that his theory of evolution by natural selection also adhered to

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[13] See Mitchell's (1995:46-47) example of mimicry in butterflies.

these principles. After all, biology was in need of the same solid foundations. It had to be wrested away from speculation and shown to be subject to ordinary physical causes and laws. But if one wanted to account for the impressive array of adaptations found among living organisms, and you wanted to account for them in terms of the action of modest everyday causes, well then you had better have time on your hands. Doing away with the notion of an extraordinary cause capable of single-handedly effecting superb new adaptations, meant opting for the slow cumulative approach - adaptations had to come into being through small incremental steps. Time thus appeared on the stage as a significant new actor. In this respect Darwin made sure to exploit the analogy between natural selection and Lyell's geology:

> I am well aware that this doctrine of natural selection, exemplified in the above imaginary instances, is open to the same objections which were at first urged against Sir Charles Lyell's noble views on 'the modern changes of the earth, as illustrative of geology;' but we now very seldom hear the action, for instance, of the coast-waves, called a trifling and insignificant cause, when applied to the excavation of gigantic valleys or to the formation of the longest lines of inland cliffs. Natural selection can act only by the preservation and accumulation of infinitesimally small inherited modifications, each profitable to the preserved being; and as modern geology has almost banished such views as the excavation of a great valley by a single diluvial wave, so will natural selection, if it be a true principle, banish the belief of the continued creation of new organic beings, or of any great and sudden modification in their structure.
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> (Darwin, 1859 [1968:142]).

Both geological and biological changes were the products of modest causes operating over great periods of time. A geological feature and a biological adaptation both have their histories accounting for their presence. There is a difference though: Things like gigantic valleys do not evolve in the sense with which we are concerned here; there is no question of reproduction and descent with modification. Geological features are not products and embodiments of history in the same significant sense that biological ones are. Lyell held that the features of the earth's surface were fully reversible: Where there is a valley today, there may some ages hence stand a mountain, and more ages into the future, a valley again. Of course, the two valleys will not look exactly the same - in that sense they are unique historical entities, but far more so are two individual organisms; in addition, there will be no connection between the two valleys: the first one will hardly have had an influence on how the second one looks. It is very different with biological features - they belong to organisms that form part of a single branching tree of life. What happened ages ago as well as what happened recently in the tree's history still affect how organisms look today. Furthermore, none of it is reversible: The same species cannot emerge twice (although somewhat similar adaptations might). With changing circumstances natural selection modifies what is already there, but it never retraces its steps.

Darwin thus proclaimed the thoroughly historical nature of biological organisms and their adaptations. There were no eternal essences to be realised. In order to explain why a particular adaptation existed, one had to produce its causal history (the *Origin* is full of examples), which combined the contingent nature of chance variation with the necessity (albeit probabilistic) of the mechanistic sifting process we have in natural selection.

Important to realise, is that the historicity of organisms and the irreversibility of their adaptational complexes cannot in itself be attributed to natural selection: Rather, new organismic variations occur quite independently of the workings of natural selection (recall the remarks made in the previous chapter). In fact, evolution would have proceeded much faster if there were no natural selection - the mutation rate then being the only limit. But as it is, natural selection weeds out most mutations, checking the number and the kind of courses evolution can take. After all, Darwin's contribution to biology was the notion of evolution *by natural selection*. Natural selection may not be able to account for variation, but it does account for *adaptation*. In other words, it determines which variations are preserved, depending upon their beneficial consequences with regard to survival and reproduction. But the irreversibility of organismic changes are again not so much due to the workings of natural selection as to the fact that organisms are complex systems not likely to undergo the same variation in reverse. In this regard, Darwin's repeated emphasis on the influence of the "laws of correlation of growth" can be interpreted as a recognition of the complexity of organismic systems. It is this original complexity of living systems, governed by laws (such as those of self-organisation) other than those of natural selection, that accounts for the fact that although natural selection may be a mechanistic process, its products are not mechanistic or ahistorical.

But the workings of natural selection do *shape* the history of organisms, determining which of the chance variations are perpetuated and which discarded. It determines which features are useful and which useless in the struggle for existence taking place in a given environment. It thus accounts for the emergence of adaptations, of traits with apparent goals and apparent functions. It renders the history of traits *causal* in a very particular sense - a sense more specific than the recognition of general physico-chemical causality, one which concerns the (macroscopic) conditions of survival and reproduction.

Although it gives rise to functional and goal-directed traits, Darwin conceptualised natural selection's shaping of organismic history as a wholly mechanistic process, itself without purpose or meaning. Daniel Dennett's casting of natural selection as an algorithmic process captures this point well. An algorithm is "a certain sort of formal process that can be counted on - logically - to yield a certain sort of result whenever it is 'run' or instantiated" (Dennett, 1995:50). Its three chief characteristics are: substrate neutrality (it is the logical structure of the procedure that guarantees the results, not the causal powers of the materials in which it is instantiated), underlying mindlessness (the process can be broken down into a series of small simple steps requiring no intelligence), and guaranteed results (if executed correctly, it will always yield the results it is supposed to). Provided that the requisite empirical conditions for the execution of the kind of process are met in nature, it will test out mechanically whatever random candidate it is presented with and yield a certain logical outcome. (Dennett, 1995:48-60). Dennett's notion of natural selection as an algorithmic process reminds of Popper's (1965 [1979:243]) characterisation of the evolutionary process in terms of the following schema:

TS_1

↗ ↘

$P_1 \rightarrow TS_2 \rightarrow EE \rightarrow P_2$

↘ ↗

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•

•

TS_n

where P_1 is a problem faced by a type of organism in its environment; *TS* is the tentative solutions to the problem in the form of new phenotypical traits; *EE* is the process of error-elimination (selection) to which the tentative solutions are subject; and P_2 is the new problem situation emerging through the former one's being solved. Each different problem situation can then be said to instantiate a new algorithm.

In natural selection, we thus have not just one algorithm, but a whole class of them yielding different results (Dennett, 1995:51).[14] What they have in common, is that they are all concerned with results that entail the preservation of traits that are useful to organisms in their struggle for existence in their particular environments. However, natural selection is probabilistic in the sense that the algorithms will generally, but not in each and every instance be instantiated in such a way that they actually do preserve the fittest trait. This is because the required conditions are not always met, and contingencies to enter into the process. Nevertheless, on the whole the expected results are produced, results apparently exhibiting design, but produced in an utterly mindless and purposeless manner, driven by nothing except the blind action of ordinary physical causes.

In following Herschel and Lyell in their adherence to the *vera causa* doctrine, Darwin bought into a concept of nature holding that natural events do not proceed by leaps and bounds but by modest changes brought about by equally modest causes acting over great periods of time to produce the more significant changes. This doctrine of *Natura non facit saltum*, to which Darwin repeatedly refers by name in the *Origin*, was duly applied by him to the biological sphere. His conceptualisation of natural selection as a

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[14] The abstract and formal aspects of Darwin's argument can be aknowledged through such an algorithmic interpretation of natural selection. Says Dennett (1995:48): "The idea [...] that Darwin should be seen, rather, as postulating that evolution is an algoritmic process, permits us to do justice to the undeniable *a priori* flavor of Darwin's thinking without forcing it into the Procrustean (and obsolete) bed of the nomological-deductive model." However, this point should not be taken as yielding to those, like Popper (1970 [1979:69-70]; 1965 [1979:241-242]), who accuse natural selection of being a "tautological" principle or a "logical truism", that is of employing the notion of the "survival of the fittest" which really means nothing but "those that survive are those that survive". These claims do not hold any water, because, in fact, *actual* survival and reproduction are not the criterion of fitness. By interpreting natural selection as a probabilistic process and fitness as a certain propensity or *chance* to survive and reproduce, the tautology objection falls away, as it is no longer the case that the fittest individuals will always survive. Cf. Mitchell (1995:48) and Wilson (1991:222). See also Wilson's (1991:217ff) countering of Popper's claims that "Darwinism is not a testable scientific theory" and that it does not really predict or explain.

process operating by small steps to preserve slight successive modifications, thus accords well with Dennett's characterisation of it as an algorithmic process. Darwin may have interpreted biological phenomena as historical phenomena, as phenomena carrying with them the unique marks of history, but he made sure that the history of life was not a wholly random and capricious affair. It was subject to a relatively systematic process of selection and elimination through ordinary every-day causes.

Throughout this thesis I have argued that an interpretation of natural selection as a mechanistic process accords well with Darwin's conceptualisation of the former. However, there are developments in evolutionary theory that challenge mechanistic interpretations of natural selection such as that proposed by Dennett (1995). Certain kinds of emphasis on the role of organisms' self-organisation and complexity in evolution could affect the way in which natural selection is conceptualised as well. For instance, Eigen (1992:123,125) does not see as selection as a "blind sieve", but rather as active and driven by an internal feedback mechanism that searches for the best route to optimal performance by virtue of an inherent non-linear mechanism. Eigen bases his interpretation on the ideas of "sequence space" and "quasi-species" - ideas which fit into the new physics of non-equilibrium states. This notion of evolution as steering very effectively in the direction of the "optimum value peak", is entirely at odds with the classical interpretation derived from Darwin. I have chosen to stick to the classical path, as a consensus on these issues has not yet emerged, and as there are important historical reasons for attending to Darwin's own conceptualisation and the tradition thereby initiated. For one, Darwin's proposing of natural selection in the form of a kind of mechanical sifting process as cause of adaptation was indeed very effective in rooting out metaphysical ideas of purpose in living phenomena. The mentioned new developments do sometimes seem to me to return to notions of "direction" and the like that should be handled with extreme care.

As for Darwin's own belief in the lack of inherent purposiveness and direction in the process of natural selection - one of the ways in which he expressed the insight, was by drawing attention to the fact that natural selection will rarely if ever produce *perfection* in the sense of perfect adaptation. That is not its goal. It has no goal. It yields whatever emerges from the struggle for existence, and that is not absolute perfection:

> Natural selection in each well-stocked country, must act chiefly through the competition of the inhabitants one with another, and consequently will produce perfection, or strength in the battle for life, only according to the standard of that country.
>
> (Darwin, 1859 [1968:232]).

> Natural selection tends only to make each organic being as perfect as, or slightly more perfect than, the other inhabitants of the same country with which it has to struggle for existence. [...] Natural selection will not produce absolute perfection, nor do we always meet, as far as we can judge, with this high standard under nature. The correction for the aberration of light is said, on high authority, not to be perfect even in that most perfect organ, the eye.
>
> (Darwin, 1859 [1968:229]).

Although Darwin was not averse to the idea of present-day inhabitants of certain climates being better adapted than ancient inhabitants of the same kinds of climate,[15] he saw this as the logical outcome of a linear and mechanical process, one operating through many trails and errors, a wasteful process, not a process that somehow quickly steers towards the best results.

This then, was Darwin's contribution to biological explanation: He demonstrated how a materialist mechanistic history could be provided of those biological traits which seem to be directed, as if by intent, to the achievement of goals and the fulfilment of functions. He extensively argued for natural selection as the *vera causa* of adaptive modification, demonstrating not only the plausibility of its existence, but also of its competence to account for the diversity of biological phenomena, as well as its actual

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[15] Stephen J. Gould (1996) will probably deny even this limited claim by Darwin. In his work, *Life's Grandeur: The spread of excellence from Plato to Darwin*, he argues against the idea of *any* general trend towards greater *complexity*; the absence of such a trend being due to the randomness with which the different environments to which organisms must adapt themselves, succeed each other. Although the more complex organisms emerged later in the history of life than the first simple organisms, that only means that there is a *passive trend* towards greater *variety*, that is, through time there arose, incidentally, by chance, a variety of organisms differing in their degrees of complexity. But the pattern of overall results emerging is not due to a *driven trend*, that is, it is not a case of each element evolving with a bias for change in a certain direction. Greater (morphological, developmental, functional) complexity per se, does not guarantee success in the struggle for existence. See Gould 1996:204ff for McShea's distinction between driven and passive trends and how they could be recognised. However, a more careful analysis and comparison with Darwin's views are needed. The question is whether Darwin himself makes the mistake Gould exposes in others, the mistake of confusing greater adaptedness with greater complexity.

responsibility for their production. His causal histories of biological adaptations drew on ordinary empirical causes, doing away with the need for metaphysical considerations and divine intention, thereby transforming biological explanation into a thoroughly scientific enterprise. He therein presented (in essence and by example, but not yet in name and explicated model) biological explanation of adaptation with an *etiological* model. He succeeded in giving adaptation a scientific causal basis in the form of a historical selection background.

Although the kind of explanation we gan give, upon Darwin's theory, of any particular adaptation, may not fit the deductive-nomological model, it is still crucial to biology, and can be characterised, following Wilson (1991:105-106) as *narrative* explanation. The latter tries to answer the question *Why?* in the "context of an assertion about some event *E* to the effect that *E* happened because *s*". It "provides a *sketch* of a *fuller* explanation of how it could be that *E* happened because of *s*". For example, it would provide a fuller explanation of the paradoxical claim that amphibians developed limbs enabling them to live on land, so that they could in fact be better adapted to remain in (get back to) the water (during droughts). But there is no simple generality connecting *E* (developing limbs) with *s* (having to remain in the water). That is why narrative explanations do not seem to fit the deductive-nomological model. However, the important thing is to gain scientific intelligibility, and that is exactly what narrative explanation gives us in its own way. Explains Wilson (1991:111):

> A narrative explanation, one which renders "*E* because *s*" plausible by suggesting certain intermediate steps which could possibly account for that change, has the merit of embodying a set of *detailed* suggestions about how the gappy explanation "*E* because *s*" could be improved. A narrative explanation contains a set of detailed hypotheses which, if subsequent research verifies them, will provide a less imperfect explanation of *E*. For the practising scientist, then, a narrative explanation is both an explanation, but one which is gappy and imperfect, and also a sketch of a research programme for eliminating acknowledged gaps.

Wilson's account of narrative explanation can be viewed as fully compatible with the etiological or selected effect model of functional and goal-directed explanation developed above. Both fully recognise the role of history in the explanation of adaptation.

I conclude with the following quotation from Darwin (which draws in part on the *Beagle* experience, and betrays his European imperialist roots), where he takes recourse to metaphor in order to describe how the acknowledgement of the historical nature of living beings makes their characteristics intelligible to us:

> When we no longer look at an organic being as a savage looks at a ship, as at something wholly beyond his comprehension; when we regard every production of nature as one which has had a history; when we contemplate every complex structure and instinct as the summing up of many contrivances, each useful to the possessor, nearly in the same way as when we look at any great mechanical invention as the summing up of the labour, the experience, the reason, and even the blunders of numerous workmen; when we thus view each organic being, how far more interesting, I speak from experience, will the study of natural history become!
>
> (Darwin, 1859 [1968:456]).

5

Conclusion

In conclusion, and to pinpoint again Darwin's important contribution to the issue of what a legitimate form of explanation in biology should consist of, we can retrace some of the ground covered in the course of this study.

To begin with, in the *first* chapter, it emerged that teleological explanation was subject to changing fortunes during the centuries since Aristotle, and indeed, the spiral went inexorably downward. From being an all-embracing metaphysical world-view bestowing meaning and purpose everywhere and upon everything, dictating the place of each object and organism in a fixed universal hierarchy; to being exorcised from the physical sciences as incompatible with a materialistic and mechanistic account of phenomena, and being uneasily confined to the life sciences; it eventually reached a point where we ask whether what we are busy with now in biology is any longer to be designated as *teleological* explanation, and whether teleology, in any sense of the word, is not now definitely a thing of the past.

In the *second* chapter, an exposition of Darwin's theory of evolution by natural selection was presented. It took the form of an analysis of his argument in terms of its main premises and conclusions, elucidating its logical structure and evidential support. It was demonstrated how Darwin strove to conform to the older empiricist *vera causa* tradition which required arguing for the existence, competence and responsibility of natural selection in order to establish it as the true cause of the origin and diversification of species.

In the *third* chapter, the dire implications of Darwin's theory of evolution by natural selection for the conceptions of design underwritten by revealed and natural theology at the time, came to light. It appeared as if the positing of an empirical, probabilistic and mechanistic process as the cause which yielded all the marvellous adaptations we used to think were individually fashioned by the hand of God (or at the very least engineered by him through secondary causes), had overthrown teleological explanation and eliminated all possibility of its return.

However, in the *fourth* chapter, it has been noted that far from banishing teleological terminology from his writing, Darwin went right ahead with its use in describing the adaptations natural selection has brought about: Adaptations were adaptations *for* certain tasks; they had ends, purposes, functions or final causes. Somehow it still made sense to speak in this manner when observing the workings of organisms - there did after all seem to be an undeniable functionality and goal-directedness to organisms and their constitutive parts. But the question was how use of terminology with such a problematic history, could be justified in biological science. The answer presented was that an etiological approach to explanations in terms of goals and functions, enable us to found these terms on an empirical causal basis - that of the process of natural selection, which, of course, was Darwin's great contribution. No longer things that lie beckoning in an unrealised future, goals and functions are now made to designate past consequences, their content being determined by the empirical causal histories of traits.

In what has gone before, the links between two distinct debates have in actual fact been traced, two debates removed from each other by a period of more or less a hundred years. The first took place within a nineteenth century milieu that was still struggling to liberate all forms of scientific explanation from religious dogma and unfounded speculation; the second took place in the aftermath of the triumph of the deductive-nomological model. What has been attempted in this study, was an elucidation of the fact that the kind of theory Darwin developed at the time, was capable not only of discrediting reigning metaphysical explanations in biology, but also of transforming the whole concept of teleological explanation in such a fundamental way that it was enabled to attain scientific legitimacy in the present. It did take more than a century for an adequate model of his reasoning to be threshed out, probably partly because, as Mayr says, Darwin continued use of teleological language in what we should now rather call (according to Mayr) a strictly teleonomic context. But, thanks to Darwin, and to leave aside all ambiguity, it is actually no longer "teleology" that is "alive and well" in biology, nor explanation in terms of goals and functions. It is explanation in terms of *apparent* goals and *apparent* functions.

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