

## Philosophical Influences on the Large Scale Structure of Darwin's *Origin*

### I. Introduction

The nature of the support Darwin offers for his theory in the *Origin*, its argumentative structure and the explanatory patterns and the methodological ideals contained within, has been a topic over which scholars have devoted much time to understanding. There is no definitive interpretation of the nature of the support in the *Origin* that most scholars accept. Progress has been made in recent years by considering the philosophy of science popular during the mid 1800's. Attention has focused on John Herschel and William Whewell. Both of these men were enormously significant figures in the scientific community in England in the 19<sup>th</sup> century and both wrote treatises on philosophy of science. Given the fact that Darwin interacted with these men early in his scientific career, it is likely that Darwin would have been influenced by them. By examining the philosophies of science advocated by these men and comparing them to the contents of the *Origin*, several scholars (Hodge 1977, 1989, 1992, 2000; Recker 1987; Ruse 1975, 2000) agree that Darwin deliberately designed the large scale structure of the *Origin* to satisfy mid-Victorian philosophical ideals<sup>1</sup>, though they disagree on the extent or details of Darwin's use of them.

Two different positions are maintained. Hodge (2000) holds that Darwin structured the *Origin* to satisfy philosophical ideals advocated jointly by Herschel and Lyell. Recker (1987) and Ruse (2000) hold that Darwin structured the *Origin* to satisfy both Herschel and Whewell's philosophical ideals about theories. Both positions enjoy a reasonable amount of support, which I will discuss later. One document, the *Outline and Draft of 1839*, Darwin's first sketch of his species theory, has been ignored by Hodge, Recker and Ruse in relation to this topic. I will argue that this document indicates that the large scale structure of the *Origin* was determined in 1839. This point is crucial for the debate for two reasons. Firstly, Whewell's *Philosophy of the Inductive Sciences*, which explicitly indicates his ideas about how a theory should be supported, was not published until 1840, *after* the large scale structure of the *Origin* had been determined. Secondly, as I will argue, at the time the *Outline and Draft of 1839* was written, Darwin was fully aware of Herschel's philosophical ideals and was explicitly making use of them in his published material. Thus, I will argue that the historical evidence lends support to Hodge's thesis that the large scale structure of the *Origin* is consistent with Herschel's ideals.

My method will be the following: I will outline Herschel and Whewell's philosophical ideals relevant to the current debate and discuss more thoroughly the positions held by Hodge, Recker, and Ruse. I will then proceed to outline Darwin's exposure to philosophical ideals up till 1839. In particular I will discuss the following: Darwin's exposure to Herschel's *Preliminary Discourse on Natural Philosophy* read in 1831 and 1838; Lyell's use of Herschel's ideals in practice in his *Principles of Geology*, which we know Darwin read very carefully during the *Beagle* voyage and after he returned to England; Darwin's species transmutation notebooks, open from late 1837 into

early 1839, which contain indications of Darwin's methodological commitments, explanatory practices, and even philosophical reflection about his theory; and the addendum to Darwin's *Journal of Researches*, begun in late 1838 and finished in 1839, which gives indication that he took Herschel's ideas very seriously. These sources indicate when and from whom Darwin got his ideas about how to support a theory prior to the determination of the large scale structure of the *Origin*. Finally, I argue that the large scale structure of the *Origin* was established in the *Outline and Draft of 1839*. All of this will support my thesis that the large scale structure of the *Origin* was designed to satisfy Herschel's philosophical ideals.

## II. Herschel and Whewell

Herschel's *Preliminary Discourse On the Study of Natural Philosophy*, published in 1830, presents his philosophy of science. Most important for the purposes of this paper are his ideas about legitimate explanation of phenomena and verification of theories.

Scientific theories are designed to explain phenomena. A phenomenon is explained when the cause of a phenomenon is discovered.

The first thing that a philosophic mind considers, when any new phenomenon presents itself, is its *explanation*, or reference to an immediate producing cause. (Herschel 1830, 144)

Herschel emphasizes that the causes referred to in explanations of phenomena should be *verae causae*. By *vera causa*, Herschel means a cause that is recognized as having a real, and not just hypothetical existence in nature. With this goal in mind, Herschel presents a number of techniques for isolating *verae causae* for the explanation of a phenomenon.

Whenever, therefore, any phenomenon presents itself for explanation, we naturally seek, in the first instance to refer to some one or other of those real causes [*verae causae*] which experience has shown to exist, and to be efficacious in producing similar phenomena. (Herschel 1830, 148)

By considering similar or analogous<sup>2</sup> phenomena the cause of the phenomenon in question may be discovered. In case that the causes of analogous phenomena do not provide an explanation of the phenomenon in question, Herschel recommends postulating a cause analogous to the causes of the analogous phenomena.

If the analogy of two phenomena be very close and striking, while, at the same time, the cause of one is very obvious it becomes scarcely possible to refuse to admit the action of an analogous cause in the other, though not so obvious in itself. (Herschel 1830, 149)

Herschel offers an example of the above method. He asks his reader to consider a stone attached to a string orbiting a hand. The cause of the orbit is obvious, the string exerts a force that maintains the stone's path around the hand. Now consider an analogous

phenomenon, the orbit of the moon around the earth. In explaining it we can postulate a cause analogous to the force the string exerts on the rock and the hand. We can suppose that there must be a central force between the earth and the moon that maintains the moons orbit around the earth. A possible cause identified in this way is at least a likely candidate to be a *vera causa* sufficient to explain the phenomenon in question; however, we must verify that it is so.

A necessary step in verification is to check whether the potential *vera causa* explains *all* the particular facts considered in the explanation of the phenomenon. If it is the case that the cause postulated is previously known to exist and it meets that requirement, the verification has been sufficient. In those instances in which a new cause is proposed an additional step is required for verification. The "...next step in verification of an induction is when we extend its application to cases not originally contemplated..." (Herschel 1830, 167) Provided that the cause can be extended to explain other phenomena, it is very likely that we have a true theory or explanation of a phenomenon. However, nothing is more convincing than when our induction is verified when we do not expect it to apply.

The surest and best characteristic of a well-founded and extensive induction, however, is when verifications spring up, as it were, spontaneously, to notice, from quarters where they might be least expected, or even among instances of that very kind which were at first considered hostile to them. (Herschel 1830, 170)

The above is a sketch of Herschel's philosophical ideals which I will now contrast with William Whewell's.

In the *Philosophy of the Inductive Sciences*, Whewell lays out his philosophy of science. His philosophy overlaps to a large extent with Herschel's, but differs in points relevant for the current discussion. Whewell agrees with Herschel that the business of science concerns itself with explaining phenomena by reference to real causes, but disagrees in what constitutes the best way to identify *verae causae*.

Whewell disagreed with Herschel's claim that causes referred to in the explanation of a phenomenon must be previously known to exist, or minimally be analogous to known existing causes. Whewell thought this was too severe a restriction on theorizing, but still maintained that only *verae causae* should be referred to in explanations of phenomena. Whewell differed from Herschel by suggesting that *verae causae* may be identified by their consilience, their ability to explain different classes of fact.

We may provisionally, assume such hypothetical cause as will account for any given class of natural phenomena; but... when two different classes of facts lead to the same hypothesis, we may hold it to be a *true cause*... and this Rule will rarely or never mislead us. (Whewell 1967b, vol II, 286)

True or real causes are identified by their consilience. In addition, Whewell suggested that another hallmark of a true theory is that it explains classes of facts not originally considered in the original induction. Given the focus on explanation of many classes of

facts in the latter chapters of the *Origin*, many have suggested that the structure is due to Whewell's influence on Darwin.

### III. Herschel and Whewell's influence in the *Origin*

As remarked before, Recker (1987) and Ruse (2000) locate Herschel and Whewell's influence in the structure of the *Origin*. Though they differ on some points they agree primarily on the following: Darwin deliberately attempted to satisfy both Herschel and Whewell's criteria for natural selection to be a *vera causa*. Herschel's criterion of referring to an analogous phenomenon to locate *vera causa* plays out in the first four chapters of the *Origin*. There Darwin makes his analogy between artificial selection and natural selection. Whewell's criterion is satisfied especially in the later chapters of the *Origin* where Darwin proceeds to demonstrate how his theory can account for many different classes of fact: biogeographical distribution, morphology, embryology, etc. This thesis enjoys some support from Darwin's correspondence. Ruse (2000) sites an 1863 letter to Bentham as evidence:

In fact the belief in Natural Selection must at present be grounded entirely on general considerations. (1) On its being a *vera causa*, from the struggle for existence; and the certain geological fact that species do somehow change. (2) From the analog of change under domestication by man's selection. (3) And chiefly from this view connecting under an intelligible point of view a host of facts. (Ruse 2000, 16)

It seems as though Darwin mentions both Herschel and Whewell's criteria for natural selection to be a *vera causa*. (2) points out the analogy between artificial selection and natural selection which satisfies Herschel's criterion, and in (3) Darwin seems to be emphasizing the explanatory power of his theory which would satisfy Whewell's criteria. (3) offers some problems for those who want to suggest that this is Whewell's influence alone. As we have seen, Herschel also highly values the ability of a hypothesis to explain a wide range of facts. In Darwin's later work, *The Variation of Animals and Plants under Domestication*, written in 1868, he writes something that more explicitly connects him to Whewell.

Now this hypothesis [natural selection] may be tested ...by trying whether it explains several large and independent classes of facts; such as the geological succession of organic beings, their distribution in past and present times, and their mutual affinities and homologies. (Ruse 2000, 17)

In this passage Darwin uses the classes of fact terminology that Whewell explicitly includes as his criterion for a true theory.

Hodge (2000) admits that after the publication of the *Origin* Darwin places special emphasis on the explanatory power of his theory and in doing so seems to be indicating his theory satisfies Whewellian ideals. Hodge believes that this is simply a rhetorical strategy Darwin implements after the publication of the *Origin* when the status of natural selection as a *vera causa* from the Herschellian criteria is called into question.

Hodge suggests that the structure of the *Origin* indicates that it is designed to satisfy Herschellian/ Lyellian<sup>3</sup> theory criteria and not Whewell's. Hodge points out that nowhere in the *Origin* does Darwin say what facts were considered prior to his theory and which were considered later, which is something Whewell recommends. Hodge believes Darwin's focus on the explanatory power of his theory in the later chapters of the *Origin* follows simply from Herschel's recommendations. It should be noted that this does not rule out Whewell's influence in the *Origin*. Whewell did not indicate that it is absolutely necessary for a theory to explain facts not considered in the original induction, but that that was a good indication of a well confirmed theory.

At this point, there is no knock down evidence that either side is correct about whose influence manifests itself in the *Origin*. Since Herschel and Whewell agreed on so much, it is difficult to be sure simply from the structure of the *Origin* who Darwin may be attempting to satisfy. In order to decide the matter, the historical details of Darwin's philosophical education and the historical drafts of the *Origin* must be considered, which is what I turn to now.

#### IV. Darwin's early encounter with Herschel

Darwin encountered Herschel's *Preliminary Discourse On the Study of Natural Philosophy* while still a student at Cambridge. The book obviously struck Darwin. In March of 1831 he writes to his cousin W. D. Fox, "If you have not read Herschel in Lardners Cyclo—read it directly."<sup>4</sup> (Burkhart, et al. Vol I, 118) In his autobiography Darwin writes "This work [Humbolt's Personal Narrative] and Sir J. Herschel's Introduction to the Study of Natural Philosophy<sup>5</sup> stirred up in me a burning zeal to add even the most humble contribution to the noble structure of Natural Science." (De Beer 1974, 38) Clearly Herschel's *Discourse* was important for the young Darwin.

There is no record of how well Darwin assimilated Herschel's philosophical ideals after this first reading, but is worth noting that Darwin was in a good position to appreciate them. At Cambridge Darwin attended John Henslow's botany lectures and his weekly scientific meetings. Darwin worked closely with Robert Grant on marine zoology and had gone on two extended geological surveys with Adam Sedgwick. Darwin was exposed to serious science from leading men in England by the time he read Herschel. Given these facts, Darwin probably he read Herschel with some care. Some seven months after reading the book Darwin set sail on the *Beagle*. Herschel's book didn't make the voyage with Darwin; however, Darwin was not without philosophical tutelage during his journey.

#### V. Lyell

Lyell, has well formulated ideas about acceptable scientific practice. *Principles of Geology* is full of commentary on the matter both explicit and implicit. Darwin initially set sail with the first volume of *Principles of Geology*. Darwin actually managed to have the following two volumes sent to him while he was away.

Lyell upholds general principles that coincide well with Herschel's beliefs. Lyell maintained a strict belief in "fixed and invariable laws" of nature and derivatively in the

“undeviating uniformity of secondary causes”. Geology then, and perhaps natural history, was characterized by explaining the world by reference to secondary causes.

Lyell had well worked out ideas about explanations of phenomena. The best explanations make reference only to secondary causes that are known to exist and are sufficient to produce or account for the phenomena in question. If such causes are not directly observable, one is licensed by the fixed laws of nature to use analogy to guide reasoning. (Lyell 1969 vol I, 165) Lyell constantly used knowledge of observable geological causes to explain the present state of the earth by reference to past geological events. Reference to a hypothetical cause to explain events was acceptable only if no known causes were sufficient to account for the phenomenon in question. If hypothesis is necessary, minimally it must be consistent with available analogies and be sufficient to account for the phenomenon in question. Thus, Lyell’s philosophical ideals place him squarely with Herschel. Lyell’s coral reef theory offers an example of his ideals in action.

Lyell begins his chapter on coral reefs by discussing the general structure of the reefs. Coral reefs are composed not solely of the zoophytes which construct them but also a “great variety of shells”, remains of fish, etc. “The reefs, which just raise themselves above the level of the sea, are usually of a circular and oval form, and are surrounded by a deep and often unfathomable ocean.” (Lyell 1990 vol II, 284) The reefs often have a lagoon in their center which is approximately fifteen to twenty fathoms deep. Lyell focuses his attention on the Maldiva Isles, a group of coral reefs in the Indian Ocean.

Lyell explains these facts by referring to an observable geological cause sufficient to produce them. He offers the hypothesis that coral reefs are built on submerged volcanoes. This accounts firstly for the linear arrangement of the Maldiva Isles. Lyell points out that if Java and Sumatra were submerged, a linear expanse of volcanoes would jut out of the water and produce a similar effect as what occurs at the Maldiva Isles. Secondly, the crater of the volcano accounts for the lagoon often found in the center of the coral reefs. Thirdly, the shape of a volcano would account for the steep angle at which the reef drops to unfathomable depths. Lyell considers a possible objection: the size of reefs, up to 30 miles in diameter, precludes the possibility of them being built on volcano craters. Lyell counters that the reefs may be settled on the remains of truncated cones, explaining their size.

Lyell introduces another fact, that there is almost always a passage that leads from the lagoon of coral reefs to the sea. Lyell, in analogy to what happens in estuaries, suggests that when the sea is at low tide, excess water that accumulates in the lagoon during high tide is flushed out through one exit. At first there are probably several exits for the water, but as the coral grows gaps are filled in till there is only one passage which is habitually kept open.

Another fact about coral reefs is that their windward side is often “higher and more perfect than the other.” Lyell rejects the obvious explanation, that the tides heap more debris on the windward side; it is not sufficient to account for all the facts. There are reefs so submerged as to be immune to the habitual action of the tides that exhibit the same structure. Lyell, following his belief that coral reefs are situated on volcanic peaks, examines activity typical of volcanoes to discover a cause adequate to explain the phenomena in question: alternate subsidence and elevation. “A repetition of such operations by the alternate elevation and depression of the same mass (an hypothesis

strictly conformable to analogy) might produce still greater inequality in the two sides, especially as the violent efflux of the tide has probably a strong tendency to check the accumulation of the more tender corals of the leeward reef, while the action of the breakers contributes to raise the windward barrier.” (Lyell 1990 vol II, 294)

About a half year after reading Herschel, Darwin encountered many of the ideals Herschel advocates put in practice by Lyell. Darwin continued to be exposed to Lyell’s work as new volumes of *Principles* were sent to him. The extent to which Herschel’s philosophy influenced Darwin while on the *Beagle* and the months up to his discovery of natural selection is a matter of speculation. There is no evidence that points directly to Herschel. However, the early transmutation notebooks give indication that Darwin was theorizing along at least Lyellian lines and consequently in conformity to Herschel’s ideals.

## VI. Darwin’s Lyellian commitments in the Notebooks

Several excerpts from the notebooks indicate that he is theorizing, consciously or not, along Lyellian lines. A large part of Darwin’s notebooks is dedicated to explaining facts by giving causes adequate to their production.

**May this not be explained on principle, of animal having come to island. where it could live—but there were causes to induce great change. like the Buzzard which has changed into Caracara at the Galapagos.** (B55 Barrett, et al. 1987, 185)<sup>6</sup>

This passage follows Darwin’s observation that “There certainly appears attempt in each dominant structure to accommodate itself to as many situations as possible,” and a number of cases where this seems to occur. Darwin attempts to explain these facts by suggesting that there was a cause, though unknown, which was responsible for transmutation of species. Darwin’s dedication to causal explanation of facts is explicit in the next passage as well, where he criticizes his theory based on his commitments.

Weakest part of theory death of species without apparent physical cause:— (B135 Barrett, et al. 1987, 203)

Darwin’s commitment to the explanatory power of a hypothesis is evident from the following passage:

Absolute knowledge that species dies & others replace them—two hypotheses fresh creations is mere assumption, it explains nothing further, points gained if any facts are connected.—(B104 Barrett, et al. 1987, 195)

Darwin begins this passage by stating a fact, species die and others replace them. He then refers to two hypotheses that will account for this fact. One hypothesis is unmentioned, that creation takes place by means of regular laws. In B98-103, Darwin theorizes using known facts about the Galapagos Islands and the hypothesis of creation according to laws and attempts to trace consequences of such a view. In B104, he

criticizes the second hypothesis, which postulates a fresh creation of species without reference to fixed laws or secondary causes. Darwin's criticism seems directed right along Lyellian lines. The "fresh creations" hypothesis is used solely to account for the facts it was intended to explain. There is no evidence that this hypothesis is true beyond the facts it was intended to explain, i.e. it explains nothing further.

Like Lyell, Darwin has a propensity to use analogy to guide theorizing. ...there are mountains in the moon,, which though not very analogous (see Edinburgh. Phil. Journal <]><sup>7</sup>, no great chains like Andes or Himalayas, but great curcular mountains, yet so analogous, that as we see mountains formed (&mountains are effect of continental elevations) we may conclude that elevation is independent of spreading out matter by action of the sea.—as no sea exists there.—(A104e-5 Barrett, et al. 1987, 119)

Darwin is criticizing Herschel's view that continental elevations occur as the result of a process of erosion of the land by the sea and upheavals due to the earth's interior heat.(Barrett, et al. 1987, 118) There is an analogous phenomenon to continental elevations, namely a chain of mountains on the moon, which have occurred in the absence of water, a fact not in accordance with Herschel's view. Darwin reasoned that Herschel's view is incorrect because it violates an analogy.<sup>8</sup>

No other passage seems to indicate Darwin's Lyellian commitments more than the following. Lyell, in his *Principles*, argues that geologists should not speculate on the origin of the earth. Instead, they should focus only on explaining the present state of the earth in reference to observable causes.(Lyell 1969 vol I, 105) Darwin writes:

it is useless to speculate <<not only>><sup>9</sup> about beginning of animal life.: generally, but even about great division, our <only> question is not, how there come to be fishes & quadrupeds, but how there come to be, many genera of fish &c &c at present day.— (C58 Barrett, et al. 1987, 257)

As Lyell warns against speculation about the origin of the earth, Darwin warns us about speculating on the origin of animal life. Following Lyell's recommendation that geology concern itself with the present state of the world, Darwin recommends that emphasis is placed on explaining animal life at the present day.

Given the above quotes from the notebooks it is established that Darwin theorizes along Lyellian lines and has assimilated Lyell's philosophical commitments to some extent. Thus, Darwin, knowingly or not, is theorizing along Herschellian lines.

## VII. Darwin's philosophical flourish in 1838

Up till late summer of 1838, there is no evidence that Darwin was thinking about philosophical issues; however, an article Darwin read at that time seems to have sparked a renewed interest in those issues that culminates with his rereading of Herschel. Between the 7<sup>th</sup> and 12<sup>th</sup> of August 1838, a notebook entry indicates Darwin read David Brewster's review of Comte's *Cour de philosophie positive*.



Darwin seems to have been impressed by Comte, especially with his insistence on banishing the use of arguments from design. Darwin, in order to establish a theory of species transmutation, would have to deal with religious opposition to his views. Comte, addressing arguments for design, argued the perfection of our solar system was the result of secondary causes. Brewster writes:

Admitting as M. Comte does, that the stability of the solar system is essential to the continued existence of Animal Species, and aware of the powerful support which such an admission lends to the argument for design... he strives to show that this effect may, with much probability, be deduced from the mode of formation of the system, as suggested by Laplace—one of the boldest speculations of modern fancy. (Schweber 1977, 245)

Darwin cherished this sentiment, that the stability of the solar system and hence the continued existence of animal life are a simple consequence of secondary causes, and extended its application. On August 16<sup>th</sup> Darwin writes:

What a magnificent view one can take of the world Astronomical <a unknown> causes, modified by unknown ones. cause changes in geography & changes of climate superadded to change of climate from physical causes.—these superinduce changes of form in the organic world, as adaptation. & these changing affect each other, & their bodies, by certain laws of harmony keep perfect in these themselves.—instincts alter, reason is formed, & the world peopled <<with Myriads of distinct forms>> from a period short of eternity to the present time, to the future—How far grander than idea from cramped imagination that God created. (D36-7 Barrett, et al. 1987, 342-3)

Darwin extends Comte's ideas by envisioning secondary causes being responsible not only for the continued existence of animal life, but for its creation and subsequent adaptations.

In the weeks following Darwin's reading of Brewster's review we see increasing philosophical reflection recorded in his notebooks, even explicit comments about how one should evaluate his theory. The following was written on the 8<sup>th</sup> of September:

In comparing my theory with any other. it should be observed not what comparative difficulties (as long as not overwhelming) What comparative solutions & linking of facts—(D71 Barrett, et al. 1987, 356)<sup>10</sup>

It is my belief that this increase in philosophical reflection prompted Darwin to reread Herschel's *Discourse* soon after his initial encounter with Brewster's review. The first good indication Darwin has been reading Herschel occurs in a letter to Lyell on the 13<sup>th</sup> of September. In it Darwin responds to a question Lyell had about his unpublished coral reef theory. Lyell wanted to use Darwin's theory to criticize Elie de Beaumont's theory that lines of elevation of mountain chains are close to parallel if they are elevated from

the ground at approximately the same time. Darwin's coral theory is potentially applicable to the topic of mountain formation because it implicates elevation and subsidence in the explanation of coral reef structure. Lyell is wondering whether there is any evidence that suggests that the elevation or subsidence of parallel coral formations occur contemporaneously. (Burkhart, et al. 1983, 100) In his reply to Lyell, Darwin does not answer Lyell's question directly. With respect to how his coral theory bears on the matter Darwin cautions Lyell on its use against de Beaumont's theory.

I think it would be prudent to quote me with great caution, until my whole account is published, & then you (& others) can judge how far there is foundation for any generalization.—mind I do not doubt its truth,—but the extension of any view over such large spaces from comparatively few facts must be received with caution. (Burkhart, et al. 1983, 105)

In this passage Darwin is concerned about using his theory of coral formations to argue against a theory of mountain elevations for two reasons. Firstly, his fully developed coral theory has not been submitted to public scrutiny, whence it can be fairly evaluated. Secondly, he is not confident that his theory, developed from few facts about Pacific coral formations, can be extended to critique global conclusions about the formation of mountains. The same type of caution is recommended in the *Discourse*:

We cannot rely on its [a law of nature] enabling us to extend our views beyond the circle of instances from which it was obtained, unless we have had experience of its power to do so; unless it actually *has* enabled us before trial to say what will take place in cases analogous to those originally contemplated; unless, in short, we have studiously placed ourselves in the situation of its antagonists, and even perversely endeavoured to find exceptions without success. (Herschel 1830, 167)

In this case Herschel is talking about laws of nature and not about theories, but Darwin seems to find his comments applicable. Just as Herschel cautions about the application of laws of nature beyond the facts from whence they were derived, Darwin cautions about the use of his theory on facts different than those which his theory deals with. Also, Darwin is following Herschel's recommendation that before the application of laws are extended they need to be scrutinized antagonistically when he suggests that others besides himself need evaluate whether his work can be generalized prior to actually doing so. Thus it appears that Darwin has been reading Herschel and is making use of his recommendations.

Sometime between the 19<sup>th</sup> and the 23<sup>rd</sup> of September Darwin comments on his style of argumentation:

The line of argument <<often>> pursued throughout my theory is to establish a point as a probability by induction, & to apply it as a hypothesis to other points. & see whether it will solve them.— (D117 Barrett, et al. 1987, 370)

This may not be an explicit connection between Darwin and Herschel but, what Darwin writes does resemble Herschellian methods. According to Herschel, hypotheses are to be arrived at by induction. Confirmation of the induction is carried out by considering all facts to which the hypothesis would apply, especially those at first considered hostile to the hypothesis. Very roughly, Darwin has approximated Herschel's recommendations in the above passage. Undeniably, this passage demonstrates Darwin's philosophical or meta-level awareness of his practice in the notebooks in late September of 1838.

There is explicit proof that Darwin read Herschel in the last quarter of 1838. In notebook C, Herschel *Discourse* is listed among books examined with reference to species. Darwin marked Herschel's book as read sometime between the 12<sup>th</sup> of October and the end of the year. (Barrett, et al. 1987, 320) Explicit reference is made to Herschel's *Discourse* in N49 dated between the 27<sup>th</sup> of November and the 27<sup>th</sup> of December but, the above quotes makes it likely that Darwin was reading Herschel shortly after reading Brewster's review.

The notebook excerpts above indicate that Darwin was learning much from Lyell and Herschel. Explicit use of the philosophical ideals Darwin learned manifested themselves in the addendum to his *Journal of Researches* written in November 1838<sup>11</sup>. Darwin writes two revealing passages:

I make no assumptions which are not supported by strong analogies and the foundation of the theory—namely, a change of climate of a peculiar kind—can be shown by reasoning, independent of the existence of erratic blocks, to be probable in a high degree: whether this is the case with the theory of M. Agassiz, I leave the reader to decide. (Barrett and Freeman 1986 vol III, 621)

In this explanation only *verae causae* are introduced, and reasons can be assigned for the belief that these causes have been in action in these districts. On the theory of debacles, it still remains to be proved that rocks can be thus *scooped* and *furrowed*, or hills *scarped*; although I am far from affirming they cannot, and scratched, I presume, they certainly would be. With respect to Sweden, where the land is now rising, and where ice even still is a transporting agent, it is undoubtedly the part of the geologist, to endeavour by long and laborious research to account for the phenomena by these real agencies. For to introduce, before it is absolutely forced upon us, the hypothesis of a deluge of mud and stones, fifteen hundred feet deep in Sweden, or three thousand in North America, which rushing over the country, rounded the northern fronts of the hills, and rolling by their eastern and western flanks, left them marked with oblique furrows, is to violate, as it appears to me, every rule of inductive philosophy. (Barrett and Freeman Vol III 1986, 627-8)

These passages are clearly indicative of the Lyellian / Herschellian philosophy. This point can be established by comparing the above passages to one in Herschel:

In framing a theory which shall render a rational account of any natural phenomenon, we have *first* to consider the agents on which it depends, or the causes to which we regard it as ultimately referable. These agents are not to be arbitrarily assumed; they must be such as we have good inductive grounds to believe do exist in nature, and do perform a part in phenomena analogous to those we would render an account of; or such, whose presence in the actual case can be demonstrated by unequivocal signs... (Herschel 1830, 197)

Herschel maintains the following about agents or assumptions in a theory in the above passage: There must be good inductive reasons for 1. their existence in nature, 2. their ability to account for the events in consideration, 3. their actual existence in the case in question. Darwin makes use of these criteria in the above passages.

In the first passage Darwin points out that he makes no arbitrary assumptions. His assumptions are supported by strong analogy and the primary agent in his theory, the change of climate, can be shown to exist independently of the facts it is used to explain. Thus, he established that there are good inductive grounds for the existence of the agents and causes he has employed in his theory. Darwin explicitly confirms his use of real existing causes in the second passage when he claims that he uses only *verae causae* in his explanation. Hence, Darwin satisfied 1. In second passage Darwin does not say he satisfies 2.; however, that is taken care of when he lays out his theory in the preceding pages. Darwin does point out in the second passage that the alternative theory which he is arguing against does *not* show how the agents or causes it introduces, namely a deluge of mud and stones, can account for the phenomena it was intended to explain. Darwin's critique is based on 2. Finally, Darwin indicates that he satisfies 3 in the second passage. He can provide evidence that the causes and agents he utilizes in his explanation were in operation in the case under consideration.

Darwin is obviously committed to the Herschellian/ Lyellian philosophical ideals. In this passage, Hodge sees Darwin upholding Lyellian ideals in particular (Hodge 2000, 38 & n.15). I am inclined to disagree. Though Darwin's writing clearly does indicate agreement with Lyellian ideals, the particular vocabulary he chooses suggests otherwise. That Darwin mentions *verae causae* seems to indicate his reading of Herschel, because nowhere to my knowledge are *verae causae* referred to in the *Principles*.

I think it is likely that Darwin intended to demonstrate his methodological allegiance with Herschel with this passage, or to argue that his application of Herschellian ideals strongly supports his theory. This passage was written in November of 1838, exactly the time in which I think it is highly likely that Darwin was reading Herschel. The coincidence of these facts is striking.

The excerpts from the addendum indicate that Darwin was keenly aware of Herschel's philosophical ideals, he consciously developed his theory within those ideals, and argued that it should be accepted for those reasons. Given that he had done so, a famous passage from the notebooks may be explained.

A letter from Herschel to Lyell was published in the 10<sup>th</sup> Bridgewater Treatise. In that letter Herschel writes:

For my own part, I cannot but think it an inadequate conception of the Creator, to assume it as granted that his combinations are exhausted upon any one of the theatres of their former exercise, though in this, as in all his other works, we are led, by all analogy, to suppose that he operates through a series of intermediate causes, and that in consequence the origination of fresh species, could it ever come under our cognizance, would be found to be a natural in contradistinction to a miraculous process—(Barrett, et al. 1987, 413)

Between December 2<sup>nd</sup> and 4<sup>th</sup> Darwin reacts to that letter:

Babbage 2<sup>d</sup> Edit, p. 226.—Herschel calls the appearance of new species. the mystery of mysteries. & has grand passage upon the problem.! Hurrah.—“intermediate causes” (E59 Barrett, et al. 1987, 413)

Darwin’s reaction can be explained by the following: Firstly, this passage closely parallels Darwin’s own sentiments in D36-7 quoted above. Secondly, E59 occurs shortly after Darwin discovers the secondary cause of species origins, natural selection. Thirdly, Darwin finds partial support for his topic and method of inquiry, in an otherwise hostile environment for such thoughts, from a man of great prestige and power and whom we know Darwin admired greatly. Finally, Darwin’s had just been consulting Herschel’s *Discourse*; the coincidence most likely struck Darwin.

Given that Darwin was well aware of Herschel’s philosophical ideals and consciously making use of them in his published works, I turn to the *Outline and Draft of 1839*.

#### VIII. The *Outline and Draft of 1839*

In the summer of 1839, Darwin had time to write up a partial draft of his species theory.<sup>12</sup> The *Outline and Draft of 1839* is nowhere near as complete as the *Sketch of 1842* or the *Essay in 1844*; however, it deserves attention because it gives an indication of how Darwin wanted to structure the argument for his theory at that time. What is remarkable is that the basic structure of the argument for his theory appears relatively constant from 1839 till the *Origin* was published in 1859. To support this claim, I will compare the structure of the *Outline and Draft of 1839* to the structure of the *Sketch of 1842*. Since it is already well established that the structure of the *Sketch of 1842*, the *Essay in 1844*, and the *Origin* are very similar (Hodge 1977), this technique will be sufficient. In 1839 Darwin envisioned the structure of the theory as follows:

- I. The Principles of Var. in domestic organisms.
- II. The possible & probable foundation of wild races. Analogous to the domestic ones of plants & animals.
- III. The (proofs) reasons for & against believing that such races have really been produced—forming what are called species. (Vorzimmer 1975, 216)

Consider the structure of the *Sketch of 1842*:

*Part I*

- I. On variation under domestication, and on the principles of selection
- II. On variation in a state of nature and on the natural means of selection
- III. On variation in instincts and other mental attributes

*Part II*

- IV, V. On the evidence from geology
- VI. Geographical distribution
- VII. Affinities and classification
- VIII. Unity of type in the great classes
- IX. Abortive organs
- X. Recapitulation and conclusion (De Beer 1958, V)

Both outlines begin by examining domestic variation and proceed to consider variation in nature and then to the evidence Darwin has for his theory. Darwin also seems to have anticipated the structure of Part II of the *Sketch* in 1839. In his 1839 he writes:

Affinity—unity of type—foetal state—abortive organs—hybrids like mongrels—difficulty of testing species from varieties—if species given up, genera must—we know that extinction within certain limits is possible, we ask for limits of this variation who can answer? (Vorzimmer 1975, 217)

“Affinity” and “unity of type” are sections VII and VIII in the *Sketch*. Included in VIII is a discussion of the “foetal state” of organisms.(De Beer 1958, 78) Section IX in the *Sketch* is on “abortive organs” and contains discussion of “hybrids like mongrels”.(De Beer 1958, 82) In the final section of the *Sketch* the considerations of “difficulty of testing species from varieties” and “if species given up, genera must” are discussed. (De Beer 1958, 85) Only the last question of the above paragraph is missing a counterpart in the second half of the *Sketch*. Given that there are so many coincidences between the *Outline and Draft of 1839* and the *Sketch of 1842* and that even the order of topics is preserved from 1839 to 1842 suggests that Darwin had given much thought to how to structure the argument for his species theory in the summer of 1839, a structure which was more or less preserved till the publication of the *Origin*.

IX. Conclusion

Given that the structure of the *Origin* is mostly fixed in 1839 and that Whewell’s *Philosophy of the Inductive Sciences* was not published until 1840 it is unlikely that Darwin purposely structured the argument for his theory to be in agreement with Whewell’s philosophical ideals. Darwin’s focus on the explanatory power of his theory, singled out as his connection to Whewell, likely comes from his Herschellian commitments that were established early on in his career.

The *Origin* is most likely structured to follow Herschel's philosophical ideals. A reasonable interpretation of the structure of the *Origin* can be made based on Darwin's comments to Bentham from his 1863 letter above. As per Herschel's recommendations, only causes known to exist were admitted into the theory, namely, the struggle for existence and variation. Darwin supported the contention that these are sufficient causes for species transmutation using an analogy with artificial selection, a phenomenon in which the cause of species change is obvious. The latter chapters of the *Origin* are the verification on the theory by showing that natural selection can explain a large body of facts—which is the hallmark of a true theory for Herschel.<sup>13</sup>

This interpretation of Darwin's intentions in structuring his argument for his theory offers a nice explanation of his reaction to Herschel's review of Whewell's *Philosophy of the Inductive Sciences*. Darwin writes, “—From Herschel's Review Quart. June 41 I see I MUST STUDY Whewell on Philosophy of Science” (Ruse 1975, 166) Darwin found that Whewell's ideas about supporting a theory agreed well with the structure of his argument for his theory.

The above arguments lend a high degree of credibility to my thesis, but some might wonder whether Darwin may have been exposed to Whewell's views prior to their publication. Ruse (1975) points out that Darwin and Whewell interacted personally when Darwin was still at Cambridge and later after he returned from the Beagle voyage. Ruse suspects that they talked about methodological issues. (Ruse 1975, 165) There is no good textual evidence in the notebooks or correspondence which supports such a claim. Anyone who has read Darwin's early correspondence looking for clues as to where Darwin got his philosophical ideals will be hard pressed to find any discussion of such matters. Thus, it is unlikely that Darwin would be discussing such issues in private with Whewell. Ruse also points out that Darwin read Whewell's *History of the Inductive Sciences* towards the end of 1838. Indeed this is true, but Whewell's views about how to support a theory appear later in *Philosophy of the Inductive Sciences*, published in 1840.<sup>14</sup> Further, we know that Darwin did not read Whewell's *Philosophy* in 1840. His first exposure to Whewell's ideas comes when from Herschel's review of Whewell in 1841. (Ruse 1975, 166) Darwin's commentary on Herschel's review, “I MUST STUDY Whewell on Philosophy of Science” seems to indicate that he was not familiar with Whewell's philosophy prior to this review. If Darwin had been familiar with Whewell's philosophical ideals he probably would not need to indicate in capital letters that he must study Whewell.

The above arguments establish that the large scale structure of the *Origin* is owing to Herschel's influence on the young Darwin. This does not rule out the possibility that Darwin tried to adapt the structure of the *Origin* to satisfy Whewell's ideals. Evidence that he did so will have to come from small details in the structure of the *Origin* such as Darwin's use of the “classes of fact” terminology. This is a project I leave for future scholarship.

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<sup>1</sup> I intend the term “philosophical ideals” to be a catch all term which refers to what constitutes acceptable methodology of scientific inquiry, desirable characteristics of theories, confirmation practices, etc.

<sup>2</sup> Herschel uses “similar” and “analogous” interchangeably. (Herschel 1830, 148-9)

<sup>3</sup> Hodge sees Lyell and Herschel upholding a unified view on theories. I will discuss Lyell’s views below.

<sup>4</sup> Lardners Cyclo is a reference to Lardner’s Pocket Cyclopedia which contained Herschel’s treatise.

<sup>5</sup> Presumably a reference to the *Preliminary Discourse*.

<sup>6</sup> B55 refers to Notebook B, page 55. This convention is followed for the A, C, D, E, M and N notebooks as well.

<sup>7</sup> Text in < > is text that Darwin deleted.

<sup>8</sup> For further use of analogy to guide theorizing see B32, B64, B39-43, D99, D70, C241, C209, & more

<sup>9</sup> Text in << >> is text that Darwin inserted.

<sup>10</sup> See also D58 written Sept. 2<sup>nd</sup> and D67 written Sept. 7<sup>th</sup>.

<sup>11</sup> See E37

<sup>12</sup> The *Outline and Draft of 1839* was originally thought to be notes written while Darwin was writing the *Sketch of 1842*. Peter Vorzimmer has argued convincingly in his (1975) that that was an incorrect assessment.

<sup>13</sup> This is an interpretation which is likely on the above analysis and no more. A convincing interpretation of the *Origin* deserves a separate analysis.

<sup>14</sup> Ruse hints that Darwin might assimilate Whewell’s consilience of induction technique from the *History*, however; the example in the *History* Ruse sights actually praises a theory on its agreement with Herschellian ideals. (See Whewell 1967a vol III, 173) Darwin could not learn the consilience technique from the *History*. See Ruse 1975, 163 and note 24.



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